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## The Strolling Astronomer

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The Marius Dome Field in Iunar Oceanus Procellarum, photographed on 1965 DEC 06 with the 61-inch (1.55-meter) reflector of Catalina Station (Catalina Photo. 374) at Colong. 0630.7. North is at top and west (IAU) to the left. This area covers about 260 km northsouth and 300 km east-west. The crater Marius is near the right margin and Reiner is at bottom. Left of Marius is the dome field described on pp. 104-108 of this issue, including the small sinuous rille in the upper left. This photograph is part of the collection recently acquired by the A.L.P.O. (see p. 103).

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# ObSERVATIONS OF MERCURY IN 1988 AND 1989 

By: Richard W. Schmude, Jr., Chemistry Department, Texas A\&M University, College Station, Texas 77843


#### Abstract

The writer carried out a visual study of the planet Mercury in May, 1988, and in April and May, 1989. Most of the observations were made with the $35.5-\mathrm{cm}$ telescope at the Texas A\&M University Observatory. This report presents drawings and a map of Mercury that covers the longitude range of $195-285^{\circ}$. One important finding was that a polarizing filter combined with color filters gives a sharper view of the planet. It is also concluded that high-resolution images of Mercury's terminator, either as seen from the Earth or with the Hubble Space Telescope, can provide information about Mercury's topography.


## Introduction

The writer observed the planet Mercury on three dates in May, 1988, and five more times in mid-1989. Figure 1 (p. 102) shows five drawings of Mercury that were made during 1989 APR 22-MAY 04. During that time interval, the longitude of Mercury's central meridian varied from $250^{\circ}$ to $309^{\circ}$ [measured in the usual westward sense], while the phase angle increased from $70^{\circ}$ to $114^{\circ}$ [the angle between the Earth and the Sun as seen from Mercury; Mercury's Greatest Elongation East was $20^{\circ} .7$ on 1989 MAY 01]. Likewise, the apparent disk diameter increased from 6.3 arcseconds on 1989 APR 22 to 8.6 arc-seconds on 1989 MAY 04. [1] I observed three types of features on Mercury; bright areas, dark areas, and terminator irregularities.

## BRIGHT AREAS

Bright areas were seen on all five dates represented in Figure 1. Of the 19 isolated bright regions that were seen, 16 were near or on Mercury's limb, meaning that they were viewed with relatively high solar lighting. This distribution is consistent with the Mariner-10 images and with visual observations of the planet, both of which show a concentration of bright areas near the limb. It is probable that the brightness of many of these regions would change as they move closer to the terminator. In fact, this may explain why Antoniadi suspected dust veils on Mercury. [2] A higher concentration of bright areas also occurs near the Moon's limb when it is viewed with the naked eye. On 1989 APR 24, I closely examined Mercury through a polarizing filter. At one point, I rotated the filter and found that the intensities of the two bright regions at the 6 o'clock and 7 o'clock positions varied, taking Mercury's South Pole to be 12 o'clock [i.e., the two regions were at Mercurian position angles of $0^{\circ}$ and $330^{\circ}$ respectively]. The feature at 7 o'clock was also found to be distinct in a red filter (Kodak Wratten 25). The north and south poles of Mercury usually appeared brighter than other regions, thus resembling the cusp-caps often seen on Venus. [3] Furthermore, this effect is also evident on some other observers' highresolution drawings of Mercury. [4]

## Dark regions

A total of 17 isolated dark regions was observed on the five dates on which the drawings in Figure 1 were made. Thirteen of these bordered the terminator and only one dark area bordered the limb; a similar distribution was observed in May, 1988. This observation is in approximate agreement with long-range Mariner-10 images of Mercury. [2,5]

The dark region seen on 1989 APR 23 and 24 , on the terminator at a latiude of $5^{\circ}-10^{\circ}$ South, made a small apparent dent on the terminator. This is consistent with the region's having an elevation lower than its surroundings. On 1989 APR 24, this region was also found not to vary in intensity as the polarizing filter was rotated. This region corresponds to a dark feature centered at $268^{\circ} \mathrm{W} / 2^{\circ} \mathrm{S}$ on the map prepared by Murray et al. [6] and to a similar feature on the map by Dollfus et al. [7]. This feature also may have been the conspicuous dark spot seen near the center of Mercury's disk by Graham on 1988 MAY 10 [8]; the sub-Earth point on that date was at $260^{\circ} \mathrm{W} / 0^{\circ}$ [9].

A second dark region that was distinct on 1989 APR 24 , at about $230^{\circ} \mathrm{W} / 25^{\circ} \mathrm{N}$, corresponds to Solitudo Phoenicis. [7] The dark region near the North Pole, seen on 1989 APR 24 , does not match any dark feature on the maps by Murray et al. [6] or Dollfus et al. [7]. This feature may be a contrast effect. The dark region at the 11 o'clock position [Mercurian position angle $210^{\circ}$ ] on the 1989 APR 24 drawing corresponds to Solitudo Atlantis. [6] The dark regions seen on 1989 MAY 01 and 04 near the center of the terminator may be the same feature; if so, this feature would correspond to Solitudo Alarum. [7] Finally, the long dark strip seen on 1989 APR 23 may be the unresolved image of the two features Solitudo Phoenicis and Solitudo Atlantis. [7]

## Terminator Irregularities

Terminator irregularities were suspected on all five dates represented in Figure 1. A dent in the terminator that was observed on 1989 APR 22 and 23 is associated with the large bright area at about $30^{\circ}-49^{\circ}$ South. Another and more distinct dent was seen on 1989 APR 24 near $271^{\circ} \mathrm{W} / 50^{\circ} \mathrm{S}$. This feature


April 22. 1989 (1:35-2:00 UT)
35.5 cm Schmidt-Cass. ( 325 X )

Secing 2-4, C.M. $=250^{\circ} \mathrm{W}$

April 23, 1989 (104-1:35 UT)
35.5 cm Schmidt-Cass. (325X) Seeing 4, C.M. $=255^{\circ} \mathrm{W}$

April 24, 1989 (0:58-1:35 UT)
35.5 cm Schmidt-Cass. ( 325 X ) Sering 5.5, C.MI $=259^{\circ} \mathrm{W}$


May 1, 1989 (1:17-1:40 UT)
35.5 cm Schmidt-Cass. (325X) Seeing 3, C.M. $=294^{\circ} \mathrm{W}$


May 4, 1989 (1:09-1:30 UT) 35.5 cm Schmidt-Cass. ( 325 K ) Seeing $3-4, C M=309 \mathrm{~W}$


Figure 1. Drawings, with a map of the portion of Mercury between longitudes $195^{\circ}-285^{\circ} \mathrm{W}$, by Richard W. Schmude, Jr. South is at the top for the drawings, but north is at the top of the map, which is on the Mercator Projection. On the dates and times indicated, the planet's disk diameter and phase (proportion illuminated) were: 1989 APR 22, $6^{\prime \prime} .3,0.67$; APR $23,6^{\prime \prime} .5$, 0.63 ; APR 24, $6^{\prime \prime} .6,0.60$; MAY 01, $7^{\prime \prime} .9,0.38$; MAY 04, $8^{\prime} .6,0.29$. Seeing is on the standard A.L.P.O. Scale, ranging from 0 for worst to 10 for perfect.
was estimated to extend beyond the terminator by .05 to .10 Mercury radii, corresponding to about $.17-.33 \mathrm{arc}$-seconds. This amount of deformation is consistent with elevations of $3 \mathrm{ki}-$ lometers or more. At that time, the terminator was at longitude $271^{\circ} \mathrm{W}$; thus, this irregularity may be due to an elevated region lying near or just west of $271^{\circ} \mathrm{W} / 50^{\circ} \mathrm{S}$. It is conceivable that this feature is related to the irregularity seen on 1989 APR 22 and 23. [Note that the above indicates an exceptional earthbased resolution of detail on Mercury, where 0.5 arc -seconds might be considered good. Corroboration by other observers with excellent conditions and equipment is highly desirable. Ed.]

One slight bulge of the terminator into the sunlit hemisphere was visible on 1989 APR 23 and 24 and was associated with the nearby dark region. This is consistent with the dark region's being depressed by about 1-2 kilometers, which is similar to the dark maria on the Moon.

Two other terminator bulges were visible on 1989 MAY 01 and 04; both were also associated with a small dark feature. Finally, the southern horn of Mercury appeared blunt on 1989 APR 24 and MAY 01; this effect was also
observed by Schröter on 1800 MAR 26, as well as by others. [10]

## The Map

Using the drawings shown in Figure 1, as well as others not published here, I have drafted a map of the portion of Mercury's surface that lies between longitudes $195^{\circ}-285^{\circ}$ West and within $60^{\circ}$ of the equator, which map is also shown in Figure 1. When constructing this map, I did not include the bright features observed lying near the limb when observed because it appears that their intensity is strongly dependent on the viewing geometry.

The map presented here is in reasonable, but not perfect, agreement with other maps. For instance, while the dark region shown here at $270^{\circ} \mathrm{W} / 5^{\circ} \mathrm{S}$ is shown on other maps, it is here about 50 percent larger. $[\mathbf{6}, \mathbf{1 0}]$ This may be due to the relatively small aperture, 35.5 cm , of the telescope used for this study. The three previously mapped regions, Solitudo Phoenicis, Solitudo Criophori, and Solitudo Atlantis, are all shown here but differ in shape from other maps. The bright area centered at $270^{\circ} \mathrm{W} / 30^{\circ} \mathrm{N}$ is consistent with a

Mercury map based on both photographs and visual observations [2], but agrees less well with the map constructed by Murray et al. [6] Unfortunately, the Mariner-10 coverage extends only from $10^{\circ}$ to $190^{\circ}$ West and thus does not overlap the area of this map. [5]

## SUMMARY

Three types of features were visible on Mercury; bright areas, dark areas, and terminator irregularities. The bright areas are concentrated near Mercury's limb, which is consistent with long-range Mariner-10 images. This suggests that the apparent brightness of these features depends on viewing geometry.

On the other hand, the dark features are chiefly seen near the terminator and are consequently presumed to be albedo features that represent real topographic irregularities. Several terminator irregularities were seen in April and May, 1989, which suggest topographic variations of at least 3 kilometers on Mercury near longitude $270^{\circ} \mathrm{W}$.

The map of a portion of Mercury's surface that is presented in Figure 1 is based on observations made chiefly in 1989. I conclude that high-resolution charge-coupled device (CCD) images, or Hubble Space Telescope images, of Mercury can provide both albedo and topographic information about that planet. For visual work, polarizing and color filters improve contrasts on Mercury.

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## a.L.P.O. aCQuires Extensive lunar Collection

In the Summer and Fall, 1989, the A.L.P.O. received a large collection of lunar photographs, maps, and publications from the AstroGeology Branch of the U.S. Geological Survey. The reason for this gift was that the building housing the Menlo Park, California, office of the AstroGeology Branch was to be demolished. The local plans were to disperse the collection to other lunar and planetary science centers, possibly discarding anything left over. We thank Dr. Don E. Wilhelms, retired from the AstroGeology staff, for bringing this situation to our attention and helping us with selecting, transporting, and storing the items that went to the A.L.P.O. The materials are presently shelved at the A.L.P.O. Director's home and in the Department of Geography at San Francisco State University.

Part of the collection consists of approximately 3291 lunar photographs from several major terrestrial observatories. Their formats range from $4 \times 5$-inch film positives and
negatives to $20 \times 24$-inch paper prints. The 1867 photographs that were taken by the Catalina, Pic du Midi, and Lowell Observatories have been cataloged through a grant by San Francisco State University. A sample photograph from this collection appears on the front cover of this issue.

We also possess 21 rolls of film copies; and 132 rolls, 10 large-format folders, and 12 boxes of paper prints, from Apollo Mission photographs. Our collection of Lunar Orbiter paper prints and microfilm is now complete, as is our collection of I:250,000-scale "Lunar Orthophotomaps." Finally, we received selected other maps on all scales, and about 7 shelf-feet of reference literature.

We are continuing to catalog this extensive collection. We also are searching for a library that will not just accept the A.L.P.O. Lunar Collection, but will also maintain it and make it available to all students of the Moon.

# The Marius Hills Region-A Unique Lunar Dome Field 

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


#### Abstract

The Marius Hills Region is a unique, huge lunar dome field located west (IAU) of Marius in the Oceanus Procellarum. A composite drawing of this area is presented, along with a comparison of Lunar Orbiter photographs and the U.S. Geologic Survey map of the region. This area deserves further observation and study, for which the composite drawing is intended as a guide.


While gathering data for our New Lunar Dome Survey, I have spent some time examining the unique lunar dome field located near the crater Marius in the Oceanus Procellarum. Located for the most part to the west [IAU sense, where Oceanus Procellarum is on the western half of the disk] of Marius on a plateau are large numbers of domes and dome complexes which are associated with wrinkle ridges, lava flows, and rilles.

These domes are unique in that they do not easily fit within our working definition of a lunar dome: a "discrete regular swelling whose major:minor axis does not exceed $2: 1$ and whose maximum slope does not exceed 5 degrees." The Marius domes often have major:minor axis ratios greater than $2: 1$; are steep, having slope angles of more than 5 degrees; and often merge with wrinkle ridges.

It is necessary to have a consistent definition for lunar domes, or else they are whatever any individual says they are. Therefore, we must strictly adhere to our definition for the purposes of the New Lunar Dome Survey. On the other hand, noted lunar authorities clearly accept the Marius structures as domes, and for this purpose we intend to review the area and to include it in our survey while withholding final judgment on how these objects should be classified. [Sometimes they are called "hills" or "cones" as well; see Wilhelms, 1987, p. 86.] Perhaps the entire area should be classified as either one huge dome complex or as multiple domes and dome complexes. This magnificent dome field is unique on the entire surface of the Moon and appears to represent a morphologically different category of lunar domes from the classical one for which our definition was made.

A composite drawing of the Marius domes area, based upon a variety of photographic atlases, spacecraft photographs, and personal observations, is shown in Figure 2 (p. 105). Because the region is located near the western (IAU) edge of the Moon [near longitude $55^{\circ} \mathrm{W}$ ], foreshortening makes it difficult to compare this earthbased view with Lunar Orbiter photographs and the U.S. Geologic Survey map. The base for this drawing was Plate F4-D (Pic du Midi photograph P14a) from Kuiper, 1960. Additional detail was added from other photographic atlases (Kopal, 1971; Viscardy, 1989) as well as from Lunar Orbiter photographs. Figures 3 and 4 (p. 106) are Lunar Orbiter-4 photographs of this area. On them, I have indicated the craters

Marius and Marius $E$ in order to help orient these illustrations for more easy comparison with the drawing. [Figure 2 is in an earthbased perspective, while the other figures are more or less as seen from directly above. Ed.] Figure 5 (p. 107) is reproduced from the U.S. Geologic Survey map of the region, and can be compared with the other figures. An area that will be inspected more closely is shown in a box in Figures 2, 4, and 5. Finally, Figure 6 (p. 108), taken from an Orbiter-5 photograph, is a closeup view of a rille system within the region. This area of the Moon was once scheduled for a manned landing ["Apollo Extension System-8." Ed.], but budget cuts canceled the Apollo Mission that would have visited it.

The "Marius Group" as referred to on the U.S. Geologic Survey map consists of the plateau surface and domes that are interpreted as representing a volcanic complex of intercalated lava and ash deposits. These deposits are thought to have originated in vents at the crests of domes. Faint Copernican rays overlap this region, identifying it as being of the Eratosthenian Age (post-Imbrian and preCopernican). Wilhelms (1987) gives the region's age as the Upper (late) Imbrian (just before Eratosthenian). These large numbers of domes were produced by volcanism. The wrinkle ridges, consisting of smooth undulating deposits, lie between the domes. Peter Schultz (1976) pointed out that lobate extensions from highly-textured domes in this region indicate that volcanic construction in this region occurred after the formation of the Oceanus Procellarum.

For the amateur observer, this region provides a unique and extensive field of domes, wrinkle ridges, rilles, and lava flows which is unlike any other region known; not only on the Moon but on any other known area in the Solar System. In Figure 2, the rille shown prominently in the boxed areas on Figures 4 and 5, and near the center of Figure 6, is not included. It would be of great interest to see whether a present-day observer would be able to spot it, referring to our map under the right lunar lighting conditions. I do not know whether this rille has ever been recorded by direct telescopic observations. [However, the U.S. Air Force chart LAC 56, the base map for the U.S. Geologic Survey map in Figure 5, shows it, and was made from earthbased photographs and drawings. A high-resolution earthbased photograph of this region, made with the Catalina Observatory 61 -inch (1.55-


Figure 2. Composite drawing of the lunar Marius Domes region in Oceanus Procellarum by Jim Phillips, M.D. Earthbased perspective with north at the top and lunar west (IAU) to the left. The drawing extends about 320 km north-south and 390 km east-west.
meter) reflector, is shown on the front cover of this issue. Ed.] This area requires further study and consideration in terms of how to classify it and whether to include it in the New Lunar Dome Survey. I am interested in observations of this unique area from other amateurs. The composite drawing in Figure 2 is intended as a guide for further observation.

Data continue to come in from interested individuals as we proceed with our New Lunar Dome Survey. Those individuals who have contributed to the program are listed below; their dedication to this long-term and difficult survey is greatly appreciated by this writer:

Schuyler Allen, United States;
Kocsis Antal, Hungary;
José Barruezo Aguirre, Spain; Joe Caruso, United States; Karl Fabian; United States; Alika Herring, United States; Harry Jamieson, United States; Craig MacDougal, United States;
Rob Moseley, England;
José Olivarez, United States;
Michael Porcellino, United States;
Zac Pujic, Australia;
Robert Robinson; United States;
George Rosenberg, United States;

John Sabia, United States; R. Turner, England;

Ed Vinson, United States; John Westfall, United States;
Ross Weyburg, United States.

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Figures 3 (top) and 4 (bottom), reproduced from Lunar Orbiter-4 high-resolution frames 150 2 and 157-2 respectively. They adjoin each other and show the crater Marius and the dome field to its west. Figure 3 is at colongitude $067^{\circ} .4$ and Figure 4 is at colongitude $073^{\circ} .5$. They are oriented here with north at the left and west (IAU) to the bottom (rotate the page 90 degrees clockwise to duplicate the orientation of the other figures in this article). Each figure covers an area about 290 km north-south (left-right) and 200 km east-west (top-bottom). The boxed area in Figure 4 is also shown in Figures 2 and 5.

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## Note by Editor:

The Marius Dome Field is quite striking when viewed between approximate colongitudes $53-64^{\circ}$ (i.e., when the sunrise terminator lies between longitudes $53^{\circ}$ and $64^{\circ}$ west). However, this region has been inconsistently described in the literature. Interestingly, perhaps the best description was by T.W. Webb in his Celestial Objects for Common Tele-scopes (New York: Dover Pub., 1962; reprint of 1917 edition), on p. 128 of Volume I: "More than 100 grey hillocks, the loftiest little exceeding 1000 ft., lie in a narrow space NE [northeast of Marius in the classical orientation]." On the other hand, standard sources such as Edmund Neison (The Moon. London:
-Continued on p. 108-

Figure 5. The Marius Dome Field shown in this section of the U.S. Geologic Survey Geologic Map of the Hevelius Region of the Moon. North at top, IAU west to left; each grid square is about 60 km on a side. The plateau defining this region is in light grey and labeled Eml. The dome classifications used on the map are: $E m 2$ ("low domes"); Em3 ("steep domes"); Em4 ("small-dome clusters"); and Ipd ("dome"). The box in the upper left shows the area boxed in Figures 2 and 4 and shown in larger scale in Figure 6 (p. 108); sr? marks a possible sinuous rille.

Longmans, Green, and Co., 1876, p. 316), Thomas Gwyn Elger (The Moon. London: George Philip \& Son., 1895, p. 83), Walter Goodacre (The Moon. Privately published, 1931, p. 268), and H. Percy Wilkins and Patrick Moore (The Moon. New York: Macmillan, 1955, p. 261) refer only to "ridges" in the area west (IAU) of Marius.

Likewise, the rille system shown in Figure 6 is not mentioned in the classical sources, although its visibility from Earth with a large telescope and excellent seeing is attested to by Figure 5, based entirely on telescopic observations, and by the Catalina Observatory photograph shown on the front cover of this issue.

Figure 6. Detailed view of rilles in the Marius Dome Field taken by Lunar Orbiter 5 on 1967 AUG 18 at Colong. 070 ${ }^{\circ}$.7. (Mediumresolution frame 215). This area is in the boxes in Figures 2,4 , and 5 , and extends about 70 km north-south and 50 km east-west. North at top; IAU west to left.


ObSERVE METEORS-XVII

By: David H. Levy, A.L.P.O. Assistant Meteors Recorder

After seventeen columns of "Observe Meteors," I have decided that I have said enough, and that this will be the last article. Over the years this column has covered many topics relating to meteors, from getting started in observing, and even how to get children interested in observing, to discerning new streams, and proper recording techniques.

I leave this column with some trepidation, for I have enjoyed writing it immensely and I think that meteor observing is among the most enjoyable of the disciplines. It requires no telescope, it can be done on virtually any clear night of the year, and as long as the sky is dark some sort of show is almost guaranteed. Meteors also provide a graphic way of showing how our planet moves through space; some observers of the the Leonid storm of 1966 felt that they were watching the Earth push its way through space.

Since its founding, the A.L.P.O. Meteors Section has placed a special emphasis in getting young people into mete-
or observing. Although group watches, during which each observer is assigned a specific area of sky, are discouraged by some advanced meteor observers as being unscientific, they are invaluable teaching mechanisms for beginners. Group watching teaches the participants the rudiments of counting meteors in a friendly, sometimes even a party-like, way. The reason that group counts have been looked down upon is that the traditional single-observer zenithal hourly rate is hard to compute from them; also group counts are said to discourage the detachment and independence enjoyed by single-observer counts. Whether that assertion is really true is still open to debate. I trust that in future years the Meteors Section will continue to thrive. Under A.L.P.O. Founder Walter Haas and current Director John Westfall, the organization has done a fabulous job promoting amateur studies of the Solar System. May the Meteors Section continue to encourage new observers to watch for these wonderful events that occur in the sky just over our heads.

# The 1986 Eastern (Evening) 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 the planet Venus for the 1986 Eastern (Evening) Apparition, based on an extensive analysis of data submitted by A.L.P.O. Venus Section observers in the United States and three other countries. Sources of data and the instruments used in acquiring information about Venus are emphasized, with a statistical analysis of the categories of features seen or suspected in the atmosphere of Venus at visual wavelengths, both in integrated light and with color filters. A similar treatment is given to the cusps, cusp-caps, and cusp-bands, together with a discussion of dark-hemisphere phenomena, including the Ashen Light. Comparative studies deal with the observers, instruments, and their visual and photographic data. Selected drawings are included in order to help the reader to appreciate the variable phenomena observed in the atmosphere of Venus in 1986.


## INTRODUCTION

Observers submitted a very fine collection of observations of Venus for the 1986 Eastern (Evening) Apparition, and this report is based on their data. Table 1, below, summarizes the geocentric phenomena of Venus for that apparition.

Table 1. Geocentric Phenomena: 1986 Eastern (Evening) Apparition of Venus. [4]

| perior Conjunction .... 1986 JAN $19{ }^{\text {d }}$ |  |  |  |
| :---: | :---: | :---: | :---: |
| Greatest Elongation |  |  |  |
|  |  |  |  |
| East ( $46^{\circ} .1$ ) | 1986 | UG |  |
| eatest Brilliancy |  |  |  |
| Magnitude -4.6) |  |  |  |
|  |  | OCT |  |
|  |  |  |  |

Notes: All times are in Universal Time (U.T.). Venus' apparent diameter during the observing period ranged from 9 ". 92 on 1986 MAR 01 to $46^{\prime \prime} .00$ on 1986 Oct 10 .

A total of 47 observations was received for the 1986 Apparition, both visual drawings and photographs taken at visual wavelengths. Figure 7 (p. 110) presents a histogram that shows the distribution of observations by month. Observational coverage was only fair during the apparition. The observational period ranged from 1986 MAR 01 [elongation $9^{\circ} .8$ ] through 1986 OCT 10 [elongation $34^{\circ} .0$ ], with 83 percent of the observations during the months of May-August, 1986.

Only six individuals submitted visual observations, photographic observations, or both during the 1986 Eastern (Evening) Apparition. They are listed in Table 2, below, along with their location, number of observations, and aperture and type of instrument.


Figure 7. Venus observations by month, 1986 Eastern (Evening) Apparition.


der Sternfreunde in Germany and with similar organizations in Belgium, France, Hungary, and Spain. We are attempting to establish and maintain an expanding international observer base in the coming years.

## OBSERVATIONS OF VENUSIAN ATMOSPHERIC DETAILS

As pointed out in Venus Reports that have appeared earlier in this Journal [2], conventional methods and techniques of making visual studies of the somewhat vague and elusive "markings" in the atmosphere of Venus have

been outlined in the appropriate Venus Section pamphlets and booklets. [1, 3] For more technical aspects of Venus observation and theory, refer to the book Venus by Hunten et al. [5] Careful study of these sources is strongly recommended, as well as of previous apparition reports, if one is unfamiliar with the general nomenclature used or with the basic observational methods.

This report is based upon descriptive notes, drawings that accompanied the notes, and numerous photographs; the latter taken at visible wavelengths. A few samples of the drawings appear along with this report in order to aid the reader in the interpretation of the phenomena reported or suspected on Venus in 1986 (Figures 1I-12, pp.114-115).

The visual and photographic data for 1986 represented almost all of the categories of dusky and bright markings on Venus that have been described in the literature cited. A quantitative treatment of this material, similar to that done in earlier Venus apparition reports, appears in Table 3 (below), which shows the percentages of observations which fitted specific categories of features.

Despite diligent efforts to minimize the subjective aspects of the data for this apparition, these remain and must affect the quantitative data in Table 3 and elsewhere. Nonetheless, some reasonable if tentative conclusions may be derived from the percentages in Table 3.

Table 3. Frequency of Occurrence of Types of Markings in the Atmosphere of Venus in the 1986 Eastern (Evening) Apparition.

Apparent Surface (Atmo- Percent. of Respheric) Feature Categories ports Submitted

| Banded Dusky Markings | $43 \%$ |
| :--- | :---: |
| Radial Dusky Markings | 0 |
| Irregular Dusky Markings | 32 |
| Amorphous Dusky Markings | 62 |
| No Markings Seen or Suspected | 32 |
| Terminator Shading | 64 |
| No Terminator Shading | 36 |
| Bright Spots or Regions |  |
| $\quad$ (exclusive of cusps) | 15 |

Notes for Table 3:

1. Descriptions of the dusky features are: Banded Dusky Markings-dusky parallel streaks roughly perpendicular to the line of cusps; Radial Dusky Markings-a spoke pattern converging at the subsolar point; Irregular Dusky Markings-elongated or roughly linear dusky streaks with no clear pattem; Amorphous Dusky Markings--shaded features with no form, definite shape, or pattern. [3]
2. During this observing season, the phase, as measured by the proportion of the disk that was illuminated, k, ranged from 0.99 (1986 MAR 01) to 0.18 (1986 OCT 10).
3. Assuming that the bright illuminated hemisphere of Venus, where there were no shadings or obvious markings, was typically assigned a relative numerical intensity of 8.8 to 9.0 in 1986, the mean assigned intensity in integrated light for the dusky markings (the first four categories in the above table) was about 7.5 to 7.7 in 1986. The mean intensity of the bright markings (last category) was then assigned to be 9.0. These intensities are on the standard A.L.P.O. scale, where 0.0 is totally black shadow and 10.0 is the brightness of the most brilliant features ever seen.
4. The scale of conspicuousness, ranging from 0 for definitely not seen to 10 for certainly seen, was used somewhat effectively in the 1986 Apparition, when the conspicuousness rating was 5.0 for the first four categories in the above table as well as for the bright spots. This result indicated that all features' conspicuousness lay somewhere between vague suspicions and strong indications.
5. Seeing conditions, on the standard A.L.P.O. scale from 0 (worst possible) to 10 (perfect), averaged about 4.7 , or generally fair.
6. Transparency conditions, expressed as the magnitude of the faintest star detectable by the naked eye on a clear, dark night in the sky near the planet (with any reference objects usually noted), were quite difficult to evaluate because nearly all observations were carried out against a twilight or daytime sky.

It is well established that 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 desirable in order to bring out any dusky features. Without a doubt, ultraviolet photographs are actively sought because many features in UV differ characteristically from those occasionally seen or suspected at visual wavelengths, particularly with respect to radial dusky patterns. Only about one-third ( 32 percent) of the drawings and other visual-wavelength observations of Venus showed the planet as completely devoid of any shadings or markings of any kind. All the photographs of Venus that were submitted showed a completely blank disk, but observers at visual wavelengths reported banded, irregular, and amorphous dusky markings more frequently than in many previous Eastern (Evening) Apparitions of Venus. Radial dusky markings were not reported in 1986; but, because the observations were so few, it would be risky to say that Venus' atmosphere was unusually active in 1986.

Most dusky markings reported in 1986 were classed as "Amorphous Dusky Markings" ( 62 percent of all observations). Other dusky atmospheric features were distributed fairly evenly between the "Banded Dusky Markings" (43 percent) and "Irregular Dusky Markings" ( 32 percent) categories.

Excluding the cusp regions, bright areas or mottling were occasionally observed during the 1986 Apparition. A small number of drawings depicted these bright spots or regions of Venus, but no photographs showed them. No ultraviolet photographs were submitted in 1986.

Color-filter techniques were used in studies of Venus during the 1986 Eastern (Evening) Apparition with some promising results when compared with integrated-light (IL) observations. The visibility of atmospheric features on Venus was enhanced by the use of such filters as the Wratten 47 (W47; violet), W25 (red), W15 (yellow), W58 (green), W80A (light blue), and variable-density polarizing filters.

Terminator shading was prominent during this apparition, and 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 Venus. In some observations, this gradation terminated in the bright limb band. Normally, this shading extended from one cusp region to the other; and the terminator shading was reported the most often from around the time of dichotomy (1986 AUG 24) and later, during the crescent phase. None of the photographs submitted in 1986 showed terminator shading.

## CuSps, CuSp-Caps, and CuSp-Bands

The most contrasting and conspicuous features in the atmosphere of Venus are sometimes found at or near the cusps of the planet,
usually when its phase coefficient, $\mathbf{k}$, the fraction of the disk that is sunlit, lies between 0.8 and 0.1. These cusp-caps occasionally appear on the planet, sometimes bounded by dark, often diffuse, peripheral cusp-bands.

Table 4, below, presents selected cusp-cap and cusp-band statistics for the 1986 Apparition.

## Table 4. Cusp-Cap and Cusp-Band Statistics: 1986 Eastern (Evening) Apparition of Venus.

| Condition of Feature(s) Perct | Percent. of Reports Submitted |
| :---: | :---: |
| No Cusp-Caps Visible | $64 \%$ |
| Both Cusp-Caps Visible | 23 |
| North Cusp-Cap Alone Visible | 0 |
| South Cusp-Cap Alone Visible | 13 |
| Either or Both Cusp-Caps Visible | ble 36 |
| North Cusp-Cap the Brighter | $2 \%$ |
| Cusp-Caps of Equal Brightness | - 21 |
| South Cusp-Cap the Brighter | 0 |
| North Cusp-Cap the Larger | $2 \%$ |
| Both Cusp-Caps of Equal Size | 11 |
| South Cusp-Cap the Larger | 11 |
| No Cusp-Bands Visible | 96\% |
| Both Cusp-Bands Visible | 0 |
| North Cusp-Band Alone Visible | l 4 |
| South Cusp-Band Alone Visible | e |
| Either or Both Cusp-Bands Visible | sible |

## Notes:

1. Assuming that the relative numerical intensity of the bright illuminated hemisphere of Venus was typically 8.6 to 9.3 in the 1986 observing season, the mean intensity of the cuspcaps was about 9.7.
2. The seeing and transparency notes for Table 3 (p. 111) apply here as well.
3. The sums of the percentages in the above table do not always equal 100 , particularly for the size and brightness of the cusp-caps. Clearly, when only one cusp-cap was visible, it was not possible to make comparisons of size and brightness.

During the 1986 Eastern (Evening) Apparition of Venus, when the southern and northern cusp-caps of Venus were recorded, it was more likely than not for them to be seen together. The southern cusp-cap was visible alone a few times in 1986. The northern cuspcap was never seen alone, and it was always either as bright as, or brighter than, the southern cusp-cap. The southern cusp-cap, however, was usually the larger of the two. In about two-thirds of the observations, neither cuspcap was reported

## Extension of the Cusps

[In theory, the illuminated portion of the limb of Venus should always subtend approximately $180^{\circ}$; any amount significantly greater
than this constitutes a cusp extension, and is presumed to be due to the planet's atmosphere. Ed.] Almost all of the observations submitted showed no cusp extensions during the 1986 Apparition, both in integrated light and with colored filters. Heath was the only observer to report a cusp extension; of about 10 degrees for the south cusp on 1986 SEP 07 , when the planet was predicted to be 43 -percent illuminated. Interestingly, he reported the Ashen Light at the same time.

## The Bright Limb Band

In 1986, 34 percent of the 47 observations submitted referred to a bright limb band on the sunlit limb of Venus. This feature extended from cusp to cusp, was narrow in width along the limb, and was uniform in intensity throughout its extent. The mean numerical intensity assigned to the limb band was 9.8 in 1986. The visibility of the bright limb band was particularly enhanced using selected col-or- and polarizing-filter techniques.

## TERMINATOR IrREGULARITIES

The terminator of Venus is the geometric curve that separates the sunlit and dark hemispheres of the planet. During the 1986 Apparition, only one of the observations submitted reported any terminator irregularities. Amorphous, irregular, and banded dusky markings merged with the terminator shading and possibly contributed to this lone report of deformities along the otherwise geometrically regular terminator.

## THE ASHEN LIGHT AND OTHER DARK= HEMISPHERE PHENOMENA

The Ashen Light, first recorded by the Italian observer G. Riccioli in 1643, is an exceedingly elusive, very faint illumination of the dark hemisphere of Venus that resembles Earthshine on the dark portion of the Moon, although the latter is of a completely different origin. It has usually been held that Venus must be viewed against a dark sky in order to have the best opportunity to detect the Ashen Light, but this occurs only at a time when Venus is low in the sky so that images suffer from the effects of poor seeing and the great contrast of the bright disk of Venus with the dark sky background.

Heath was the only observer to report a definite Ashen Light in 1986. On 1986 SEP 07 at 18 h 30 m U.T., using a $30.5-\mathrm{cm}$ Newtonian reflector at $190 \times$, he described the Ashen Light as extending along the limb of the dark hemisphere of Venus. His drawing made at that time is reproduced on p. 114 as Figure 11. The illumination was best seen with a blue (W47) filter, and was only suspected in green light (W58); it was not seen at all in the red (W25). During the observation, which was made near sunset, the seeing was estimated as 4.0 on the A.L.P.O. $0-10$ scale. Heath's colleague, A.J. Hollis, confirmed the former's
observational impressions of the Ashen Light in 1986.

## Estimates of Phase and Dichotomy

The "Schroeter Effect" on Venus, a discrepancy between the predicted and observed dates of dichotomy (half phase), was reported in 1986. The predicted half-phase occurs when $\mathbf{k}=0.500$ and $\mathbf{i}$, the phase angle or angle between the Sun and the Earth as seen from Venus, equals $90^{\circ}$. The observed-minus-predicted discrepancies for Venus for 1986 are given in Table 5, below.

Table 5. Observed and Predicted Dichotomy of Venus: 1986 Eastern (Evening) Apparition.
[Note:The observer was A.W. Heath] Predicted Dichotomy... 1986 AUG $24^{\text {d }} .89$, phase angle $90^{\circ} .00$.
Observed Dichotomy... 1986 AUG $19^{\mathrm{d}} .80$ phase angle $87^{\circ} .06$.
Discrepancy (Observed - Predicted) $=-5^{\mathrm{d}} .09$

## CONCLUSIONS

A fair level of activity was reported in the atmosphere of Venus during the 1986 Eastern (Evening) Apparition, but we can say little definite beyond this because of the small number of observations that were submitted. Thus, regular monitoring of the planet by diligent participants over many years remains our major goal, and interested readers are cordially invited to join us in our efforts to gather reliable information about the planet Venus.

## References

1. Benton, Julius L. (1973). An Introduction to Observing Venus. Savannah, GA: Review Publishing Co.
2. $\qquad$ (1989). "The 1987-88 Eastern (Evening) Apparition of the Planet Venus: Visual and Photographic Observations. JAL.P.O., 33, Nos. 10-12 (Oct.), 145-156.
3. $\qquad$ (1987). Visual Observations of Venus: Theory and Methods (The ALPO Venus Handbook). Savannah, GA: Review Publishing Co.
4. U.S. Naval Observatory. (1985). The Astronomical Almanac for the Year 1986. Washington: U.S. Government Printing Office. [Note that physical ephemeris information on Venus, at more frequent intervals than in the Astronomical Almanac, can be found in the A.L.P.O. Solar System Ephemeris for each year.]
5. Hunten, D.M., et al., eds. (1983). Venus. Tucson: University of Arizona Press.


## Selected Drawings of Venus in the 1986 EASTERN (EVENING) APPARITION

In both Figures 11 and 12: Seeing is on the Antoniadi Scale where II is good, III is moderate, and IV is poor. "Diam." is the disk diameter in arc-seconds, and $\mathbf{k}$ is the proportion of the disk that is sunlit.

Figure 11 (p. 114). A series of twelve drawings by David L. Graham with a $15.2-\mathrm{cm}$ ( $6.0-\mathrm{in}$ ) refractor at $166 \times$. To view Figure 12, turn its page 90 degrees clockwise to obtain the standard orientation with south at top. The illuminated hemisphere will then be to the left on each drawing.. Contrasts are necessarily exaggerated in these views.The twelve individual drawings will then have the following arrangement:
Top Row. 1986 MAY 13. Diam. $=11$ ".7, $k=0.88$. From left to right:
20h 15m U.T. Integrated Light. Seeing III. Observed $\mathbf{k}=0.87$.
20 h 27 m U.T. Yellow (W15) filter. Seeing III-II. Observed $\mathbf{k}=0.90$.
20h 35m U.T. Red (W25) filter. Seeing III-II. Observed $\mathbf{k}=0.89$.
20 h 45 m U.T. Light blue (W44A) filter. Seeing III. Observed $\mathbf{k}=0.89$.
Middle Row. 1986 JUN 03. Diam. $=12^{\prime \prime} .7$, $\mathbf{k}=0.82$. From left to right:
20h 00m-20h 07 m U.T. Integrated Light. Seeing IV-III. Observed $\mathbf{k}=0.76$.
20h $12 \mathrm{~m}-20 \mathrm{~h} 18 \mathrm{~m}$ U.T. Yellow (W15) filter. Seeing III. Observed $\mathbf{k}=0.76$
20h $22 \mathrm{~m}-20 \mathrm{~h} 27 \mathrm{~m}$ U.T. Red (W25) filter. Seeing III-IV. Observed $\mathbf{k}=0.76$.
$20 \mathrm{~h} 31 \mathrm{~m}-20 \mathrm{~h} 38 \mathrm{~m}$ U.T. Light blue (W44A) filter. Seeing III. Observed $k=0.76$.

Bottom Row. 1986 Jul 08. Diam. $=15^{\prime \prime} 6$, $k=0.70$. From left to right:
20 h 30 m U.T. Integrated Light. Seeing III-IV. Observed $\mathbf{k}=0.67$.
20h 45m U.T. Yellow (W15) filter. Seeing III. Observed $k=0.66$.
20h 55 m U.T. Light blue (W44A) filter. Seeing IV. Observed $\mathbf{k}=0.64$.
21 h 05 m U.T. Green (W58) filter. Seeing III-IV. Observed $\mathbf{k}=0.68$.


Figure 12. Drawing of Venus by Alan W. Heath on 1986 SEP 07, $18 \mathrm{~h} \mathrm{30m} \mathrm{U.T}. \mathrm{30.5-}$ cm . reflector, $190 \times$, blue (W47) filter. Seeing IV. South at the top and preceding (celestial east) to the right. Planet very low in sky near sunset. Note Ashen Light along limb of night hemisphere. Diam. $=28^{\prime \prime} .2, \mathbf{k}=0.42$.

ObSERVATION AND COMMENTS


We continue the series of Hydrogen-Alpha solar photographs by Jean Dragesco that appeared in the preceding issue (Vol. 34, No. 2) on p.61, in this case combining a photograph of a prominence with a Hydrogen-Alpha photograph of the solar disk itself.

Figure 13. Composite print of solar prominence (above disk) and filament (on disk) by Jean Dragesco. $35.5-\mathrm{cm}$ Schmidt-Cassegrain telescope with 0.6 $\AA$ Hydrogen-Alpha filter. Taken on 1990 MAY 14 at 11 h 10 m Universal Time. The filament is the same feature as the prominence; but the photograph of the disk received a relatively short exposure, silhouetting the filament. The exposure for the prominence was longer, making it appear light against the relatively dark sky.

# RECESSIONS OF THE SOUTH POLAR CAP OF MARS IN 1986 AND 1988 

By: Harry T. Cralle, Assistant Mars Recorder; and Jeff D. Beish and Donald C. Parker, Mars Recorders.


#### Abstract

The recessions in latitude of the edge of the Martian South Polar Cap (SPC) in 1986 and 1988, as measured by A.L.P.O. members using Newtonian telescopes with filar and reticle micrometers, exhibited a near-linear retreat of 6.2 sols (Martian solar days) per degree of latitude from early Southern Spring at Ls (planetocentric solar longitude) $185^{\circ}$ through early Summer to Ls $285^{\circ}$ in 1986; and 6.7 sols per degree from Ls $183^{\circ}$ to $290^{\circ}$ in 1988. The SPC in both recessions was observed to retreat from about $-60^{\circ}$ to $-86^{\circ}$ latitude, with a 98 -percent areal reduction from 9.66 to 0.18 million sq. km . Because the SPC was visible in late Southern Summer, a remnant cap is likely to have persisted during both recessions. A statistical analysis of the SPC recessions in 1892, 1894, 1909, 1924, 1956, 1971, 1977, 1986, and 1988 showed that the recessions of 1977, 1986, and 1988 were significantly (probability under .005 ) slower, and those of 1892 and 1956 significantly (probability under .01 ) faster, than the other recessions.


## INTRODUCTION

In 1784, William Herschel reported that "..the poles of Mars were distinguished with remarkable luminous spots." [11] After describing his careful observations of these phenomena, Herschel wisely concluded that "..the bright spots are owing to the vivid reflection of light from frozen regions; and that the reduction of those spots is to be ascribed to their being exposed to the Sun." This report more than two hundred years ago commenced the attempt to understand the Martian polar caps and their seasonal recessions. During the recent apparitions of 1986 and 1988, members of the A.L.P.O. faithfully carried on this long tradition of telescopic observations of these still "remarkable luminous spots."

The vast frozen deposits on Mars are solid carbon dioxide in the South Polar Cap (SPC) [18, 17], and solid carbon dioxide and waterice in the North Polar Cap (NPC) [9, 19]. The thickness of the frozen solids in the polar regions has not been measured directly. Hess et $a l$. used the seasonal variations in atmospheric pressure to infer a mean thickness of the order of tens of centimeters for the seasonal carbon dioxide deposits of the polar caps. [12]

This thinness of the frost deposits permits the extensive seasonal retreats of the Martian polar caps during their hemispheric Spring and Summer. The inclination of the Martian rotational axis to its orbital plane, $25^{\circ}$, is similar to that of the Earth $\left(23^{\circ} .4\right)$ and generates analogous seasonal changes. However, the Martian year lasts 668 Martian solar days (sols) or 687 Earth days. Moreover, the high eccentricity of Mars' orbit, 0.093 as compared with the Earth's 0.017 , produces significant heating differences between Mars' Northern and Southern Hemispheres. While the Northern Spring occurs near aphelion (with a Mars-Sun distance of 1.67 A.U. [astronomical unit; 149.6 million km ]) and lasts 194 sols or 199 Earth days; the Southern Spring occurs near perihelion (with a Mars-Sun distance of 1.38 A.U.) and is only 143 sols or 147 Earth days in length. Consequently, the Southern Hemisphere has shorter Springs and Summers
with greater solar insolation and warmer temperatures than does the Northern Hemisphere.

The prime mover behind the recessions of the Martian polar caps is the sublimation of solid carbon dioxide into gaseous carbon dioxide by the increased solar insolation received following the hemispheric Spring Equinox. At their maximum extents, the NPC and SPC reach equatorwards to about $+50^{\circ}$ and $-45^{\circ}$ latitude, respectively. [10] The SPC at maximum is larger than the NPC at maximum because Southern Autumns and Winters occur near aphelion and are therefore longer and colder than those in the North, which occur near perihelion. Both caps recede from these maximum extents to hemispheric latitudes greater than $80^{\circ}$. A permanent or remnant cap at both poles persists throughout that pole's summer. While the SPC remnant consists mostly of carbon dioxide, the NPC remnant consists of water-ice. [10] These remnant caps are very small, with diameters of only 350 km for the SPC and 1000 km for the NPC. [5] The recessions of the Martian polar caps are important climatic events, with about 20 percent of the entire planetary atmosphere being annually cycled in and out of the caps. [10]

Because the Spring and Summer sublimation of bright solid carbon dioxide reveals underlying deposits of comparatively low albedo (dark) materials, the seasonal recessions of the Martian polar caps are readily observed by telescopes on Earth. This paper presents observations of the 1986 and 1988 recessions of the SPC, and compares those recessions to the recessions observed in 1892, 1894, 1909, 1924, 1956, 1971, and 1977.

## Máterials and Methods

Three observers contributed measurements of the SPC recession in 1986, and six did for 1988. Their names, locations, number of observations, and instruments are listed in Table 1 (p. 117). All observers used Newtonian telescopes and either a filar or a reticle micrometer. The method of measuring a Martian polar cap using a reticle micrometer has been described by Cralle [6], while the

Table 1. Observers and Instruments, Martian SPC Measurements, 1986 and 1988.

| Observer and Location | $\begin{aligned} & \text { Num } \\ & \text { Obser } \\ & -1986 \end{aligned}$ | ber of vations 1988 | Telescope Data | Magnification(s) | Micrometer |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Jeff Beish. Miami, FL | 17 | 12 | $32-\mathrm{cm} \mathrm{f} / 7$ Newt. | $802 \times$ | Filar |
| Harry Cralle. Bryan, TX | 28 | 129 | $20-\mathrm{cm} \mathrm{f} / 7$ Newt. | 284× | 12-mm reticle |
| Karl Fabian. Chicago, IL | 0 | 19 | $20-\mathrm{cm} \mathrm{f} / 6$ Newt. | 245×, 625× | 12.7 -mm reticle |
| Jim Meadows. Memphis, TN | 0 | 3 | $25-\mathrm{cm} \mathrm{f} / 5.6$ Newt | . $254 \times, 356 \times$ | $12-\mathrm{mm}$ reticle |
| Don Parker. Miami, FL | 32 |  | $41-\mathrm{cm} / 6 / 6$ Newt. | $1140 \times$ | Filar |
| Ken Schneller. Euclid, OH | 0 | 4 | $20-\mathrm{cm} \mathrm{f} / 9 \mathrm{Newt}$. | $440 \times$ | Microscope Filar |

method of measurement using a filar micrometer was described by Dobbins et al. [7] and by Beish and Capen [2]. The calculation of the latitude of the edge of the polar cap from micrometer measurements was discussed by Beish et al. [3] and by Dobbins et al. [7].

We have compared the recessions of 1986 and 1988 with previous SPC recessions. The data for the 1892 and 1894 recessions were measurements by Barnard, reported by Slipher. [20] The 1909 recession data were measurements by Lowell and Slipher, reported by Slipher. [20] The data for 1924 were also measurements by Slipher. [20] The 1956 recession was measured and reported by Dollfus. [8] The 1971 recession was measured from International Planetary Patrol photographs by James and Lumme. [14] Finally, the 1977 recession was observed by the Viking Orbiter 2 and reported by James et al. [17]

The slopes of the SPC regression lines [plotting the latitude of the SPC edge against Ls, the areocentric longitude of the Sun] were statistically tested for homogeneity according to the procedure of Steel and Torrie [21] in order to examine possible interapparitional variability in their rates. It is very important to note that the results from these comparisons are suggestive rather than definitive because the data sets are measurements by different observers, using different instruments and
techniques. Moreover, the data for the various recessions sometimes differ in their temporal coverage, in terms of Ls; and in their spatial coverage, expressed in Martian longitude.

## Results and Discussion

The Recessions of the South Polar Cap in 1986 and 1988.-The A.L.P.O. measurements of the SPC during the recessions of 1986 and 1988 are graphed in Figures 14 and 15 , respectively, on p. 118. Observations of the 1986 recession commenced near Ls $170^{\circ}$, before the Southern Spring Equinox at Ls $180^{\circ}$; and terminated in late Southern Summer near Ls $330^{\circ}$, well after the Southern Summer Solstice at Ls $270^{\circ}$. Similarly, observations of the 1988 recession began shortly after the Southern Spring Equinox near Ls $185^{\circ}$, and ended after Ls $330^{\circ}$ in late Southern Summer.

There were no evident discontinuities, abrupt changes, or sustained "plateaus" in the recession graph during the retreat in latitude of the SPC edge until near the end of the 1986 (Figure 14) and 1988 (Figure 15) recessions. From Ls $185^{\circ}$ to $285^{\circ}$ in 1986, the retreat of the SPC edge was nearly linear with a high linear correlation coefficient between latitude of cap edge and Ls of -0.95 (Table 2, below).
(Text continued on p. 119)

Table 2. Comparisons of South Polar Cap Recessions, 1892-1988.

| Year | Observer(s) | Number of Observations* | Ls** | Rate, Sols per Degree.o | Linear Correlation Coefficient*** |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1892 | Barnard | 33 | $206^{\circ}-256^{\circ}$ | 3.8a | -0.96 |
| 1894 | Barnard | 14 | $209^{\circ}-271^{\circ}$ | 4.3ab | -0.96 |
| 1909 | Lowell-Slipher | 145 | $173^{\circ}-270^{\circ}$ | 4.9bc | -0.96 |
| 1924 | Slipher | 261 | $173^{\circ}-270^{\circ}$ | 5.2c | -0.97 |
| 1956 | Dollfus | 69 | $225^{\circ}-270^{\circ}$ | 3.9a | -0.95 |
| 1971 | James-Lumme | 30 | $186^{\circ}-261^{\circ}$ | 4.9bc | -0.98 |
| 1977 | Viking Orbiter 2 | 11 | $177^{\circ}-289^{\circ}$ | 6.1 d | -1.00 |
| 1986 | A.L.P.O. | 51 | $185^{\circ}-285^{\circ}$ | 6.2 d | -0.95 |
| 1988 | A.L.P.O. | 154 | $183^{\circ}-290^{\circ}$ | 6.7 d | -0.98 |

* Referring to the period during which the recession of the SPC edge was nearly linear.
**Recessions which have the same letter following the number did not have statistically significant (probability<05) recession rate differences according to the procedure of Steel and Torrie. [21] See Figure 19 (p. 122) for a graph of these recessions and Table 3 (p. 119) for specific statistical comparisons. See text (p.121) for the sources of these data.
$* * *$ A correlation coefficient of $\pm 1.00$ is the highest possible negative linear correlation between two variables.


Figure 14. Recession of the edge of the South Polar Cap in 1986 during Martian Southern Spring and Summer. The line was derived from a linear regression analysis of the data from Ls $185^{\circ}$ to $285^{\circ}$. The arrows at Ls $180^{\circ}$ and $270^{\circ}$ mark the Southern Spring Equinox and Summer Solstice, respectively.


Figure 15. Recession of the edge of the South Polar Cap in 1988 during Martian Southern Spring and Summer. The line was derived from a linear regression analysis of the data from Ls $183^{\circ}$ to $290^{\circ}$. The arrows at Ls $180^{\circ}$ and $270^{\circ}$ mark the Southern Spring Equinox and Summer Solstice, respectively.
(Text continued from p. 117) The recessional rate during this period, from early Southern Spring through early Southern Summer, was 6.2 sols per degree of recession in latitude, or 9.5 km per sol. From Ls $183^{\circ}$ to $290^{\circ}$ in 1988, the retreat of the SPC edge was also nearly linear, with a very high linear correlation coefficient of -0.98. During this period from early Southern Spring through early Southern Summer, the recessional rate was 6.7 sols per degree or 8.8 km per sol.

In both 1986 and 1988, the edge of the SPC was observed to retreat from about $-60^{\circ}$ to $-86^{\circ}$ latitude (see Figures 14 and 15 ). These recessions involved a 98 -percent reduction in the areal extent of the SPC; from a maximum of 9.70 million sq km to a minimum of 0.18 million sq km , or from 6.7 to 0.1 percent of the Martian surface. Little change was observed in the size of the SPC after Ls $285^{\circ}$ in 1986 and after Ls $290^{\circ}$ in 1988. Moreover, the SPC was clearly visible and was measured well into late Southern Summer during both recessions. Hence, a remnant cap at the South Pole probably persisted throughout the summers of both recessions.

The recessions of the SPC have exhibited certain spatial irregularities. One of these was the fact that the rate of retreat in latitude has differed with the Martian longitude. For example, James et al. [15] reported that the recession of the SPC edge at longitude $20^{\circ}$ to $40^{\circ}$ was slower than that at longitude $180^{\circ}$ to $200^{\circ}$ [note that longitude is measured continuously westward; from $0^{\circ}$ to $360^{\circ}$ ]. These differences were explained by the progressive asymmetry of the SPC relative to the South Pole, such that the cap's major axis is at longitude $20^{\circ}$ $40^{\circ}$ and its minor axis at $180^{\circ}-200^{\circ}$. Observations by Cralle at these two different longitudes during the 1988 recession are shown in Figure 16 (p. 120). Linear regression analysis indicated that the retreat of the SPC edge was slower at longitude $20^{\circ}-40^{\circ}, 6.9$ sols per degree, than at longitude $180^{\circ}-200^{\circ}$, which was 6.6 sols per degree.

Other spatial irregularities in the reces-
sions of the SPC included various dark rifts of frost-free deposits and detached bright regions. [22] These features were very prominent in the 1988 recession. Large rifts such as Rima Australis, Depressio Magna, Rima Angusta, and others were observed. Some of the bright regions also observed were Thyles Mons, Mons Argenteus, Novissima Thyle, and the Mountains of Mitchel. Two drawings showing some of these SPC features are given in Figure 17 (p. 120), and a polar-projection map of the region is given on Figure 18 (p. 122). A more detailed report on these rifts and bright spots will appear later in the complete Mars Section reports on the two apparitions.

Comparison of the Recessional Rates of the South Polar Cap in Various Years.How did the recessions of the SPC in 1986 and 1988 compare with those for previous years? Interapparitional variability in the recessions of the NPC has been reported in several investigations, including those by Capen and Capen [4], Iwasaki et al. [13], James et al. [16], and Beish and Parker [2]. James et al. [15] also found evidence for interapparitional variability in the recessions of the SPC.

A linear regression analysis was made of the recessions of the SPC for 1892,1894 , 1909, 1924, 1956, 1971, 1977, 1986, and 1988; and the trend-lines for those years are graphed in Figure 19 (p. 122). These retreats of the SPC are expressed on that figure in terms of areocentric degrees of cap radius in order to conform with the data format in Slipher [20] and Dollfus [8]. Each recession had an extended period of nearly linear retreat during the Southern Spring, which occasionally extended into the early Southern Summer. The linear correlation coefficients for these periods were always high, ranging from -0.95 to -1.00 (see Table 2).

The statistical significance of the differences between the recessions for the several years are given in Table 3 (below). The rates of retreat of the SPC in 1986 and 1988 were not significantly different from one another or (Text continued on p. 121)

## Table 3. Statistical Significance of Differences between Martian South Polar Cap Recessions for Years Studied.

| Year |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Year | 1892 | 1894 | 1909 | 1924 | 1956 | 1971 | 197 | 19861988 |  |
| 1892 | -- |  |  |  |  |  |  |  |  |
| 1894 | NS | -- |  |  |  |  |  |  |  |
| 1909 | ** | NS | -- |  |  |  |  |  |  |
| 1924 | ** | * | NS | -- |  |  |  |  |  |
| 1956 | NS | NS | ** | ** | -- |  |  |  |  |
| 1971 | ** | NS | NS | NS | ** | -- |  |  |  |
| 1977 | *** | *** | *** | *** | *** | *** | -- |  |  |
| 1986 | *** | *** | *** | *** | *** | *** | NS | -- |  |
| 1988 | *** | *** | *** | *** | *** | *** | NS | NS | -- |

Notes: See Figure 19 (p. 122) for a visual display of these recessions, Table 2 (p. 117) for their numerical rates, and the text (p. 121) for the sources of the data. The symbols in the table indicate statistical significance; the likelihood (p) that the apparent difference between two recessions was due to random causes, as follows: NS = not significant ( $\mathrm{p}>.05$ ); * $=$ significant ( $\mathrm{p}<.05$ ) ; ** $=$ very significant ( $\mathrm{p}<.01$ ) ; *** $=$ highly significant ( $\mathrm{p} .<.005$ ).


Figure 16. Comparison of the recession of the edge of the South Polar Cap in 1988 at longitude ranges $20^{\circ}-40^{\circ}$ and $180^{\circ}-200^{\circ}$ from measurements by Cralle.


Figure 17. These drawings of Mars show the dark rifts and bright spots that appeared during the recession of the South Polar Cap in 1988. Both drawings were made by Cralle with a $20.3-\mathrm{cm} \mathrm{f} / 7$ Newtonian telescope at $427 \times$ using Wratten red (W23A), yellow (W15), and light blue (W80A) filters, and have south at the top and Martian east to the left. The drawing on the left shows Mars on 1988 JUL 19, 08h 10 m U.T.; central meridian longitude (CM) $277^{\circ}$; seeing 6 [on the A.L.P.O. Scale which runs from 0 for worst to 10 for perfect], transparency 4 [on the A.L.P.O. scale; from 0 for worst to 5 for perfect]. The features it shows include the dark rifts called Rima Australis and Depressio Magna, the bright spot Novissima Thyle, and the dark collar surrounding the SPC. The drawing on the right was made on 1988 AUG 16, 06 h 45 m U.T., $\mathrm{CM}=353^{\circ}$; seeing 7, transparency 3. It depicts, on the right side of the SPC; the bright spot, Mons Argenteus; and the surrounding dark rift, Rima Angusta. The left side of the SPC shows the detached bright region called "The Mountains of Mitchel" and the dark rift, Rima Australis. The dark collar surrounding the SPC is again visible.
(Text continued from p. 119) from the 1977 recession that was photographed by the Viking Orbiter 2 Mission. However, the 1977, 1986, and 1988 recessions were significantly slower than the recessions of $1892,1894,1909,1924,1956$, and 1971, with the probability of the apparent difference being due to chance being less than 0.005 . Moreover, the recessions of 1892 and 1956 were significantly more rapid than all of the other recessions except the one of 1894; this with a probability level under 0.01 . James et al. [15] also found that the recession of 1956 was unusually rapid.

These results support the existence of interapparitional variability in the seasonal retreat of the SPC. They suggest that three classes of recessions may have been observed since 1892 (see Table 2). One class is relatively rapid, such as the recessions of 1892 and 1956 , with rates of 3.8 and 3.9 sols per degree respectively. The second class has a more moderate rate, and includes the recessions of 1894, 1909, 1924, and 1971, whose rates range from 4.3 to 5.2 sols per degree. The third class is relatively slow, as exhibited in the 1977,1986 , and 1988 recessions, with recessional rates ranging from 6.1 to 6.7 sols per degree.
[And what will the 1990-91 Apparition hold? As we go to press, the current rapid recession is already under way, and should continue until about September, 1990. Note that Mars will be conveniently high in the sky for Northern Hemisphere observers during this apparition. Using an inexpensive eyepiece reticle [6], you will find it relatively simple to make SPC measurements yourself, and this is a good time to begin. Ed.]

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(See Figures 18 and 19 on p. 122)


Figure 18. (Above) Summary sketch map of the South Polar Cap bright spots and dark rifts in 1988 as observed by Cralle with a $20.3-\mathrm{cm} \mathrm{f} / 7$ Newtonian telescope at $356 \times$ and $427 \times$ with filters such as the W12 (yellow), W15 (yellow), W21 (orange), W23A (red), W25 (red), W30 (magenta), W58 (green), and W80A (light blue).

Figure 19. (Left).


Linear Regression Lines for the Recessions of the South Polar Cap in 1892, 1894, 1909, 1924, 1956, 1971, 1977, 1986, and 1988. See the text and Tables 2 and 3 for further information.

# The 1986-88 APPARITION OF PERIODIC COMET TEMPEL 2-1987g 

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


#### Abstract

The report discusses the 18th observed apparition of Periodic Comet Tempel 2 (1987g), including its history, recovery, orbit, magnitude, and size of coma.


## Discovery and Brief History

This comet was discovered from Milan, Italy on 1873 JUL 03 by William Tempel . [1] The discoverer was a German astronomer who lived from 1821 to 1889 [2], and who discovered 13 comets between 1859 and 1877. The discovery magnitudes of his comets ranged from +6.0 to +9.5 , with nearly all of them found north of the celestial equator. [3] For his early discoveries, he used a $10-\mathrm{cm}$ ( $4-\mathrm{in}$.) refractor. [4]

When Tempel found this comet, it was at magnitude $+9.5,101$ degrees from the Sun [5], in the morning sky in the constellation Cetus. It was followed for nearly five months before it became too faint to observe. With an orbital period of 5.3 years, it has since been observed on all subsequent returns except for those of 1883, 1889, 1910, 1935, and 1941. It is best seen when perihelion occurs in late Summer; in 1925 it neared naked-eye visibility. [6]

Making such frequent visits to the inner Solar System, this comet has been studied rather well. The surface of its coma appears to be dusty rather than icy [7], and the rotational period of the nucleus is believed to be one of the shortest on record, 4.8 hours. [8]

## Recovery

Using predictions of its location, T . Gehrels and A.L.P.O. Assistant Comets Recorder James Scoti recovered this comet on images made on 1986 DEC 29. They employed the 0.91 -meter ( 36 -inch) SPACEWATCH telescope at Kitt Peak Observatory. Periodic Comet Tempel 2 was then recorded at magnitude +20.4 ; at right ascension 11 h 20 m .0 , declination $+12^{\circ} 52^{\prime}$ ( 1950.0 coordinates). [9] It was then at an amazing 4.26 AU [astronomical unit; 149.6 million km ] from the Sun and 3.77 AU from the Earth. One of the Gehrels-Scotti recovery images is reproduced to the right in Figure 20.

On previous visits, the comet had been recovered at 3.80 AU from the Sun ( 1982 FEB 03 ) and at 3.55 AU ( 1961 MAR 19 ). On the night of 1986 DEC 29, Jim Scotti not only imaged Periodic Comet Tempel 2, but also made the last observations of Comet Bowell (1982I) and Periodic Comet Holmes, as well as recovering Comet Longmore. [10]

Periodic Comet Tempel 2 was nearly stationary on 1986 DEC 29; its motion nearly matched that of the Earth, causing the comet to appear to stand almost still against the background stars, giving Scotti a difficult time in picking out the comet. Only after another
set of photographs had been taken a month later did reëxamination of the December 29th plates reveal the comet. [10] [Thus the comet was not really "discovered" until 1987, resulting in the designation " 1987 g ". Ed.]

## ORbIT

With one of the shortest orbital periods of the more than 700 known comets, the orbit for Periodic Comet Tempel 2 is well-defined. The orbital parameters, as published by Don Yeomans in MPC 11522 [Minor Planet Circular], are:

| Time of Perihelion... | T |
| :---: | :---: |
| Distance at Perihelion. | 1.3834282 AU |
| Argument of Perihelion... | $191^{\circ} .03900$ |
| Ascending Node. | $119^{\circ} .11831$ |
| Inclination. | $012^{\circ} .43177$ |
| Eccentricity. | 0.5444281 |
| Orbital Period. | 5.29 years |
| Semimajor Axis.......... | 3.0366847 AU |

The orbit of Periodic Comet Tempel 2 is sketched in Figure 21 on the next page.

The comet-Earth distance at recovery, 3.8 AU , decreased to a minimum of 0.77 AU in late June, 1988. The comet-Sun distance decreased from 4.3 AU at recovery to 1.38 AU


Figure 20. Recovery image of Periodic Comet Tempel 2 on 1986 DEC 29. The image was obtained using the 0.91 -meter SPACEWATCH Telescope and a CCD (Charge-Coupled Device) by J.V. Scotti and T. Gehrels when the comet was at a distance of 4.26 AU from the Sun. Additional data are in the upper left of the image. Note that this is a negative image, and covers an area approximately 9 arc-minutes vertically and 15 arc-minutes horizontally.


Figure 21. Sketch of the orbit of Periodic Comet Tempel 2 in 1988 in relation to that of the Earth.
on 1988 SEP 16. At perihelion, the comet traveled at 20 miles per second. With its relatively small orbital inclination, Periodic Comet Tempel 2 slowly crossed the ecliptic, passing southward on 1988 SEP 02.

Well-placed in the evening sky for the second half of 1988, the comet was observed by the eight A.L.P.O. members listed in Table 1 , below. The comet traveled through Libra, Ophiuchus, Scorpius, Sagittarius, and Microscopium, often seen against the bright summer Milky Way background. It passed near three globular clusters; NGC 6284 on 1988 SEP 07, M54 a month later, and M55 two weeks after that. The appearance of the comet in early September, 1988, is shown in Figure 22 in the upper right.

## Magnitude

Periodic Comet Tempel 2 was picked up by A.L.P.O. observers in July, 1988, and was followed by them until late November of that year. Their magnitude estimates ranged from +12.5 to +8.1 , and were graphed by Gary Kronk, who supplied the diagrams in Figures 23 and 24 (p. 125).

Figure 23 shows the comet's apparent total visual magnitude, as corrected for aper-


Figure 22. Periodic Comet Tempel 2 is the faint cloud at the center of this photograph by Chris Schur, taken on 1988 SEP 08, using a $41-\mathrm{cm}$ ( 16 -in.) reflector at $f / 4.5$. 15 minutes exposure on Kodak Technical Pan 2415 Film.
ture, as a function of the date of observation. The comet appeared brightest shortly before perihelion on 1988 SEP 16.

For Periodic Comet Tempel 2, Kronk calculated an absolute magnitude [what the comet's magnitude would be were it simultaneously 1 AU from both the Earth and the Sun] of +5.64 . Another important parameter is $\mathbf{N}$, expressing how rapidly a comet changes its absolute magnitude with distance from the Sun. In the case of Periodic Comet Tempel 2, Kronk calculated $\mathbf{N}$ to be equal to +9.8 . Figure 24 shows the absolute magnitude of this comet as a function of date.

However, no single model described the comet's magnitude at all well under all condidions because Comet Tempel 2 brightened very rapidly as it approached the Sun, yet dimmed very slowly as it pulled away. While this behavior may not have constituted a fullfledged outburst, it does indicate a rapid brightening. The A.L.P.O. observations yielded a pre-perihelion absolute magnitude of 2.65 and an $\mathbf{N}$ value of +33 ! Periodic Comet Tempel 2's absolute magnitude before perihelion is graphed in Figure 25 (p. 125).

Finally, the analysis graphed in Figure 26 (p. 126) indicates a post-perihelion absolute magnitude of +6.72 , with $\mathbf{N}$ equal to +4.9 .

Table 1. Participating Observers of Periodic Comet Tempel 2 (1987g).

| Observer | Location | Instrument(s)* | Type of Observation |
| :---: | :---: | :---: | :---: |
| Clark, M. | Armadale, W. Australia | $30-\& 25-\mathrm{cm} \mathrm{R1}$. | Visual |
| Kronk, G. | Troy, Illinois, U.S.A. | $33-\mathrm{cm} \mathrm{Rl}$. | Visual |
| Modic, R. | Richmond Heights, Ohio, U.S.A. | $20-\mathrm{cm} \mathrm{R1.;} 5-\mathrm{cm} . \mathrm{Bi}$. | Visual |
| Nowak, G. | Williston, Vermont, U.S.A. | $20-\mathrm{cm} \mathrm{Rl}$. | Visual |
| Pearce, A. | Woodlands, W. Australia | $20-\mathrm{cm} \mathrm{Rl}$. | Visual |
| Schur, C. | Payson, Arizona, U.S.A. | $41-\mathrm{cm} \mathrm{Rl}$. | Photographic |
| Seargent, D. | The Entrance, NSW, Australia | $8-\mathrm{cm} \mathrm{Bi}$. | Visual |
| Simmons, K. | Callahan, Florida, U.S.A. | $32-\mathrm{cm} \mathrm{Rl}$. | Visual |

> *R1. = reflector, Bi. = binoculars.


Figure 23. Apparent visual magnitude of Periodic Comet Tempel 2, as reported by A.L.P.O. observers and reduced to a standard aperture. The data set consists of 52 estimates made between 1988 JUL 04 and NOV 28.


Figure 24. Absolute visual magnitude determination for Periodic Comet Tempel 2, based on 52 estimates made by A.L.P.O. members between 1988 JUL 04 and NOV 28. This analysis, for the entire apparition, indicated $\mathbf{H o}_{0}=+5.64$ and $\mathbf{N}=+9.8$


Figure 25. Pre-perihelion absolute visual magnitude determination for Periodic Comet Tempel 2, based on 29 estimates made by A.L.P.O. members between 1988 JUL 31 and SEP 15. This analysis indicated $\mathbf{H}_{0}=-2.65$ and $\mathbf{N}=+33$.

## COMA Size

The coma, or "head," of the comet ranged in apparent angular diameter from 0.2 to 10 arc-minutes, as seen from the Earth. These an-gular-size estimates, as converted to its actual diameter, and projected onto the plane of the sky, are graphed on Figure 27 (p. 126). The
actual diameter of the comet's coma varied from roughly 100,000 to $300,000 \mathrm{~km}$.

## TAIL LENGTH

No A.L.P.O. observers reported seeing a tail on Periodic Comet Tempel 2. This result is not unusual because the comet often displays


Figure 26. Post-perihelion absolute visual magnitude determination for Periodic Comet Tempel 2, based on 12 estimates made by A.L.P.O. members between 1988 SEP 28 and NOV 28. This analysis indicated $\mathbf{H}_{0}=+6.72$ and $\mathbf{N}=+4.9$.
no tail and has never had a tail longer than one degree in this apparition. [11]

## ACKNOWLEDGEMENT

The A.L.P.O. comet observers listed in Table 1 contributed more than 50 visual observations. The Australian observers were especially productive. We thank David Seargent, Andrew Pearce, M. Clark, Gary Kronk, Gary Nowak, Robert Modic, and Karl Simmons for the observations that they contributed. Gary Kronk calculated the magnitude parameters and constructed the graphs. The photographs were contributed by Jim Scotti and Chris Schur.

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## COMET CORNER

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

## Present Comet Activity

Only three new comets were discovered, and a single returning comet recovered, during the first five months of 1990. The latest discovery, Comet Levy (1990c), is described in the next article (pp. 129-130). However, other comets are visible. Comet Austin (1989c1) after perihelion proved to be several magnitudes fainter than expected, although you can still see it in the southern evening sky. Observers may also wish to monitor Periodic Comet Schwassmann-Wachmann 1 for outbursts. Comet Skorichenko-George (1989el), after spending the Spring in the evening sky, enters our morming sky this August. It is joined by Periodic Comets Wild 2, Honda-Mrkos-Pajdusakova, and Encke; the last two should become binoculars objects. In the following paragraphs are brief descriptions and ephemerides for each visible comet. The ephemerides are for 0h Universal Time; " M " refers to visibility in the morning, and " $E$ " in the evening, skies.

Comet Austin (1989 1 1).-A comet new to the inner Solar System, this object apparently burned off a great deal of material shortly after discovery, giving the impression that it would be a bright object after its perihelion on 1990 APR 10. However, it peaked at magnitude +4 in March, 1990, and began to dim after that. It is still visible in the southern evening sky. Observers are asked to send their observations of it to the Comets Recorder by the end of August for analysis. [His address is given on the inside back cover of this issue.]

Table 1.
Ephemeris of Comet Austin (1989c1).

| 990 | 2000.0 Coörd. |  | Elong. from Sun | Total Mag |
| :---: | :---: | :---: | :---: | :---: |
| U.T. Date | R.A. | Decl. |  |  |
|  |  |  |  |  |
| JUL 23 | 1522.8 | -36 21 | 116 E | +11.3 |
| 28 | 1524.3 | -36 32 | 112 E | +11.6 |
| AUG 02 | 1526.5 | -36 43 | 108 E | $+11.9$ |
| 07 | 1529.3 | -36 54 | 104 E | +12.2 |
| 12 | 1532.6 | -37 05 | 100 E | +12.4 |
| 17 | 1536.4 | -3716 | 096 E | +12.7 |
| 22 | 1540.5 | -37 28 | 093 E | +12.9 |
| 27 | 1545.0 | -37 39 | 089 E | +13.1 |

Periodic Comet Schwassmann-Wachmann 1.-This comet is in a near-circular 15 -year orbit. It is usually near magnitude +17 , but will occasionally have an outburst to magnitude $+12-+14$. Please report all positive and negative sightings of it to this Recorder. [If you so not see it, report your estimated limiting magnitude.]

Table 2. Ephemeris of Periodic Comet Schwassmann-Wachmann 1.

| 990 | 2000.0 Coörd. | $\begin{aligned} & \text { Elong. } \\ & \text { from Sun } \end{aligned}$ | Total |
| :---: | :---: | :---: | :---: |
| U.T. Date | R.A. Decl. |  | Mag |
|  |  |  |  |
| Jul 23 | $0147.2+2032$ | 088 M | +17.4 |
| 28 | $0148.4+2047$ | 092 M | +17.4 |
| AUG 02 | $0149.3+2102$ | 097 M | +17.4 |
| 07 | $0150.0+2115$ | 101 M | +17.3 |
| 12 | $0150.4+2127$ | 106 M | +17.3 |
| 17 | $0150.5+2137$ | 110 M | +17.3 |
| 22 | $0150.4+2146$ | 115 M | +17.2 |
| 27 | $0149.9+2153$ | 120 M | +17.2 |
| SEP 01 | $0149.2+2159$ | 125 M | +17.2 |
| 06 | $0148.2+2203$ | 130 M | +17.2 |
| 11 | $0147.0+2205$ | 135 M | +17.1 |
| 16 | $0145.5+2205$ | 140 M | +17.1 |
| 21 | $0143.8+2203$ | 145 M | +17.1 |
| 26 | $0141.8+2159$ | 150 M | +17.1 |
| ОСт 01 | $0139.7+2154$ | 154 M | +17.1 |
| 06 | $0137.5+2146$ | 159 M | +17.1 |
| 11 | $0135.2+2137$ | 164 M | +17.1 |
| 16 | $0132.8+2127$ | 167 M | +17.0 |
| 21 | $0130.4+2115$ | 169 M | +17.0 |
| 26 | $0128.0+2102$ | 168 E | +17.0 |
| 31 | $0125.7+2049$ | 165 E | +17.1 |
| Nov 05 | $0123.5+2034$ | 161 E | +17.1 |
| 10 | $0121.5+2020$ | 156 E | +17.1 |
| 15 | $0119.6+2005$ | 152 E | +17.1 |
| 20 | $0117.9+1951$ | 146 E | +17.1 |
| 25 | $0116.5+1937$ | 141 E | +17.1 |
| 30 | $0115.3+1923$ | 136 E | +17.2 |

Comet Skorichenko-George (1989e1).Discovered in late 1989, this comet was closest to the Sun at 1.57 AU [Astronomical Unit; 1 AU equals 149.6 million km ] on 1990 APR 12. This intrinsically bright comet is now receding from the Sun in the morning sky, and will be a nearly constant 3.2 AU from the Earth between August and November, 1990.

Table 3. Ephemeris of Comet Skorichenko-George (1989e1).

| 1990 | 2000.0 Coörd. | Elong. | Total |
| :---: | :---: | :---: | :---: |
| U.T. Date | R.A. Decl. | from Sun | Mag |
|  |  |  |  |
| AUG 22 | $0815.9+0202$ | 029 M | +10.5 |
| 27 | $0822.3+0023$ | 031 M | +10.6 |
| SEP 01 | 08 28.5-01 16 | 034 M | +10.7 |
| 06 | 08 34.3-02 56 | 037 M | +10.8 |
| 11 | 08 39.9-04 36 | 040 M | +10.9 |
| 16 | 08 45.2-06 17 | 043 M | +10.9 |
| 21 | 08 50.2-07 59 | 046 M | +11.0 |
| 26 | 0854.9 -09 41 | 049 M | +11.1 |

(Table continued on p. 128)

Table 3. Ephemeris of Comet Skorichenko-George (1989ei)-Continued.

| 1990 | 2000.0 Coörd. | Elong. from Sun | Total |
| :---: | :---: | :---: | :---: |
| U.T. Date | R.A. Decl. |  | Mag |
|  |  |  |  |
| OCT 01 | 08 59.2-11 24 | 052 M | +11.2 |
| 06 | 09 03.2-13 08 | 056 M | +11.2 |
| 11 | 09 06.9-14 52 | 059 M | +11.3 |
| 16 | $0910.1-1636$ | 062 M | +11.4 |
| 21 | 09 13.0-18 21 | 065 M | +11.5 |
| 26 | $0915.4-2006$ | 069 M | +11.5 |
| 31 | $0917.4-2150$ | 072 M | +11.6 |
| Nov 05 | $0918.9-2324$ | 075 M | +11.6 |
| 10 | $0919.9-2517$ | 078 M | +11.7 |
| 15 | 09 20.4-26 59 | 082 M | +11.8 |
| 20 | 09 20.3-28 38 | 085 M | +11.8 |
| 25 | $0919.6-3016$ | 088 M | +11.9 |
| 30 | $0918.3-3151$ | 092 M | +12.0 |

Periodic Comet Honda-Mrkos-Pajdusakova.-As of mid-May, this comet has not yet been recovered, but this object has an orbital period of only 5.3 years. It should pass near Earth ( 45 million km ) this summer, and reach perihelion on 1990 SEP 12. [Presumably, the following ephemeris is somewhat uncertain and should be revised after this comet is recovered. Ed.]

Table 4. Ephemeris of Periodic Comet Honda-Mrkos-Pajdusakova.

| 1990 | 2000.0 Coörd. | Elong. from Sun | Total |
| :---: | :---: | :---: | :---: |
| U.T. Date | R.A. Decl. |  | Mag |
|  | h m ${ }^{\circ}$, |  |  |
| JuL 23 | $0132.0-0145$ | 099 M | +9.6 |
| 28 | $0233.9+0242$ | 088 M | +9.1 |
| AUG 02 | $0345.4+0732$ | 074 M | +8.7 |
| 07 | $0456.3+1133$ | 061 M | +8.5 |
| 12 | $0557.2+1405$ | 051 M | +8.4 |
| 17 | $0645.5+1524$ | 044 M | +8.4 |
| 22 | $0723.5+1557$ | 039 M | +8.4 |
| 27 | $0754.7+1603$ | 036 M | +8.4 |
| SEP 01 | $0821.7+1550$ | 035 M | +8.4 |
| 06 | $0846.5+1520$ | 034 M | +8.4 |
| 11 | $0910.4+1433$ | 033 M | +8.6 |
| 16 | $0933.7+1331$ | 032 M | +8.9 |
| 21 | $0956.3+1216$ | 031 M | +9.3 |
| 26 | $1017.9+1051$ | 030 M | +9.7 |
| OCT 01 | $1038.2+0922$ | 030 M | $+10.3$ |
| 06 | $1057.2+0751$ | 030 M | +10.8 |
| 11 | $1114.7+0623$ | 031 M | +11.3 |
| 16 | $1131.0+0457$ | 031 M | +11.8 |

Periodic Comet Encke.-This comet has the shortest period of any known comet, 3.3 years, and will be closest to the Sun on 1990 Oct 28 . We will be able to observe it before perihelion as it both brightens and nears the Sun.

Table 5. Ephemeris of Periodic Comet Encke.

| 1990 | 2000.0 Coörd. | Elong. from Sun | Tot |
| :---: | :---: | :---: | :---: |
| U.T. Date | R.A. Decl. |  | Mag |
|  | h |  |  |
| AUG 12 | $0407.6+3051$ | 074 M | +13.5 |
| 17 | $0426.2+3204$ | 074 M | +12.9 |
| 22 | $0447.2+3316$ | 075 M | +12.3 |
| 27 | $0511.5+3421$ | 074 M | +11.7 |
| SEP 01 | $0539.5+3515$ | 073 M | +11.2 |
| 06 | $0612.0+3549$ | 071 M | +10.6 |
| 11 | $0649.4+3547$ | 069 M | +10.0 |
| 16 | $0731.6+3454$ | 065 M | +9.5 |
| 21 | $0817.3+3251$ | 060 M | +9.0 |
| 26 | $0904.6+2928$ | 054 M | +8.6 |
| OCT 01 | $0950.8+2448$ | 047 M | +8.3 |
| 06 | $1034.2+1911$ | 041 M | +8.0 |
| 11 | $1113.9+1301$ | 034 M | +7.9 |
| 16 | $1150.7+0641$ | 028 M | +7.8 |
| 21 | $1226.1+0021$ | 022 M | +7.9 |
| 26 | 13 02.4-05 54 | 016 M | +8.0 |

Periodic Comet Wild 2 (1989t).—Discovered in 1978, this comet has an orbital period of 6.2 years and will be closest to the Sun, at 1.58 AU, in mid-December, 1990. We can expect it to be visible in amateur-sized telescopes for most of 1991.

Table 6. Ephemeris of Periodic Comet Wild 2 (1989t).

| 0 | 2000.0 Coörd. | Elong. from Sun | Total Mag |
| :---: | :---: | :---: | :---: |
| U,T. Date | R.A. Decl. |  |  |
|  |  |  |  |
| ОСт 01 | $1018.7+1024$ | 035 M | +12. |
| 06 | $1032.0+0914$ | 036 M | +12.0 |
| 11 | $1045.3+0801$ | 038 M | +11.9 |
| 16 | $1058.7+0646$ | 039 M | +11.8 |
| 21 | $1112.1+0529$ | 041 M | +11.7 |
| 26 | $1125.7+0411$ | 042 M | +11. |
| 31 | $1139.3+0251$ | 043 M | +11.5 |
| OV 05 | $1153.0+0130$ | 045 M | +11 |
| 10 | $1206.8+0009$ | 046 M | +11.3 |
| 15 | 12 20.6-01 13 | 047 M | +11.2 |
| 20 | $1234.5-0233$ | 049 M | +11.1 |
| 25 | 12 48.5-03 54 | 050 M | +11.1 |
| 30 | 13 02.5-05 13 | 051 M | +11. |

# A.L.P.O. Comet Update: Comet Levy (1990c). 

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

On the morning of 1990 MAY 20 A.L.P.O. Assistant Meteors Recorder David Levy of Tucson, Arizona, discovered his sixth comet. He was using his 16 -inch $(41-\mathrm{cm})$ reflector and had searched for 60 hours since his fifth comet find, in August, 1989.

He found this comet in the morning sky, 3.1 AU [Astronomical Unit; 1 AU equals 149.6 million km ] from the Earth and 2.6 AU from the Sun. The comet should brighten as it approaches both. It will move through opposition and into our evening sky in late August, passing 64 million km from us, and then will become favorably placed for SouthernHermisphere observers

The preliminary elements that follow are from IAU Circular 5030, and were calculated by Daniel Green. The magnitude predictions are my own; I used an absolute magnitude of +5.0 [i.e., the theoretical magnitude of the comet were it simultaneously 1 AU from the Sun and the Earth] and an " $N$ " of +3.0 [ $N$ is a measure of how rapidly a comet brightens as it approaches the Sun]. Early indications are that this comet may be slightly brighter than these predictions.

| Time of Perihelion. | 990 OCT 24.359 ET |
| :---: | :---: |
| Distance at Perihelion..... | 0.93849 AU |
| Argument of Perihelion... | $242^{\circ} 579$ |
| Ascending Node........... | $138^{\circ} .570$ |
| Inclination... | $131^{\circ} .623$ |
| Eccentricity.................. | 1.00 (assumed parabolic) |

The preliminary ephemeris of Comet Levy is given below in Table 1. Under elongation from the Sun, " M " indicates visibility in the morning, and " $E$ " in the evening, sky.

Table 1. Ephemeris of Comet Levy (1990c).

| 1990 | 2000.0 Coörd. | Elong. from Sun | Total |
| :---: | :---: | :---: | :---: |
| U.T. Date | R.A. Decl. |  | Mag |
| (0h U.T.) |  |  |  |
| JUL 23 | $2350.3+2929$ | 107 M | +7.3 |
| 28 | $2339.5+2850$ | 114 M | +6.9 |
| AUG02 | $2324.2+2739$ | 121 M | +6.5 |
| 07 | $2302.4+2533$ | 130 M | +6.0 |
| 12 | $2231.5+2155$ | 140 M | +5.4 |
| 17 | $2148.2+1535$ | 151 M | +4.9 |
| 22 | $2050.9+0527$ | 155 M | +4.4 |
| 27 | $1943.7-0731$ | 141 E | +4.2 |
| SEP 01 | 1838.2-19 14 | 121 E | +4.2 |
| 06 | $1743.5-2709$ | 103 E | +4.5 |
| 11 | 17 02.3-31 53 | 090 E | +4.7 |
| 16 | 1632.0-34 42 | 079 E | +4.9 |
| 21 | 16 09.5-36 29 | 070 E | +5.1 |
| 26 | $\begin{array}{llllll}15 & 52.3 & -3741\end{array}$ | 063 E | +5.3 |
| Oст 01 | 15 38.6-38 33 | 056 E | +5. |

[Table I continued in upper right.]

Table 1. Ephemeris of Comet Levy (1990c).-Continued.

| 1990 | 2000.0 Coörd. | Elong. | Total |
| :---: | :---: | :---: | :---: |
| U.T. Date | R.A. Decl. | from Sun | Mag |
| (0h U.T.) | h m |  |  |
| OCT 06 | $1527.3-3910$ | 050 E | +5.5 |
| 11 | $1517.6-3938$ | 044 E | +5.6 |
| 16 | $1509.1-4000$ | 039 E | +5.7 |
| 21 | $1501.5-4015$ | 035 E | +5.8 |
| 26 | $1454.5-4026$ | 031 E | +5.9 |
| 31 | $1448.0-4034$ | 027 E | +6.0 |
| Nov 05 | $1441.9-4038$ | 025 E | +6.1 |
| 10 | 14 36.0-40 41 | 024 E | +6.2 |
| 15 | $1430.3-4043$ | 025 E | +6.3 |
| 20 | $1424.8-4043$ | 027 E | +6.5 |
| 25 |  | 030 E | +6.6 |
| 30 | $1413.3-4045$ | 034 E | +6.7 |

## Notes by Editor.

If Comet Levy lives up to the above predictions, it should be an easy naked-eye object in late August and early September. (A 1990 JUN 22 estimate by John Bortle with $20 \times 80$ binoculars places Comet Levy at magnitude +8.7 ; about 0.5 magnitudes brighter than the model used for the above ephemeris.)

Visibility conditions for Comet Levy are quite favorable. Somewhat unusual for a comet, it should be at maximum brightmess when it is near opposition to the Sun (which occurs on 1990 AUG 25), and thus visible then for most of the night.

Figures 28 and 29 (p. 130) show Comet Levy's predicted path through the sky; Figure 28 for the period 1990 JUL 28 -SEP 01, and Figure 29 for 1990 SEP 01-OCT 31. Interestingly, this path is similar to that followed by Comet Austin (1989c1), except that (a) Comet Levy is about $5^{\circ}$ farther south, and, (b) Comet Levy follows Comet Austin's path about three months later than did Comet Austin. This latter difference makes Comet Levy much more conveniently visible.

In August and September, Comet Levy crosses the Summer Milky Way, which may make it harder to find, but may also produce some attractive photographs and visual views of the comet near deep-sky objects. The comet passes close to at least three such objects: (1) 1990 AUG $15,02 \mathrm{~h}$ U.T., 15 arc-minutes northwest of spiral galaxy NGC 7177 (magnitude +12); (2) 1990 Aug 18, 06h U.T., 48 arc-minutes northwest of globular cluster M15 (magnitude +6 ); and (3) 1990 SEP 27, 12 h U.T., 2 arc-minutes north of globular cluster NGC 5986 (magnitude +7 ). Because the last object is about 10 arc-minutes in diameter, Comet Levy should actually transit the globular cluster, making occultations of its stars by the comet's nucleus a real possibility.


Figure 28 (above). Predicted path of Comet Levy (1990c) for 1990 JUL 28-SEP 01. Ticks are shown for every day ( 0 h U.T.), with dates labeled every 5 days. Limiting magnitude +6 . Rightascension lines are every 40 minutes and declination lines every $10^{\circ}$. Generated by Voyager program, © Carina software.


Figure 29 (above). Predicted path of Comet Levy (1990c) for 1990 SEP 01-OCT 31. Ticks are shown for every day ( 0 h U.T.), with dates labeled every 5 days. Limiting magnitude +6 . Rightascension lines are every 40 minutes and declination lines every $10^{\circ}$. Generated by Voyager program, © Carina software.

# A Summary of Observations of the 1989 Mar 07 Partial Solar ECLIPSE 

By: Francis G. Graham, A.L.P.O. Solar Eclipses Recorder

On March 7, 1989, a partial solar eclipse was visible over North America west of a line running approximately from Mazatlán (Mexico) through Tulsa and Chicago, Ontario, and Quebec to Nain, Labrador. The eclipse began east of Hawaii at a predicted Universal Time (U.T.; all times in this report are U.T.) of 16 h 16 m 51 s , and was scheduled to end in central Greenland at 19 h 58 m 11 s . The maximum magnitude of this eclipse, defined as the fraction of the solar diameter covered by the Moon, was 0.826 , near Nome, Alaska. [1]

One month prior to the eclipse, I sent a form letter requesting observations and timings to American Lunar Society members, and also to selected A.L.P.O. members in the visibility zone. This report summarizes the results of five persons who submitted observations of the eclipse. A sixth, Paul Maxson, has published his excellent observations in an earlier issue of this Journal. [2]

Observations of this eclipse were particularly interesting because a large sunspot group, SESC 5395 [Space Environmental Services Center designation number], was visible at that time near the solar limb at heliographic longitude $255^{\circ}$, latitude $+35^{\circ}$. [3] Jennie Dingess and this Recorder photographed this feature with the Gadela Refractor at Kent State University while the eclipse was in progress elsewhere. Other observations received are described below by observer.

Gordon Garcia, of Hoffman Estates, Illinois, who has sponsored many issues of the A.L.P.O. Solar Section's Rotation Report, used an observing site just inside the eclipse visibility zone in Coral Woods, McHenry County, Illinois (longitude $88^{\circ} 35^{\prime} 04^{\prime \prime} \mathrm{W}$. latitude $42^{\circ} 13^{\prime} 11$ " N , elevation 280 meters). There was no cloud cover at that location, and seeing was 3-4 arc-seconds in the $25^{\circ} \mathrm{F}$ air. Using an 8 -inch ( $20-\mathrm{cm}$ ) Celestron Schmidt-Cassegrain at $67 \times$, he timed first contact at 18 h 29 m 52 s $\pm 3$ seconds. His three fine white-light photographs were taken at $18 \mathrm{~h} 47 \mathrm{~m}, 18 \mathrm{~h} 50 \mathrm{~m}$, and 18 h 54 m .

Bob Garfinkle of Union City, California, observed the eclipse from that location. Observing was hampered by intermittent clouds until 17 h 10 m , but at 17 h 11 m he reported the first contact of the Moon's limb with the sunspot group SESC 5385, located at heliographic longitude $324^{\circ}$, latitude $+25^{\circ}$. The Moon completely covered the region (second contact) at 17 h 1 lm 13 s . After that, clouds prevented observation from 17 h 12 m $17 \mathrm{~h} 19 \mathrm{~m}, 17 \mathrm{~h} 38 \mathrm{~m}-17 \mathrm{~h} 51 \mathrm{~m}$, and after 18 h 00 m . He also took air temperatures with a shaded thermometer: $62^{\circ} \mathrm{F}$ at 17 h 29 m .; $57^{\circ} .5$ F at 17 h 52 m ; and $60^{\circ} \mathrm{F}$ at 18 h 12 m .

Richard Hill of Warner \& Swasey Observatory in Tucson, Arizona, submitted seven
photographs taken with a Celestron 8 -inch ( $20-\mathrm{cm}$ ) Schmidt-Caessegrain telescope. They were exposed at prime focus on Kodak TP 2415 Film at $17 \mathrm{~h} 09 \mathrm{~m}, 17 \mathrm{~h} 20 \mathrm{~m}$, 17 h 25 m , $17 \mathrm{~h} 45 \mathrm{~m}, 17 \mathrm{~h} 55 \mathrm{~m}, 18 \mathrm{~h} 20 \mathrm{~m}$, and 18 h 40 m . He recorded first contact at 17 h 08 m and last contact at 18 h 45 m . His seeing was about 1-2 arc-seconds.

David Weier of the American Lunar Society observed this eclipse from Madison, Wisconsin, at longitude $89^{\circ} 18^{\prime} 17^{\prime \prime} .5 \mathrm{~W}$, latitude $43^{\circ} 05^{\prime} 42^{\prime \prime} \mathrm{N}$, making timings with WWV shortwave time signals. First contact was obscured by billowing cumulus clouds, but occurred prior to 18 h 23 m 30 s . The last contact was reliably timed and reduced to give a U.T. of 19 h 03 m 22.2 s .

John Westfall observed from San Francisco at longitude $122^{\circ} 29^{\prime} 45^{\prime \prime} .1 \mathrm{~W}$, latitude $37^{\circ} 44^{\prime} 06^{\prime \prime} .4 \mathrm{~N}$, elevation 24 meters. He used a CCD black-and-white video camera with a 4 inch ( $10-\mathrm{cm}$ ) f/l0 refractor, stopped down to 1 -inch $(2.5-\mathrm{cm})$ aperture and with a Tuthill SolarSkreen Filter. The videotape had an effective seeing resolution of about 5 arc-seconds, but was frequently interrupted by clouds. Corrected timings of sunspot occultations made from the videotape were: SESC $5386,17 \mathrm{~h} 28 \mathrm{~m} 22 \mathrm{~s}$; SESC 5405 , first contact at 17 h 49 m 21 s , second contact at 17 h 50 m 06s; SESC 5395 complex, first contact 17 h 52 m 52 s , second contact 17 h 59 m 11 s . (These times are accurate to only $\pm 2$ seconds because of the way the Eclipse Recorder reduced the tape.) As the Moon left the Sun's disk, SESC 5395 was uncovered. SESC 5395's third contact was lost due to a video error, but last contact was at 18 h 52 m 01 s . The last contact of the Moon's limb with the Sun was timed from the video at 18 h 53 m 43 s .

This Recorder deeply thanks all the above observers for their participation. As is the policy with the A.L.P.O. Solar Section, all observations are kept and are made available to scientific inquirers for the cost of copying and mailing. Please write to this Recorder (address on inside back cover) for further information.

## References

1. Espenak, Fred. Fifty Year Canon of Solar Eclipses: 1986-2035. NASA Reference Publication 1178, revised. Washington: N.A.S.A., July, 1987. p. 149.
2. Maxson, Paul, "Personal Observations of the Partial Solar Eclipse of 1989 Mar 07." JALP.O., 33, Nos. 7-9 (July, 1989), pp. 122123 and front cover.
3. Space Environmental Services Center. "HAlpha Synoptic Chart." Preliminary Report and Forecast of Solar Geophysical Data \#709 (April, 1989).

# Recent A.L.P.O. METEOR ObSERVATions 

By. Robert D. Lunsford, A.L.P.O. Meteors Recotrder

Table 1, below, summarizes those observations received by the A.L.P.O. Meteors Section as of early June, 1990.

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


Table 1-Continued.

| $\begin{gathered} 1990 \\ \text { U.T. Date } \\ \hline \end{gathered}$ | Observer and Location | Universal Time | Number and Type of Meteors Seen* | Comments ${ }^{*}(+N=$ <br> Limiting Magnitude) |
| :---: | :---: | :---: | :---: | :---: |
| APR 22 | James Richardson, CA | 10:10-10:45 | 7 LY ; 5 SP | (var); $50 \% ; \mathrm{LYZHR}=22$ |
|  | Robert Lunsford, CA | 11:00-12:00 | $22 \mathrm{LY} ; 9 \mathrm{SP}$ | +6.6; LY ZHR = 21 |
| 23 | Mark Davis, VA | $\begin{aligned} & 05: 00-06: 00 \\ & 06: 15-07: 15 \end{aligned}$ | $\begin{aligned} & 1 \mathrm{LY} ; 2 \alpha \mathrm{~B} ; 3 \mathrm{SP} \\ & 7 \mathrm{LY}, 2 \mathrm{SP} \end{aligned}$ | $\begin{aligned} & +5.6 \\ & +5.6 \end{aligned}$ |
|  | " | 07:30-08:30 | 5 LY ; 5 SP |  |
| 29 | James Richardson, CA | 08:20-09:20 | $1 \alpha S ; 1 \alpha B ; 6 \mathrm{SP}$ | +5.5 |
|  | 4son, CA | 09:20-10:20 | 9 SP | +6.0 |
|  | " " " | 10:20-11:20 | 13 SP | +6.0 |
|  | " ، " | 11:20-12:20 | 7 SP | (var.) |
| MAY 03 | James Richardson, CA | 09:30-10:07 | 3 SP | +5.0 |
|  |  | 10:07-11:07 | $1 \mathrm{\eta A} ; 4 \mathrm{SP}$ | +5.5 |
|  | Robert Lunsford, CA | 10:47-11:47 | $1 \eta \mathrm{~A} ; 4 \mathrm{SP}$ | +6.1 |
|  | James Richardson, CA | 11:07-11:45 | $1 \eta A ; 6 S P$ | +4.0 |
| 04 | J. Kenneth Eakins, CA | 09:05-10:05 | $2 \eta \mathrm{~A} ; 1 \mathrm{SP}$ | +5.1 |
|  |  | 10:05-11:05 | $1 \eta \mathrm{~A}$ | +5.3 |
|  | James Richardson, CA | 10:46-11:07 | $1 \eta A ; 5 S P$ | +6.5 |
|  | Robert Lunsford, CA | 10:47-11:47 | $4 \eta \mathrm{~A} ; 7 \mathrm{SP}$ | +6.5 |
|  | $\underset{\text { James Richardson, CA }}{i /}$ | $\begin{aligned} & \text { 11:07-12:07 } \\ & 12: 07-12: 15 \end{aligned}$ | $11 \mathrm{\eta A} ; 3 \mathrm{SP}$ (none seen) | $\begin{aligned} & +6.0 ; \eta \mathrm{A} \text { ZHR }=28 \\ & +4.0 \end{aligned}$ |
| 05 | J. Kenneth Eakins, CA | 07:00-08:00 | (none seen) | +4.9 |
|  |  | 08:00-09:00 | 1 SP | +5.0 |
|  | " " ، " | 09:10-10:10 | 1 SP | +5.1 |
|  | Robert Lunsford, CA | 09:47-10:47 | $5 \eta \mathrm{~A} ; 1 \alpha \mathrm{~S} ; 13 \mathrm{SP}$ | +6.1 |
|  | J. Kenneth Eakins, CA | 10:10-11:10 | $1 \eta A ; 1 S P$ | +5.1 |
|  | James Richardson, CA | 10:20-11:07 | $1 \eta A ; 8$ SP | +5.0 |
|  | Robert Lunsford, CA | 10:47-11:47 | $14 \eta A ; 1 \alpha S ; 8 \mathrm{SP}$ | $+6.0 ; \eta \mathrm{A} \mathrm{ZHR}=37$ |
|  | James Richardson, CA | 11:07-12:07 | $3 \mathrm{\eta A} ; 3 \mathrm{SP}$ | +5.5 |
|  | J. Kenneth Eakins, CA | 11:10-12:10 | $4 \eta A ; 1$ SP | +4.7 |
|  | James Richardson, CA | 12:07-12:20 | $1 \eta \mathrm{~A}$ | +3.0 |
| 06 | George Gliba, MD | 07:55-08:55 | $5 \eta A ; 4$ SP | +5.3; $10 \%$ |
|  | Robert Lunsford, CA | $\begin{aligned} & 09: 47-10: 47 \\ & 10: 47-11: 47 \end{aligned}$ | $1 \eta A ; 2 S P$ <br> $10 \eta A ; 1 \alpha S ; 6$ SP | $\begin{aligned} & +6.0 \\ & +6.0 ; \eta \mathrm{A} \mathrm{ZHR}=26 \end{aligned}$ |
| 16 | James Richardson, CA | 04:20-05:20 | 3 SP | +6.0 |
|  |  | 05:20-06:20 | 3 SP | +6.0 |
|  | " " " | 06:20-07:00 | 3 SP | +6.0 |
| 27 | Bruce Bowden, NC | 02:00-03:00 | (none seen) | +3.4; $25 \%$ |
|  | Margaret Bowden, NC | 02:00-03:00 | (none seen) | +3.4; $25 \%$ |
|  | Deborah Carroll, NC | 02:00-03:00 | 1 SP | +5.5; $25 \%$ |
|  | Rex Carroll, NC | 02:00-03:00 | 1 SP | +5.1; $25 \%$ |
|  | Barbara Hands, NC | 02:00-03:00 | 1 SP | +3.4; $25 \%$ |
|  | Dennis Hands, NC. | 02:00-03:00 | (none seen) | +3.4; $25 \%$ |

[^0]
## COMING SOLAR-System Events: August - October, 1990

## What to Look For

We use this column to alert our readers about events happening in the Solar System during the next three months; giving the visibility conditions for major and minor planets, the Moon, comets, and meteors. You can find more detailed information in the 1990 edition of the A.L.P.O. Solar System Ephemer-is. (See p. 148 to find out how to obtain this publication.) Celestial directions are abbreviated. The symbol " indicates arc-seconds. All dates and times are in Universal Time (U.T.). For the time zones in the United States, U.T. is found by adding 9 hours to H-ADT (HawaiiAleutian Daylight Time), 8 hours to ADT (Alaska Daylight Time), 7 hours to PDT, 6 hours to MDT, 5 hours to CDT, and 4 hours to EDT. (Add one less hour if you are on Standard Time.) Note that this addition may put you into the next U.T. day!

## The Planets: Saturn Well-Placed; Mars becoming So

Saturn is the one planet that is convenient $t 0$ view in the evening sky, and it is best placed for S-Hemisphere observers at declination $22^{\circ} \mathrm{S}$ in Sagittarius. It transits (crosses the meridian, thus reaching its highest altitude) in the late evening in August and September and near sunset in October. During this period, the Globe's equatorial diameter shrinks from 18" to $16^{\prime \prime}$ and the Globe-Ring total visual magnitude (Mag.) dims from +0.1 to +0.6 . The Rings' major axis diminishes from $42^{\prime \prime}$ to $37^{\prime \prime}$, and the Rings are well-presented with the Earth $24^{\circ}$ above their north face.

These years, Uranus and Neptune are not far from Saturn, also in Sagittarius, so they too are well-placed in the $S$ in the evening sky. Uranus is at Mag. $+5.7,3^{\prime \prime} .7$ in diameter; while Neptune is Mag. +7.9 , diameter 2".3.

Mars moves from Aries to Taurus, farther from the Sun in the morning sky, becoming bigger and brighter. By the end of our period it is visible in the late evening in the SE. It is well-placed for northem observers, moving from $14^{\circ}$ to $23^{\circ} \mathrm{N}$ of the equator as it brightens from Mag. -0.1 to -1.6 and grows in diameter from $9^{\prime \prime}$ to $17^{\prime \prime}$. Thus, the planet is coming close enough for photography and high-resolution visual observation. The 5 Polar Cap, tilted from $15^{\circ}$ to $4^{\circ}$ toward us, will continue to shrink. Also, by October there is a high probability of dust storms.

Jupiter is a morning object in the E , in Cancer and still rather close to the Sun. Observation of it should become feasible in September and October. It is a prominent object brightening from Mag. -1.8 to -2.2 , at declination $21^{\circ}-18^{\circ} \mathrm{N}$. There are several reasons to watch Jupiter whenever possible, including activity in the $N$ Equatorial Belt and $N$ Temperate Current, possible darkening of the

Great Red Spot, and of course the possible reappearance of the $S$ Equatorial Belt.

In terms of the inferior planets, Venus continues to be poorly placed in the predawn eastern sky. On AUG 01 it will be $24^{\circ} \mathrm{W}$ of the Sun, but this shrinks until the planet is in Superior Conjunction with the Sun on NOV 01. At Mag. -3.9, its disk diameter contracts from 11 " to $10^{\prime \prime}$ while its phase (proportion illuminated) increases from 91 to 100 percent.

There will be a close conjunction near 23 h on AUG 12, with Venus (Mag. -3.9) just 2.5 arc-minutes N of Jupiter (Mag. -1.8), and both planets $21^{\circ} \mathrm{W}$ of the Sun. The two planets will be above the horizon in daylight throughout the Pacific Basin, including Australia and New Zealand; in N America except the east coast, and E Asia. Observers in India, SE Asia and W China can see the conjunction in the predawn E sky.

The innermost planet, Mercury, has two visibility periods during our three-month forecast, when it is more than $15^{\circ}$ from the Sun. The first is an evening apparition between Jul 16 and AUG 30, with a Greatest Elongation East of $27^{\circ}, 4$ on AUG 11, more favorable for viewing from our S Hemisphere. The second apparition falls between SEP 18 and OCT 01, centered on the date of Greatest Elongation West of $17^{\circ}, 8$ on SEP 24; this morning apparition favors northern observers.

In order to be complete, we note a close conjunction at 06 h on OCT 16, with Venus only 1.5 arc-minutes $S$ of Mercury. In theory this will be visible from the E Hemisphere, but the two planets will then be only $4^{\circ} \mathrm{W}$ of the Sun; you may need a coronagraph!

There are no less than six minor planets that reach opposition between AUG 16 and OCT 03 with magnitudes +10.0 or brighter. Their 10-day ephemerides are given in the A.L.P.O. Solar System Ephemeris: 1990, but their opposition circumstances are summarized below:

|  | Opposition Data |  |  |
| :---: | :---: | :---: | :---: |
| Minor Planet | 1990 Date | Magnitude | Declination |
| 40 Harmonia | AUG 16 | +9.4 | $20^{\circ} \mathrm{S}$ |
| 20 Massalia | Aug 19 | +9.8 | $12^{\circ} \mathrm{S}$ |
| 29 Amphitrite | Aug 22 | +9.1 | $17^{\circ} \mathrm{S}$ |
| 704 Interamnia | Aug 29 | +10.0 | $17^{\circ} \mathrm{N}$ |
| 10 Hygiea | SEP 08 | +9.9 | $01^{\circ} \mathrm{S}$ |
| 42 Isis | OCT 03 | +9.5 | $14^{\circ} \mathrm{S}$ |

Although not in opposition, three other minor planets will be fairly bright: 1 Ceres at Mag. $+8.5-8.7 ; 2$ Pallas, Mag. $+8.7-9.0$; and 4 Vesta, Mag. +8.1-6.8 Note that 1951 Lick will pass near the Earth in early August, reaching Mag. +12.9 ; while 944 Hidalgo will do the same in in October at Mag. +14.1. More detailed ephemerides of these last two bodies are given in the A.L.P.O. Solar System Ephemeris: 1990.

## The Moon

During the current three-month period, the schedule for the Moon's phases is:
New Moon First Quarter Full Moon Last Quarter
JUL 22.1 JUL 29.6 AUG 06.6 AUG 13.7
AUG 20.5 AUG 28.3 SEP 05.1 SEP 11.9 SEP 19.0 SEP 27.1 OCT 04.5 OCT 11.1
OCT 18.7 OCT 26.9 NOY 02.9 NOV 09.5

The four lunations above are Numbers 836-839 in Brown's series. The Full Moon of AUG 06 marks a partial lunar eclipse, described on p. 89 of the last issue (Vol. 33, No. 2, April, 1990).

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

| East | North | West | South |
| :---: | :---: | :---: | :---: |
| JuL 25 | JUL 30 | AUG 08 | AUG 13 |
| AUG 22 | AUG 26 | SEP 04 | SEP 09 |
| SEP 17 | SEP 22 | OCT 01 | OCT 06 |
| ОСт 13 | ОСт 19 | ОСт 29 | Nov 02 |

Lunar $E$ and $W$ above follow the usage of the International Astronomical Union, with Mare Crisium near the east limb. Libration and solar lighting provide good views of the SW limb on SEP 05-07; and of the S and SW limb on OCT 03-08 and OCT 31-NOV 04. The W limb can be seen well on AUG 06, SEP 0405, and OCT 04. Likewise, the E limb will be well presented on AUG 22-23.

## occultations

Eight minor planets and one satellite are busy occulting stars in the August-October pe-
riod, as shown in the table below which lists the date, occulting object, visual magnitude of asteroid or satellite/star, and zone of visibility for each of these occultations. The occultation of a 9th-Mag. star by Neptune's satellite Triton is particularly interesting.

AUG 01.51. Triton, 13.5/9.2. Pacific Oc. except E SEP 08.17. 40 Harmonia, 10.8/9.2 N So. America SEP 09.08. 8 Flora, 11.2/9.2. N Cent \& NE U.S.A SEP 11.21.20 Massalia, 11.1/7.9. South America SEP 24.02. 19 Fortuna, 12.0/9.2 NW Africa, SE

Europe, Cent. Asia
SEP 29.31. 29 Dido, 13.8/9.2. S Pacific Ocean
OCT 09.48. 87 Sylvia, 13.0/9.4. S Pacific Ocean OCT 09.51.02 Pallas, 8.9/7.5. S Pacific Ocean OCT 22.75. 185 Eunike, 13.0/8.5. N Australia

The Moon occults major planets no less than six times between AUG 18 and OCT 25

The first such event is an occultation of Jupiter on AUG 18, visible in much of North America, SW Europe, and NW Africa. This is the second in a series of four monthly occultations of Jupiter. Figure 29, below, shows the visibility zone in North America for this occulcation. At that time, the Moon will be $26^{\circ} \mathrm{W}$ of the Sun, and 5-percent illuminated. Most areas will have daylight for this event, and we recommend that observers there locate the Moon first and then locate Jupiter. In the region W of the line Winnipeg-Kansas CityHouston, the Sun will be below the horizon for immersion. For observers $W$ of the Edmonton-Denver-Austin line, emersion will also occur before sunrise.

Jupiter itself will be at magnitude -1.8 , with a disk $32^{\prime \prime}$ in equatorial diameter. This means that there will be a graze zone about 58 km wide where Jupiter will be only partly occulted. This graze zone includes Charleston,


Figure 29. Visibility zone in North America for the 1990 AUG 18 occultation of the planet Jupiter by the Moon. The lines "Immersion" and "Emersion" mark where the Moon will be rising for those phases of the occultation. The location abbreviations are defined in the text.

SC; Houston, TX; and Bordeaux, France. Making the event more interesting is the fact that all four Galilean Satellites will be visible and thus will also be occulted by the Moon.

The occultation circumstances for selected stations are given below. For the North American stations, the standard 2-letter abbreviations used in Figure 29 are identified. Under both "Immersion" and "Emersion", the U.T. hour and minute (expressed as hhmm) are followed by the position angle (measured $0-360^{\circ}$ eastward from celestial north).

| Location | Immersion | Emersion |
| :---: | :---: | :---: |
| Atlanta, GA(At) |  |  |
| Austin, TX ( Au ) |  |  |
| Chicago, $11 . \mathrm{Ch})$ | 1128 (125 ${ }^{\circ}$ ) | 1231 (262 ${ }^{\circ}$ ) |
| Charleston, SC ( Cn ) | 1156 (187 ${ }^{\circ}$ ) | 1205 (202 ${ }^{\circ}$ ) |
| Denver, CO (De) | $1119\left(117^{\circ}\right)$ | 1217 (266 ${ }^{\circ}$ ) |
| Edmonton, Alb. (Ed) | 1137 (069 ${ }^{\circ}$ ) | 1225 (316 ${ }^{\circ}$ ) |
| Halifax, N.S. (Ha) | 1154 (124 ${ }^{\circ}$ ) | 1308 (275 ${ }^{\circ}$ ) |
| Houston, TX (Ho) | 1140 (185 ${ }^{\circ}$ ) | 1147 (1980) |
| Kansas City, Mo (KC) | 1123 (130 ${ }^{\circ}$ ) | 1220 (255 ${ }^{\circ}$ ) |
| Los Angeles (LA) | (not visible) | $1208\left(260^{\circ}\right)$ |
| $77^{\circ} .5 \mathrm{~W} / 42^{\circ} .5 \mathrm{~N}$ (MA) | 1143 (1319) | 1251 (2630) |
| Montreal, Que. (Mo) | 1142 (120 ${ }^{\circ}$ ) | 1253 (274) |
| $122^{\circ} \mathrm{W} / 38^{\circ} \mathrm{N}$ (NC) | (not visible) | 1212 (276) |
| $109^{\circ} \mathrm{W} / 34^{\circ} \mathrm{N}$ (NM) | $1117\left(132^{\circ}\right)$ | 1207 (249 ${ }^{\circ}$ ) |
| Toronto, Ont. (To) | $1136\left(124^{\circ}\right)$ | 1243 (2670) |
| Vancouver, B.C. (Va) | $1132\left(072^{\circ}\right.$ ) | 1220 (311 ${ }^{\circ}$ ) |
| Washington, DC (Wa) | $1140\left(146^{\circ}\right)$ | $1238\left(248^{\circ}\right)$ |
| Winnipeg, Man. (Wi) | 1130 (093 ${ }^{\circ}$ ) | 1232 (2940) |
| Barcelona, Spain | 1354 (043 ${ }^{\circ}$ ) | 1412 (012 ${ }^{\circ}$ ) |
| Bordeaux, France | 1355 (029 ${ }^{\circ}$ ) | 1357 (025 ${ }^{\circ}$ ) |
| Lisbon, Portugal | 1331 (084 ${ }^{\circ}$ ) | 1427 (334*) |
| Madrid, Spain | 1340 (067 ${ }^{\circ}$ ) | 1421 (350 ${ }^{\circ}$ |

Less than one day after the Jupiter occultation, on AUG 19,00h, the Moon will pass in front of Venus, as seen from Indonesia, New Guinea, N Australia, and New Zealand. Venus will be at Mag. $-3.9,20^{\circ} \mathrm{W}$ of the Sun.

Three days later, W, Central, and E Africa, along with Madagascar, will have their turn with an occultation of Mercury on Aug 22, 11 h . Mercury will be $24^{\circ} \mathrm{E}$ of the Sun, at Mag. +1.0 .

The third in the series of occultations of Jupiter occurs on SEP 15, 06h, with the planet $47^{\circ} \mathrm{W}$ of the Sun at Mag, -1.9. The event will be visible from N and Central Africa. The final Jupiter occultation will happen on OCT $12,19 \mathrm{~h}$. Jupiter will then be $69^{\circ} \mathrm{W}$ of the Sun, at Mag. -2.0. Most of Australia (except Western Australia) should see this event.

Finally, on OCT 25, 18h, there is the first of a series of six occultations of Saturn, but it will be visible only from Antarctica.

Meanwhile, there will be four occultations of the +1.2-Mag. star Antares in three months: (1) AUG $01,09 \mathrm{~h}\left(121^{\circ} \mathrm{E}\right.$ of the Sun); from Indonesia, New Guinea, and N and Central Australia. (2) AUG 28, 17h ( $94^{\circ} \mathrm{E}$ ); from NE South America, $S$ Africa, and Madagascar. (3) SEP 25, 01h ( $68^{\circ} \mathrm{E}$ ); from Hawaii, Central America, and NW South America. (4) Oct 22, $09 \mathrm{~h}\left(41^{\circ} \mathrm{E}\right.$ ); from S Asia, Indonesia, and Japan.

The series of passages of the Moon across the Pleiades open star cluster (M45) continues: AUG 14, 06h, 43-percent sunlit Moon; visible from the E United States and E Canada. SEP 10, $12 \mathrm{~h}, 65$-percent Moon; from W North America and Hawaii. OCT 07, 19h, 85 -percent Moon; from Asia. The Beehive (M44; Praesepe) star cluster is occulted just once: SEP 15, 07h, 15 -percent Moon; from S South America.

## Comets

Several telescopic comets, and possibly one naked-eye comet (Comet Levy 1990c), will be present in the sky. For more information, see the two articles by Don E. Machholz, "Comet Corner" and "Comet Update," on pp. 127-130 of this issue.

Besides those comets already mentioned, during this three-month interval Periodic Comet Kearns-Kwee (1989u) will be approaching its 1990 NOV 22 perihelion and slowly brightening from Mag. +13 to +12 . A 5 -day ephemeris for this object is available in the A.L.P.O. Solar System Ephemeris: 1990.

## Meteor Showers <br> (Contributed by Robert D. Lunsford, AL.P.O. Meteors Recorder)

The Perseids peak on the moming of August 13th (local time) this year. Unfortunately, the Last Quarter Moon will limit meteor counts as it overpowers the fainter meteors. Expect to see no more than 30 Perseids per hour at best.

The Kappa Cygnids peak on AUG 18 and the waning crescent Moon should not interfere. These slow, bright meteors are best seen in the evening hours following sunset.

The best shower of September is the Southern Piscids, which peak near SEP 20, when the 1 -day Moon will not be a problem. Observe these slow meteors after midnight; their peak rates are near 5 per hour.

The Draconids peak on ОСТ 09, but it is doubtful that any display will occur. Also, there will be a Last Quarter Moon near that date. Comet Giacobini-Zinner is the source of this shower. As this comet is still two years from perihelion, no meteor activity is likely until 1992.

The Orionids reach their maximum on OCT 21 this year. Conditions are good as the young crescent Moon will be long set on Saturday, October 20th, and Sunday, October 21st (local time), which are prime momings for the Orionids. We encourage everyone to observe on those mornings as up to 30 Orionids per hour should be visible under dark skies. High rates should continue through October 24th, so we ask those able to observe on weekday momings to please do so. Plots of Orionid paths have revealed a double radiant NE of Betelgeuse. Also, while observing the Orionids, activity may be noticed from the Taurids, Epsilon Geminids, Delta Aurigids, and the Northern Piscids.

# Position Measurements of the Minor Planet 747 Winchester USing a Filar Micrometer 

By: Donald C. Parker, A.L.P.O. Mars Recorder, Institute for Planetary Research Observatories; and Michael C. Mooney, Southern Cross Astronomical Society


#### Abstract

On 1984 NOV 28, the minor planet 747 Winchester was predicted to occult the $+9.0-$ magnitude star SAO 114569. Although the occultation did not occur for the southern Florida observing site, the separations and position angles of the asteroid relative to the star were measured six times with a filar micrometer. A track for the minor planet relative to the star was plotted and extrapolated in order to reveal that 747 Winchester passed 1.24 arc-seconds south-southwest of SAO 114569 at 06 h 15 m 50 s U.T. as seen from the observing station. This paper describes the methods used for observation and data analysis.


## Introduction

On the morning of November 28, 1984 (local time and U.T.), the minor planet 747 Winchester was predicted to occult the +9.0 magnitude star SAO 114569. Although this event was thought to be most probably visible from South America [1], communications from David W. Dunham of IOTA [International Occultation Timing Organization] suggested that there was considerable uncertainty as to the asteroid's track. The authors therefore decided to observe the star from southern Florida in case an occultation occurred there Furthermore, because Parker had gained considerable experience in using a filar micrometer $[2,3]$, we made an attempt to measure the minor planet's position in relation to the star.

## Methods and Materials

Local Conditions.-Micrometric observations were made from the Institute for Planetary Research Observatories (I.P.R.O.) Parker Observatory in Coral Gables, Florida, at longitude $80^{\circ} 16^{\circ} 41^{\prime \prime} \mathrm{W}$, latitude $25^{\circ} 39^{\prime} 04^{\prime \prime} \mathrm{N}$, at an elevation of 7 meters above sea level.

The skies were clear except for occasional high cirrus. Astronomical seeing was excellent; 8-9 on the A.L.P.O. scale which ranges from 0 for terrible to 10 for perfect. The limiting magnitude was +4.5 for the naked eye.

Telescope.-Measurements were made with a $32-\mathrm{cm}$ ( 12.5 -inch) f/6.5 Newtonian telescope on a permanent equatorial mounting. This instrument had been used for a number of years for high-resolution visual and photographic work and has excellent optics. The hour-angle drive is controlled by a quartzcrystal oscillator, while the declination axis has a special ultra-slow motion direct current drive designed for micrometer work.

Micrometer.-A Darbinian bifilar micrometer was used for all measurements. [2] This instrument had been used by I.P.R.O. members for several years for planetary surface measurements and has provided accurate results that are consistent with those obtained by "professional" instruments. [3] A low-power ( $27-\mathrm{mm}$ focal length) ocular was used on the micrometer in order to avoid too great a mag-
nification of the 12 -micron filaments. The high telescopic magnification required was provided with an eyepiece-projection magnifier that used a $9-\mathrm{mm}$ focal length orthoscopic ocular to give an approximate magnification of $1050 \times$. [4] Positive locks were employed on all parts of this system in order to ensure that no change in projection distance occurred.

Micrometer Calibration.-SAO 114569 was first located in the telescopic field at approximately 06 h 00 m U.T. (Universal Time) The micrometer was rotated until the third, or perpendicular, wire was oriented in an exact east-west direction. This orientation was checked again after the final measurement, when no field rotation was detected. The position angle (PA) measurements were read from the micrometer's protractor when the star and the asteroid were bisected by the third wire, and later corrected for the field reversal caused by the projection system

The "screw constant" (SC) of the micrometer was determined by separating the wires by exactly 5.000 mm and measuring the time (dt) that it took for the star to drift between them. Six timings were made with an electronic stopwatch. The SC was calculated by the formula:
$\mathrm{SC}=15.04 \mathrm{dt} \cos$ (declination) $/ 5.000 \mathrm{~mm}$.
Time.-A "Cronos" Model 3-S electronic stopwatch was started on a WWV shortwave time signal at 06 h 1 lm 00 s .00 U.T. This watch had been used for a number of occultations [5] and had been checked against a PC118 cesium-beam frequency standard and had been found quite accurate; to within $\pm 0.05$ seconds over 18 minutes. The stopwatch had been modified so that its start and lap times could be controlled with a microswitch. The instrument was checked against WWV on numerous occasions throughout the observing session and any discrepancies were noted.

Method of Measurement.-The asteroid was moving too rapidly with respect to the star to permit both direct and indirect measurements, so only indirect measurements were made. [2] The micrometer's "zero" was determined visually and agreed with that calculated from several thousand direct and indirect measurements of planetary features.

Each measurement consisted of bisecting the star and asteroid by a vertical wire, with their PA exactly parallel to the horizontal wire, at which time the electronic stopwatch's "lap time" switch was pressed. Next, a final check of the PA was made quickly, with both objects bisected by the horizontal wire. The micrometer separation, PA, and time were immediately recorded and the next set of measurements was begun.

Data Reduction.-The micrometer readings were converted into arc-seconds using the "zero" and screw constants. In Figure 30, below, the measures are plotted, as converted into the coördinates $X$ (east-west) and $Y$ (north-south). The line in Figure 30 was computed using linear least-squares regression, but agrees closely with the line as drawn freehand. The correlation coefficient was also determined.

Because the measurements did not begin until after the time of appulse (closest approach of the two objects), this time was not directly determined. It was indirectly found by determining the X -value of the point on the regression line that was closest to the star. Then a regression of time as a function of X allowed the time for that point to be computed.

## Results

Constants.-The stopwatch was Os. 16 slow. This error did not change throughout the observing period and was added to the observed times.

In determining the screw constant, the transit time for the star to drift 5.000 mm at the focal plane of the projection system was $2.39 \pm 0.03$ seconds, giving a screw constant of $7.19 \pm 0.09$ arc-seconds per millimeter, which is in excellent agreement with previously determined values for this system. [The " $\pm$ " symbol is used to indicate $\pm 1$ standard error. Ed.] This implies that the effective focal length of the system was $28,700 \mathrm{~mm}$ ( 1130 in), yielding a magnification of $1060 \times$.

In terms of position angle, the east-west field orientation did not change during the observing session.

Measurement.-Separations and position angles were determined at six different times as shown in Table 1, below.

Table 1. Measurements of 747 Winchester Relative to SAO 114569, 1984 NOV 28.
U.T. $6 \mathrm{~h} \pm$ Separation Position Angle X-Value

| 19 m 33 s | $1^{\prime \prime} .61$ | $238^{\circ} .0$ | $+1^{\prime \prime} .365$ |
| :--- | :--- | :--- | :--- |
| 22 m 42 s | $2^{\prime \prime} .76$ | $266^{\circ} .5$ | $+2^{\prime \prime} .755$ |
| 26 m 31 s | $3^{\prime \prime} .41$ | $275^{\circ} .6$ | $+3^{\prime \prime} .394$ |
| 29 m 27 s | $4^{\prime \prime} .46$ | $277^{\circ} .6$ | $+4^{\prime \prime} .421$ |
| 31 m 52 s | $5^{\prime \prime} .23$ | $279^{\circ} .5$ | $+5^{\prime \prime} .158$ |
| 36 m 43 s | $6^{\prime \prime} .42$ | $282^{\circ} .1$ | $6^{\prime \prime} .277$ |

The correlation coefficient from the measures above was +0.991 [where 0 indicates no relation between the points on the graph and +1.000 would result if the points all fitted the line perfectly; the standard error of the points was $\left.\pm 0^{\prime \prime} .115\right]$. The direction of motion of the minor planet was $293^{\circ} .7 \pm 1^{\circ} .4$.

By extrapolation of the path, the asteroid would have been $1^{\prime \prime} .24 \pm 0^{\prime \prime} .11$ south-southwest of the star at its closest approach, at PA $203^{\circ} .7 \pm 1^{\circ} .4$. A regression analysis of time as related to the X -coördinate of the asteroid gave the U.T. of closest approach as 06 h 15 m $50 \mathrm{~s} \pm 43 \mathrm{~s}$.

## DISCUSSION

Figure 30 reveals that there was a surprisingly good fit for the path of 747 Winchester. This is encouraging, because this project was done only in order to provide other observers in the area with a prediction of the time of possible occultation. We believe that this may now be a viable method for providing the positions of minor planets. However, one should bear in mind that there are a number of inherent errors in the technique. The reader should


Figure 30. Positions of asteroid 747 Winchester plotted relative to the star SAO 114569. The units of the X- and Y-axis are arc-seconds relative to the star. The line represents the bestfitting regression line to the observations, indicating the closest approach (appulse) as shown.
consult references 2, 4, 7, and 8, which describe in great detail the use of the filar micrometer in planetary and double-star work.

In asteroid measures there is an additional source of error, which presumably would also apply to comet measures. Minor planets can move so rapidly in relation to the comparison star that making both direct and indirect measures is impossible. Likewise, it can be impossible to make exactly simultaneous determinations of separation and PA. Thus it is highly desirable that two persons participate in the observation; one to make, and the other to record, the measurements.

A continuous-readout digital or recording micrometer head would also be highly desirable. The I.P.R.O. plans to construct such a micrometer when funding becomes available. Furthermore, the "zero" of the micrometer has been estimated by wire approximation rather than by the more accurate method of direct-indirect readings. In the present study, the estimated "zero" agreed to within 1 micron with that obtained by thousands of planetary measurements. It is important that the instrument be zeroed accurately beforehand under the same temperature conditions as during the planned observation. Also, the same person should make the measurements because the estimation of wire position varies widely between different observers.

The reader may be surprised by the small angular separations and the very high magnification mentioned in this paper. In measuring planetary surface and atmospheric phenomena and in double-star work, accuracy on the order of $0.05-0.10$ arc-second can be achieved by using the direct-indirect repetitive measurement technique. However, with the single measurements required by minor-planet studies, one cannot expect greater accuracy than $0.1-0.5 \mathrm{arc}$-seconds. While these values are still quite small, they are readily achievable by experienced micrometrists. Thus it is imperative that the observer become proficient with the micrometer on planets and double stars before he or she attempts asteroid work as described here.

The magnifications employed may appear impossibly high. One often reads that the maximum magnification for a telescope is about 50 per inch of aperture. We have found that in viewing and measuring high-contrast subjects, such as the Martian Polar Caps and double stars, that this "limit" can be exceeded easily. However, this procedure presumes excellent optics (our are on the order of $1 / 30$ wave), a minimal central obstruction, perfect collimation, and so forth. Also, the astronomical "seeing," or atmospheric image sharpness, must be very good. We on the southeast Florida coast are blessed with usually fine seeing. On the night of observation, SAO 114569 appeared as a clean disk with one complete diffraction disk about 80 percent of the time!

## Summary

Although there was no occultation of SAO 114569 observed from southern Florida, micrometer measurements of the position of minor planet 747 Winchester revealed that the asteroid passed 1". 24 south-southwest (PA $204^{\circ}$ ) of the star at 06 h 15 m 50 s on 1984 NOV 28 U.T. We hope that these data will be helpful in refining the orbit of 747 Winchester and that this micrometric technique will prove useful to other observers for appulses of asteroids with stars whose positions are known accurately.

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IThe editor has recomputed the regression line for 747 Winchester's path as described in the above paper. There was no substantive difference in the result except in the distance and time of closest approach, which were originally stated to be I". 41 and 06 h 13 m 43 s , respectively. The PA was unchanged.]

## Book Reviews

## Edited by José Olivarez

On the Glassy Sea: An Astronomer's
Journey. By Tom Gehrels. American
Institute of Physics, 335 East 45th Street, New
York, NY 10017. 1988. 340 pages. Price £19.95 cloth (ISBN 0-88318-598-9).

## Reviewed by David H. Levy

"Examinations," Tom Gehrels tells us, "were oral and could be held at any time. The student would simply call on the professor and tell him that he felt ready to take his examination ... So at 11 in the morning, coffee time in the Netherlands, the nervous student would sit with the professor's family, drink coffee, and eat koek, Dutch ginger cake, and talk about the weather or whatever was the topic of the day. After a while, the maid, the children and the Mrs. would leave, and the discussion became more technical. If the student had mastered the subject, that was clear within some 10 min utes, and the professor would ask for the grade card, enter his evaluation, and that was that. If it did not go quite so well, the interrogation might last a little longer. Worse, the professor would ask the student to come back in a day or two, for a certain part in particular. Worse yet, one could be asked to come back in three weeks. If, however, the suggestion was made to come back in a year, that meant never."

Although Tom Gehrels denies that On the Glassy Sea is an autobiography, this remarkable book is really a reflection of the life, the times, and the philosophy of its famous author. This segment above from page 72 reminisces from Gehrels' days at Leiden University in his early days of preparing to be an astronomer.

If you expect this book to be a simple astronomer's life you will be surprised, for it is vastly more than that. The book deals with concentration camps, hiking through the United States, and perhaps most curiously of all, a mystic philosophy which is unique to reside in a scientist's mind. Through its pages you will get an insight into the unusual Dutchman who continued the task set by John Goodricke, Bart Bok, Gerard Kuiper, and others who made Holland's contribution to astronomy so enormous. Much of this insight comes from a deep conscience; conditioned by concentration camps and a soldier's view of war, Gehrels carries his strong feelings toward humanity to the very proposals he makes later. His science is never esoteric; even his current Spacewatch program is designed to search for asteroids that might someday strike the Earth and kill its inhabitants. This Spacewatch camera, Gehrels has said in public lectures, is really "a search for God." This program is directed toward the human condition every bit as much as his decision some years ago to demonstrate outside a nuclear plant.

Glassy Sea is an important book for two reasons. In its thorough discussion of the

Dutch education process in astronomy, it offers insight into not just the substance but the process of an astronomer's education. The other reason is that the book, in discussing unconventional philosophy, successfully escapes the public's image of a scientist trapped in a limited world view based on logic and experimental result.

The book is full of delightful stories about Gehrels' encounters with the great astronomers of the previous generation. In one of his early visits up to Palomar Mountain he expects to observe from 10 pm until 2 am . He is sharing the night with Fritz Zwicky, who wanted to change the arranged schedule so that Gehrels would get only the tail end. Gehrels decides quickly what to do: "'Wait a minute, Fritz," and you never saw a giant turn around so quick. ... He was furious, strutting to the phone to call the Director in Pasadena ... this was going to be a gawdawful time on this mountain, and Zwicky slamming down that telephone. ... Then he was turning around with a naughty grin on his face, saying, 'Now let's have dinner.' We were the best of friends the rest of his life, and oh, yes, the times of switching were exactly $10: 00$ and $2: 00$, with courtesy.; He would have loathed me if I had yielded."

Glassy Sea goes into some depth about Gehrels' work with asteroids, including his discovery of the "opposition effect" that explains why asteroids reflect more light and brighten up as they approach the opposition point, like the Moon does. Chapter 12 goes much more deeply into the science that went into the Pioneer missions, carefully describing the evolution of ideas that led to these pioneering missions to Jupiter and Saturn. If the science makes the chapter interesting, however, the politics of spaceflight makes it fascinating. How disappointing that with all that was gleaned from Pioneer, the experience of Gehrels and his team was not sought out for the following Voyager missions. Although he makes light of it on page 131, I suspect that this waste of talent still troubles him deeply to this day.

A scientist of Gehrels' stature can write of his failures with some detachment as time goes by. The nicest writing of his failure involves his not finding 2060 Chiron. "Charles Kowal had kindly suggested that we coordinate our programs by observing separate parts of the sky. It was a reasonable and efficient proposal, but for some stupidly competitive reason I waved it aside. Nature made the final judgment: Charlie found Chiron, while I failed to recognize its images on my plates."

The book's direction turns sharply in the last chapters to an increasingly mystic discussion of eastern philosophy. For those who are interested in this aspect of Gehrels' life, the prose, poetry, and advice contained here are
like the icing of a complex cake. If, as some readers found, the last chapters are too much of a turn, they still do not detract from the book's basic strength. By this time we are familiar with the intensity, the depth, and the fun of this man. We remember something from an earlier chapter about the thoughts of a late-night observer: "Toward 3 AM," Gehrels writes on page 95 , "the tired brain could have a vague dream of charming girls rushing up the mountain, tearing their gowns on the thickets, to be with this Great Astronomer. It has not happened yet, but who knows?"

Perhaps this strength of book and author is nicely summarized in the back cover picture of the author riding his bicycle, smiling like a man in charge, his hands clutching not the handlebars but a copy of Saturn from his Space Science Series. He's thinking of Saturn, and he's going ahead full speed. After reading this book, you know he'll never fall off.

> Introduction to Observing and Photographing the Solar System. By Thomas A. Dobbins, Donald C. Parker, and Charles F. Capen. Willmann-Bell, Inc., P.O.
> Box 35025, Richmond, VA 23235, 1988
> 215 pages. Price $\$ 19.95$ cloth (ISBN 0-943396-17-4)

> Reviewed by Phillip W. Budine

When I picked up this book and started reading it, I couldn't put it down! The book is well written, interesting, informative, and has a nice flow in the style of writing. I was absorbed with its contents, and it gave me great enthusiasm to observe. I wish that this book had been written almost 40 years ago when I began observing!

I especially found Chapter 2, "Telescopes and Observing Techniques," most informative. Here, telescopes are discussed and the types and modifications necessary for highquality planetary observation are described. Here also is much information on seeing, collimation, and how to report observations.

Chapters 3-13 give the "Cosmic Setting" and introduce the reader to "observing" and "what to observe" on the major planets, the Moon, the asteroids, and comets. The chapter on Mars is well done and very extensive. Additionally, these chapters are well presented and are well illustrated throughout.

Chapter 14 is titled, "A Primer on Solar System Photography." Primer? I would consider this chapter practically the bible on Solar-System photography! I have never read such an extensive piece of work on photography, and the new techniques described should be useful well into the 1990's. Indeed, considering that Dr. Donald C. Parker, one of the foremost planetary photographers in the world today, is the primary author makes Chapter 14 especially valuable.

Chapter 15, "Measuring Planetary Features with a Filar Micrometer," was a delight to see in this book because this information is not usually readily available.

I really cannot find any flaws with Introduction to Observing and Photographing the Solar System, and I recommend it highly to all who have an interest in observing the planets, whether they be beginners or professionals. I urge that this book is a must for every observer's library, especially because it is a "Solar System observing manual" in all respects! This book has long been needed and I think that the authors did an excellent job in producing a very fine book at a modest price-highly recommended!

Introduction to Asteroids. By Clifford J. Cunningham. Willmann-Bell, Inc., P.O. Box 35025, Richmond, VA 23235. 1988 208 pages. Price $\$ 19.95$ paper (ISBN 0-943396-16-6).

## Reviewed by J. V. Scotti

What is the field of asteroid research all about? Who studies these small members of our Solar System? Why do they study these objects? What do we currently know about asteroids? Their shapes? Their sizes? What do they look like? Where are they located? These are just some of the items addressed in Introduction to Asteroids by Clifford J. Cunningham. This book provides a source of information about the study of minor planets that should be found on the bookshelves of anyone who might be interested in what we know about our Solar System.

The field of asteroid research is relatively young. The first minor planet, Ceres, was discovered on New Year's Day, 1801. Until the 1970 's, this field remained mostly in its infancy with only limited physical studies being done. The study of asteroids was limited chiefly to their discovery and their dynamical evolution. An explosion of research coincided with the publication in 1971 of the first of three books composed of refereed research papers devoted to asteroids by the Space Science Research Series and its precursors. These three books, Physical Studies of Minor Planets, Asteroids, and the most recent, Asteroids $I I$, are intended for professional researchers. Cunningham's book does a superb job of consolidating the mass of information for the more casual reader.

Cunningham does an amazingly thorough job with nearly every aspect of asteroid research. He is able to condense the often complex work that is presented in research papers into a more digestible form for the reader who is interested in a summary of the field, but not in all the details required by the professional. Indeed, this book provides an excellent source of references, making it a good starting point for those interested in learning more about any particular area of asteroid research.

I am amazed by the volume of information which had to have been not only read, but understood by the author in order to be as complete and as up-to-date as possible in the information presented. The author's enthusiasm and love for asteroid research permeates
this work and it is a joy for the reader to experience this pleasure as he or she reads the book.

One of the most enjoyable sections of this work is that containing a short biography of, and a quotation from, each of a large number of the current students of asteroids. Through this section, one gets a feeling for what sort of people study asteroids, and what these persons expect to get from their studies. This particular section contrasts well with the infusion of humanistic views of asteroid research found in nearly every section of the book

Although the book is well written, it has some errors, mostly minor. In fact, it appears that most of the errors present are due to editorial or printing mistakes. There are a number of misspellings and missing commas and periods. One minor problem is the author's inconsistent use of units; such as degrees Kelvin in one paragraph, then degrees Centigrade in another nearby paragraph. These errors are occasionally annoying, but do not detract from the overall content and enjoyment of the book.

I highly recommend this well-written and comprehensive summary of the ongoing research on asteroids to all those who are interested in the small bodies of our Solar System.

Telescopic Optics-Evaluation and Design.
By Harris G.J. Rutten and Martin A.M. van Venrooij, edited by Richard Berry. WillmannBell, Inc., P.O. Box 35025, Richmond, VA
23235. 1988. 374 pages, appendix. Price $\$ 24.95$ cloth; supplementary software $\$ 24.95$. (ISBN 0-943396-18-2).

## Reviewed by Richard Hill

I have followed the writings of the above authors for years. When I head about this book I was quite excited. In general, I have not been let down.

This book is an extension of articles by these authors that appeared in the magazine Telescope Making. This work is not without its faults, and some have been pointed out by Alan Gee on page 617 of the June, 1989, issue of Sky \& Telescope. However, never before have so many telescope designs been discussed in such detail within one book.

Although I have worked as an optician and have been grinding telescope optics since 1963, I have tried to evaluate this work from the standpoint of the user and observer with only brief exposure to optical fabrication. I think that this is an important book for both the user and the maker of telescopes, if a few problems can be surmounted.

I found minor mathematical errors scattered throughout the last half of the book. As far as I could tell, none were fatal. However, they could be frustrating for the uninitiated. For example, near the middle of page 239 , the book states,
"For generalized aspherics, the first term in eq. 20.3.4 may be replaced by eq. 20.3.1, $Y_{r}$ by C, and SC by K, thusly: .."

In neither equation is there a term $\mathrm{Y}_{\mathrm{r}}$. Indeed, no such term was defined earlier in the chapter. Some quick manipulation revealed that $\mathrm{Y}_{\mathrm{r}}$ $=1 / \mathrm{R}$. This could be quite confusing for the novice, and the term should have been defined clearly. There are a number of these little glitches, some undoubtedly "typos", but careful readers can work around them.

Possibly the weakest chapter was "The Shiefspiegler," which unfortunately is one of the most important designs for lunar and planetary observers! The forms presented there are not the best of the tilted telescope (TCT) designs. The authors state:
"It would be cumbersome to give raytracing results for all the TCT designs proposed by Anton Kutter, Arthur Leonard, Richard Buchroeder, and others."
Yet, of the three systems presented, all by Kutter, only two are diffraction-limited on axis at the aperture and focal ratio chosen. Even these two designs rapidly degrade as one moves off axis. This fact could lead readers to conclude that such off-axis designs are of little or no value. A Yolo design [invented by Arthur Leonard] should have been analyzed, as well as Buchroeder's 10 -inch $\mathrm{f} / 19.2$ threemirror equiradius aspheric primary design. These two systems are very well-corrected and just could be the best lunar and planetary telescope designs today! (See Design Examples of Tilted-Component Telescopes, by Richard Buchroeder; Optical Sciences Center, University of Arizona, Technical Report No. 68.) Likewise, Schupmann telescopes were not analyzed, being only mentioned in passing as "An intriguing design..." This omission also is unfortunate because this design offers excellent lunar and planetary images.

Also in the section where Schupmann telescopes were mentioned under "Unusual Compound Systems," the Christen Triplet Objective was examined. Diagrams on page 134 showed it to be only marginally better than the Fraunhofer objective diagramed on page 58! Apparently the authors used an old set of data; lenses now produced by Christen are substantially better than the one described.

The problems pointed out in the last two paragraphs appear to be related. It would appear that the authors preferred to evaluate European designs. This emphasis could have stemmed from an inability to obtain good data on American designs, perhaps because both authors are from the Netherlands. But even so, Arthur Leonard's designs have been widely published and should be readily available. So also for the Schupmann design. I hope that these will be examined in a later edition

Solar-System observers will be interested in Chapter 18, "Resolution, Contrast and Optimum Magnification." Here, the authors discuss modulation transfer, also called "contrast transfer." They emphasize strongly the degradation caused by obstructions in the optical path, but only superficially take into account degradation caused by residual aberrations. This selectivity could lead less-informed
readers to the conclusion that any unobstructed telescope would out-perform an obstructed one on low-contrast objects. Such a conclusion would be incorrect. There are obstructed designs, such as the Rumak Maksutov, that are easily diffraction-limited if made conrectly. Such a telescope, with its small secondary on the corrector, can detect very low-contrast planetary features. On the other hand, even were a Fraunhofer doublet made perfectly, it would still suffer horribly from residual coma, astigmatism, and chromatic aberration. Even on axis, these problems would seriously reduce contrast in all but green light. A spot diagram for a $200-\mathrm{mm} \mathrm{f} / 14.7$ Trischiefspiegler, an unobstructed design, on page 121 showed that even on axis it was not diffraction-limited by a factor of two! While the last design is perfectly color-corrected, the reduction in contrast would be severe. The obstructed Rumak design would outperform either the doublet or the Trischiefspiegler on low-contrast objects.

Despite these problems, the book is overall a good one. There is no other single book today that brings together so much information. I encourage the authors to work out the bugs and to produce another edition in the future. It would then stand as a masterwork for decades. This book is very inspirational. In fact, due to it I have begun two instruments; one in the design stage, the other under construction. However, if you become so motivated, consult an additional source or have your design traced in some manner as a backup before you begin pushing glass. It is much less expensive to waste time and paper than to waste time and glass

At any rate, whether you are a telescope builder or a user, this book will provide you with much valuable information and insight.

> The Moon Observer's Handbook. By Fred W. Price. Cambridge University Press, 40 West 20th Street, New York, NY 10011. 1988. 309 pages. Price $\$ 34.50$ cloth (ISBN 0-521-33500-0).
> Reviewed by Jim Phillips, M.D.

In his preface to The Moon Observer's Handbook, Fred Price states that he has written this book in order to ".. help amateur observers of the Moon to observe effectively, to record their observations accurately and, where possible, to make contributions of scientific value." I believe that any interested person will be helped by reading this book in his or her quest to become a competent lunar observer. This book has many plusses and some significant weaknesses. However, overall I recommend it to any amateur astronomer interested in observing the Moon. I do disagree with the author's statement in the introduction that so many good maps of the Moon are in existence that there was no need to include one. Certainly a handbook like this can
be written without a comprehensive map of the Moon. However, I consider that one of the biggest hindrances to the present-day amateur is the lack of readily-available detailed lunar maps that are easily usable at the telescope.

The first two chapters, "Our Moon" and "The Moon's Motion and Consequent Phenomena," cover definitions of terms and give at least superficial coverage to such matters as phases of the Moon, earthshine, sidereal and synodic months, eclipses, and so forth. In these chapters, Price states that he intends to use the "classical" east-west lunar convention rather than the more recent, opposite system advocated by the International Astronomical Union. I think that this is an unfortunate mistake. Also, Price uses terms for varioussized lunar craters that were popular during the 1950's and earlier such as walled plains, mountain rings, and ringed plains. However, most modern texts do not use these terms, and they could be confusing to the beginner. Price also states his preference for the volcanic origin of lunar craters. I maintain that most data favor the meteoritic theory, but defend Price's right to come to his own conclusions and to state his own preference.

In the chapter on the lunar observer's telescope, Price gives a superficial but accurate account of most optical designs. As an apoch-romatic-refractor buff, I would have liked to have seen them covered in that chapter.

The Moon Observer's Handbook excels primarily in Chapters 4-7, which comprise the majority of the book ( 185 of the 282 pages of text). Here the author is in his element. He knows the telescopic appearance of the lunar surface and has spent long hours at the eyepiece drawing and describing lunar features under varying lighting conditions. Here, he takes the reader on a tour of the surface of the Moon through the telescope.

Very often, Price refers to observations made by the great lunar observers of the past, and he has received some criticism for this usage. But, just as the deep-sky observer can relate to descriptions by visual observers of the 19th century, made prior to the invention of photography, lunar observers can refer to observations and drawings by other astronomers who actually observed visually through the telescope. As far as what I shall see through my 6 -inch refractor when I observe the Moon, I find that my views have more in common with the drawings produced by Price and others than with any Lunar Orbiter photographs. So, I welcome these drawings in this chapter along with Price's use of verbal descriptions by past lunar observers such as Elger, Goodacre, and others. Where I think that Price has gone astray, however, is in bringing up questionable lunar detail seen by these early observers which he does not clarify even when this can be readily done by looking at modern Lunar Orbiter photographs. For example, on page 106 , Price states that:
"There is some debate as to whether there is a central elevation in Proclus. I have seen one or two short ridges near the center of the floor but would not consider any of them as central elevations in the usual sense of the word. Running across the floor, I have seen a dark line, visible just when the sunrise shadows have receded. It requires very steady seeing. Nothing like this has been mentioned in the descriptions of Proclus by Neison, Elger, Webb, or Wilkins and Moore..."

In my opinion, Price should then have added something like the following:
"Using Lunar Orbiter photographs IV61H 2 and IV66-H2, one can see hummocky elevations on the floor of Proclus. There is a low-level elongated elevation covering the southwest (IAU) quadrant of the floor and which extends into the northwest quadrant. Other smaller elevations are also noted. The edge of the elongated elevation could account for a north-south linear feature (the dark line noted by Price in his own observations.)"

Clearly, Price should not have stopped with the use of visual observations! By using the visual observations together with the Orbiter photographs, one can present a more complete and more accurate picture. Nevertheless, I think that the descriptions given by Price in the chapter "The Moon from New to Full" are outstanding, and I recommend them.

Chapter 5, "Observing and Recording," is superb. The author very nicely covers in detail
observing in general and drawing in particular.
Chapter 6, "Mysterious Happenings on the Moon," covers such controversial subjects as disappearances and appearances of various craters and craterlets, mists, clouds, and obscurations, as well as other forms of transient lunar phenomena. Price may here take a little liberty in suggesting that perhaps more is going on than there really is, but I enjoyed this chapter.

A series of suggestions for research comprises Chapter 7. I could spend a long time in defending Price for making suggestions for original work, but I shall just say that anyone who thinks that everything is known about the surface of the Moon, and that all useful work has been done, is misguided. There are many projects available to the interested amateur, and the ones discussed in this chapter are very worthy of consideration.

The book concludes with a number of Appendices, which include descriptions of interesting books, atlases, and charts. Appendix 6 consists of a method for calculating the Sun's selenographical colongitude, which is very helpful. Appendix 7 includes addresses of astronomical organizations.

In conclusion, in spite of the weaknesses described, Fred Price's The Moon Observer's Handbook is well worth the cost, and I recommend it for any interested lunar observer. Add to it a good lunar map and a set of Lunar Orbiter photographs to help answer any questions that the book raises, and you should be set to begin your own lunar observing program.

## New Books Received

## Notes by José Olivarez

The Skywatcher's Handbook. By Colin A. Ronan and Storm Dunlop. Crown Publisher's Inc., 225 Park Avenue South, New York, NY 10003. 1989. 224 pages. Price $\$ 13.95$ paper (ISBN 0-517-57326).

This readable and well-illustrated paperback has two themes. One is that two great sciences have arisen from the study of the sky-meteorology and astronomy. The other is that the combined study of these two sciences can be a rewarding pursuit open to all who are curious about the sky. Thus, the first two major sections of this handbook are devoted to exploring the day and night sky. The "Daylight Sky" section gives the basics of meteorology, while the "Night Sky" section helps in picking out the more spectacular astronomical objects. A third section deals with "Observing and Recording the Sky," describing the best ways to photograph the day and night skies, as well as how to build and equip home meteorological and astronomical observatories.

This is a great introductory book for those who may wish to combine their interests in the sciences of meteorology and astronomy into a
unified exploration of the sky!

Nonradial Oscillations of Stars. By Wasburo
Unno. University of Tokyo Press; distributed by Columbia University Press, 562 West 113th Street, New York, NY 10025. 2nd edition, 1989. 420 pages. Price $\$ 64.50$ cloth (ISBN 0-86008-439-6).

In his preface, the author states that recent observations have revealed that nonradial oscillations and related phenomena are inherent to most stars and have two theoretical aspects. One aspect is that stars are like musical instruments that are able to oscillate with variation in wavelength or in frequency. The other is that stars function as heat engines that drive their oscillations.

This highly technical monograph covers nonradial oscillations of stars from the basics to the most recent developments and is intended as a textbook on the new field of "astroseismology" in which the internal structures of the Sun and stars can be probed by using their oscillations.

## ANNOUNCEMENTS

## A.L.P.O. BUSINESS

1990 A.L.P.O./Astronomical League Convention.-As described in the previous two issues, the A.L.P.O. will be holding its 40th Convention, in connection with the Astronomical League's $A L C O N^{\prime} 90$ on the campus of Washington University in St. Louis on July 31-August 4, 1990. As we go to press at the beginning of July, eight A.L.P.O. papers have been submitted, along with a dozen entries in our "Solar System Portraiture" display and contest. The three A.L.P.O. eventsPaper Session, Workshop, and Business Meet-ing-will all be held on Thursday, August 2nd. We also plan to present our annual Walter H. Haas Observing Award during our Paper Session on August 2nd. Then, among other matters, the Business Mecting will discuss our 1991 convention site. We have received two invitations so far; to meet with the Western Amateur Astronomers at Manmoth on the east face of the Sierra in California; or to join the Symposium for Research Amateur Astronomy in La Paz, Baja California Sur, Mexico on July 8-10, immediately prior to the total solar eclipse on July 11, 1991.

We hope to see you in St. Louis!
A.L.P.O. Supporters.-A pleasant duty of the Editor is to list periodically those A.L.P.O. members who have contributed more than the minimal dues needed to retain their membership. We are also happy to note that the number of such persons has recently increased! Were it not for the persons listed below, the A.L.P.O. and its products would be the poorer.

Below are the current A.L.P.O. Sponsors, who have contributed $\$ 40$ or more this year: Julius L. Benton, Jr., Paul H. Bock, Darryl J. Davis, Robert B. McClellan, Philip R. Glaser, Erland I. Jensen, David McDavid, Patrick S. McIntosh, José Olivarez, Dr. Arthur K. Parizek, Dr. Thomas C. Peterson, Jim Phillips, Kenneth Schneller, Ventura County Astronomical Society, Richard J. Wessling, and Matthew L. Will.

The next lists contains the present Sustaining Members of the A.L.P.O.; those who have contributed $\$ 20$ per year: Butch Bradley, Klaus Brasch, Harper M. Bruce, Reginald F. Buller, Nancy J. Byrd, Clark R. Chapman, Thomas P. Davis, Jack Eastman, Alan French, Harvey W. Herman, Mike Hood, Harry D. Jainieson, H.W. Kelsey, Charles Klausing, Truman P. Kohman, Daniel Louderback, Robert E. Lucas, Robert D. Lunsford, David D. Marks, David D. Meisel, Col. John W. Mohr, Lee Morrow, David J. Raden, Louis A. Renzulli, Richmond Astronomical Society, Richard W. Schmude, Peter C. Scott, Lee M. Smojver, Donald W. Spain, Richard Stanton, Michael E. Sweetman, Ken Thomson, Bradley W. Timerson, William A. Vance, and Dr. Gary L. Walker.

Eclipse Recorder's Address Changes.Our Recorder for Solar Eclipses and for Lunar Eclipses and Photometry, Francis G. Graham, has a new address: P.O. Box 209, East Pittsburgh, Pennsylvania 15112.

Brand-New Edition of Lunar Eclipse Handbook.-Recorder Francis G. Graham has revised and reissued the A.L.P.O. Lunar Section's Lunar Eclipse Handbook, including much new material since the 1979 edition. Now 38 pages in length, the booklet includes maps of the visibility zones for lunar eclipses from 1990 through 1996. A copy may be obtained from him at the address given in the previous announcement for $\$ 7.00$, which includes postage. He also notes that he can supply copies of our Lunar Photometry Handbook at $\$ 8.00$ each, postpaid.

Membership Directory Being Prepared.A.L.P.O. Membership Secretary Harry D. Jamieson is compiling a Membership Directory, which will be available at cost to A.L.P.O. members only. It will list members both alphabetically and, for the United States, by ZIP Code, and will list addresses but not telephone numbers. Remember to please contact Mr. Jamieson (address on front cover) if you do not wish to be listed. The purpose of the Directory is to stimulate interaction between members, and an important feature of this is that names will be accompanied by "interest codes." If you want to communicate with members with interests similar to yours, it is important that you inform Mr. Jamieson about your interests. The interest codes he is using are: $0=$ the Sun; $1=$ Mercury; $2=$ Venus; $3=$ the Moon; $4=$ Mars; $5=$ Jupiter; 6 $=$ Saturn; $7=$ Uranus, Neptune, and Pluto (remote planets); $\mathrm{A}=$ Asteroids (minor planets); $\mathrm{C}=$ Comets; and $\mathrm{M}=$ Meteors. You are of course permitted to have more than one code!

Errata.-Member Donald H. DeKarske has kindly pointed out two errors in the last issue of the J.A.L.P.O. First, the caption for Figure 8 on page 57 should read "Michael E. Sweetman." Second, the caption for Figure $\overline{I 5}$ at the top of page 59 should read "Selected Drawing, 1987-88 Apparition of Saturn."

## Amateur Observers and the Hubble Space Telescope

As most of our readers are undoubtedly aware, five amateur astronomers have been granted a total of 17 hours observing time on the Hubble Space Telescope (HST). Amateur HST proposals are evaluated by the "Amateur Astronomy Working Group" (AAWG), where the major amateur-astronomy organizations in the United States, including the A.L.P.O., are represented. We thank A.L.P.O. Founder Walter H. Haas for evaluating those proposals that dealt with Solar-System subjects.

Those amateur observations ranked highest by the AAWG were forwarded to the Director of the Space Telescope Science Institute in Baltimore, who selected the final five to be awarded spacecraft observing time from the Director's Discretionary Time. These observation are scheduled for the first 12 months of science operations.

The amateur observing program for the HST has been extended to a second year. Unfortunately, as we go to press, we have learned of the colossal ineptitude that resulted in the launch of a Space Telescope that had not been optically tested, and thus which now suffers from spherical aberration that limits its resolution. The effect of this degradation on the amateur observations is at present unclear. Apparently, projects involving photometry and spectroscopsy will be less affected than imaging projects. The latter observing programs may be delayed until the ailing NASA shuttle fleet can deliver and install correcting lenses for the HST. However, the AAWG continues to encourage amateur proposals, even if their execution may have to wait for the HST to be repaired.

So, devise a proposal which uses the full potential capabilities of the HST; one that could not be done on Earth. We invite those who made it to the second phase of proposals for the initial year, but did not make the "final five," to polish up their proposals and to try again. Naturally, the A.L.P.O. hopes to see many good Solar System projects submitted.

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 to:

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

## The Rest of the Universe

Centennial Campaign of the Astronomical Society of the Pacific.-The other great astronomical organization based in San Francisco is of course the Astronomical Society of the Pacific. Now a century old, the A.S.P. has established a Centennial Endowment and is soliciting tax-deductible bequests. The Endowment will help the A.S.P.'s public outreach and educational assistance programs, as well as their technical support program for graduate students and astronomers. For further information, write to: Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, California 94112-9947.

Hubble Space Telescope Audiotape.-A new audiotape featuring an introductory talk about the Hubble Space Telescope is available from the Astronomical Society of the Pacific. The speaker is Stephen Maran of the NASA Goddard Space Flight Center. The cassette tape runs for 60 minutes and is accompanied
by a reading list about the HST. The cost is $\$ 12.95$, which includes domestic shipping and handling, but not the sales tax for California residents (foreign residents: please remit U.S. funds and add $\$ 3.00$ for mailing). Send orders to: A.S.P., Hubble Tape Orders, 390 Ashton Avenue, San Francisco, CA 94112.

Division for Planetary Sciences Annual Meeting.-The "DPS" is a Division of the American Astronomical Society, and its 22nd annual meeting will be held in Charlottesville, Virginia, on October 22-26, 1990.This is the major meeting of the professional planetary science community, but you do not have to be a "pro" to attend. The registration fee before October 1st is $\$ 140$ for DPS members, $\$ 170$ for non-members, and $\$ 85$ for students. For more information, contact: Pam Jones, Program Services Department, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, Texas 77058.

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