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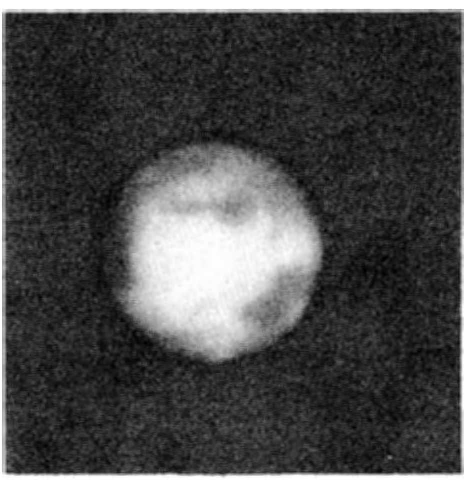

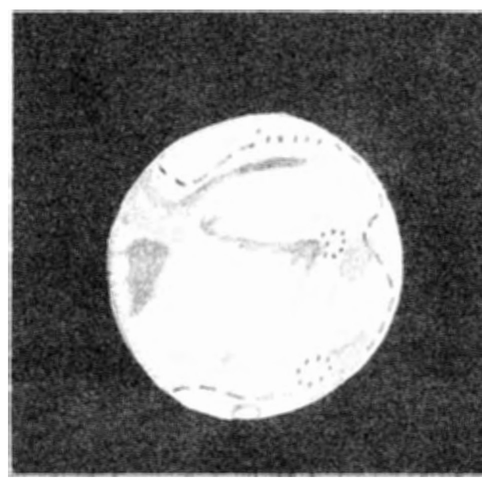

As Comet Halley recedes, the planet Mars is approaching. 1986 is the Red Planet's most favorable apparition since 1971, with opposition on July 10th.

These two views of Mars are separated by one Martian year. On the left, the photograph by Mars Recorder Donald C. Parker was taken on May 1, 1984, at 05:00 U.T. (Martian date Aug. 14), when the central meridian longitude was 343 Deg., with a 32-cm. Newtonian telescope at f/198, using a 5-second exposure on Kodak TP-2415 Film (no filter); seeing 8 (0-10 scale), transparency 5 (0-5 scale). The drawing on the right is by Mars Recorder Charles F. Capen, done on April 17, 1986, at 09:30-10:00 U.T. (Martian date Aug. 29), at central meridian longitude 326-333 Deg., using a 31-cm. Newtonian telescope at 590X with Wratten Filters Nos. 30, 25, 21, 57, 64, 38A, and 47; seeing 6-7, transparency 5 (limiting magnitude).

On both views, Martian south is at the top, a small North Polar Cap is at the bottom, Syrtis Major is the elongated dark area to the left, and Mare Acidalium is to the lower right. The dashed-outlined zones in the Capen drawing were bright with the blue (W-47) and light-blue (W-38A) filters and probably represent Martian clouds. See also the two articles in this issue on pages 181-183 and 183-189 as well as the Notice on page 223.

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IN THIS ISSUE

A SIMPLE TECHNIQUE FOR OBTAINING VIOLET LIGHT PHOTOGRAPHS OF MARS

By: Donald C. Parker, M.D., Jeff D. Beish, and Charles F. Capen, A.L.P.O.
Mars Recorders, Institute for Planetary Research Observatories

Color filters are indispensable tools for the planetary observer. Not only do they improve planetary contrasts for both surface and atmospheric features, but they also reduce irradiation and the "seeing" effects caused by turbulence in the Earth's atmosphere. Filters are particularly useful for the Mars observer. The thin but dynamic Martian atmosphere is usually opaque to violet light but allows free passage of longer wavelengths. Thus red, orange, or yellow filters permit the study of surface details and enhance the contrast between the ochre desert regions and the blue and brown "albedo" features. On the other hand, blue and violet filters best reveal atmospheric phenomena such as clouds, limb hazes, equatorial cloud bands, and polar hoods [Capen, 1984].

The authors are conducting an intensive study of Martian atmospheric phenomena. The source material for this research is the voluminous record of blue and violet light observations made by the A.L.P.O. Mars Section during the past 25 years. Violet filter observations, using a Wratten 47 (W-47) Filter or its equivalent, have assumed a special importance because this filter best reveals the upper atmosphere of Mars. Furthermore, the W-47 is the standard filter by which the date and extent of the unpredictable and still poorly-understood "blue clearing" is estimated. During periods of violet clearing the Martian atmosphere becomes remarkably transparent to violet light, allowing surface features to be seen as well with a W-47 as with a red or orange filter.

While the W-47 can be employed to advantage visually with telescopes as small as 20 cm. aperture, much larger instruments are required for violet-light Mars photography. The reason for this is that the W-47 Filter is quite dense, allowing a peak transmittance of only 50.3 percent at 440 nM [Eastman Kodak, 1981].* Parker has determined that exposure times for Mars on commonly-used black-and-white and color films must be increased by a factor of 20 when using a W-47 Filter, as compared with unfiltered exposures.

These unacceptably-long exposures may be avoided by employing a high-speed emulsion such as 3M 1000, a color slide film which has minimal reciprocity failure as compared with other new "superspeed" films and which has allowed Parker to reduce violet-light exposure times to a manageable 7 seconds at f/198. Unfortunately, such fast films are so grainy that composite color printing, a costly and time-consuming procedure, is usually required.

The authors have developed a method for producing a permanent record of violet-light data without resorting to laborious darkroom work. This technique takes advantage of a valuable property of color transparencies; their ability to store accurate color information, even though this may not be apparent when the slide is viewed in white light. For many years, Capen has studied A.L.P.O. Mars Section slides by projecting them through a W-47 Filter. Their images on the screen show Mars much as it would appear visually in violet light, with clouds and hazes markedly enhanced. Because the authors required permanent records for their climatic studies, they merely extended Capen's technique by means of copying the slide through a W-47 Filter onto a moderately high-contrast black-and-white film. The resulting negatives and subsequent black-and-white prints brought out Martian atmospheric details which were barely visible on the original slide, even when the slide was projected through the W-47 Filter. Furthermore, the amount of violet clearing could be estimated very accurately.

In practice, the authors usually photograph Mars on Kodak Ektachrome 200 Slide Film, an emulsion that possesses good speed and color balance and yet maintains acceptable acutance and low grain. Furthermore, this film may be processed readily at home, or at a local photolab, in a matter of hours. An Ektachrome transparency is placed in a slide copier and a W-47 or other appropriate filter is inserted between it and the light source. The slide is then photographed onto Kodak Technical Pan Film (TP 2415), which is developed to display moderate to high contrast. The authors process TP 2415 in Rodinal 1:25 Developer for 14 minutes at 68°F, yielding an emulsion speed of ISO 250-300 and a Contrast Index of 0.8. If more contrast is desired, the film may be exposed at ISO 125-160 and developed in D-19.

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* "nM" refers to the wavelength of light, where 1 nM equals one millionth of a millimeter or 10 Angstrom units. Note that the <u>mean</u> visual transmittance of sunlight by the W-47 Filter is only 2.8 percent. [Editor]

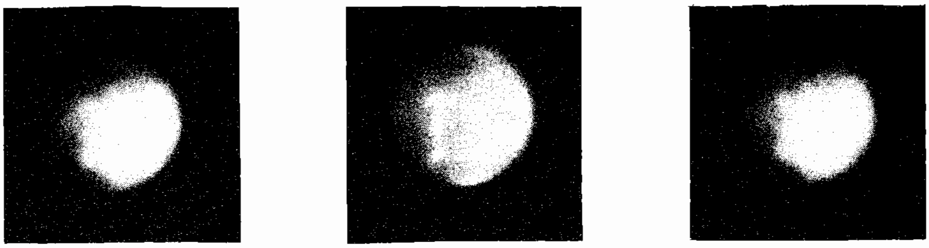

Figure 1. Three black-and-white copies on Kodak Technical Pan 2415 film of the same 3M 1000 color transparency of Mars, taken on 1984 APR 21, 06:03 U.T., with a 32-cm Newtonian reflector at f/198 and a 3-second exposure. The left frame was copied with no filter (integrated light), the center view with a Wratten 47 Filter in violet light, and the right view with a Wratten 29 Filter in red light. Note the arctic hazes and orographic clouds in the Nilokeras and Ganges areas in the center, violet-light view. Central meridian 087°6, declination of Earth +10°8, disk diameter 15"5. South at top. Photograph and copies by D.C. Parker.

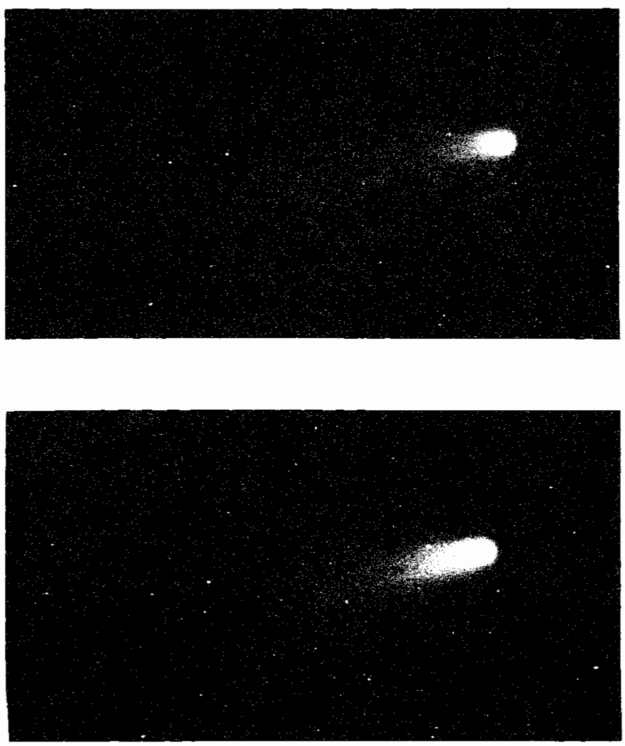

Figure 2. The filter-copying technique used with a 3M 1000 color photograph of Comet P/Halley, taken 1986 MAR 08, 10:37 U.T., with a 15-cm., f/4, Newtonian telescope and a 2-minute exposure. Both frames are copies onto Kodak Technical Pan 2415 Film. The upper view was made with a Wratten 80A Filter in blue light, which shows the comet's gas (plasma) tail. The lower frame used a Wratten 12 Filter, in yellow light, which highlights the dust tail. Note the straight appearance of the gas tail, compared to the curved dust tail. South at top. Original photograph and copies by D.C. Parker.

Several slide-copying arrangements are satisfactory for making black-and-white negatives from color slides. The authors employ a simple tubular copying device that attaches to a 35-mm camera body and which is aimed at an appropriate light source such as an electronic flash, photoflood, or blue sky. For W-47 Filter work the color temperature of the light source is relatively unimportant, but a standard 5500° Kelvin (daylight) source is preferred. In the authors' work, the slide copier is placed a few inches from a 250-watt photo blue bulb covered by a diffuser. A camera meter reading should be taken before any slides or filters are placed in the copier. A properly-exposed unfiltered slide of Mars will require an increase in exposure on TP 2415 of 3-4 stops over the base value. Red or yellow filters demand little further increase in exposure because TP 2415 has extended red sensitivity and Mars is bright in red light. When a W-47 Filter is placed between the light source and the slide, however, the exposure must be prolonged significantly--approaching 10 to 12 stops over the base value. Thus, if the camera's meter reads 1/125-second with no slide or filter, a proper exposure for a W-47 filtered Mars photograph would be about 16 seconds! If your copying equipment allows changing the aperture of the lens, it is possible to reduce such rather long exposures by opening up the lens. This will also avoid some of the reciprocity failure which no doubt occurs with the TP 2415 emulsion. However, because of the extremely small depth of focus encountered in 1:1 copy work, and because slides are rarely flat unless glass-mounted, the authors find it preferable to keep the copy lens' focal ratio high (f/16 to f/32) while using long and liberally-bracketed exposure times.

This method has worked quite well for astronomical subjects other than Mars; indeed, it may be employed successfully on any Solar System object that can be photographed on color slide film. The blue plasma tail of Comet Halley has been enhanced by rephotographing it through a light blue (W80-A) Filter, as shown in Figure 2 (p. 182). The mysterious "Blue Features" in Jupiter's North Equatorial Belt were darkened and delineated significantly when color transparencies of the Giant Planet were rephotographed in red light by means of W-29 or W-25 Filters. The authors hope that A.L.P.O. astronomers will avail themselves of this technique. Those who do not possess darkrooms or who shy away from any form of film processing are still encouraged to photograph the Moon and planets with color slide film and to submit duplicates of their better slides to the appropriate A.L.P.O. Recorders.

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A MARTIAN OBSERVER'S MENU FOR 1986

By: C.F. Capen, D.C. Parker, and J.D. Beish, A.L.P.O. Mars Recorders

Abstract. This paper discusses the 1986 Martian perihelic apparition's geometric characteristics, seasonal aspects, and observational prospects that are significant for the study of atmospheric and surface changes, providing graphs, charts, and a calendar of seasonal events. Predictions are made for the times and locations of seasonal dust storms and the development of dark rifts within the brilliant South Cap.

Introduction

This year Mars will be closer to Earth than it has been since 1971. From early June until September 1st the apparent disk diameter will be larger than it has been for over a decade, and will reach 23".2 between July 14th and 20th, which is 93 percent of the maximum 24".9 diameter attained in August, 1971, during that very favorable apparition. This year's large telescopic disk is excellent for critical color filter observations of Martian clouds, the dazzling behavior of the thawing South Cap, and variable surface albedo features, with telescopes as small as 6 in. (15 cm.) aperture during the comfortable summer and autumn nights. For information on how to observe Mars, see References 1, 4, and 5. Figure 3 (p. 184) compares Mars' 1986 minimum distance and maximum apparent diameter with those for other oppositions between 1956 and 1999.

Apparition Characteristics

Like Comet Halley, Mars remains far south during this apparition, with a declination of -14° in January, continuing southward during the Spring, leveling off at -28° in August, and moving back north to -03° by the end of December. To Northern Hemisphere observers, the planet will never be high in the sky and seeing conditions will often be impaired when using high magnifications. [Text continued on p. 185.]

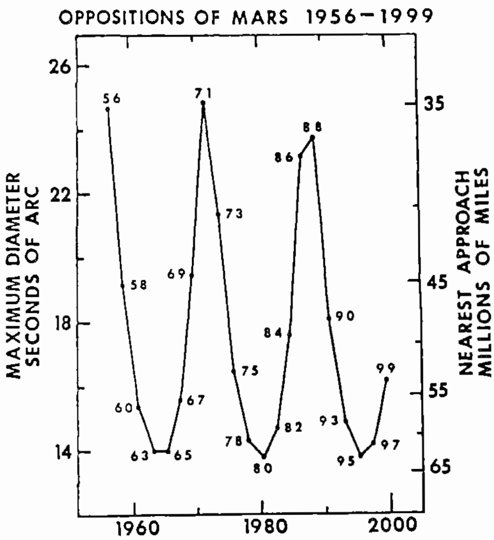
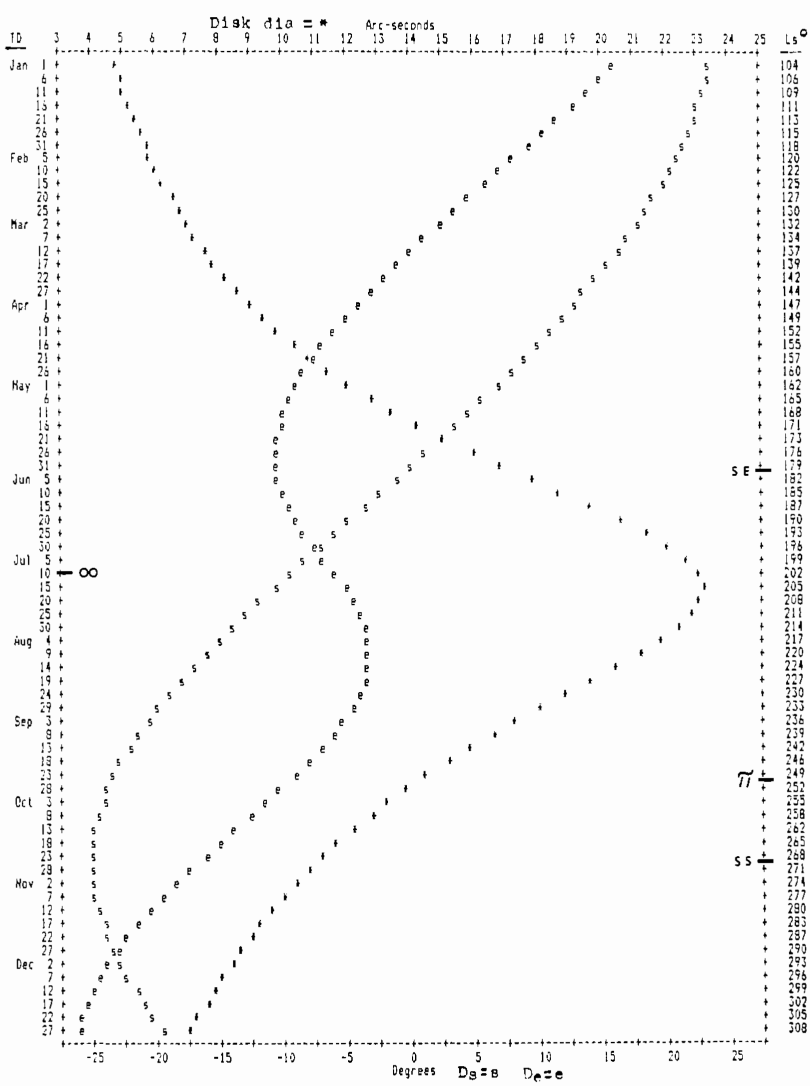


Figure 3. Maximum apparent disk diameter and minimum distance of Mars for its oppositions between 1956 and 1999, inclusive. Note the favorable conditions for the 1986 opposition.

Figure 4 (below). A graphical ephemeris for physical observations of Mars for 1986. The left column gives the terrestrial 0-hr. U.T. date (TD). The right column shows the areocentric longitude of the Sun (L_s), in degrees, which defines the Martian seasonal date. The top line gives the apparent Martian disk diameter in arc-seconds and the bottom line shows areocentric latitudes in degrees, with "s" for the Sun and "e" for the Earth. "SE" indicates the Martian southern Spring Equinox, "SS" the southern Summer Solstice, and "π" the date of perihelion. Prepared by J.D. Beish.



[Text continued from p. 183.

Mars will be at opposition in mid-year, on July 10, 1986, and useful visual observations can be made almost all year because the disk diameter exceeds 6".0 from February 6th on. Photography of Mars can be done when the disk diameter exceeds 10".0, which is from April 11th through November 8th. The visual observation of fine details, using color filters, as well as quality photography, is possible when the disk diameter is above 12".0, or between April 30th and October 15th. The finest of the surface albedo features, and possibly the larger topographic features, can be detected with a disk diameter over 20".0, during the two months between June 17th and August 17th. Regarding Mars' apparent size, refer to the graphical physical ephemeris shown in Figure 4 (p. 184) and to References 1 and 7. These disk-diameter limits are only approximate because astronomers using 12-in. (31-cm.) or larger telescopes, or those with high-quality planetary-type optics, and with good seeing conditions, can achieve useful data with smaller disk diameters over longer periods of time. Table 1 (p. 189) lists chronologically the times of seasonal-phenomena events that possibly may be observed during this apparition.

Martian Polar Regions

During the last four aphelic apparitions, from 1978 through 1984, Mars' Northern Hemisphere was tilted earthward during the northern Spring and Summer. When the North Polar Cap (NPC) was seen to thaw, observers made careful micrometer measurements of its shrinking size. This year, the NPC will be covered most of the time by a polar hood of clouds and the tilt of the Martian rotational axis will favor the observation of the Southern Hemisphere. Figure 5 (below) shows the major albedo features near the Martian South Pole.

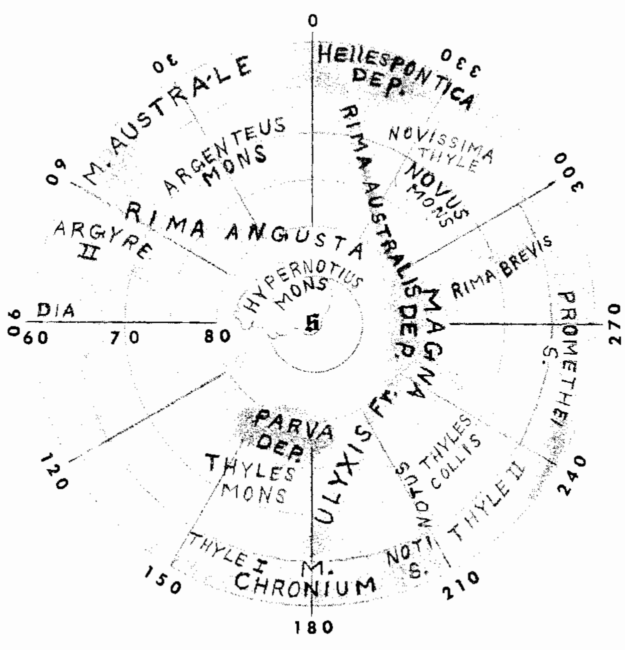


Figure 5. An orthographic south polar projection reference map of the Martian south polar feature locations and names. Drafted by C. Capen. See also text.

The South Pole of Mars will be tilted earthward, with the areocentric declination of the Earth (D_e) varying from -04° in April, to -10° in May, to -03° in August, to -26° in December, allowing the observation of antarctic hazes and of the spring-summer shrinking of the South Polar Cap (SPC). In terms of the "normal" seasonal progression of events, as the South Pole of Mars emerges from the darkness of Winter at the time of Mars' southern Spring Equinox, the dull-grey polar hood begins to dissolve poleward and reveals the brilliant white edge of the SPC. The grey, hazy hood lingers over the Pole for several weeks, giving the cap the appearance of a "Life-Saver" that should be seen and photographed from the last week in July through mid-August, 1986. The composition of the SPC is chiefly CO_2 ice, and once free of the polar hood and exposed to direct sunlight, it sublimates rapidly, shines brilliantly, and undergoes spectacular changes during the rapid spring thaw.

As the SPC shrinks back, a delicate, intricate, dark rift system develops and peripheral projections brighten, then become detached remnants. Soon after opposition, near 210°L_s (see the caption of Figure 4 for a definition of L_s), one of the first dark rifts to appear is the Magna Depressio (270°W, 80°S). At the seasonal orbital position near 215° L_s, a dark rift, Rima Australis, appears between 290°W and 350°W, connecting with Magna Depressio, and the SPC develops a bright projection from 010°W to 020°W in Argenteus Mons. The south polar chart on page 185 (Figure 5) shows the relative positions of these features. By 220°L_s, a bright projection, Novissima Thyle, develops at 300°W to 330°W, and a dark rift, Rima Angusta, appears at 60°W to 300°W. The Novissima is the famous recurrent cap remnant located south of Hellas, also known as the "Mountains of Mitchell," discovered in 1845. Once the Novissima becomes detached from the cap edge it is known as Novus Mons ("New Mountains"). This year, look for Novus Mons to become detached from the cap edge during the second week of August at about 225°-230°L_s, and to disappear in early October. By early August, the SPC will be rapidly shrinking, and its brilliant whiteness will contrast with its dark rifts, making the South Cap the most salient and beautiful feature on the Martian globe.

The SPC and its peripheral bright patches can best be seen with the aid of orange, yellow, and green filters. Because this cap will be tilted earthward for most of the apparition, observers who have ocular micrometers can make important systematic diameter measurements of the diminishing spring SPC from June to November, which can be compared with the recession curves of the 1971 and 1973 caps. [3] It will be significant to see whether the summer remnant cap disappears sometime in November.

Martian Weather

It is well known that the Martian atmosphere is very dynamic, exhibiting several types of salient condensates that are easily detected with the aid of color filters and modest-sized telescopes. White water clouds, local yellow dust clouds, global dust storms, bluish limb hazes, and bright surface ice-fogs and frosts have been studied with increased interest in the past decade. Observations of these meteorological features indicate that their behavior and occurrence is most often coupled with the seasonal sublimation and condensation of polar-cap material. An intensive statistical meteorology study program is now in progress at the Institute for Planetary Research Observatories, utilizing quality visual and photographic data obtained during each apparition by the A.L.P.O. International Mars Patrol (IMP) programs.

Approaching local Martian noon, discrete white <u>orographic clouds</u> , identified as water clouds by the Mariner 9 spacecraft, are seen in summertime forming on the upper slopes of the large volcanoes (Olympus Mons [133°W, 18°N], Ascraeus Mons [104°W, 11°N], Pavonis Mons [112°W, 00°], Arsia Mons [120°W, 09° S], and Elysium Mons [212°W, 25°N]), and between Tharsis Tholus and Valles Marineris (80°-100°W, 04°N). These seasonal clouds ("W-clouds") were well observed during northern Summer (120°-160°L_s) in 1984 after the rapid thawing of the NPC. In this apparition, it will be valuable to learn if the orographic clouds occur twice each Martian year, because they originate in the equatorial region of the planet. Look for them after the large southern basins, Hellas and Argyre, have lost their whiteness and have returned to a dark-ocher hue, and during the rapid retreat of the SPC from southern mid-Spring until Summer (235°-270°L_s), from August to late October. Because of the observed appearance and seasonal behavior of the great southern basins, the authors suspect that they act as "cold traps" during Mars' southern Autumn and Winter, thus controlling the water vapor in that hemisphere. Because orographic clouds are best seen through blue and violet filters, they are well-elevated and are probably generated by mechanical uplift, and grow by convection.

A planetary system of faint, white clouds with variable shapes and opacities, known as the <u>equatorial cloud band</u> (ECB), is occasionally seen extending across Mars' disk. Because the ECB is detected best in ultraviolet and violet light, it resides at a chilly, high altitude, and is probably composed of CO ice crystals. Because the ECB is equatorial, it too may occur twice each Martian year, appearing with the sublimation of each cap. Thus, watch for it during Martian Spring and Summer, from July through December, 1986.

Limb haze appears as a bright misty arc of light on the sunrise or sunset limb of Mars, and is caused by the observer's oblique view through the equivalent of several Martian atmospheres of aerosols, which may consist of CO_2 crystals, fine dust, cirrus-type water clouds, or a mixture of these. Consequently, the observation of the limb brightening's color and density, and its global location, as determined with color filters, is a very sensitive method of diagnosing the global system of Martian weather and unusual polar phenomena, and in detecting dust storms that have begun on the other side of the planet.

Limb haze may be seasonal or nonseasonal, and it disappears around local 8 or 9 A.M. because it does not rotate with the planet. It is best seen in violet light if at high altitudes, or in blue light if at mid-altitudes.

A most delicate and challenging feat of observation is the detection of volatiles at the boundary between the Martian atmosphere and its surface. In this volatile regime, ice-fogs and frosts , often called bright patches , can be distinguished from elevated clouds by means of comparing their relative brightnesses and boundary definitions as seen with the aid of blue, blue-green, green, and yellow filters. If the suspect bright feature appears brighter in blue light than it does in green or yellow light, it is an atmospheric cloud. If it is brighter and better-defined in blue-green light than in blue or yellow light, it is probably ice-fog contiguous to the surface. If the patch appears brighter and with a sharp boundary in green and yellow light, and is not well seen in blue light, it can be identified as surface frost. A boundary-layer volatile's diurnal behavior and location also helps to distinguish it from clouds and limb haze. Fogs and frosts form in the chill of the Martian night, rotate with the planet, sublimate in the morning sunlight, and usually disappear by local noon. Fogs normally form in valleys, in fossae (linear depressions), basins, and on upper slopes. Frosts are usually noted on cool, light albedo features, plana (plateaus), montes (mountains), and the floors of large craters. Because these volatiles are topographically-controlled, the discovery of their locations and seasonal occurrence is most important to the study of Martian weather patterns and areography. [1]

Records of observations of Mars indicate that yellow dust storms occur around the time of southern Summer Solstice ($270^\circ L_s$), soon after perihelion passage ($250^\circ L_s$). During the last two perihelic apparitions, an initial dust cloud was sighted in the Serpentis-Noachis region on September 21, 1971, having developed overnight, and another one appeared in morning light next to Solis Lacus on October 13, 1973. Each bright cloud soon evolved into a global obscuration that persisted for several months. When a great dust storm has reached maturity, Mars' disk appears bright orange and few, if any, surface features can be identified.

This apparition, the Martian windy season can be anticipated to occur about three months after opposition, from late September through October. Look for a bright streak northwest of Hellas Basin across Serpentis-Noachis (320°W, 30°S), or in the "Eye of Mars" (the Solis Lacus region; 90°W, 30°S), or perhaps this year within the Chryse Basin (40°W, 10°N), the last because dust clouds were reported in Chryse during the last two apparitions, in 1982 and 1984. [2] The discovery of new dust-cloud sensitive areographic locations is most important to future Martian exploration missions. To detect dust clouds, use red, yellow, and magenta filters.

For a thorough discussion of how to observe the various Martian atmospheric phenomena, see References 1, 2, 4, and 5. For the latest color photography technique, see Reference 6, the preceding article in this issue. Also see Table 1 (p. 189) for predictions of these phenomena.

Surface Albedo Features

The Martian winds and the drifting "sands of time" have done little to affect the locations and the general appearances of the major dark albedo features first charted by Wilhelm Beer and J. von Maedler from disk drawings that they made in 1830-32 with a Fraunhofer 4-inch refractor. However, many albedo features do change their boundary shapes, colors, and albedo contrasts with time. There are two types of variation: seasonal and annual changes are usually predictable, but secular or long-period changes are unpredictable. E.M. Antoniadi predicted seasonal changes in the shape of Syrtis Major in his 1920 "Martian Calendar of Events." In the 1950's, observers of the Oriental Astronomical Association (O.A.A.) discovered large secular changes in the Gomer Sinus and Alcyonious-Laocoontis areas (220° to 280°W). A mysterious darkening in Daedalia, within the "Eye of Mars," was discovered in 1973 by A.L.P.O. and O.A.A. observers, and remains unexplained. In 1977, a new, broad, dark streak was discovered in the Aetheria desert, between Nubis Lacus and Elysium (240°W, 25°N), by A.L.P.O. astronomers. This feature was subsequently located on Viking Orbiter images taken in 1975, but apparently it had gone undetected by Viking scientists. This salient feature was still noted in 1982 and 1984, when a nearby feature, Elysium, took on an unusual angular appearance. Be sure to check these past active areas this year for color and albedo changes with the aid of color filters and the Mars chart shown in Figure 6 (p. 188).

The Hellas Basin merits special attention during these Martian southern seasons. Early in the apparition, Hellas will be mostly covered by a dull-grey haze hood. In our late May and early June, it should become clear and the south part of the basin will be covered with bright frost. Later in the Martian Spring, Hellas should be free of ice and haze, when its basin floor will be a dark-ocher color and its surface structure can be seen. At the approach of Summer Solstice, during October, the basin is expected to become flooded with dust if a violent storm occurs. This seasonal scenario for Hellas is most speculative because little exploration or research has been done within the basin. The Hellas and Argyre basins will be favorably tilted for our observations, so record their seasonal aspects as you see them this Summer and Fall, in order to add to our understanding of the Martian world.

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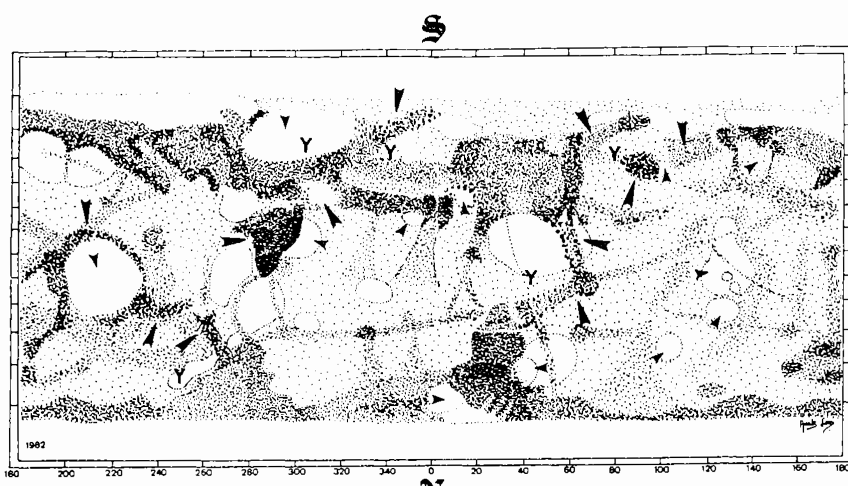


Figure 6. Mars chart showing areas of probable changes during 1986. The large arrows indicate dark-albedo features that have had recent contrast changes reported. The small arrows indicate light-albedo areas that are known to exhibit seasonal bright, white patches. Regions where initial yellow dust clouds have been observed during Martian local Summer are indicated by "Y." This 1982 Mars base chart was rendered by Leo Aerts of Belgium from 270 Mars drawings made by Belgian and Dutch planetary astronomers. Additional features from 1984 and 1986 A.L.P.O. observations have been added by C.F. Capen. South at top.

Table 1. A Martian Calendar of Seasonal Phenomena for 1986.

This table applies to the Southern Hemisphere for the period of the Martian late Winter through mid-Summer. The first column gives the Terrestrial U.T. Date (TD), the second lists the areocentric longitude of the Sun in degrees (L_s), and the third column, "Phenomena," describes seasonal events and possible other phenomena for investigation. For abbreviations, see text.

TD 1986	L_s °	Phenomena
14 MAY	170	Late southern winter, NPH and SPH present. Does SPH or frost cover Hellas? W-clouds present? D_e 10°S. Disk Dia. 14"; quality visual and photographic filter observations possible.
01 JUN	180	Southern Spring Equinox. S. Pole emerges from darkness of Winter. SPH thinning. Look for and measure SPC maximum Dia. > 65°. Disk Dia. 17"; D_e 10°S.
19 JUN	190	SPC should be free of SPH. NPH bright. Syrtis Major E. border fading? Frost patches may brighten. D_e and D_s 07°S.
05 JUL	200	Measure thawing SPC Dia. Syrtis Major dark and shrinking. Check Hellas. Good surface contrasts expected; fine detail for mapping features. Disk Dia. 23"; D_e 07°S.
10 JUL	203	Mars at Opposition (05-hr. U.T.; Declination 28°S).
16 JUL	206	Mars closest to Earth (11-hr. U.T.; 60.37 million km.).
23 JUL	210	SPC develops dark Magna Depressio (270°W, 80°S). Syrtis Major narrows rapidly. Disk Dia. 23"; D_e 04°S.
31 JUL	215	SPC develops Rima Australis rift connecting Magna Depressio (290°- 350°W). SPC bright projection Argenteus Mons (10°-20°W). SPC Novissima Thyle (300°-330°W) bright projection appears? Limited yellow cloud in Serpentis-Hellespontus possible. Disk Dia. 23"; D_e 03°S.
08 AUG	220	Is Novissima Thyle detached from cap? Dark rift Rima Angusta (60°-270°W) appears in SPC. Dust cloud in Noachis-Hellas? Disk Dia. 21"; D_e 03°S.
24 AUG	230	SPC in rapid retreat. Bright elongated Novissima Thyle is detached from SPC and becomes isolated Novus Mons. Rima Australis broadens. Magna Depressio becomes dusky. Salient NPH. Disk Dia. 19"; D_e 04°S.
09 SEP	240	Measure smaller SPC. Novus Mons small, bright, high contrast. Rima Australis widens. Isolated bright spot on SPC (155°W)? Atmosphere very clear? Check violet clearing and Hellas. Disk Dia. 16"; D_e 06°S.
23 SEP	250	Mars at perihelion. SPC ca. 26° Dia.? White clouds present? Is Elysium bright? Frost patches on light areas. Syrtis Major narrow. Disk Dia. 15"; D_e 09°S.
09 OCT	260	Novus Mons reduced to a few bright patches and soon disappears. SPC Dia. 16°. Hellas bright spot? Numerous bright patches. Begin windy season. Initial dust clouds in S. Hemisphere? Disk Dia. 13"; D_e 13°S; D_s 24°S.
25 OCT	270	Southern Summer and Northern Winter Solstices. SPC Dia. ca. 14°. Yellow dust clouds and low contrast of disk features possible. Disk Dia. 11"; D_e 16°S.
10 NOV	280	NPH may extend to 45° or 40° N. If disk feature contrasts are low, a global dust storm is raging. Look for white clouds. Disk Dia. 10"; photography of fine details difficult. D_e 20°S.
26 NOV	290	SPC small. Check W-clouds and frost patches. Disk Dia. 9"; D_e and D_s 23°S.
14 DEC	300	SPC remnant becomes difficult to see. Check disk for clouds and violet clearing. Disk Dia. 8"; still large enough for color filter observations. D_e 25°S.
30 DEC	310	Is SPC remnant visible in mid-Summer? Antarctic hazes present. Check for W-clouds and violet clearing. Disk Dia. 7"; D_e 26°S.

SOUTHERN GLOBE AND RING FEATURES OF SATURN: A SUMMARY ANALYSIS OF MEAN VISUAL RELATIVE NUMERICAL INTENSITY ESTIMATES FROM 1966 THROUGH 1980

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

Abstract. --This report investigates visual intensity estimates for Saturn's Southern Hemisphere belts and zones and its southern Ring components for fourteen apparitions from 1966 APR 02 through 1980 AUG 12, comparing the patterns of intensity variations between features. Included with the text analysis are several graphs and tables.

Introduction

This report is restricted to the Southern Hemisphere of Saturn's Globe and the southern face of its Ring System, and is limited to a comparative summary investigation of mean visual relative numerical intensity estimates, for integrated light, accumulated for selected features from 1966 APR 02 through 1980 AUG 12, thus beginning with the edgewise presentation of the Rings in 1966-67 and continuing to the edgewise presentation of 1979-80. These data were collected over fourteen apparitions of Saturn by a host of dedicated individuals in the United States and abroad, using instruments ranging from 6.0 to 155.0 cm. in aperture. Detailed information, beyond the scope of this report, has appeared in this Journal for each of the observing seasons included in this summary (see the "References" at the end of this report).

Visual Photometry: An Analysis

Visual relative numerical intensity estimates (visual photometry) were carried out by observers using integrated light (no color filters) employing the standard A.L.P.O. Intensity Scale, where 0.0 represents black shadows and 10.0 denotes the most strikingly brilliant features of Solar System objects. All Globe and Ring features of Saturn were assigned numerical relative intensities (brightnesses) based on this 0 - 10 scale, but with a further reference standard for Saturn of 8.0 for the outer third of Ring B. When the Rings were at or near their edgewise presentations, the reference standard became an arbitrary 7.0 for the Equatorial Zone (EZ). Detailed information for carrying out visual photometry can be found in Benton (1981).

Mean intensities were computed for the entire fourteen apparitions in question, and the results are presented in Table 1 (p. 191). The selected zones, belts, and Ring components are given in Table 1 so that each category lists the features in decreasing order of mean intensity, also giving standard deviations and the number of observations used in the analysis. The reader can recognize easily those zones which were the most conspicuous, the brighter intensities (larger numerical values) usually indicating a greater visual prominence. With the belts of Saturn, as a rule, the darker the feature in question, the more obvious it was to observers. Naturally, the relative prominence of a feature may have affected the conspicuousness of an adjoining one. Also, these considerations need to be taken into account for the specific Ring components and their visibility.

Saturn and its Ring System are diagrammed in Figure 7 (p. 192), showing the various Southern Hemisphere belts, zones, and Ring components that can be seen with small or moderate apertures. This diagram uses the standard A.L.P.O. Saturn nomenclature.

Table 2 (p. 191) gives, for each apparition from 1966-67 to 1979-80, the exact observational period and, for that period, the numerical range of $\underline{B}$ (the planetocentric latitude of the Earth referred to the plane of the Rings, positive when north, negative when south). Table 3 (p. 193) is derived from Tables 1 and 2 and from Figures 8 through 10, which appear on pp. 194 - 196. Table 3 is useful because it presents overall mean intensity variations and lists by category those features of Saturn in the same order as in Table 1. For each belt, zone, or Ring component is given the maximum and minimum mean visual relative numerical intensity (in integrated light), the apparition(s) of record, and the inclusive values of $\underline{B}$. Finally, the range from maximum to minimum brightness is given in mean intensity units for each feature.

Table 1. The Southern Hemisphere of Saturn, 1966 - 1980: Mean Visual Relative Numerical Intensity Estimates.

	No. of Estim.	Mean Intensity with Standard Deviation
Zones:		
EZ	480	6.95 ± 0.50
STrZ	280	5.88 ± 0.40
STeZ	376	5.53 ± 0.75
SEB Z	261	4.99 ± 0.37
SPR	585	4.39 ± 0.68
Belts		
SPC	176	5.14 ± 0.66
STeB	125	4.17 ± 0.40
EB	99	3.83 ± 0.92
SEBs	269	3.57 ± 0.33
SPB	107	3.46 ± 0.30
SEBn	308	3.05 ± 0.26

	No. of Estim.	Mean Intensity with standard Deviation
Rings:		
B (outer 1/3)	- STANDARD = 8.0 -	
B (inner 2/3)	372	6.78 ± 0.55
A (entire)	159	6.09 ± 0.64
Crape Band	240	2.23 ± 0.90
C (ansae)	241	1.22 ± 0.36
Cassini's Division (B10)	237	0.64 ± 0.65

Table 2. Observational Periods and Numerical Values of B by Apparition, 1966-67 through 1979-80.*

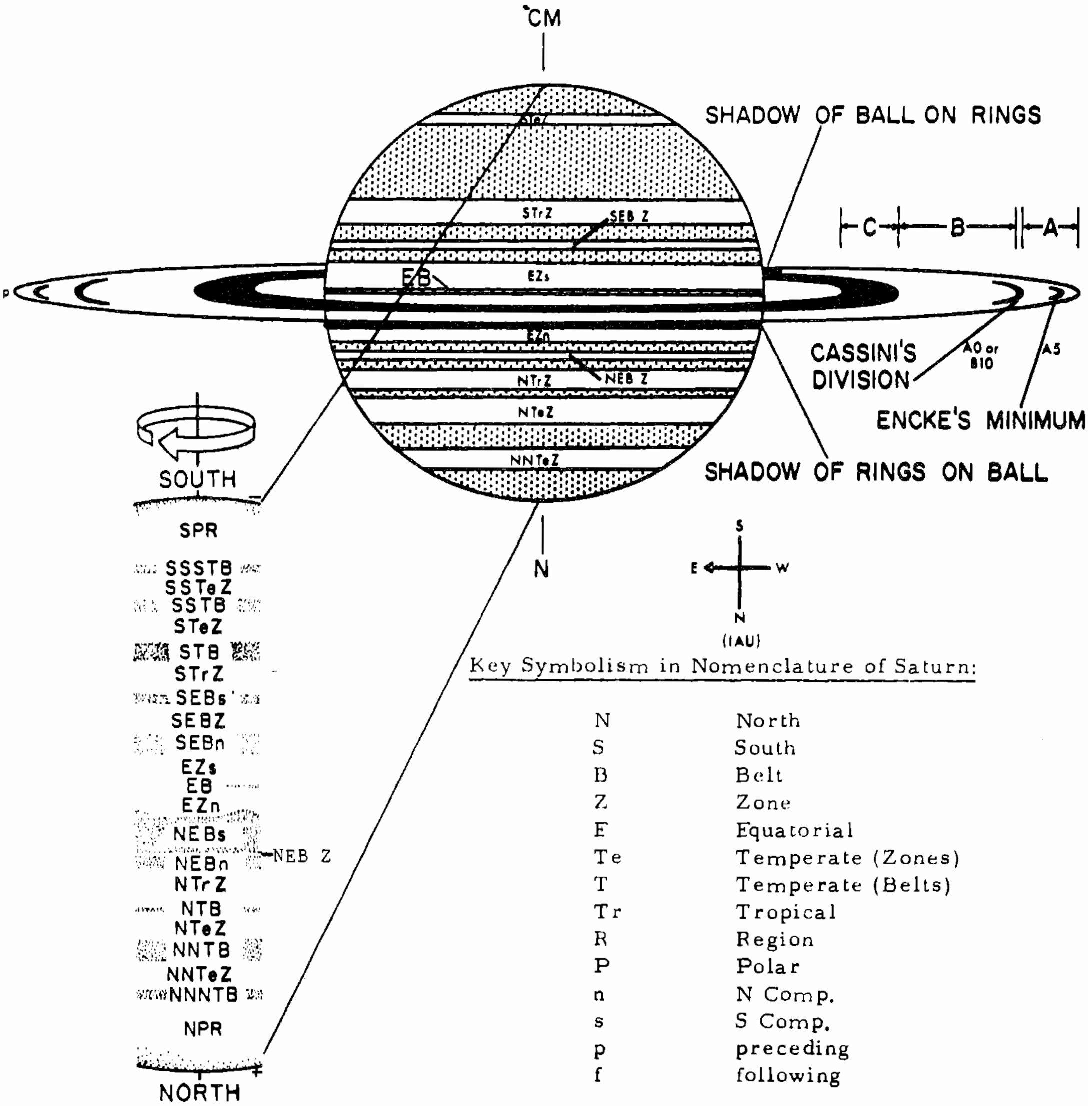
Apparition	Observational Period	Numerical Value of B	Apparition	Observational Period	Numerical Value of B
		° °			° °
1966-67	APR 02-FEB 15	+ 0.3/- 3.0	1973-74	JUL 15-JUN 05	-25.9/-26.9
1967-68	MAY 20-MAR 02	- 5.5/- 8.6	1974-75	JUL 15-JUN 22	-23.7/-25.5
1968-69	MAY 30-MAR 15	-11.1/-13.9	1975-76	SEP 02-JUN 30	-20.0/-22.5
1969-70	JUN 15-APR 05	-16.3/-18.9	1976-77	SEP 19-JUN 25	-15.3/-18.2
1970-71	JUN 20-APR 25	-20.9/-23.1	1977-78	OCT 16-JUN 21	- 9.8/-13.1
1971-72	SEP 02-APR 30	-24.4/-25.7	1978-79	OCT 11-JUL 21	- 4.1/- 7.4
1972/73	OCT 03-MAY 22	-26.4/-26.9	1979-80	OCT 22-AUG 12	+ 1.7/- 1.6

* The Observational Period begins in the first year of the apparition and ends in the second year. *B* is the Saturnicentric latitude of the Earth, referred to the ring plane, positive when north. If *B* is negative, the southern face of the Rings is visible and the Southern Hemisphere of the Globe is best presented. The range of B-values is for each observational period only.

Figures 8 through 10 contain graphs of mean visual relative numerical intensities plotted against time from the 1966-67 through the 1979-80 apparitions, for Saturn's southern belts, zones, Ring components, and associated features. Although variations in the brightness of a specific feature may have indeed taken place within any given apparition, this discussion relates only to overall mean intensities for each apparition. Data with respect to specific intensity fluctuations within any apparition can be found in the previously-cited apparition reports.

The sequence of Saturn's belts and zones in Figures 8 and 9 is from the south polar limb of the planet toward the equator. Belts and zones which have apparent interrelationships have been divided into separate graphs for clarity (e.g., the SPR, SPC, and SPB all appear in the top graph in Figure 8). With regard to the Ring System, there has been no specific order of treatment of Ring components and features in Figures 9 and 10, although Ring B appears separate from the others for greater clarity.

At this point, the reader is encouraged carefully to examine Figures 8 through 10, along with Tables 1 through 3. The following points are worthy of mention with respect to the Southern Hemisphere of Saturn and the southern face of the Ring System: [Text continued on p. 193.]



Key Symbolism in Nomenclature of Saturn:

N	North
S	South
B	Belt
Z	Zone
E	Equatorial
Te	Temperate (Zones)
T	Temperate (Belts)
Tr	Tropical
R	Region
P	Polar
n	N Comp.
s	S Comp.
p	preceding
f	following

Example of Usage: NEBn is North Equatorial Belt, N Comp.
& STeZ is South Temperate Zone.

Figure 7. Nomenclature of Saturn's Globe and Rings, drawn with south at top with a small southerly ring inclination. Note that the "Ball" and the "STB" are referred to in the text as the "Globe" and the "STeB" respectively. Features mentioned in the text but not shown in the diagram are: (1) SPC (South Polar Cap), near the South Pole; (2) SPB (South Polar Belt), encircling the SPR; (3) TWS (Terby White Spot), an apparent brightening on the Rings adjacent to the Shadow of Globe on Rings; (4) Crape Band, Ring C crossing the Globe; and (5) the Ansae, the portions of the Rings apparently farthest from the Globe.

Table 3. The Southern Hemisphere of Saturn, 1966 - 1980: Overall Mean Intensity Variations.

	Brightest Mean Intensity			Darkest Mean Intensity			Range in Mean Intensity Units
	Value	Appar.	B-Range	Value	Appar.	B-Range	
Zones							
			° °			° °	
EZ	7.8	1967-69	- 5.5/-13.9	6.1	1975-76	-20.0/-22.5	1.7
STrZ	6.6	1971-72	-24.4/-25.7	5.3	1975-76	-20.0/-22.5	1.3
STeZ	6.8	1978-79	- 4.1/- 7.4	4.1	1970-71	-20.9/-23.1	2.7
SEB Z	5.8	1977-78	- 9.8/-13.1	4.5	1967-69	- 5.5/-13.9	
					1971-72	-24.4/-25.7	1.3
SPR	5.5	1974-75	-23.7/-25.5	2.9	1973-74	-25.9/-26.9	2.6
Belts							
			° °			° °	
SPC	6.3	1971-72	-24.0/-25.7	3.8	1977-78	- 9.8/-13.1	2.5
STeB	4.9	1978-79	- 4.1/- 7.4	3.7	1973-74	-25.9/-26.9	1.2
EB	4.9	1977-78	- 9.8/-13.1	3.8	1970-71	-20.9/-23.1	
					1972-73	-26.4/-26.9	
					1975-76	-20.0/-22.5	1.1
SEBs	4.1	1977-78	- 9.8/-13.1				
		1979-80	+ 1.7/- 1.6	3.0	1967-69	- 5.5/-13.9	1.1
SPB	3.9	1978-79	- 4.1/- 7.4	2.7	1977-78	- 9.8/-13.1	1.2
SEBn	3.4	1971-72	-24.4/-25.7				
		1972-73	-26.4/-26.9				
		1977-78	- 9.8/-13.1	2.5	1967-69	- 5.5/-13.9	0.9
Rings							
B (outer 1/3)	------------------ 8.0, Standard Excluding 1979-80 ------------------						
			° °			° °	
B (inner 2/3)	7.4	1975-76	-20.0/-22.5	5.5	1966-67	+ 0.3/- 3.0	1.9
A (entire)	7.0	1970-71	-20.9/-23.1	4.5	1966-67	+ 0.3/- 3.0	2.5
Crape Band	5.1	1966-67	+ 0.3/- 3.0	1.5	1967-69	- 5.5/-13.9	3.6
C (ansae)	1.8	1978-79	- 4.1/- 7.4	0.6	1975-76	-20.0/-22.5	1.2
B10 (Cassini's Divis.)	2.0	1966-67	+ 0.3/- 3.0	0.0	1975-76	-20.0/-22.5	2.0
Sh G on Rings	1.0	1966-67	+ 0.3/- 3.0	0.0	1970-71	-20.9/-23.1	
					1976-77	-15.3/-18.2	1.0

[Text continued from p. 191.]

1. The largest time variation in overall mean intensity among belts and zones was for the STeZ, folllowed by the SPR and SPC. The feature with the least variation for both belts and zones was the SEBn.

2. With the exception of the SPC, the range of variation in mean intensity was less for Saturn's belts than for its zones.

3. The consistently brightest zone, in terms of mean intensity from 1966-67 through 1979-80, was the EZ. The darkest belt for that period was the SEBn.

4. In Figure 8, it is worthwhile to note how the mean intensity of the SPR was interrelated with that of the SPC and, less closely, with the SPB, affecting the contrast between these features during the study period. A less significant relation between the STeZ and the STeB is apparent in Figure 9.
[Text continued on p. 196.]

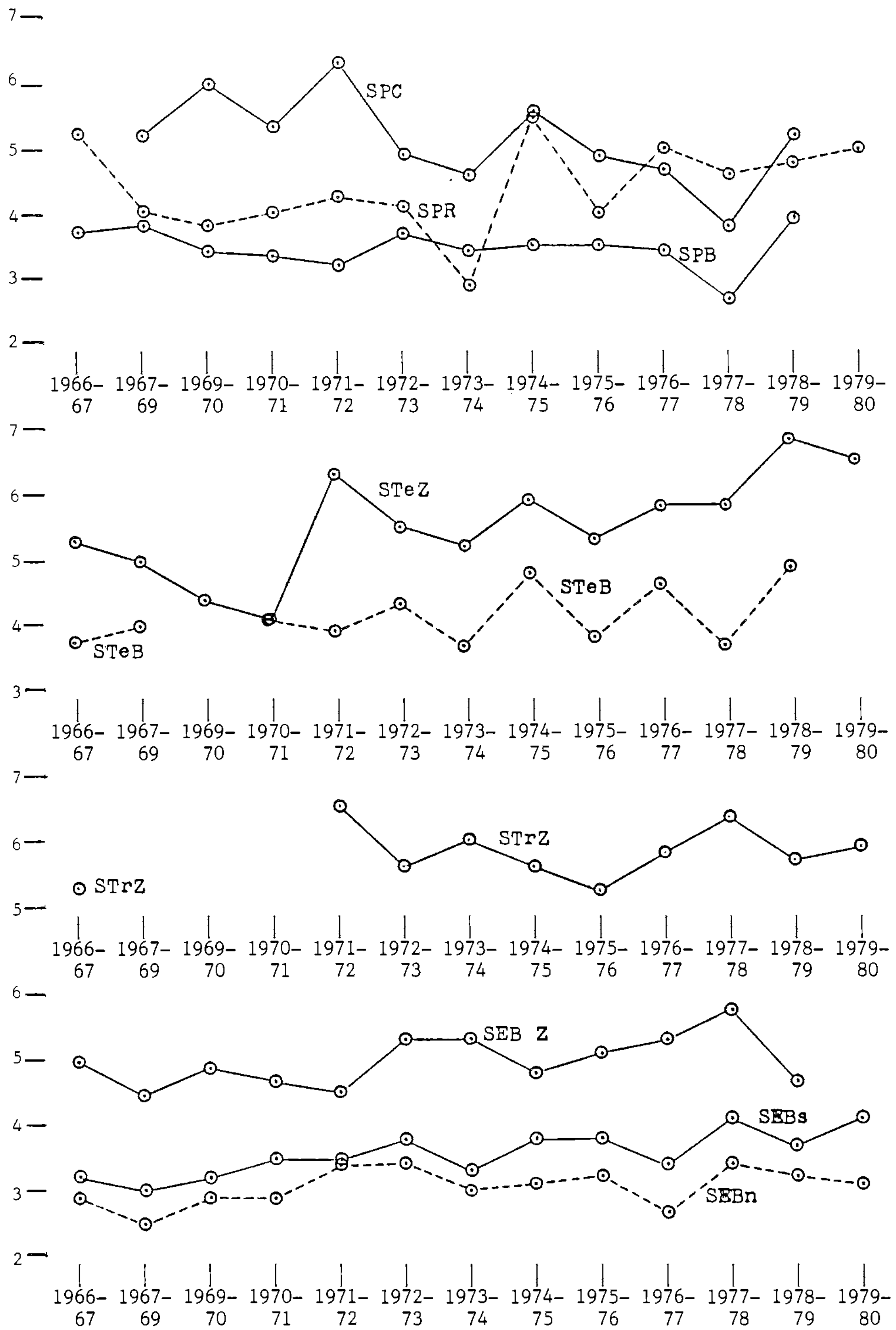


Figure 8. Mean visual numerical intensities of Saturnian Globe features between the SPR and the SEBn, inclusive, plotted by apparition. Numerical intensities are plotted on the vertical scales of each of the four graphs. Note that the 1967- 68 and 1968-69 apparitions have been combined. See also text.

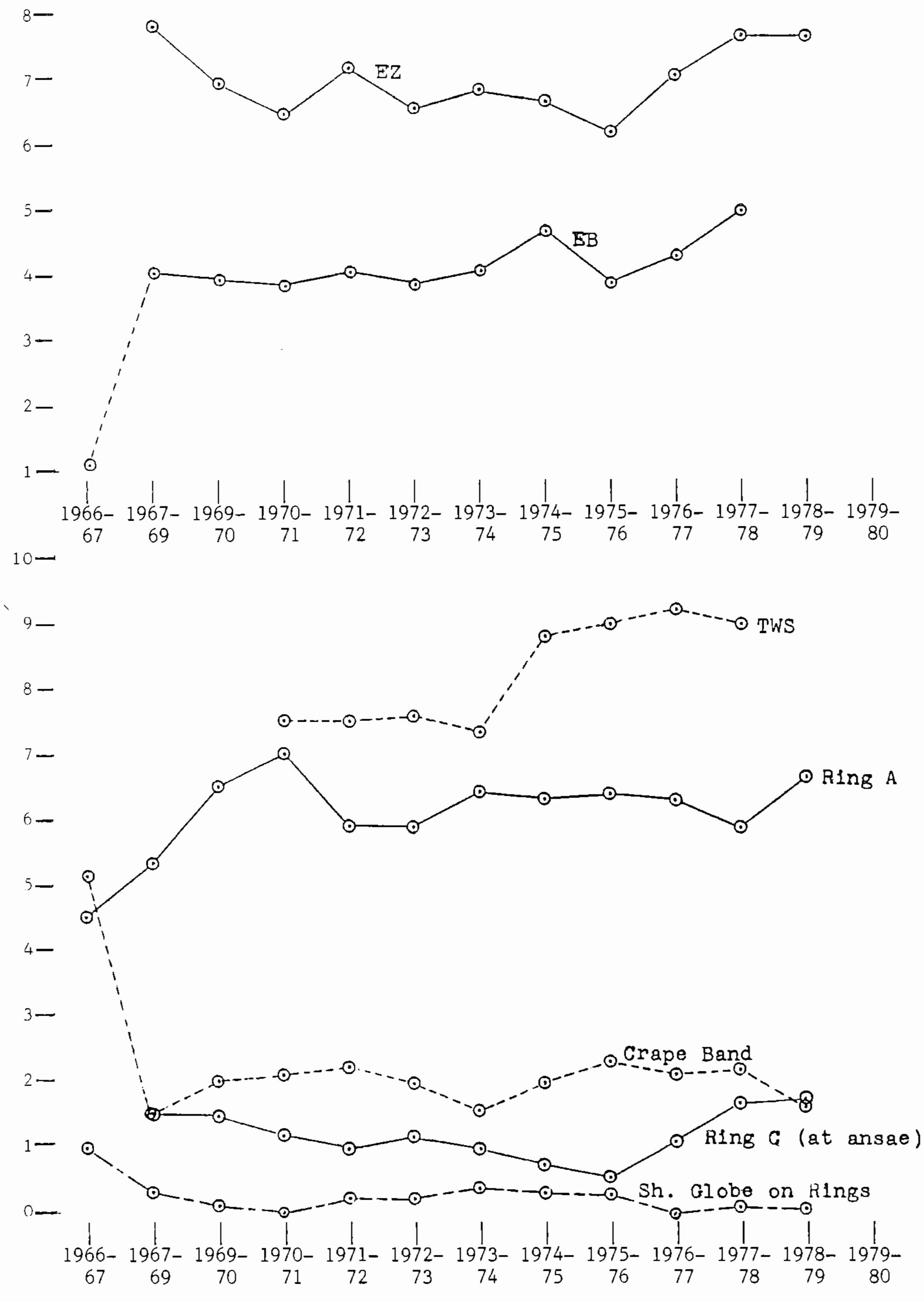


Figure 9. Mean visual numerical intensities of Saturnian Globe features (the EZ and the EB) and Ring features (TWS, Ring A, Crape Band, Ring C, and the Shadow of Globe on Rings), plotted by apparition. Numerical intensities are plotted on the vertical scales of each of the two graphs. Note that the 1967-68 and 1968-69 apparitions have been combined. See also text.

Figure 10. Mean visual numerical intensities of Saturnian Ring features (Ring B, outer 1/3 and inner 2/3, and Cassini's Division), plotted by apparition. Numerical intensities are plotted on the vertical scale. Note that the 1967-68 and 1968-69 apparitions have been combined. See also text.

[Text continued from p. 193.]

5. Looking at Figure 8, the brightness relationships by apparition of the STeZ and the STrZ are similar to those described for these features in past apparition reports, where it has been customary to compare these two zones.

6. The following Southern Hemisphere features tended to show similar patterns of variation in mean intensity:

A. STrZ and SEB Z from 1973-74 through 1978-79, with the exception of 1975-76 (see Figure 8).

B. EZ and STrZ from 1971-72 through 1977-78 (see Figures 8 and 9).

C. STeB and EB from 1973-74 through 1976-77 (see Figures 8 and 9).

D. SEBs and SEBn from 1966-67 through 1978-79, with the exception of 1971-72 (see Figure 8).

E. SPR and SPC from 1971-72 through 1978-79, with the exception of 1976-77 (see Figure 8).

F. SPC and SPR together similar to the pattern of the STeZ from 1970-71 through 1978-79, with the exception of 1976-77 for the SPC and 1977-78 for the STeZ (see Figure 8).

G. STeB and STeZ from 1972-73 through 1978-79, with the exception of 1977-78 (see Figure 8).

H. SteB, STeZ, SPR, and SPC from 1972-73 through 1978-79, with the exception of the SPC in 1976-77 and the STeZ in 1977-78 (see Figure 8).

I. The reader will be able to recognize several less evident shorter-term intensity variation patterns among the belts and zones in the Southern Hemisphere of Saturn through further examination of Figures 8 and 9.

7. The darkest mean intensity of Saturn's zones coincided largely with numerical values of B farther south than -20 , although no clear relationships between values of B and collective belt and zone intensities could otherwise be ascertained. Nonetheless, the data in Table 3 are interesting with respect to individual features.

8. The largest apparent variation in overall mean intensity with time among Ring features was that of Ring A. Table 3 shows that the Crape Band (Ring C in front of the Globe) had the largest variation, but we shall not consider this feature as a distinct Ring component for comparative purposes. [Under some lighting conditions, the Crape Band may be confused with the Shadow of the Rings on the Globe. Ed.] In addition, it is worth noting that, aside from 1966-67, the mean intensity variation of the Crape Band was insignificant (see Table 3 and Figure 9).

9. The smallest variation in overall mean intensity with time among Ring features was that of the Shadow of the Globe on the Rings, followed closely by Ring C (ansae; see Table 3). [Any deviation of the Shadow of the Globe on the Rings from completely black may be an instrumental effect. Ed.]

10. Both Ring A (entire) and Ring B (inner 2/3) were most prominent at values of B near -20° to -23°, while they were less conspicuous at or near edgewise presentations, as expected from geometry (see Table 3).

11. Comparing Figures 9 and 10, the reader can perceive similar mean intensity variation patterns between Ring A (entire) and Ring B (inner 2/3). This is particularly so from 1974-75 through 1978-79.

12. Similar mean intensity variation patterns are also evident between Ring C (ansae) and Cassini's Division (B10) from 1970-71 through 1978-79, with the exception of 1974-75 (see Figures 9 and 10).

13. Although the feature is definitely a contrast effect, it is useful to note how the prominence of the Terby White Spot (TWS) changed and persisted from 1974-75 through 1977-78 after a period of fairly stable intensity from 1970-71 through 1973-74 (see Figure 9).

14. The belts and/or zones of the Globe and the Ring features tended to show similar patterns of mean intensity variation as follows:

A. Ring A (entire) and Ring B (inner 2/3), together, with the SPB from 1973-74 through 1978-79 (see Figures 8, 9, and 10).

B. Ring B (inner 2/3) with the SEBs from 1967-69 through 1972-73 (see Figures 8 and 10).

C. The EZ and EB, together, with Ring C (ansae) from 1973-74 through 1978-79, with the exception of 1973-74 for the EB (see Figure 9).

D. The SEB Z and Ring B (inner 2/3) from 1967-69 through 1975-76, with the exception of 1974-75 (see Figures 8 and 10).

E. The STrZ and Ring C (ansae) from 1973-74 through 1977-78 (see Figures 8 and 9).

F. Less pronounced or shorter-term intensity variations may be apparent upon examination of Figures 8 through 10.

There is a possible correlation between linear units on the A.L.P.O. Intensity Scale and geometric ratios of absolute intensities of Globe and Ring features, in much the same way as relationships exist between stellar magnitudes. If the mean intensity values are to be trusted, although internal systematic errors undoubtedly exist, then we can assume that the variations with time by apparition are useful in obtaining some idea as to how various features in Saturn's Southern Hemisphere and its southern Ring face behaved. An assumption has been made, reinforced by very careful analysis, that all observers were certain of the identification of the features estimated at any given time, and consistently from apparition to apparition. There is some possible confusion among observers, however, between the Crape Band (Ring C crossing the Globe) and the shadow of Ring C upon the Globe. Also, the width of Ring C and its projection onto the Globe, along with the shadow of the Globe on the Rings, were subject to normal geometric variations that may have affected their intensity behavior during each apparition. [Likewise, the much greater reported darkness of the EB in 1966-67 is surely due to confusion at that time between this faint belt and either or both the nearby shadow of the Rings on the Globe or with the Crape Band. Ed.] Finally, because observational participation varied from apparition to apparition, the number of numerical relative intensity estimates varied as well. So, the best that we can hope for at present is that the data presented here are at least an indication of how Saturn's southern regions behaved over time from 1966-67 through 1979-80. Certainly, carefully-executed simultaneous observational programs, with extensive participation by A.L.P.O. members, should provide more useful data in the future, along with an idea of the significance of both systematic and random errors in observed intensities.

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GALILEAN SATELLITE ECLIPSE TIMINGS: 1983/85 REPORT (Part I)

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

Introduction

This report describes the eighth year of the A.L.P.O. Jupiter Section's Galilean Satellite Eclipse Timing Program, which now has received and analyzed some 2116 visual timings of the disappearances and reappearances of the satellites Io, Europa, Ganymede, and Callisto as they enter and leave the shadow of the planet Jupiter. These timings are compared with two published ephemerides in order to improve our knowledge of these satellites' orbits. The first such

Ephemeris is that developed by Sampson in 1910, which is used in the Astronomical Almanac and several other publications. The second is the "E-2" ephemeris developed by Jay Lieske of the Jet Propulsion Laboratory, which is used for planning the Galileo space mission and in studying the effects of tides on Io in changing its orbit. Previous reports on our Program hae been given in "Galilean Satellite Eclipse Timings: 1975-1982 Report" (JALPO 30 , 45-53, 105-115, and 145-154; Oct., 1983, and Jan. and Apr., 1984) and in "Galilean Satellite Eclipse Timings: 1982/1983 Report" (JALPO 31 , 105-119; Jan., 1986).

Observations

Fully 480 visual timings were received for the 1983-1985 Jupiter apparition, which in theory covered the period 1983 DEC 14 - 1985 JAN 14 (dates of conjunction; opposition was on 1984 JUN 29), which is the largest number of timings received in five years. Timings came from members of the A.L.P.O., the National Association of Planetary Observers (Australia), and the Royal Astronomical Society of New Zealand. A.L.P.O. members contributed 55 percent of the observations (265) and comprised 62.5 percent of the observers (30 out of 48). Due to Jupiter's southerly declination (-23.1 degrees at opposition), Southern Hemisphere observers had an advantage during this apparition. Table 1, below, provides some statistics on the observations that were received.

Table 1. Summary Statistics: 1983/85 Galilean Satellite Eclipse Timings.

By Event*		By Month (with Elongation*)		By Aperture	
1D	70	1984 JAN, 025° W	1	6 cm.	80
1R	124	FEB, 050° W	10	7.5	30
--	---	MAR, 075° W	24	8	1
1	194	APR, 102° W	25	8.9	2
		MAY, 132° W	50	9	15
2D	52	JUN, 164° W	67	10	35
2R	82	JUL, 163° E	61	11	32
--	---	AUG, 131° E	72	11.4	5
2	134	SEP, 101° E	96	15	32
		OCT, 075° E	51	20	164
3D	59	NOV, 049° E	20	25	40
3R	42	DEC, 025° E	3	32	12
--	---			36	25
3	101	(Note: Elongations from the Sun are for the 15th day of each month.)		41	2
				48	1
4D	22			51	4
4R	29				
--	--				
4	51				

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

Jupiter's inner Galilean satellites were timed more often than its outer ones simply because the closer a satellite is to Jupiter, the shorter is its orbital period and thus the more often that it is eclipsed. It is notable that eclipses of Callisto occurred, and were observed, for the first time since the 1979/80 apparition. As usual, more timings were made of eclipse reappearances (277, 58 percent) than of disappearances (203, 42 percent), chiefly because many disappearances occur at inconvenient early morning hours. This factor also meant that more timings were made after opposition (303; 63 percent) than before (177; 37 percent), as shown in the monthly frequency column. In addition, the period near Jupiter's evening quadrature (occurring on 1984 SEP 27) was popular for observations because the phase angle was at a maximum (11.1 degrees), making eclipses occur farthest from the disk and allowing them to be easily timed. The earliest timing was on 1984 JAN 25 at elongation 33 degrees west and the last was on 1984 DEC 03 at elongation 34 degrees east. As with previous apparitions, it appears impractical to make eclipse timings within six or seven weeks of conjunction.

As has been the case for several apparitions, 20 cm. was by far the most popular aperture. Nonetheless, successful timings were made with instruments as small as 6-cm. aperture and a few observers employed relatively large telescopes in the 32 to 51-cm. category. The mean aperture used was 17 cm., and the smaller instruments were more common than the larger. Each visual timing that was received will be listed individually in the Appendix in Part II of this Report, which will appear in a later issue.

Reduction

The procedure for converting timings into residuals from an ephemeris prediction was described in the previously-cited 1975-1982 report. In summary, four analyses are done because the two ephemerides are treated separately as are eclipse disappearances and reappearances. Letting Y(i,j) stand for the observed-minus-predicted time difference, in seconds, for ephemeris/i/ ("Sampson" versus "E-2") and event type /j/("D" for disappearance and "R" for reappearance), the following model is used:

$$Y(i,j) = A(i,j) + B(i,j)X \ ,$$

where _A(i,j)_ and _B(i,j)_ are coefficients found by regression and _X_ is the reciprocal of the aperture (in cm.) used. This model thus allows for aperture effects as well as for systematic differences between disappearance and reappearance timings. For ephemeris _i_ , the orbital residual in seconds of time is found by taking the mean of its A(i,D) and A(i,R)-coefficients. For both timing and orbital residuals, a positive value means that an event was observed later than predicted (thus the ephemeris was "fast") and a negative residual indicates that the event was observed earlier than the ephemeris predicted (the ephemeris was "slow"). As a check of this method, each satellite's diameter is estimated on the basis of the difference between its disappearance and reappearance residuals, which indicates the time taken by Jupiter's shadow edge to cross the disk of the satellite.

Although this method usually significantly reduces the variance (scatter) among the timings, there are often a number of timings that differ markedly from the majority. It is a somewhat subjective decision as to which timings to exclude from analysis. The writer excluded any timings that differed from the regression model at a 5-percent level of significance. This process changes the model and it is then recalculated, which may result in other timings being excluded; this iterative process is done at most two times. For this apparition, 31 timings (6.5 percent of the total) were excluded from the "Sampson" analysis, while 46 (9.6 percent) were excluded from the "E-2" analysis. Those timings that were excluded from regression are marked by asterisks in the "Residual" columns of the Appendix.

1983/85 Results

Figure 11 (p. 201) graphs the results of the timing reductions for the 1976/77 - 1983/85 apparitions. The results for this last apparition are then described by each ephemeris used. Table 2 (p. 203) gives results for the Sampson ephemeris, while Table 3 (p. 205) does the same for the E-2 ephemeris. In each table, each of the four Galilean satellites is given in a separate column. In interpreting these results, one should bear in mind that the Sampson ephemeris predictions are given to only 1-minute precision, while those of the E-2 ephemeris are to 1 second. Thus in most cases the standard errors are greater for the Sampson ephemeris than for the E-2 ephemeris.

Going down the rows of Tables 2 and 3, the first group of items is for eclipse disappearances and the second group is for reappearances. For each, the number of timings received is given first, followed in parentheses by the number of timings used for regression. The second item is the coefficient of determination ("R-squared"), which describes the proportion of the variance of the timings that is explained by the aperture-regression model. Third, the two regression coefficients are given with their 1-standard error uncertainty ranges; all such uncertainty ranges are indicated by the " $\pm$ " symbol. Finally the standard error of estimate for the regression model is given, followed by the predicted time residual for three commonly-used apertures. [Text continued on p. 202.]

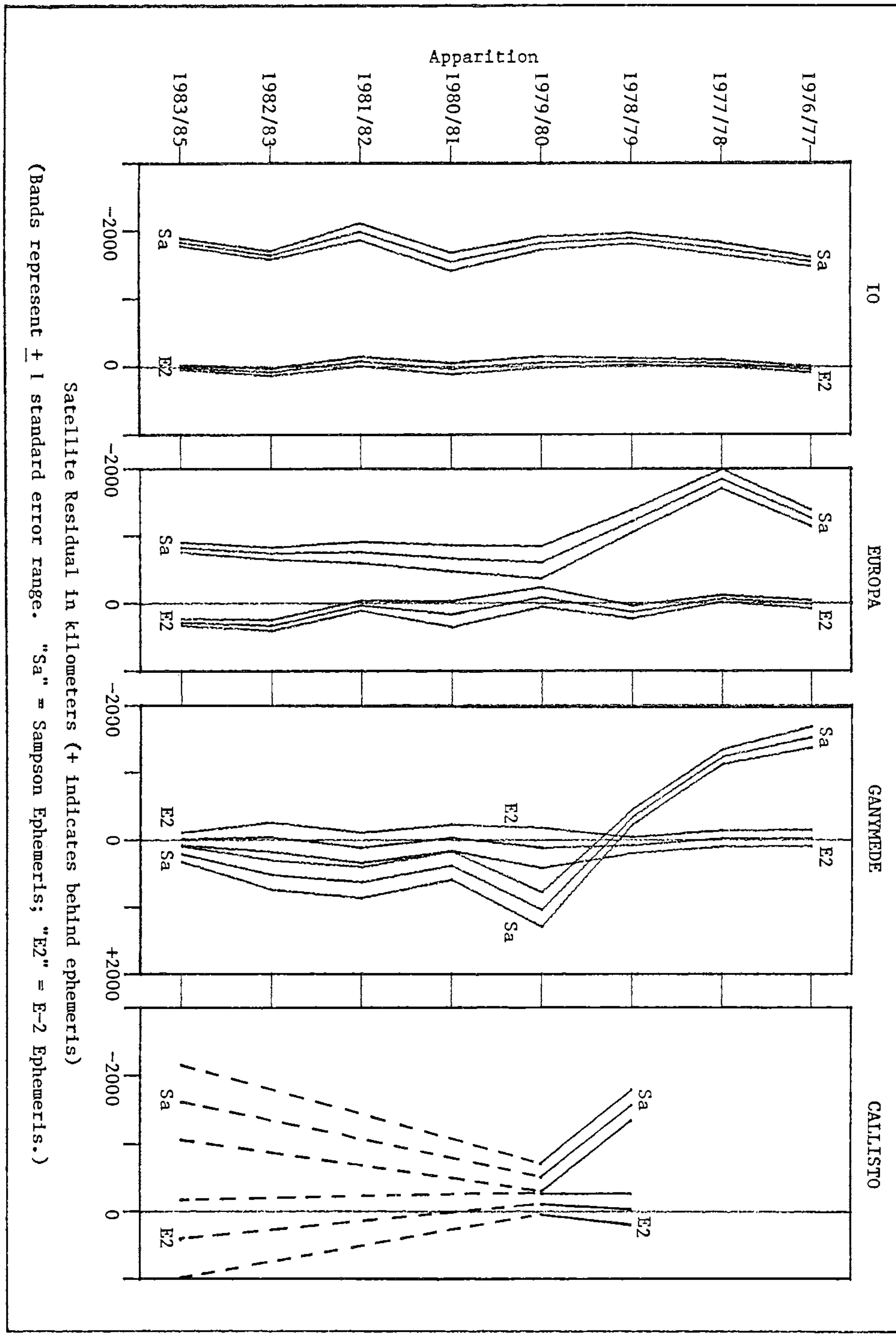

Figure 11. Graphs of orbital residuals for the Galilean Satellites from the 1976/77 through the 1983/85 apparitions, showing deviations in kilometers from the Sampson ("Sa") and the E-2 ("E2") ephemerides. The bands represent ± 1 standard error ranges. Note that Callisto did not undergo eclipses during the 1980/81, 1981/82, and 1982/83 apparitions. See also text.

[Text continued from p. 200.]

The remaining data in each column are derived from the combined disappearance and reappearance data. The first items give the orbital residuals from the ephemeris and their uncertainty ranges in units of seconds of time and orbital arc in both degrees and kilometers. The last items give the satellite diameters, first in seconds of time, and then in kilometers, both uncorrected ("Prelim.") and corrected ("Corr.") for the satellite's angle of entry into, or its exit from, Jupiter's shadow. The corrected diameter is then compared with the Voyager-derived diameter for the satellite ("Standard;" 3640 km. for Io, 3066 km. for Europa, 5216 km. for Ganymede, and 4890 km. for Callisto). For the coefficient of determination ("R-squared"), the orbital time residual ("Seconds") and the diameter-comparison entries, statistical significance is shown by "-" for not significant, "*" for significance at the 5-percent level, and by "**" for significance at the 1-percent level.

Sampson Ephemeris. --As shown in Table 2 (p. 203), between 14 and 53 percent of the variances of the individual timings are explained by the aperture model, which is statistically significant in all cases. As expected, the uncertainties of both regression coefficients, and the magnitude of the B-coefficient, increase regularly with distance from Jupiter. This is probably a joint effect of the progressively slower satellite velocities, wider penumbra of Jupiter, and fewer timings made, as the distance from Jupiter increases. For all satellites except Europa, the absolute values of the B-coefficients (the effect of aperture) are somewhat higher for reappearances than for disappearances, the opposite of the results for the 1982/83 apparition; none of these differences are statistically significant, however.

The observed-Sampson orbital residuals, also graphed in Figure 11 (p. 201), indicate that the Sampson ephemeris is in serious error for all satellites except Ganymede. The amount of error, when compared with the 1982/83 apparition, increased for Io and Europa, but decreased for Ganymede; the amount of change was significant only for Io. As for Callisto, its error increased, but not significantly, from its 1979/80 value (-62.6 sec.).

The observed-Sampson residuals of Io and Europa show no clear-cut trend over time. Io's residuals varied little over the eight apparitions studied, with a mean value of -1744 ± 58 km. The residuals of Europa were also fairly constant, with a mean of -989 ± 150 km. for the whole period. Neglecting the variations in Europa's residuals for the first three apparitions, the mean residual for the period 1979/80 - 1983/85 was -718 ± 40 km. The coverage for Callisto is as yet too sparse to discern any pattern. Ganymede is a special case, however. The value of its residual increased fairly consistently between the 1976/77 and the 1981/82 apparitions, but has decreased between 1981/82 and 1983/85 as follows:

1976/77 . .	-141.0 ± 14.4 sec.	1980/81 . .	+ 35.0 ± 19.8 sec.
1977/78 . .	-113.8 ± 10.2	1981/82 . .	+ 58.4 ± 21.2
1978/79 . .	- 31.3 ± 10.1	1982/83 . .	+ 48.0 ± 20.0
1979/80 . .	+ 95.5 ± 23.5	1983/85 . .	+ 19.4 ± 11.0

The observed-Sampson Ganymede residuals above are graphed against time in Figure 12 (p. 204). For the entire period, given the uncertainties of the values, a linear trend is still possible (i.e., statistically significant; R-squared = .544*), and implies that Ganymede's current orbital period is 0.5 ± 0.2 seconds longer than that assumed by Sampson. On the other hand, a much better fit (R-squared = .869**) is given by the model:

$$\text{Residual} = -45 \text{ sec.} + 123 \text{ sec.}[\sin(29.9^{\circ}T - 52^{\circ})] ,$$

where T = the number of apparitions since that of 1976/77. The residuals predicted by this model are also graphed in Figure 13. The time argument, 29.9 degrees per apparition, implies that the residual is cyclical with a period of 12.0 Jovian apparitions or 13.2 terrestrial years. It is tempting to postulate a long-term pertubation coinciding with Jupiter's period of revolution (11.9 years), the Solar activity period (about 10.9 years), Jovian resonance with Uranus (13.8 years) or Neptune (12.8 years), or a combination of the above. Perhaps what is happening to Ganymede as regards the Sampson ephemeris will be clearer when we have additional data from future apparitions.

Table 2. Satellites Compared With Sampson Ephemeris, 1983/85.

Satellite: . . .	Io	Europa	Ganymede	Callisto
Disappearance --				
Number of Observations	70 (65)	52 (50)	59 (56)	22 (22)
Coefficients:				
R-squared	.135**	.386**	.161**	.253*
A (seconds)	- 1.4 ± 5.0	+ 69.1 ± 7.8	+351.5 ± 17.8	+ 527.3 ± 117.0
B	-170 ± 54	-437 ± 81	-632 ± 196	-3316 ± 1274
Standard Error (sec.)	± 21.5	± 27.9	± 67.7	± 263.7
Aperture Residual (sec.):				
6 cm.	-30 ± 5	- 4 ± 8	+246 ± 20	- 25 ± 123
10 cm.	-18 ± 3	+25 ± 4	+288 ± 10	+195 ± 61
20 cm.	-10 ± 3	+47 ± 5	+320 ± 11	+362 ± 68
Reappearance ---				
Number of Observations	124 (115)	82 (74)	42 (40)	29 (27)
Coefficients:				
R-squared	.228**	.236**	.533**	.493**
A (seconds)	-209.8 ± 4.8	-190.1 ± 7.6	-312.7 ± 12.8	-919.0 ± 66.9
B	+307 ± 53	+409 ± 87	+810 ± 123	+3664 ± 743
Standard Error (sec.)	± 24.4	± 32.1	± 38.8	± 175.8
Aperture Residual (sec.):				
6 cm.	-159 ± 5	-122 ± 9	-178 ± 11	-308 ± 74
10 cm.	-179 ± 3	-149 ± 4	-232 ± 6	-553 ± 38
20 cm.	-194 ± 3	-170 ± 4	-272 ± 8	-736 ± 40
Orbital Residual -------				
Seconds	-105.6 ± 3.5**	- 60.5 ± 5.4**	+ 19.4 ± 11.0-	-195.8 ± 67.4**
Orbital Arc	-0°.248 ± °.008	-0°.071 ± °.006	+0°.011 ± °.006	-0°.049 ± °.017
Kilometers	- 1830 ± 60	- 831 ± 75	+ 211 ± 119	- 1609 ± 553
Diameter -------				
Seconds	208.4 ± 7.0	259.2 ± 10.9	664.3 ± 21.9	1446.4 ± 134.7
km. (Prelim.)	3610 ± 120	3560 ± 150	7225 ± 239	11880 ± 1107
km. (Corr.)	3539 ± 118	3266 ± 138	6297 ± 208	6870 ± 640
Compared with Standard	-101 (-2.8%)-	+200 (+6.5%)-	+1081(+20.7%)**	+1980(+40.5%)**

The diameters for the satellites Io and Europa, as calculated from the Sampson-based eclipse timings, are in good agreement with the Voyager-derived values. However, those for Ganymede and Callisto differ significantly from the Voyager diameters. As with the previous seven apparitions, our diameters for Ganymede are too large, possibly due to the large width of Jupiter's penumbra (1915 km.) at Ganymede's orbit. Penumbral effects may also be the cause for the considerable overestimation of Callisto's diameter.

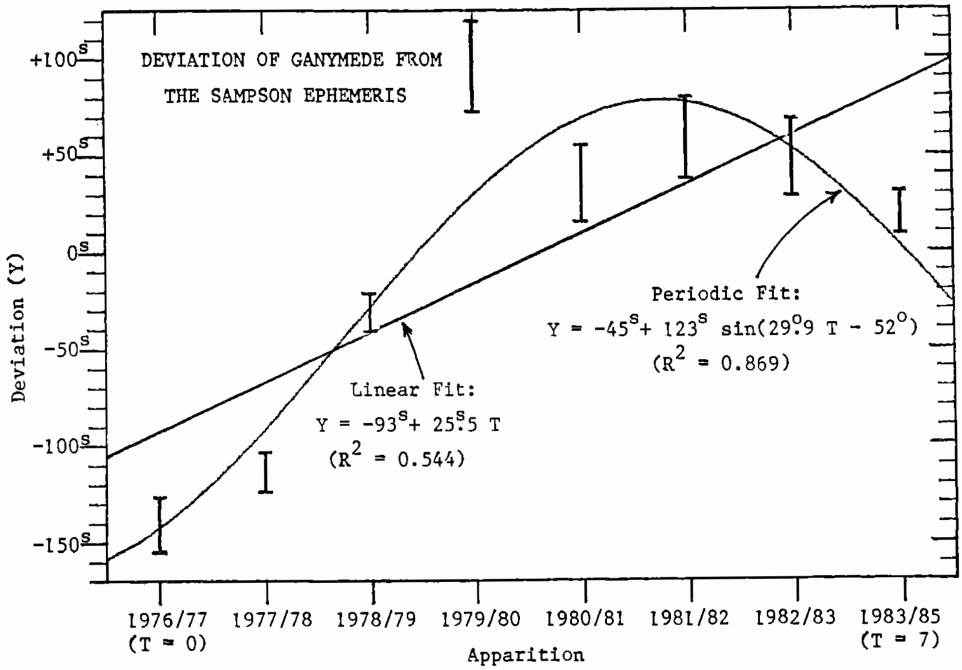

Figure 12. Deviation of the satellite Ganymede from the Sampson ephemeris from the 1976/77 through the 1983/85 apparitions. Vertical bars represent observed deviations with ± 1 standard error ranges. The line and the curve represent a linear and a periodic fit to the deviations, respectively, along with their regression formulae and coefficients of determination (R^2). See also text.

E-2 Ephemeris. --As shown in Table 3 (p. 205), and similar to the results for the Sampson ephemeris, the aperture model was statistically significant for all four satellites, explaining between 26 and 62 percent of the variance of the timings. Again, the timing uncertainties and the absolute values of the B-coefficients increase regularly with the distance of each satellite from Jupiter. Likewise, for all satellites except Europa, the aperture effect (i.e., absolute value of the B-coefficient) is greater for reappearances than for disappearances; as was the case with the Sampson ephemeris, none of these differences are significant.

There were no significant differences between our 1983/85 timings and the E-2 ephemeris predictions for Io, Ganymede, and Callisto. However, this was the second apparition in a row where Europa showed a significant difference from that ephemeris. In 1982/83, Europa's E-2 residual was +24.1 ± 5.8 seconds; significantly different from that ephemeris but quite close to its residual for the 1983/85 apparition. With the results for two successive apparitions in agreement, this effect appears real, and suggests that, somehow, Europa dropped about 300 kilometers back in its orbit, when compared to the E-2 ephemeris, between 1981/82 and 1982/83 and that it continues behind the ephemeris. This satellite exhibited no such time change in terms of the Sampson ephemeris, so this effect is unique to the E-2 ephemeris.

The timing-derived satellite diameters that were based on the E-2 ephemeris appear accurate for Io, but are significantly too large for Europa, Ganymede, and Callisto. For the last two satellites, the reasons for this are probably the same as were suggested in the Sampson ephemeris section above. For Europa, it is difficult to determine what may be the cause of this error, but it may be a bias caused by having relatively few disappearance timings for that satellite, and observers should make an effort to make more timings of the eclipses of Europa, particularly for disappearances.

Table 3. Satellites Compared With "E-2" Ephemeris, 1983/85.

Satellite: . . .	Io	Europa	Ganymede	Callisto
Disappearance --	--------------	--------------	---------------	-------------
Number of Observations	70 (63)	52 (46)	59 (56)	22 (22)
Coefficients:				
R-squared	.499**	.623**	.266**	.260*
A (seconds)	-104.6 ± 2.8	+154.2 ± 4.8	+310.6 ± 13.8	+ 820.1 ± 119.2
B	-242 ± 31	-431 ± 51	-674 ± 152	-3439 ± 1299
Standard Error (sec.)	± 12.0	± 16.9	± 52.6	± 268.7
Aperture Residual (sec.):				
6 cm.	+64 ± 3	+ 82 ± 5	+198 ± 15	+247 ± 126
10 cm.	+80 ± 2	+111 ± 3	+243 ± 8	+476 ± 63
20 cm.	+92 ± 2	+133 ± 3	+277 ± 8	+648 ± 70
Reappearance ---	--------------	--------------	---------------	---------------
Number of Observations	124 (107)	82 (70)	42 (38)	29 (28)
Coefficients:				
R-squared	.441**	.350**	.617**	.511**
A (seconds)	-103.7 ± 3.1	-113.2 ± 6.2	-313.9 ± 9.9	-719.1 ± 73.4
B	+318 ± 35	+405 ± 67	+738 ± 97	+4081 ± 782
Standard Error (sec.)	± 14.8	± 25.5	± 29.4	± 197.4
Aperture Residual (sec.):				
6 cm.	-51 ± 3	-45 ± 7	-191 ± 9	- 39 ± 77
10 cm.	-72 ± 2	-73 ± 3	-240 ± 5	-312 ± 40
20 cm.	-88 ± 2	-93 ± 4	-277 ± 6	-515 ± 44
Orbital Residual -------	---------------	--------------	---------------	---------------
Seconds	+ 0.4 ± 2.1-	+ 20.5 ± 3.9**	- 1.7 ± 8.5-	+ 50.5 ± 70.0-
Orbital Arc	+0°.001 ± °.005	+0°.024 ± °.005	-0°.001 ± °.005	+0°.013 ± °.017
Kilometers	+ 7 ± 36	+ 282 ± 54	- 18 ± 93	+ 414 ± 575
Diameter -------	---------------	--------------	---------------	----------------
Seconds	208.3 ± 4.2	267.4 ± 7.8	624.5 ± 17.0	1539.2 ± 140.0
km. (Prelim.)	3609 ± 73	3673 ± 108	6792 ± 185	12643 ± 1150
km. (Corr.)	3538 ± 71	3370 ± 99	5922 ± 162	7243 ± 659
Compared with Standard	-102 (-2.8%)-	+304 (+9.9%)*	+706(+20.7%)**	+2353(+48.1%)**

Non-Visual Timings

In keeping with the current trend towards using electronic data recording for amateur observations, four "non-visual" timings were received for the 1983/85 apparition. These are summarized in Table 4 (p. 206).

Table 4. Non-Visual 1983/85 Galilean Satellite Eclipse Timings.

Event	1984 Date	Observer With Aperture	Residuals Sampson	"E-2"	Method	Notes
			s	s		
1R	SEP 30	Manly, P. (20 cm.)	-155	- 73	Video	6.9-cm. equivalent
1R	OCT 07	Manly, P. (20 cm.)	-200	- 78	Video	17.5-cm. equivalent
4R	OCT 07	Manly, P. (20 cm.)	-580	-332	Video	10.7-cm. equivalent
4R	OCT 07	Gonzalez, G. (51 cm.)	-199 ± 4	+ 49 ± 4	Photo-electric	Half-brightness*

* Instant when Callisto was one-half of its uneclipsed brightness. Results are significantly different from both ephemerides but are not significantly different from the analyses of visual timings.

Peter L. Manly used a Litton model 841 image intensifier and a RCA TC2055/UC camera with a video tape recorder on a Celestron-8 telescope, using tele-extenders at f/40 and f/80 for his video timings. Despite his use of an image intensifier, his times approximate those made visually using an instrument of about only half his aperture. He noted that scattered light from Jupiter proved a problem and that the satellite's signal-to-noise ratio was only about 10. Nonetheless, the two (observed - E-2) residuals for Io's reappearances were quite consistent, and the writer feels that further such experimentation should be done.

The photoelectric timing by Guillermo Gonzalez was done with a fairly large aperture, using a blue filter. The time indicated is that when Callisto was one-half of its uneclipsed brightness, which should correspond to the predicted time for the middle of eclipse egress. This time differed quite significantly from both the Sampson and, unexpectedly, the E-2 ephemerides. However, his residuals were extremely close to those found from our analysis of the visual timings, differing by only 3 seconds and 1 second for the Sampson and the E-2 residuals, respectively, so that one good photoelectric timing may be worth 29 visual timings!

Summary and Prospects

Once again, our timings have shown the Sampson ephemeris to have significant errors for Io, Europa, and Callisto, and suggest that there may be a periodic error for Ganymede. As has been found for previous apparitions, the E-2 ephemeris has no significant errors for Io, Ganymede, and Callisto. However, for the second successive apparition, the latter ephemeris appears to have a significant error for Europa.

Looking toward future apparitions, it is clear that our results would have more weight were observers to try harder to observe more eclipse disappearances for Io and Europa, and to time as many events before opposition as after. Certainly, given the rarity of eclipses of Callisto, every effort should be made to time those that are visible. Finally, the video and, particularly, the photoelectric timing methods look very promising, and we urge those observers so equipped to experiment with these new methods.

We are very grateful to the large number of contributors for the 1983/85 apparition, particularly those new to our program. We hope they will stay with us, and we also welcome further newcomers to our long-term program.

[Part II of this report, the catalog of observations, will be published in a subsequent issue.]

THE TOTAL LUNAR ECLIPSE OF JULY 6, 1982: A DARK AND ASYMMETRIC UMBRA

By: John E. Westfall, A.L.P.O. Lunar Recorder

General

A.L.P.O. members in the Americas are in a drought of total lunar eclipses, with the last favorable one on April 24, 1986, and the next such on August 17, 1989. Thus, it is appropriate to remind our readers that these events do occur, and to suggest the variety of observations that can be made of them. This report analyzes previously-unpublished observations of the total eclipse of the Moon on July 6, 1982. These observations were submitted by the following persons, to whom we are grateful:

Observer	Instrument(s)	Types of Observation
A.P. Abbott	Eye, 7X50 Binoc.	Notes.
F.G. Graham	35mm camera, 13-cm. Refr., 25-cm. siderostat.	Notes, 4 limb & 54 crater contact timings, photoelectric photometry, 6 photographs, 1 sketch.
W.H. Haas	Eye, 3X50 Binoc., 8-cm. Refr., 32-cm. Refl.	Notes, 3 limb & 15 crater contact timings, 9 magnitude estimates.
G.T. Nowak	7X50 Binoc., 11- & 32-cm. Refl's.	Notes, 2 limb contact timings, 2 magnitude estimates, 1 sketch.
J.E. Pearsall	20-cm. Refl.	Notes, 1 limb & 11 crater contact timings.
K. Rhea	10-cm. Refr., 15-cm. Refl.	Notes, 1 limb contact timing, 1 photograph.
T.J. Robertson	Eye, 7X50 Binoc., 15-cm. Refl.	Notes, 3 limb & 3 crater contact timings, 1 magnitude estimate, 4 photographs.
R. Robotham	Eye, 7X50 Binoc., 15-cm. Refl.	Notes, 3 limb contact timings.
G. Shearer	15-cm. Refl.	1 luminosity estimate.
J. Shearer	15-cm. Refl.	1 luminosity estimate.
K.& W. Simmons	Eye, 14X100 Binoc., 20-cm. Refl.	Notes, 6 crater contact timings, 3 magnitude estimates.
J.R. Smith	7X50 Binoc.	Notes.
D. Spain	Eye, 7X35 Binoc., 9-cm. Refl.	Notes, 3 magnitude estimates, 2 sketches.
R. Tatum	11-cm. Refl., 18-cm. Refr.	Notes, 1 photograph.
G.J. Waffen	7X50 Binoc., 11-cm. Refl.	Notes, 2 limb & 6 crater contact timings, 1 magnitude estimate.
R.J. Warren	8-cm. Refl.	Notes, 1 limb & 20 crater contact timings.
J. West	15-cm. Refl.	Notes, 13 crater contact timings.
J. Westfall	11X80 Binoc., 12-cm. f/6.3 Camera, 36-cm. Refl.	Notes, 91 photoelectric measures, 1 magnitude estimate, 37 photographs.
M. Will	Eye, 7X35 Binoc., 15-cm. Refl.	Notes, 20 magnitude estimates.

There was considerable interest in this eclipse because totality was expected to be very dark due to the widespread presence in the Earth's stratosphere of volcanic dust from the El Chichon volcanic eruption in Mexico in March-April, 1982. This was also a particularly favorable eclipse, at least for Western Hemisphere observers. The Moon's center passed only 3 arc-minutes south of the umbral center and the eclipse umbral magnitude was 1.722 (a magnitude greater than 1.00 indicates a total eclipse; the maximum value possible is about 1.87). Its 106-minute total phase was also the longest until the year 2000! The predicted times of the eclipse phases were:

Moon Enters Penumbra	04:22.2, 06 JUL 1982 U.T.
Moon Enters Umbra (1st Contact). . .	05:32.8
Totality Begins (2nd Contact). . . .	06:37.7
Middle of the Eclipse.	07:30.9
Totality Ends (3rd Contact).	08:24.1
Moon Leaves Umbra (4th Contact). . .	09:29.0
Moon Leaves Penumbra	10:39.6

The Penumbra

The observations of the penumbra that were submitted for the eclipse were mainly of the entering phase. Here, the chief interest was in determining when the pennumbral shading could be first detected, seven observers estimating this time. As with other lunar eclipses, there was a systematic difference in these timings, depending on the type of instrument used. The five telescopic estimates of the time of first sighting of the penumbra ranged from 04:31 to 05:23, with a median of 04:52, using 11- to 32-cm. apertures. The five naked-eye and binocular first sightings ranged between 05:00 and 05:24, and had a median of 05:10.

When the color of the penumbra was described at all, it was usually noted as grey, although Will, using binoculars at 05:32, described a brownish tone. Between 08:29 and 09:05 (shortly after the end of totality), he saw a bluish hue on the umbra/penumbra boundary. Will also perceived the innermost portions of the penumbra as greenish both just before and just after totality. Given the extreme darkness of the umbra, it appears unlikely that this was a contrast effect. If confirmed, this effect might be analogous in cause to the "green flash" sometimes seen at earthly sunrises and sunsets.

The Umbra: General Appearance

Besides extensive written notes, 4 drawings and 19 photographs showing the umbra were submitted. Naturally, the edge of the umbra was the first portion seen, and descriptions of the umbral edge disagreed somewhat. Haas saw the umbra/penumbra boundary as poorly defined, about 30-40 arc-seconds wide, and slate-grey in color. Waffen and Will agreed that the umbral edge was ill-defined, but Tatum saw it as sharp. Rhea described this feature as "irregular and jagged," while Will saw it as a medium yellow (binoculars) or reddish (telescope) zone perhaps 0.1-0.15 lunar diameter (i.e., about 200 arc-seconds) in width.

All observers agreed that the interior of the umbra was unusually dark, remaining invisible until well into the umbral phases. Generally, no detail within the umbra was noted until 06:06 to 06:28 (mean = 06:16; when the umbra covered about half the disk). As the eclipse progressed, faint warm hues began to be seen, but Haas described this event as "definitely the least colorful eclipse which I have ever seen," based on about 50 years of lunar eclipse observation. Similarly, both Robertson and Spain commented that they had never seen a darker eclipse.

The faint colors within the umbra were best seen during totality. It soon became evident to all who viewed it that the shading within the umbra was asymmetric. The northern half of the Moon was very dark ("barely visible") and most often characterized as grey or greyish-black. Only Waffen and Haas detected color in this zone, describing it as "dark maroon" and "brownish" respectively. The darkest portion of the shadow appeared to lie slightly west (IAU direction convention) of the Moon's north pole. At best, only the lunar limb and maria outlines could be seen in the lunar Northern Hemisphere.

In contrast, the southern portion of the Moon was considerably brighter than the northern, and warm colors were frequently reported for the southern highlands. This area's hues were variously described as "coppery," "faintly pinkish," "reddish-brown," "dull orange" or "copper orange," "pink to red," and "red-orange." The outer portions of the southern umbra were brighter and more orange or even more yellow than its interior. This brighter and more colorful zone moved along the Moon's limb from southeast to southwest (IAU) during the course of totality. The marked north-south difference in the Moon's brightness was surprising, given that the Moon passed very near the shadow center.

Observers' notes and sketches that described the umbra were confirmed by Westfall's series of 37 photographs, which were taken with a 75-cm. focal length lens (f/6.3) on Ektachrome 400 Film. Figure 13, below, shows the general appearance of the Moon during totality, based on these photographs combined with other contributors' sketches and verbal descriptions.

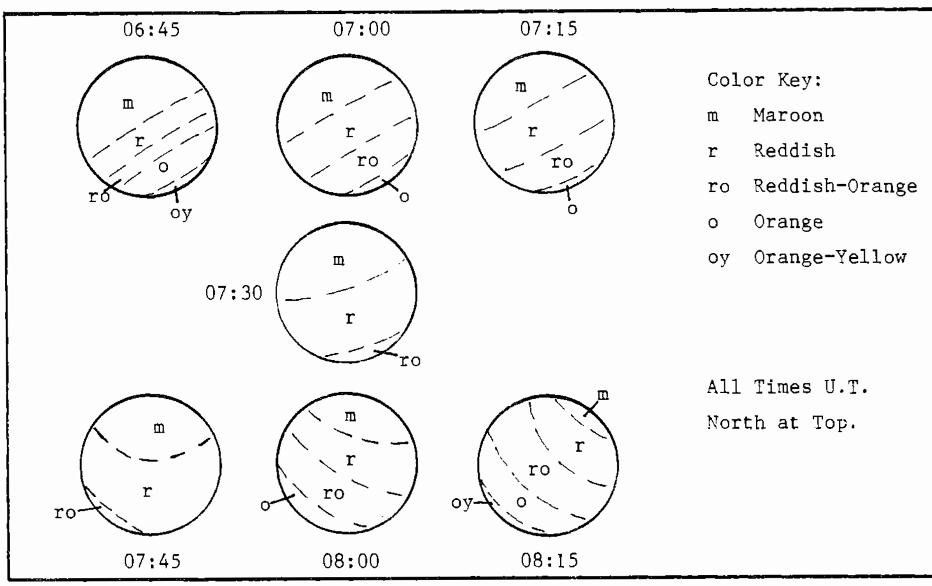

Figure 13. Sequential schematic drawings of the appearance of the Moon during totality for the total lunar eclipse of July 6, 1982.

Westfall conducted visual-band photoelectric photometry of the craters Anaxagoras, Copernicus, and Tycho throughout the penumbral and umbral phases of this eclipse. His results have been published previously (see References), but he did find, at mid-totality, that the Moon's center was only one-third, and the north limb only one-tenth, as bright as the south limb.

The Umbra: Luminosity and Stellar Magnitude

The eclipsed Moon's brightness can be described by either of two ways; its apparent integrated stellar magnitude, or its "Danjon Luminosity " (L ; both should refer to mid-totality). The latter is a subjective evaluation of the umbral brightness on a whole-number scale from 0 (darkest) to 4 (brightest). (For more precise definitions, see the A.L.P.O. Lunar Eclipse Handbook , listed in References .) Some 17 such estimates were made, with the following results:

L = 0 . . . 1 estimate	L = 1-1/2 to 2 . 1 estimate
L = 1/2 . . 3 estimates	L = 2. . . . . . 7 estimates
L = 1 . . . 2 estimates	L = 2-1/2. . . . 1 estimate
L = 1-1/2 . 2 estimates	

The mean of all 17 estimates was 1.46 $\pm$ .18 (" $\pm$ " means standard error throughout this report), falling between L = 1 ("Dark eclipse, grey or brownish coloration; details distinguishable only with difficulty.") and L = 2 ("Deep red or rust-colored eclipse, with a very dark central umbra and the outer edge of the umbra relatively bright."). The overall average, however, may not be very meaningful because most of the estimates fell into two distinct groups--seven with L = 1 ± 1/2 and seven with L = 2. This disagreement is probably due to the Moon's actual appearance as not resembling any of the Danjon-Scale definitions and also to the asymmetry between the Moon's Northern and Southern Hemispheres. L = 1 (or even 0) would fit the Northern hemisphere, while L = 2 would fit the Southern.

The Moon's apparent stellar magnitude, integrated over the entire disk, if carefully estimated, is a more objective measure of the darkness of a lunar eclipse. Here, 40 estimates were made by nine observers, who compared the Moon with bright stars by such means as the out-of-focus naked eye, and by viewing the Moon in reversed binoculars or as reflected in a convex mirror. These magnitude estimates, made throughout the eclipse, are plotted in Figure 14, below.

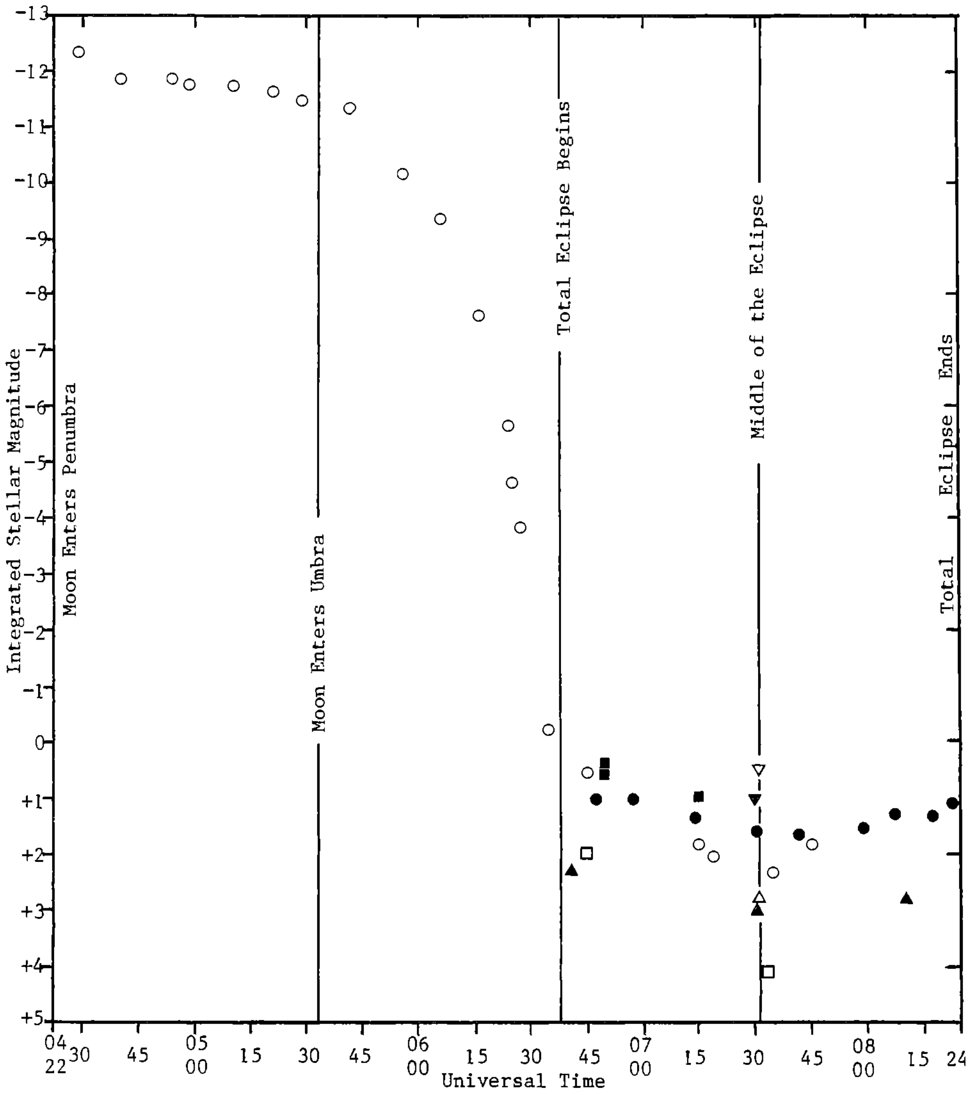

Figure 14. Nine observers' estimates of the stellar magnitude of the Moon during the total eclipse of July 6, 1982. Observer Key: ● Haas, □ Nowak, △ Robertson, ■ K. and W. Simmons, ▲ Spain, ▼ Waffen, ▽ Westfall, ○ Will.

Much of the magnitude variation in Figure 14 is due to actual expected changes in the Moon's brightness as the eclipse progressed. However, there is also considerable individual "scatter." Taking the seven estimates made within 10 minutes of mid-totality (i.e., from 07:21 to 07:41 U.T.), the Moon's mean stellar magnitude was +2.1 ± 0.4. When compared with full sunlight, this represents a dimming of about 14.7 magnitudes, or by a factor of 760,000!

At least in terms of Danjon luminosity, this was the darkest lunar eclipse since that of June 25, 1964 (when $\underline{L}$ = 0.3). It is interesting that the eclipse of July 6, 1982, was overshadowed only six months later by the extremely dark event of December 30, 1982, when the mean luminosity, $\underline{L}$, was 0.25 and the mean mid-eclipse magnitude +3.0.

Limb and Crater Contact Timings

A simple but scientificaly useful project for umbral lunar eclipses is to time the umbral contacts with the Moon's limb, together with prominent craters. These timings can then be used to calculate the amount by which the observed umbral radius exceeds that predicted by geometry; this excess is due to the effect of the Earth's upper atmosphere.

Seven observers timed the umbral limb contacts I - III, giving these mean times: I = 05:33.3 ± 0.4, II = 06:38.5 ± 1.0, III = 08:24.8 ± 0.5. Six persons timed a total of 68 crater contacts, only 4 of which had to be rejected due to crater misidentification. Their results are summarized below. For comparison, the results reported in Sky & Telescope magazine (see References), which used many more timings, are also given. (Note that some observers contributed to both reports.)

Type of Contact		No. of Timings	Umbral Enlargement	Sky & Telescope Results
Limb:	I	5	1.53 %	1.60 % (25 timings)
	II	7	1.02	1.02 (21 timings)
	III	3	2.79	2.24 (11 timings)
Entrance, 18 Craters		56	2.23 ± .22	2.02 ± .10(31 craters, 538 timings)
Exit, 8 Craters		8	2.89 ± .22	2.24 ± .13(16 craters, 159 timings)

The A.L.P.O. group agreed well with the larger group for limb contacts I and II, but reported somewhat greater umbral enlargement for contact III and for crater contacts. Taken together, an umbral enlargement of about 2.0 - 2.1 percent appears likely. This is not very different from most other eclipses, despite the unusually dark umbra of this event.

Occultations and Lunar Transient Phenomena

At the time of this eclipse, the Moon was located in a rich star field in Sagittarius, and several observers commented about background stars becoming visible as the Moon darkened. Four observers also noted that they witnessed stellar occultations. In only one case was the star clearly identified and an accurate time recorded; W. Simmons with the disappearance of 8th-magnitude SAO 187543 at 06:46:02.0, from Callahan, Florida (30° 30' 23" N, 81° 49' 28" W).

Only one possible LTP (Lunar Transient Phenomenon) was noted. Between 08:41 and 08:51 (i.e., after totality), D. Spain saw the interior and the surroundings of Gassendi as indistinct, becoming clearer after 08:51. Although seeing was then slowly deteriorating, Spain noted that nearby lunar features were distinct at the same time. Gassendi is a notorious LTP site, and it is unfortunate that there was no confirmation of this possible event.

Public Education

An important side effect of a total lunar eclipse is that it at least briefly interests the public in astronomy. Two observers made specific efforts in public education on the night of July 5-6, 1982.

Kermit Rhea and his colleague Kenneth Renshaw were interviewed by a reporter and a 5-column article on the lunar eclipse appeared in their local newspaper, illustrated by three photographs taken by themselves.

Working at the Buhl Science Center in Pittsburgh, Francis Graham and his associates sponsored a public observing night. The weather was largely clear, and about 250 persons arrived, observing the eclipse with 25- and 13-cm. refractors. One innovative touch was that of engaging the public in making some 54 crater contact timings. Each participant was rewarded with a lease to a lunar crater! Although their timings were not of scientific value, many lay-persons undoubtedly gained an appreciation of our Moon and of its observation.

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A.L.P.O. SOLAR SECTION OBSERVATIONS FOR ROTATIONS 1745 - 1747

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

General

This reporting period, covering 1984 02 05 to 1984 04 26, was characterized by moderate activity with several large regions per rotation. Collections of activity regions frequently stretched across major portions of the solar disk and were visible to the suitably-protected naked eye. These regions were internally most active in the earlier rotations and became less active later, though no less complex. In most cases, activity was well observed, although several regions went totally unnoticed by Section members.

The highest International Sunspot Number (R_I), 121, occurred in Rotation 1745 on 02/23, with the maximum American Sunspot Number (R_A), 123, on 02/11. The lowest R_I occurred in Rotation 1747, on 04/10 when the count was 12, while the lowest R_A of 7 was on 04/09. The closeness in dates of the highs and lows attests to the longitudinally-concentrated activity that was observed. [1-4]

In this report, all values were compiled using Bartels Cycle Day Numbers as published by the National Oceanic and Atmospheric Administration (NOAA) in Boulder, Colorado. [1-5] All dates and times are in Universal Time (U.T.), and activity regions will be referred to by their Space Environmental Services Center Numbers (SESC), assigned by NOAA, and refer to activity in all wavelengths. Relative directions will be designated P for preceding and F for following. Celestial directions will be N, S, E, W, NE, and so forth. For definitions of other terms used here, see our Handbook , available from the Recorder for $US 4. [6]

The observers who contributed data for this report are:

Observer	Telescope Aperture (cm.)	Telescope f-ratio	Telescope Type	Telescope Stop (cm.)	Location
Blackburn, N.	15	f/15	Refractor	--	Missouri, U.S.A.
Dragesco, J.	35.5	f/10	Sch.-Cas.	12	Benin, W. Africa
Hill, R.	20	f/10	Sch.-Cas.	10	Arizona, U.S.A.
Maxson, P.	20	f/10	Sch.-Cas.	15	Arizona, U.S.A.
Otero, J.	7.5	f/16	Refractor	?	Venezuela
Tatum, R.	17.8	f/15	Refractor	8.9	Virginia, U.S.A.
Timerson, B.	31.7	f/4	Newtonian	11.4	New York, U.S.A.
Young, S.	20	f/10	Sch.-Cas.	--	California, U.S.A.

Rotation 1745 (1984, 02 05.07 - 03 03.40)

Sunspot Number [1,2]	Mean	Maximum (date)	Minimum (date)
R_I	83.7	121 (02/23)	50 (02/18)
R_A	82.6	123 (02/11)	39 (02/17)

In this rotation, nearly all regions reached their maximum areas before central meridian passage. There were two large collections of regions, with few spots between them. The first collection consisted of SESC's 4408, 4410, 4411, 4412, 4413, and 4414 (4413 was probably 4393 from Rotation 1744 and 4414 had been 4392). The second collection comprised SESC's 4421, 4422, 4423, and 4426 (4421 was probably 4399 from Rotation 1744, 4422 was most likely 4403, and 4426 had been 4406). Figure 15, below, shows the disk during this rotation.

Figure 15. White-light solar photograph on 1984 FEB 24, 20:46 U.T., during Rotation 1745, near the time of the highest International Sunspot Number for this reporting period. Taken by N. Blackburn with a 15-cm. folded refractor, stopped to 7.5 cm., at prime focus using Kodak Technical Pan Film 2415. From E to W the SESC Regions are 4423, 4422, 4421, and 4420 at the southwest. See also text.

No high-resolution coverage was available for the first collection until 02/13. Because most coverage was whole-disk, activity can be discussed in general terms only. Complex and extensive faculae were observed near SESC 4410 by all observers. Even larger and more extensive faculae were noted near SESC's 4413 and 4414, especially by Young, and all were connected as seen on 02/06. The next day, these were brighter and, on 02/08 these regions stretched in an unbroken chain across more than two-thirds of the visible disk! By 02/09, all large spots had penumbrae, when the groups dominated the central two-thirds of the disk and were easily visible with the slightest optical aid. As the P regions began leaving the disk on 02/11, the large and extensive facular regions could be seen again. One of these regions, SESC 4413, was shown by Young to contain no less than one dozen umbral spots within a large penumbra. By 02/14, all observers reported large, bright faculae, decreasing in complexity and area as the collection was leaving the disk.

The second collection began to appear on the E limb on 02/17 while the last of the first collection left. SESC 4421 led the collection and was quite well developed as it came into view. Otero was the first observer to show one of these groups, on 1984 02 17 at 10:13 U.T. Eight hours later, Young noted extensive, bright faculae. On this date, SESC 4421 consisted of one spot, divided by a light bridge. By the next day the light bridge had subsided and the main spot consisted of over ten umbral spots in one penumbra, surrounded by large, bright faculae. From this time on, SESC 4421 decreased in area and complexity until it left the disk on 02/29. All the other regions in this collection decreased in size and complexity throughout their passage across the disk.

Rotation 1746 (1984, 03 03.40 - 03 30.71)

Sunspot Number [3]	Mean	Maximum (date)	Minimum (date)
R_I	80.8	117 (03/16)	42 (03/10)
R_A	80.9	120 (03/16)	43 (03/10)

Although this rotation did not quite reach the highest counts of the reporting period, it did have the most activity. The most interesting and best-observed area included a string of regions spanning half the disk, containing SESC's 4429, 4430, 4431, 4433, 4434, 4436, 4438, and 4442. Although these regions began to appear on 03/03, there was no good coverage until 03/11. While the smaller regions came and left this collection, the most long-lasting and stable regions proved to be SESC's 4429, 4430, and 4431, with 4433, 4436, and 4438 forming after central meridian passage.

Shortly after they came onto the disk, it was obvious that SESC's 4429, 4430, and 4431 were all declining. On 03/13, SESC's 4430 and 4431 both were round with some associated pores, while SESC 4429 was not circular, but was nonetheless declining and becoming more nearly round. By the next day, SESC 4429 was quite round, although by then SECS's 4430 and 4431 were too near the limb and too foreshortened to show any detail. When SESC 4429 left the disk on 03/15, it showed little activity and was reduced to a lone round spot.

SESC 4433 began on 03/13 as a quasi-circular grouping of about 40 umbral spots, many of which formed a cluster surrounded by a poorly-formed penumbra. By the next day, the group had consolidated into two mutually-perpendicular lines of spots. The P line was oriented E-W and contained three large umbrae with light bridges separating them. The F line was aligned N-S, with a larger concentration to the N and a rather isolated spot to the S. By 03/15, the P spots were divided by light bridges into three major clusters. One portion consisted of a detached penumbral fragment enclosing a few small umbral dots. The F line was also divided into three portions and had decreased in area. By 03/16, the detached penumbra in the P line had nearly totally dissipated while a light bridge continued to separate the other two sections. The F, N-S, line had diminished further in area but continued to maintain the same separation among its spots. A thin irregular chain of small umbra spots, pores, and detached penumbrae connected the N and S spots in the F line. When this region went behind the limb on 03/17, it was evident that both the P and the F portions had declined in area.

SESC 4438 formed on 03/14. The first detailed Solar Section observation of it was a Dragesco photograph on 03/15, when it contained chiefly pores and small umbral spots. An F spot was by far the largest and had a small penumbra. There was an explosion of activity on the next day, when the P and the F portions each contained a large spot with a penumbra and had many umbral spots and pores among them. The P spot was elongated E-W and had a penumbra on its P side. The F spot was cut in half by a light bridge but was still nearly twice the area that it had been on the previous day. On 03/17, the P spot had elongated by means of forming an umbral extension to the E, where there had been no penumbra on the day before. The F spot was beginning to show signs of dissolution, and the spots and pores between the P and the F spots were then consolidating into a larger spot. On 03/18, the last day of coverage and about one day before the region passed behind the limb, the P spot was becoming more nearly round and the F spot was breaking up and decaying. The new middle spot had developed a rudimentary penumbra, while new pores and umbral spots had formed in the area to the N between the P and F spots.

Rotation 1747 (1984, 03 30.71 - 04 26.98)

Sunspot Number [3,4]	Mean	Maximum (date)	Minimum (date)
R_I	63.3	113 (03/31)	12 (04/10)
R_A	61.9	119 (03/31)	7 (04/09)

This rotation was not as well observed as the two previous ones. Its main feature was SESC 4455, which came onto the disk on 03/27 (in Rotation 1746) and left on 04/08. This region was observed only sporadically between 03/29 and 04/02. The only other large region was SESC 4468, for which we had only whole-disk coverage. Figure 16, below, is a hydrogen-alpha photograph showing SESC 4455, along with the less-observed SESC 4454.

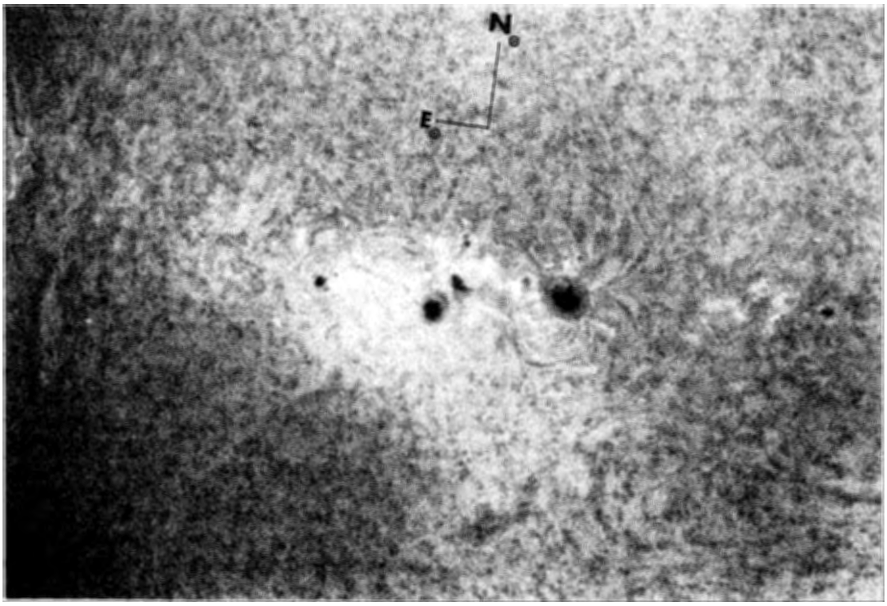

Figure 16. Hydrogen-alpha photograph of SESC Regions 4454 and 4455 on 1984 MAR 31, 16:16 U.T., during Rotation 1747. SESC 4455 is near the center, while the smaller SESC 4454 is near the west edge. Taken by R. Tatum with a 17.8-cm. refractor, stopped to 8.9 cm., with Barlow projection at f/60., on Kodak Technical Pan 2415 Film with a DayStar 0.7-Angstrom Filter. See also text.

SESC 4455 was located at L330S05 [longitude 330°, latitude 05° S]. In the previous rotation there had been no visible-light activity at this position. As Solar Section coverage began, this region was seen as two large, fairly symmetrical spots, with a rather disorganized collection of umbral spots sharing a rudimentary penumbra. Following this was apparently a portion of detached penumbra that had come from the F spot. On the next day (03/29; still in Rotation 1746), the two main spots had become more nearly round. The collection of spots in the middle was breaking up and moving closer to the F spot. Part of the F spot umbra had detached to the E but still remained within the penumbra of the parent spot. One day later (03/30), this detached umbra had become quite round. By then, the P spot was elongated E-W and was in the process of joining with some small nearby umbral spots. The umbra of the P spot was beginning to show signs of breaking up. Meanwhile, the F and middle spots were merging. There were many pores and umbral spots surrounding the F spot. The detached penumbral portion that was following the group had now become a true spot, forming a penumbra on its F side. The last day of Section coverage of this region was on 04/02, when the P spot's umbra and penumbra were breaking up. It is likely that a light bridge formed a day or two later. Almost all the pores and free umbral spots had disappeared. The F spot had merged with the middle spots and the largest of these could now be seen in the F spot penumbra. A small umbral spot to the E, outside the F spot penumbra, had formed a rudimentary penumbra of its own. The third spot, formerly a detached penumbra, was diminishing.

No other regions were studied in detail during this rotation, although there was whole-disk coverage to the end.

Any A.L.P.O. members wishing to join the Solar Section in observing, or simply desiring more information about the Section, are encouraged to contact the Recorder: Richard E. Hill, 4632 E. 14th St., Tucson, Arizona 85711, U.S.A.

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5.) Preliminary Report and Forecast of Solar-Geophysical Data, issues covering the reporting period.
6.) Hill, Richard E., The Handbook for the White Light Observations of Solar Phenomena. Revised April, 1984.

COMET NOTES: VII

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

Our comet column this issue was intended to celebrate the success of Comet Halley, but the recent death of Charles Capen overshadows our present thoughts.* In some ways "Chick" Capen was the essence of what the A.L.P.O. stands for, an organization intended to encourage excellence in observing by example and by teaching. Through his superb drawings of Mars, Chick set a standard to which planetary observers could aspire, and his frequent articles in the Strolling Astronomer about Mars, and more recently Comet Halley, offered clear and concise teaching of observational methods.

To lose an observer and teacher of the caliber of Chick Capen is a terrible blow to the A.L.P.O. We will miss his insights, both in print and at the many annual meetings that he attended. Most of all we will miss his sparkling and inspiring drawings of Mars. Let us mourn his death, but more importantly let us honor him by observing Mars this year with a devotion and quality that would be a credit to his memory.

The last few months have been the busiest ever experienced in the history of cometary science. In late January, Comet Halley was brightening rapidly as it closed in on the Sun. My last pre-perihelion observation was on the night of January 27/28, when at Tumamoc Hill near Tucson I recorded the comet in a one-second CCD exposure a few seconds before it set. When it reappeared a month later it was far brighter, with a striking gas tail and a dust tail with seven parts. Many of us will recall the stunning view of the naked-eye double star Alpha Capricorni, Beta Capricorni, and P/Halley nearby.

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* Also see our "Announcements" section on p. 223. Editor.

Then came the epochal week of spacecraft encounters in early March. Vega I and Vega II initially recorded hints of a nucleus shrouded in huge dust jets. The strengths of these jets, especially intense for the Vega I encounter and weaker for Vega II, were successfully predicted from a series of ground-based observations of the near-nucleus area by Stephen Larson et al. of the International Halley Watch. Also, one of the Japanese missions recorded a "breathing" hydrogen coma that appeared to confirm the 2.17-day nuclear rotation period determined by Zdenek Sekanina and Larson. The highlight of the encounters was clearly the Giotto Mission, whose famous images of the 15-by-8 km. nucleus, backlit by the jets, provided a major insight into our understanding of comets.

After the space encounters came travel of a more earthly nature, when many of us headed south for better views of P/Halley. Although the comet was brighter in March, it was much better placed for observation in April (at least in the Southern Hemisphere), and the fan-shaped tail complex, while shorter than predicted, was exciting to watch.

Then came the total lunar eclipse on April 24th, after most of the trips were over, during which some Australian observers reported a tail length of from 20 to 40 degrees. Partly as the result of a series of outbursts that took place during the last week in April, the eclipse observations heralded the fine show that Halley would put on during early May, with a long, straight tail stretching south of Corvus.

In early June, Halley quietly dipped below naked-eye visibility, leaving us with observations and memories. It was not a very bright comet, but it was bright enough for useful amateur work for a longer period than for any other recent comet. As it leaves the inner Solar System we wave a nostalgic farewell to an old friend.

OBSERVING METEORS: VII

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

With this issue we announce the appearance of the A.L.P.O. Meteor Observer's Guide, Observe-Meteors, by David H. Levy and Stephen J. Edberg. This is a guide to observing meteors through visual means, as well as by photography, spectroscopy, and radio. It is available from the Astronomical League Book Service, c/o Jerry Sherlin, 1001 S. Cornelia Street, Sioux City, Iowa 51106, for $ 5.50.

The purpose of this book is to encourage observers to enter the exciting field of meteor study, as well as to standardize the data that are reported to the Meteors Section. We hope that the book will inspire people to enter this field. By offering a choice of clearly-designed report forms, we hope to make their users comfortable with any of several methods of observing.

After a short chapter on "Historical Notes" and a meteor "Glossary," the guide offers descriptions of the major showers of the Quadrantids, Lyrids, Eta Aquarids, Delta Aquarids, Perseids, Orionids, Taurids, Leonids, and Geminids. The section that follows considers "The Meteor Observer," and suggests ways to make meteor observing pleasant and safe.

Other chapters consider visual, photographic, and radio observing procedures, and an "Appendix" offers suggestions on introducing meteors to school children. The book contains two lists of annual meteor showers, one basic and one advanced, as well as a "Foreword" by one of the best-known meteor astronomers, Peter Millman.

Preliminary reports indicate that the Eta Aquarids of 1986 were considerably stronger than normal. On the morning of maximum, May 5, 1986, J.V. Scotti and D. Levy reported 33 and 24 meteors respectively in one hour of watching, of which a number were bright and left trains. We encourage other observers of this shower to send their reports to the Section as soon as possible.

This summer's Perseid shower is well worth watching, especially because activity has fluctuated in recent years. [This shower will be at maximum on August 12th, and above one-quarter its peak rate between August 7th amd 17th. Ed.] Many, but not all, observers reported that the 1985 display was significantly poorer than in preceding years. Recent experiences with both the Eta Aquarids and the Perseids offer good examples that meteor observing is an activity full of surprises, an activity that rewards a careful, consistent observer.

TWO EASTERN-HEMISPHERE EVENTS IN FALL, 1986

Fall, 1986, will be a good time to be in the Eastern Hemisphere because people there will be able to watch a total lunar eclipse on October 17th and a transit of Mercury across the Sun's disk on November 13th. (All the dates and times in this article are in Universal Time ["U.T."]; position angles ["P.A."] are measured 0°- 360°, north counter-clockwise through east.)

Total Lunar Eclipse: October 17, 1986

This event will be of umbral magnitude 1.250, with the Moon's center at mid-eclipse just 16 arc-minutes north of the shadow center. The entire eclipse will be visible from eastern Europe, the eastern half of Africa, and all Asia except for its northeast. Only the early phases can be seen from Japan, northeastern Asia, Australia, and New Zealand, while only the later phases can be seen from the remainders of Europe and Africa, the eastern half of South America, the northeasternmost United States and Canada, Greenland, and Iceland. The predicted times of the eclipse phases on October 17, 1986, are:

Moon enters Penumbra . .	16:19.7 U.T.	Moon leaves Totality . .	19:55.2 U.T.
Moon enters Umbra. . . .	17:29.2	Moon leaves Umbra. . . .	21:06.7
Moon enters Totality . .	18:40.7	Moon leaves Penumbra . .	22:16.3
Middle of the Eclipse. .	19:18.0		

An idea of the types of scientifically-useful observations that can be made during a total lunar eclipse can be had from the report on the July 5-6, 1982, lunar eclipse on pages 207-212 of this issue. A copy of the A.L.P.O. Lunar Eclipse Handbook can be obtained, for $US 1.50, from Lunar Recorder Francis G. Graham, P.O. Box 209, East Pittsburgh, PA 15112, U.S.A.

Transit of Mercury: November 13, 1986

Transits of the planet Mercury across the Sun's disk occur only every 3-13 years. This November, the entire transit will be visible from southern and eastern Asia, Australia, New Zealand, and Antarctica. Ingress (the beginning) can be seen also from northeastern Asia, southwestern Alaska, Hawaii, and all but the easternmost Pacific Basin. Egress (the end) will be visible also from central and western Asia, eastern Europe, and Africa (except for its northwest). A similar Eastern-Hemisphere transit will occur on November 6th, 1993, but Western-Hemisphere observers won't see one until November 15th, 1999! The geocentric Universal Times of the transit events on November 13th, 1986, are:

Ingress, Exterior Contact. .	01:43.0	(P.A. 084°.9; Mercury first touches the Sun's limb).
Ingress, Interior Contact. .	01:44.9	(P.A. 084°.6; Mercury completely on the Sun's disk).
Least Angular Distance . . .	04:07.0	(Mercury only 7' 50".6 from center of the Sun's disk).
Egress, Interior Contact . .	06:29.1	(P.A. 322°.9; Mercury begins to leave the Sun's disk).
Egress, Exterior Contact . .	06:31.1	(P.A. 322°.6; Mercury completely off the Sun's disk).

The times above will vary by about ± 45 seconds depending on the observer's location. Mercury's disk will take about 115 seconds to enter and leave the disk of the Sun.

The apparent diameter of Mercury will be only 9".9, so at least a 50-mm. telescope used either with a safe full-aperture solar filter or with image projection will be needed to see it silhouetted against the Sun. One interesting experiment would be to time carefully the four contacts; when properly reduced, these can give approximate values for Mercury's diameter and for the difference between Universal Time and "Ephemeris Time" (the last based on atomic clocks). Appearances to watch for are the "black drop" effect at ingress and egress (an apparent teardrop-shaped outline of Mercury), a bright aureole surrounding Mercury, and a bright spot on Mercury's dark side. These all are probably psychological or instrumental illusions, but are interesting to see.

BOOK REVIEWS

[A sizeable backlog of book reviews awaits publication, and we feel it best to begin with the oldest. Thus this issue contains reviews of books that are several years old. Editor.]

Orbiting the Sun: Planets and Satellites of the Solar System. By Fred L. Whipple. Harvard University Press, 79 Garden Street, Cambridge, MA 02138. 1981. 334 pages, index, illustrations. Price $ 22.50 cloth, $ 7.95 paper (ISBN 0-674-64125-6).

Reviewed by Ron Doel

When the original edition of this book, then titled Earth, Moon, and Planets, appeared in 1941, the advent of spacecraft exploration still remained sixteen years distant. Pluto had been discovered only a decade before, and Miranda, the innermost major moon of Uranus, would not be found for another seven years. The past 1910 encounter with Halley's Comet was closer in time than its present one.

Fred Whipple has played a major role in the exploration of the planetary system for nearly a half-century. He has studied the atmosphere of Venus and the primitive, pristine bodies of the Solar System, in particular meteors and comets. This Harvard astronomer is best known for his "dirty snowball" model of comet nuclei. In Orbiting the Sun, it is thus fortunate that Whipple offers not merely a survey of what is now known about the planets, but narrates and discusses previous developments as well, giving some sense of the explosion of new data and of theories which have emerged in the planetary sciences.

This book, long a standard reference on the Sun's family, offers a pleasing mixture of observation and theory, including a number of intriguing digressions and discussions. After providing a narrative of the discovery of Neptune and Pluto, Whipple describes the Earth in terms of weights and measures, a novel and rewarding approach. He then tells about the identification of meteoritic impact features on the Earth's surface. Magnetospherics and geophysics are also treated in a clear, cogent section. A chapter on observing the Moon, in part written before it was studied from spacecraft, rests comfortably alongside a companion chapter called "The Nature of the Moon," which discusses the results from Apollo Misions and recent lunar science theories in detail.

The remainder of this work focuses on the other planets in the Solar System, individually and collectively. Whipple's extended treatment of Mars describes its geological and climatological characteristics, and argues that the dramatic wanderings of the Red Planet's axis of rotation could cause sudden, cataclysmic floods during periodic warmings of the polar caps. Studies of Jupiter's atmosphere over the last century are noted, and Whipple includes past photographs of Jupiter to illustrate, for different years, the enormous difference between zonal patterns and the appearance of semi-permanent features such as the Great Red Spot. Two final chapters compare the structure and development of planets and satellites, and review theories about the origin of the Solar System.

One drawback in the current paperback edition--not Whipple's fault--is the poor quality of several black-and-white illustrations, which prove embarrassing to this otherwise carefully-prepared Harvard Press edition. A number of helpful appendices are gathered at the end, including a partial almanac of planetary data and a star chart. Although these do not substitute for an observer's guide, they are far more helpful as a reference. The narrative chapters preceding them remain Whipple's most enduring contributions. With its new and updated harvest of information, this classic account still retains its usefulness and vitality.

High Energy Astrophysics and Cosmology. Edited by Jian Yang and Cisheng Zhu. Gordon and Breach, Science Publishers, 50 West 23rd Street, New York, NY 10010. 1984. 529 pages. Price $ 65.00 cloth (ISBN 0-677-31340-3).

Reviewed by Joel W. Goodman

High Energy Astrophysics and Cosmology is as imposing as it sounds. This volume is the Proceedings of a workshop held by the Academia Sinica of China and the Max Planck Society of West Germany in April, 1982, in Nanjing, China. The meeting was held for the purpose of promoting interaction between astrophysicists from those two countries, and only 4 of the 51 scientists attending were from other countries (i.e., Japan and the United States). The Proceedings include 41 articles on 9 subjects ranging from pulsars to compact stars, binary systems, accretion disks, black holes, quasars and galaxies, massive neutrinos and cosmology, and a miscellaneous category with a few contributions on such meaty topics as Cerenkov emission and synchrotron spectra. The treatment is highly mathematical and is clearly intended for the professional specialist. In view of this fact and the price of the book, it is unlikely to cause a stampede to the local bookstore by readers of The Strolling Astronomer .

The Moment of Creation: Big Bang Physics from Before the First Millisecond to the Present Universe. By James S. Trefil. Macmillan Publishing Company, 866 Third Ave., New York, NY 10022. 1983. Price $ 6.95 paper. [Also available from Charles Scribner's Sons, 115 Fifth Avenue, New York, NY, 10003. 1983. 240 pages, illustrations. Price $ 15.95 (ISBN 0-684-17963-6).

Reviewed by Clifford J. Cunningham

A master of analogy, Professor James Trefil brings this talent to bear on a range of complex concepts that form our current understanding of "Big Bang" physics. The origin of the Universe, its ultimate fate, and the subatomic particles that allow us to understand these cosmic issues are explained for the layman without the need for a refresher course in tensor calculus and topology.

The book is divided into three Parts. In Part One, Trefil covers the evidence for the Big Bang, our resulting estimate for the age of the Universe, and some problems with that theory. Part Two covers in some detail the particles that comprise the atom and the theoretical framework that is leading to a unification of the four known forces of nature. The concluding Part probes the conditions at the very beginning of the Universe and how it may evolve in the far future. For those who don't want to get "bogged down" in particle physics, Trefil has given a summary of each chapter in Part Two, but I recommend that the reader not skip the text in lieu of the chapter summaries.

Trefil's ability to explain difficult concepts is put to the test when he tackles spontaneous symmetry breaking. He succeeds by using an analogy with snowflakes, which do not change their appearance when rotated through 60 degrees, stating, "We say that the underlying symmetry of the atoms is broken when the atoms are assembled into a snowflake. Because this process occurs without any outside interference, we say the symmetry is spontaneously broken. Spontaneous symmetry-breaking is an extremely important concept because it shows that interactions that govern a particular phenomenon may actually be much more symmetric and more simple than the phenomenon itself."

In such a fast-moving field of research as particle physics, no book can be truly up-to-date; but the recent discovery of the Z-particle, which was predicted by a pivotal theory explained by Trefil, only reinforces the view that our insights into the origin of the Universe are on the right track. As a lucid explanation of what that "right track" is, Tefil's book will remain a useful standard for several years.

The Universe of Galaxies. Readings from Scientific American. Compiled by Paul W. Hodge. W.H. Freeman and Co., 41 Madison Avenue, New York, NY 10010. 1984. 8.5X11-in., 113 pages. Price $ 20.95 cloth (ISBN 0-7167-1675-5), $ 10.95 paper (ISBN 0-7167-1676-3).

Reviewed by David D. Meisel

Although not so well publicized as the revolution of our thoughts on planetary objects, the revolution of thinking about galaxies that has come about in the last few years is every bit as exciting and profound. As with other books in the Scientific American series, this one is written and edited by acknowledged experts in the field. All the articles in this relatively-thin volume are quite timely and well chosen. With the exception of the H-R diagram on page 9, which is virtually a blank grid in the review copy, the articles are well illustrated. In some cases, the legends of the figures contain additional information that is not repeated in the text, so readers are encouraged not to skip these in going through the book.

After a foreword by Paul Hodge, the compiler, the book begins with a masterful view of the Milky Way by the late Bart Bok. The scene then shifts to Hodge's essay on the Andromeda Galaxy where it is made clear that it and the Milky Way are twins only to the same degree that are the Earth and Venus! (Later in the book one can compare these two relatively-normal galaxies to the peculiar object Centaurus A, as described by Jack Burns and Marc Price.) The remaining articles cover general points rather than concentrating on single objects. Vera Rubin describes galaxy rotational characteristics, Steve and Karen Strom discuss disk-galaxy evolution, Alan and Juri Toomre describe tidal effects, and Roger Blanford, Mitchell Begelman, and the late Martin Rees speculate on the possible nature and origin of cosmic jets. The volume ends with two articles (one by Steve Gregory and Laird Thompson, the other by Pat Osmer) describing the structure of the early Universe as revealed by galaxies and quasars at the limit of present optical detection.

All these articles are well written and the whole set can be read in one evening, but I suspect that several of them will be tough going for the novice and some review of each article's content is recommended. In fact, I think that the entire volume is much more enjoyable if it is digested in small doses. One article per evening with some time for reflection in between is plenty! (If your knowledge of galaxies stopped some years ago when it was thought that one was dealing with relatively-placid objects, be prepared for some shocks.) This volume contains the usual brief bibliography for each article, should the reader want to explore a given topic in more depth.

All in all, I think that this volume provides an inexpensive way for the planetary enthusiast to get an accurate overview of a field in which the Solar System must find its ultimate context.

The Story of Astronomy in Edinburgh. By Hermann A. Brück. Columbia University Press, 562 West 113th Street, New York, NY 10025. 1983. 151 pages. Price $ 17.50 cloth (ISBN 0-85224-480-0).

Reviewed by Russell C. Maag

Hermann A. Brück, Regius Professor of Astronomy and Astronomer Royal for Scotland, traces the story of astronomy in Edinburgh from its beginning until 1975. This publication is intended to be of interest to the general public as well as to astronomers and historians of science. Dr. Brück completed the manuscript for publication following his retirement as Astronomer Royal for Scotland and for the 400th anniversary of the founding of the University of Edinburgh in 1583.

The book is divided into three parts, beginning with the early days of the town of Edinburgh, and the founding, first of the College and later of the University. The quaint life-styles of the townsfolk and of the students are discussed along with that of the academicians, especially in the Departments of Mathematics and of Astronomy. The Astronomy Department made great strides with the appointment of James Gregory in 1674, the first of the family of "academic Gregories," three of whom were to follow each other in the same Edinburgh Chair of Mathematics. James Short, one of Edinburgh's great telescope makers, had much to do with the instrumentation and the development of the first observatory on Calton Hill, where the major observatory complex exists today. He also built reflecting telescopes of the Gregorian design, using speculum metal, and described them as "by far the best of their lengths that have yet been executed," compared with others that he saw in England and several other European countries while on vacations. Charles Piazzi Smyth was one of the early influential Professors of Astronomy at Edinburgh, who later helped establish the famous Cape Observatory in South Africa. Professor Piazzi Smyth is also described as one of the original investigators of the astronomical reasons for the building of the Great Pyramid of Cheops at Giza, a fascinating account!

The second part of the book describes the new Royal Observatory from 1888 to 1957, which shows the rapid growth and achievements that this major observatory has had in terms of astronomy in general.

The third part considers modern times, new technologies, and the change and updating of equipment to meet the challenge of recent advances in astronomy. The Observatory's twin 16-inch telescopes with computerized controls, spectracon image recorders on the 36-inch telescope, a 16/24-inch Schmidt Camera, kinetheodolites for satellite tracking, and Skylark rocket instrumentation for space observations are all contributing to Man's eternal quest for finding the answers to the "Riddle of the Universe"!

This historical sketch shows that the Royal Observatory of Edinburgh differs from other national observatories of the nineteenth century in that for most of its time the chief interest of its astronomers has been physical, rather than positional, astronomy. Astrophysics, spectroscopy of the Sun and stars, and the pioneering and refinement of such analysis has had, and will continue to have, much influence upon our understanding of the physical parameters of stellar dynamics.

For students of the history of astronomy, this review of the great influence that national observatories have had upon astronomy is a must. There is much information packed into this book, coupled with a 4-page bibliography, and it is probably not overpriced for many astronomical institutional libraries.

NEW BOOKS RECEIVED

Notes by J. Russell Smith

The Voyages of Columbia: The First True Space Ship. By Richard S. Lewis. Columbia University Press, 562 West 113th Street, New York, NY 10025. 1984. 8.5X11-in., 223 pages, illustrations. Price $ 24.95 cloth.

Because this book is closely related to astronomy, it should be of interest to many of our readers. The contents are: "The Winged Space Ship," "Orphan of the Storm," "The Early Years: The Shuttle Shapes Down," "The Gold Over the Rainbow," "From Success to Failing," "The Great Skylab Rescue Mission," "Shield of Sand," "The Universe or Nothing," "Countdown," "Liftoff," "First Flight of a Used Spaceship," "Eight Days in March," "The Fourth Test," "We Deliver," "Epilogue," "Space Shuttle Flight Summary," "Notes", and "Index."

From Quark to Quasar. By Peter Cadogan. Cambridge University Press, 32 East 57th Street, New York, NY 10022. 1985. 10.5X10-in., 183 pages, illustrations. Price $ 24.95 cloth (ISBN 0-521-30135-1).

The contents of this book are "Introduction," "The Human Range," "Beyond the Earth," "The Stellar Range," "The Galactic Range," "The Biological Range," "The Invisible Range," and an "Overview." This is an excellent book.

1986 Yearbook of Astronomy. Edited by Patrick Moore. W.W. Norton and Company, 500 Fifth Avenue, New York, NY 10110. 1985. 8.25X5.5-in., 231 pages + notes on contributors. Price $ 15.95.

The first 65 pages contain star charts, followed by several pages on "The Planets and the Ecliptic," a chart of "Phases of the Moon 1986," "Longitudes of the Sun, Moon, and Planets in 1986," "Events in 1986," "Monthly Notes for 1986," "Eclipses in 1986," "Occultations in 1986," "Comets in 1986," "Minor Planets in 1986," "Meteors in 1986," and "Some Events in 1987." These are followed by an "Article Section" and a "Miscellaneous Section." I found this an excellent book.

Supernovae. By Paul and Leslie Murdin. Cambridge University Press, 32 East 57th Street, New York, NY 10022. 1985. 260 pages + index, illustrations. Price $ 24.95 cloth (ISBN 0-521-30038-X).

The authors cover their subject in the following chapters: "Supernovae in Space and Time," "Guest Stars," "The Renaissance Supernovae," "Supernovae in Other Galaxies," "The Crab and Its Mysteries," "Discovering Pulsars," "Supernovae Remnants," "Types of Supernovae," "The Making of a Neutron Star," "Supernovae in Binary Stars," "Creation of the Elements," "Cosmic Rays," "Black Holes from Supernovae," "Final Chapter," "Booklist," and the "Index." This is an outstanding book on this subject.

Jupiter. By Seymour Simon. William Morrow and Company, 105 Madison Avenue, New York, NY 10016. 1985. 32 pages, illustrations. Price $ 11.75 cloth (ISBN 0-688-05796-9).

This is an elementary book for the beginner who wishes to learn about our largest planet, and is well illustrated with many colored photographs.

Meteorites. Their Record of Early Solar-System History. By John T. Wasson. W.H. Freeman and Company, 41 Madison Avenue, New York, NY 10010. 1985. 267 pages + index. Price $ 34.95 cloth (ISBN 0-7167-1700-X).

The author covers his subject in the following chapters: "Meteorite Recovery. Fall Phenomena, Craters, and Orbit," "Composition and Taxonomy," "Ages, Isotopes, and Interstellar Grains," "Iron Meteorites: Evidence for and Against Core Origins," "Igneously Formed Silicate-Rich Meteorites," "Setting the Scene: Models of Solar System Formation," "Chronditic Meteorites as Products of the Solar Nebula," "Differences Between and Within Chrondite Groups: Evidence Regarding Nebula-Fractionation Processes," and "Relationship to Planets, Asteroids, and Comets: At What Solar Distances Did the Meteorites Form?" There are also nine Appendices and an index. If you are interested in meteorites you will wish this book.

NOTICE: DEATH OF CHARLES F. CAPEN

It is with much sorrow that we must announce that "Chick" Capen, longtime A.L.P.O. Mars Recorder and first recipient of our Walter H. Haas Observing Award, passed away suddenly at his home on May 28, 1986. Chick was one of the most respected, productive, and valuable of our organization's officers and his unexpected loss is a serious blow to all of us. As an example of his many contributions, note the first two articles in this issue. We intend that the next issue shall be a memorial to him, and shall contain articles by and about him.

As Chick left us, his favorite planet, Mars, was drawing closer. As we observe the Red Planet during this perihelic apparition we will be constantly reminded of the many contributions he made to its study. The work of the Mars Section is continuing under the leadership of Mars Recorders Donald Parker and Jeff Beish; Dr. Parker asks that, for the time being, Section correspondence be addressed to him.

ANNOUNCEMENTS

Further News Regarding 1986 A.L.P.O. Convention. --Our previous issue (p. 178) announced the 36th A.L.P.O. convention, to be held with the annual Astronomical League Convention in Baltimore on August 4-10. It is now confirmed that the A.L.P.O. will host a paper session on Thursday, August 7th, from 1 to 5 P.M. We will conduct our annual Business Meeting commencing at 7:30 P.M. the following day. Also, an A.L.P.O. Observing Workshop will be held on Saturday morning, August 9th, from 10 A.M. until Noon. We will display an exhibit and will present the 1986 Walter H. Haas Observing Award at the banquet on Saturday evening. A.L.P.O. members will also be interested to know that convention guest speakers include the well-known Ben Mayer, Dr. Michael Kaiser, speaking on the Voyager-2 Uranus encounter and Dr. John Brandt, an authority on comets. Please also note that the International Amateur-Professional Photoelectric Photometry Symposium will be held concurrently from 9 A.M. to 5 P.M. on Saturday, August 9th; those interested in this event should contact Blaine F. Roelke, 6700 Keysville Road, Keymar, MD 21757 (telephone: work 301-338-4924, home 301-235-2017).

Other Summer 1986 Events. --On July 12-17, the Astronomical Society of the Pacific will hold its 98th Annual Meeting in Boulder, Colorado, which will include a 3-day workshop on teaching astronomy in grades 3-12 and a series of nontechnical lectures. To find out more write: Summer Meeting Dept., A.S.P., 1290-24th Ave. San Francisco, CA 94122.

The fourth annual "Spaceweek" will occur on July 16-24, 1986. This event is a nationwide observance for the purpose of public education about the space program, including lectures and telescopic observing sessions. Information about this project can be had from: Spaceweek National Headquarters, P.O. Box 58172, Houston, TX 77258.

Staff Address Changes. --Please note that the address of our Founder/Director Emeritus, Prof. Walter H. Haas, has been changed to: 2225 Thomas Drive, Las Cruces, NM 88001. Also, Venus-Saturn-Lunar Recorder Dr. Julius L. Benton, Jr., has moved to: 305 Surrey Road, Savannah, GA 31410. All correspondence to them should go to the above addresses, also given on our inside back cover.

New Solar and Lunar Recorder. --Mr. Francis G. Graham, P.O. Box 209, East Pittsburgh, PA 15112, has been appointed as Solar Recorder (Eclipses) and also as Lunar Recorder (Eclipses and Photometry). In his Solar Section capacity, Mr. Graham will promote, coordinate, analyze, and report observations of solar eclipses. In the Lunar Section, he will perform the same duties for lunar eclipses, as well as promoting lunar photoelectric photometry, particularly as this technique applies to lunar eclipses, the Selected Areas Program, and the Lunar Transient Phenomena Program. Mr. Graham has conducted eclipse and lunar observations for many years, is the President of the American Lunar Society, and is currently completing his doctoral dissertation in the field of Planetary Science. Write him for more information, or to obtain copies of the Lunar Section publications A.L.P.O. Lunar Eclipse Handbook ($ 1.50) and Lunar Photoelectric Photometry Handbook ($ 4.00).

As a consequence of Mr. Graham's appointment in the Solar Section, all the Solar Section staff (i.e., Richard Hill, Paul Maxson, Randy Tatum, and Francis Graham) are now listed as "Recorders."

Erratum. --Mr. Jeff D. Beish, the principal author of the paper "Calculating Martian Polar Cap Latitudes," which appeared on pages 137-140 of our last issue, requests that the following note be added after the first paragraph on page 140: "Note that the above equations apply to the North Polar Cap ONLY! To calculate for the South Polar Cap , both sets of equations (8 and 9, and 10 and 11) are to be reversed and should be:

Before opposition: South Polar Cap

$$k' = \{(1 + \cos i)(1 + \cos I[S])\}/4, \text{ if } I[S]>0 \quad (8a)$$

$$k' = (1 + \cos i)/(1 + \cos I[S]), \quad \text{if } I[S]<0 \quad (9a)$$

After opposition: South Polar Cap

$$k' = (1 + \cos i)/(1 + \cos I[S]), \quad \text{if } I[S]>0 \quad (10a)$$

$$k' = \{(1 + \cos i)(1 + \cos I[S])\}/4, \text{ if } I[S]<0 \quad (11a)."$$

A.L.P.O. Membership/Subscription Status. --Occasionally, we receive inquiries from members concerning the date of expiration for their membership and subscription (the two are coincident). This information is given on the top line of the address label for our Journal ; e.g., "31.10" means the subscription will expire with Volume 31, Nos. 9-10. Also, a renewal notice is included with the issue of expiration. One should also remember that the normal membership/subscription period is by the volume , or about 18 months.

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NOTICE

In order to facilitate the reproduction of drawings in future issues readers are requested to exaggerate contrasts on drawings submitted. Extremely faint marks cannot be reproduced. Outlines of planetary discs should be made dark and distinct. It is not feasible to reproduce drawings made in colors. Following these precepts will permit better reproductions.

Persons requiring prompt acknowledgement of correspondence or contributed observations from staff members are requested to furnish stamped, self-addressed envelopes.

STAFF