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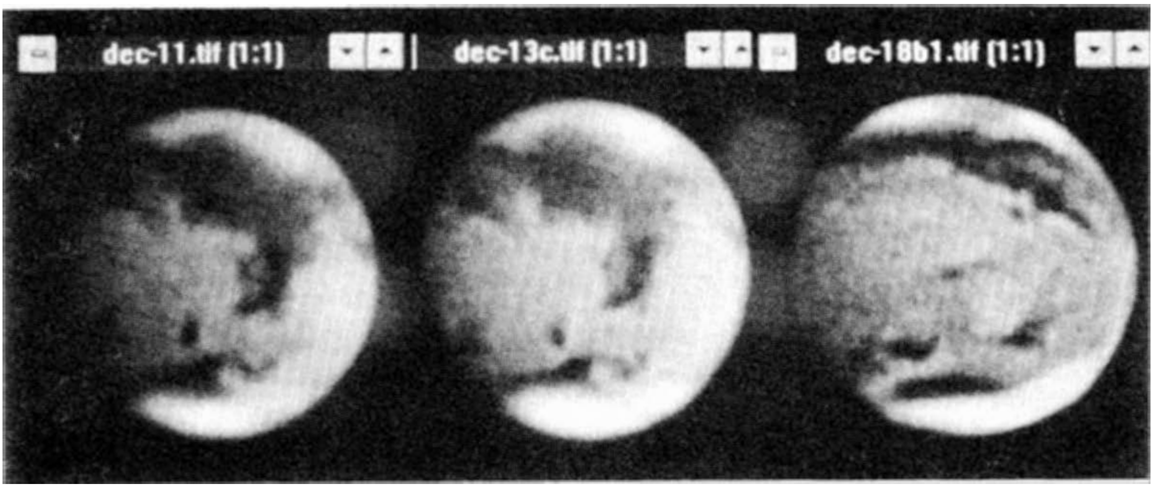

Three CCD images of Mars by Donald C. Parker. 16-in (41-cm) Newtonian telescope, f/48. The images are three-color composites (red, green, and blue). South at top; Martian west to the right. From left to right, data are: 1992 Dec. 11, 06h07m-06h13m UT, CM 268-269°; 1992 Dec. 13, 06h41m-06h54m UT, CM 258-261°; 1992 Dec. 18, 05h44m-05h50m UT, CM 200-201°. Mars' diameter was about 14" on these dates. The two left-hand views feature Syrtis Major to the right of center, and show a bright North Polar Cap (bottom) and blue-green clouds over Hellas (upper right). The rightmost image shows the Amazonis-Cebrenia region; note the Cerberus, Erebus, Styx, Chaos, and Hyblaeus "canals" below, and to the lower left and right of, center.

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In This Issue

THE APPARITIONS OF TWO FAINT COMETS

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

ABSTRACT

This report examines the apparitions of two faint, professionally discovered comets. Both comets were found as the result of near-Earth asteroid surveys. The first, Comet Shoemaker-Holt-Rodriquez, behaved normally. The second, Comet Helin-Roman-Alu, displayed an unusual brightness change.

COMET SHOEMAKER-HOLT-RODRIQUEZ (1988h = 1989 V)

DISCOVERY

On 1988 JUN 11.401 UT, the team of Henry E. Holt and Henry R. Holt (father and son) and Tim A. Rodriquez exposed a plate using the 0.46-m (18-in) Schmidt telescope on Palomar Mountain. About two weeks later, Carolyn Shoemaker examined the plate and discovered a short blurred streak; the sure sign of a comet. The object was also found on photographs exposed on June 12. The newly-found comet was then in the constellation Sagitta, at magnitude +14, and moving westward at a rate of 12 arc-minutes per day. **[1]**

This was Carolyn Shoemaker's 14th comet discovery; all of hers being photographic finds. With this comet, she had discovered more comets than anyone else in the Twentieth Century. This was the third named discovery for the Holts, and they have since found several more. As for Tim Rodriquez, this was his first and (so far) only discovery.

Because this was the eighth comet discovered or recovered during 1988, it was designated 1988h. [It was also the fifth comet to reach perihelion in 1989, and so received the additional designation 1989 V.] The year 1988 saw little comet activity; there were only 15 new comets discovered, most of them faint, and three returning comets recovered.

ORBIT

The initial orbit was calculated almost immediately, with a refined orbit calculated by Daniel Green of the SAO [Smithsonian Astrophysical Observatory] on July 19. The elements given by the latter **[2]** are:

Time of perihelion:	1989 JUN 12.480
Distance of perihelion:	2.47202 AU
Argument of perihelion:	232°.204
Ascending Node:	114°.572
Inclination:	097°.659
Eccentricity:	1.000 (parabolic)

The comet had a high inclination [technically retrograde] and did not approach the Sun closely. Perihelion occurred almost exactly one year after discovery. When it was discovered, the comet was unusually distant; 4.50 AU from the Sun and 3.95 AU from the Earth. [AU = Astronomical Unit; the mean distance of the Earth from the Sun; 149,597,870 km].

The comet subsequently moved south, entering the evening twilight by the end of 1988. In March, 1989, it emerged into the morning southern sky. It continued moving south, reaching a southernmost declination of -74° in late June, 1989. It then faded as it moved slowly northeastward among the stars.

Since this comet was best seen from the Southern Hemisphere, one would expect that the A.L.P.O. Comets Section would receive very few observations. However, the Australian Comet Section, a very active group of observers, submitted 21 visual magnitude estimates over the summer of 1989. In addition, we received a dozen observations from 1988.

MAGNITUDE

The veteran comet observer, author, and A.L.P.O. Member, Gary Kronk, analyzed the magnitude estimates. Correcting them for telescope aperture, he plotted both apparent and absolute magnitudes.

A comet's apparent magnitude is its brightness as it appears through a telescope. The absolute magnitude assumes a standard distance of 1.0 AU from both the Earth and the Sun. Because a comet is almost never at such a distance, we calculate the absolute magnitude from the following formula:

$$m = H_o + 5 \log D + 2.5\, n \log R,$$

where: m = apparent visual magnitude; H_o = absolute visual magnitude; D = Comet-Earth distance in AU; R = Comet-Sun distance in AU; and n = a parameter representing the rate the brightness changes as the comet-Sun distance changes. A high value represents a comet whose brightness changes rapidly.

Kronk determined the absolute magnitude, H_o, of Comet Shoemaker-Holt-Rodriquez to be +6.82±0.04. This is near the mean for all comets. The "n" figure was +2.9, which means that the comet did not vary much in its brightness as it approached and then moved away from the Sun. The mean n-value for all comets is about +3.5.

Figure 1 (p. 146) shows the apparent visual magnitude of Comet Shoemaker-Holt-Rodriquez over time, with estimates ranging from magnitude +11.0 to +14.0. *Figure 2* (p. 146) shows the comet's absolute magnitude, and has remarkably little scatter.

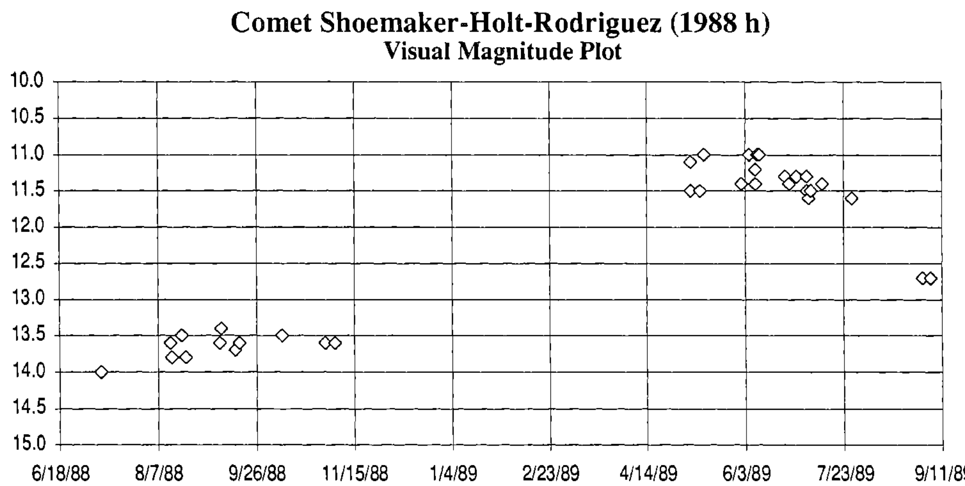

Figure 1. Visual estimates of the magnitude of Comet Shoemaker-Holt-Rodriquez in 1988-1989.

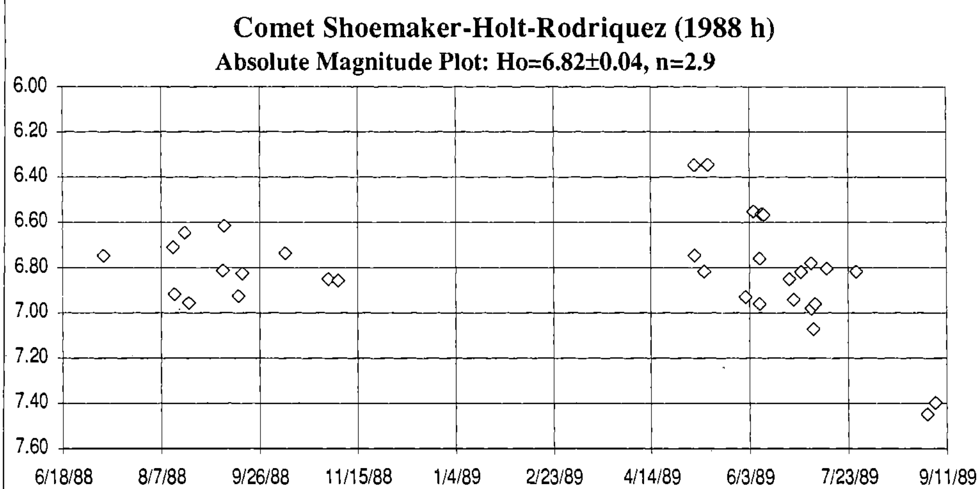

Figure 2. Computed absolute magnitude of Comet Shoemaker-Holt-Rodriquez in 1988-1989.

COMA SIZE

The size of a comet's head, or coma, is determined by knowing its apparent size and its distance from the Earth. Our observers reported a mean coma size of 150,000 km. While this may appear very large, remember that the coma is really a near-vacuum! As a final note, no tail was reported for this comet.

Now let's consider a second comet, one displaying a slightly different behavior than the one just described

COMET HELIN-ROMAN-ALU (1989v = 1989 XXI)

DISCOVERY

On October 2, 1989, Eleanor Helin reported the discovery of a new comet on photographs taken on 1989 OCT 01.339 UT. The photographs were taken by herself, Brian Roman, Jeff Alu, and R. Bambery with the 0.46-m (18-in) Schmidt telescope at Palomar Mountain. The comet was near opposition, at magnitude +14.5, and was moving west-southwest at about 1° per day. **[3]**

Eleanor Helin had already found several comets, and was to discover a total of five in 1989. Brian Roman shared her 1989 discoveries. This was Jeff Alu's first find, but he would discover two more with the same team later in 1989. This Near-Earth Asteroid Survey team found three comets in one month! This one was found on OCT 01; a periodic comet was discovered on OCT 02, and a second periodic comet was found on OCT 26.

Orbit

The orbit was calculated on October 12 by Dan Green of the SAO, with the following elements **[4]**:

Time of perihelion:	1989 Dec 15.820
Distance of perihelion:	1.05005 AU
Argument of perihelion:	067°.917
Ascending Node:	007°.794
Inclination:	046°.331
Eccentricity:	1.000 (parabolic)

This orbit placed the comet in the Northern-Hemisphere evening sky from its discovery through the end of 1989. It then entered the morning sky below the North Pole, with a minimum elongation from the Sun of 72° (1989 Dec 20). Through mid-March, 1990, the comet remained in the morning sky, reaching a northernmost declination of +65° in mid-February. In late March, it entered the evening sky and continued moving southward, pulling away from both the Earth and the Sun.

This comet was 0.53 AU from the Earth when found; close for a new discovery. This distance decreased to a minimum of 0.49 AU three weeks later. At discovery, the comet was 1.50 AU from the Sun, and this distance decreased to 1.05 AU at perihelion, about two and one-half months later, before increasing again.

All of the 66 observations that the A.L.P.O. received were made before the end of 1989. This was a very busy time for comet watchers, with at least four comets under observation at the time.

Magnitude and Coma Size

Gary Kronk analyzed the magnitude estimates for this comet as well. Eliminating four observations that were affected by moonlight, the remaining 62 observations yielded an absolute magnitude of +10.18, with n equal to +6.1.

His time graph of apparent magnitude is shown in *Figure 3* (below), and his absolute magnitude chart is in *Figure 4* (p. 148). He stated that:

> "The magnitude estimates were very consistent until October 29, when the comet seems to have distinctly brightened by about 0.7 magnitude. The brightness estimates remained relatively consistent until about November 21, when a fading set in that brought the absolute magnitude down by 0.5 magnitude by about November 30." **[5]**

Kronk added that this change was not due to the comet's proximity to the Earth, as it was on October 21, because the change took place a week later. This effect was also not due to observations being affected by moonlight, as the four such observations had been removed.

Kronk also pointed out that the comet remained diffuse in appearance until November 6. Then its aspect became harder to estimate, with some observers reporting it as condensed. A drawing by Don C. Pearce that shows its appearance on 1989 Oct 28 is given in *Figure 5* (p. 148).

As seen from Earth, the apparent coma size increased as it approached us, and then decreased as it pulled away. The actual size was computed consistently as 75,000 km. No tail was reported.

References

1. Central Bureau for Astronomical Telegrams. *International Astronomical Union Circular No .4618*. Issued June 25, 1988, by Brian Marsden.

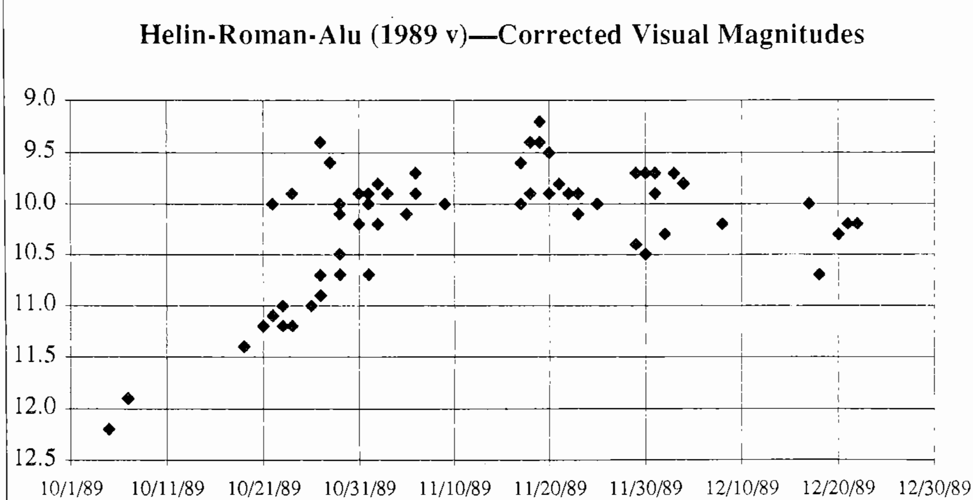

Figure 3. Visual estimates of the magnitude of Comet Helin-Roman-Alu in 1989

by Daniel W.E. Green.

3. *IAU Circular 4869*. Issued October 2, 1989, by Daniel W.E. Green.

4. *IAU Circular 4875*. Issued October 12, 1989, by Daniel W.E. Green.

5. Private communication by Gary Kronk, February 5, 1991.

Appendix Table: Participating Observers, Observing Sites, and Telescopes.

Comet Shoemaker-Holt-Rodriquez

Paul Camilleri	Victoria, Australia	20-cm reflector
Andrew Pearce	Scarsborough, WA, Australia	20-cm reflector
David Seargent	The Entrance, NSW, Australia	15- and 25-cm reflectors

Comet Helin-Roman-Alu

Paul Camilleri	Victoria, Australia	20-cm reflector
Jost Jahn	Rodenteich, Germany	20-cm reflector
Gary Kronk	Troy, IL, United States	33-cm reflector
Robert Modic	Richmond Heights, OH, United States	20-cm reflector
Gary Nowak	Essex Junction, VT, United States	20-cm reflector
Don Pearce	Bellaire, TX, United States	33-cm reflector
Jim Pryal	Kirkland, WA, United States	20-cm reflector
David Seargent	The Entrance, NSW, Australia	25-cm reflector

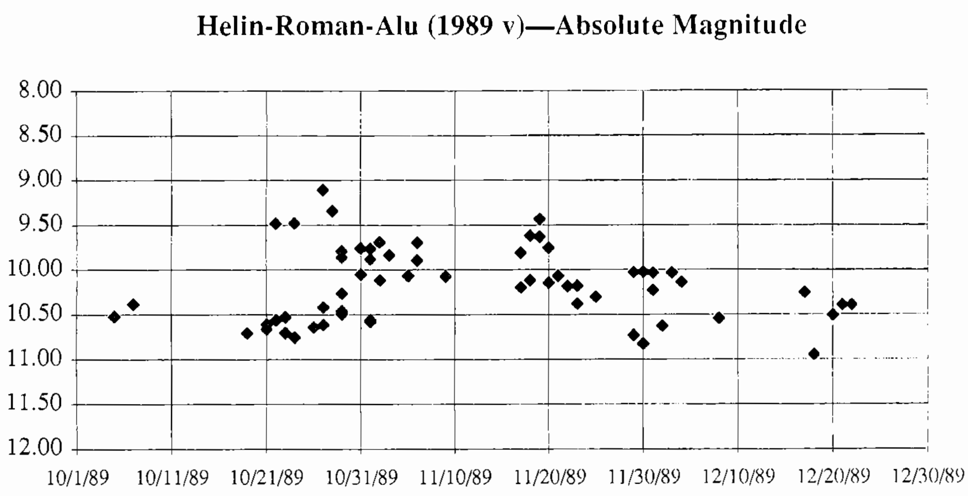

Figure 4. Computed absolute magnitude of Comet Helin-Roman-Alu in 1989

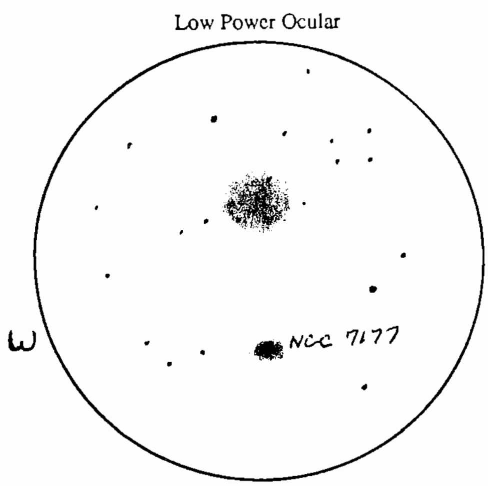

Figure 5. Drawing of Comet Helin-Roman-Alu (1989v) by Don C. Pearce, from Columbus, Texas 1989 Oct 28, 03h15m UT. 33-cm (13.1-in) reflector, 115X. The seeing was 7 on the A.L.P.O. scale, which ranges from 0 (worst) to 10 (perfect); the transparency was 4.9 on the A.L.P.O. scale of 0 (worst) to 5 (best). The field of view covers 43 arc-minutes, with the diameter of the comet's coma (above center) estimated as *ca.* 5 arc-minutes. Mr. Pearce also estimated the total visual magnitude of the comet as +10.1. Below center is the 11.1-magnitude Galaxy NGC 7177. South at top; simple inverted view.

COMET CORNER

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

PRESENT COMET ACTIVITY

Through the winter of 1992-93, only a few comets are visible. Please send your observations of them to the writer (address on inside back cover).

Periodic Comet Schwassmann-Wachmann 1.—This comet is in a nearly circular orbit at about 5 AU [1 Astronomical Unit equals the mean distance of the Earth from the Sun; 149,597,870 km] from the Sun. It is normally quite faint, but will occasionally outburst to magnitude +11 or +12. You may wish to monitor this comet. (See *Table 1,* below and top right column.)

Periodic Comet Schaumasse (1992x).—This comet has an 8-year orbital period. Its current visit is a favorable one, with the comet closest to the Sun at 1.2 AU on 1993 MAR 04. In February, 1993, the Earth will be within 0.6 AU of this comet. The path of this comet during February-March, 1993, is plotted in *Figure 1* on p. 150. (See *Table 2*, to the right.)

Periodic Comet Swift-Tuttle (1992t).—Recovered on 1992 SEP 27, this comet is responsible for the Perseid meteor shower. It was closest to the Sun on 1992 DEC 12. As 1993 opens, this comet is rapidly moving south in the evening sky and will soon be visible only to southern observers. Please send all your observations of it to the Comets Recorder. (See *Table 3*, to the right and on p. 150.)

EPHEMERIDES

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

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

1993 UT Date (0h UT)	2000.0 Coörd. R.A. h m		2000.0 Coörd. Decl. ° '		Elongation from Sun °		Total Mag.
FEB 02	05	13.0	+30	32	126	E	+17.4
07	05	12.4	+30	23	121	E	+17.5
12	05	12.0	+30	14	116	E	+17.5
17	05	12.0	+30	06	111	E	+17.5
22	05	12.4	+29	58	106	E	+17.6
27	05	13.0	+29	51	101	E	+17.6
MAR 04	05	14.0	+29	44	096	E	+17.6
09	05	15.3	+29	37	092	E	+17.6
14	05	16.8	+29	31	087	E	+17.7
19	05	18.7	+29	25	083	E	+17.7
24	05	20.8	+29	20	078	E	+17.7
29	05	23.1	+29	15	074	E	+17.8

(continued on top of right column)

Ephemeris of Periodic Comet Schwassmann-Wachmann 1—Continued.

1993 UT Date (0h UT)	2000.0 Coörd. R.A. h m		2000.0 Coörd. Decl. ° '		Elongation from Sun °		Total Mag.
APR 03	05	25.7	+29	10	069	E	+17.8
08	05	28.5	+29	06	065	E	+17.8
13	05	31.5	+29	02	061	E	+17.8
18	05	34.7	+28	58	057	E	+17.9
23	05	38.0	+28	54	052	E	+17.9
28	05	41.5	+28	50	048	E	+17.9
MAY 03	05	45.2	+28	46	044	E	+17.9
08	05	49.0	+28	43	040	E	+18.0

Table 2. Ephemeris of Periodic Comet Schaumasse (1992x).

1993 UT Date (0h UT)	2000.0 Coörd. R.A. h m		2000.0 Coörd. Decl. ° '		Elongation from Sun °		Total Mag.
FEB 02	03	45.3	+33	32	108	E	+8.8
07	03	54.3	+35	37	105	E	+8.6
12	04	05.6	+37	42	103	E	+8.4
17	04	19.6	+39	44	101	E	+8.3
22	04	36.6	+41	40	100	E	+8.2
27	04	55.4	+43	27	098	E	+8.1
MAR 04	05	17.5	+45	00	098	E	+8.1
09	05	42.3	+46	14	098	E	+8.2
14	06	09.4	+47	04	098	E	+8.3
19	06	38.3	+47	26	098	E	+8.4
24	07	08.2	+47	17	098	E	+8.6
29	07	38.3	+46	35	099	E	+8.8
APR 03	08	07.7	+45	23	100	E	+9.0
08	08	35.7	+43	42	101	E	+9.3
13	09	01.8	+41	39	101	E	+9.6
18	09	25.9	+39	17	102	E	+10.0
23	09	47.9	+36	44	103	E	+10.4
28	10	07.9	+34	03	103	E	+10.8
MAY 03	10	26.1	+31	18	103	E	+11.2
08	10	42.8	+28	34	103	E	+11.6
13	10	58.1	+25	52	103	E	+12.1
18	11	12.3	+23	14	102	E	+12.5
23	11	25.5	+20	42	101	E	+12.9
28	11	37.9	+18	16	100	E	+13.4

Table 3. Ephemeris of Periodic Comet Swift-Tuttle (1992t).

1993 UT Date (0h UT)	2000.0 Coörd. R.A. h m		2000.0 Coörd. Decl. ° '		Elongation from Sun °		Total Mag.
FEB 02	21	05.9	-35	21	019	E	+7.8
07	21	15.2	-37	19	022	E	+8.0
12	21	24.7	-39	16	026	E	+8.2
17	21	34.7	-41	12	030	E	+8.4
22	21	45.1	-43	07	034	E	+8.5
27	21	56.0	-45	04	038	E	+8.7

(continued on p.150)

Ephemeris of Periodic Comet Swift-Tuttle—Continued.

1993 UT Date (0h UT)	2000.0 Coörd. R.A. h m	Decl. ° '	Elongation from Sun °	Total Mag.
Mar 04	22 07.6	-47 01	042 E	+8.9
09	22 19.9	-49 00	046 E	+9.0
14	22 33.1	-51 01	050 E	+9.2
19	22 47.4	-53 04	054 E	+9.3
24	23 02.8	-55 08	058 E	+9.4
29	23 19.8	-57 13	062 E	+9.6
Apr 03	23 38.5	-59 18	066 E	+9.7
08	23 59.3	-61 21	070 E	+9.8
13	00 22.7	-63 20	073 E	+9.9
18	00 48.9	-65 13	077 E	+10.1
23	01 18.5	-66 56	080 E	+10.2
28	01 51.5	-68 25	083 E	+10.3
May 03	02 28.0	-69 36	085 E	+10.4
08	03 07.1	-70 36	088 E	+10.6
13	03 47.8	-70 52	089 E	+10.7
18	04 28.4	-70 54	091 E	+10.8
23	05 07.5	-70 33	092 E	+11.0
28	05 43.7	-69 55	093 E	+11.1

Those wishing to compute their own ephemerides for these three comets may use these orbital elements. [In order, they are: The UT date of perihelion passage, the perihelion distance, the argument of the perihelion, the longitude of the ascending node, the orbital inclination, and the orbital eccentricity.]

Value	Comet P/S-W 1	Comet P/ Schaumasse	Comet P/ Swift-Tuttle
T	1989 Oct 26.7	1993 Mar 04.1	1992 Dec 12.3
q (AU)	5.7718	1.2022	0.95812
ϖ	049°.897	057°.451	153°.013
Ω	312°.123	080°.386	139°.456
i	009°.367	011°.846	113°.430
e	0.04466	0.70487	0.96359

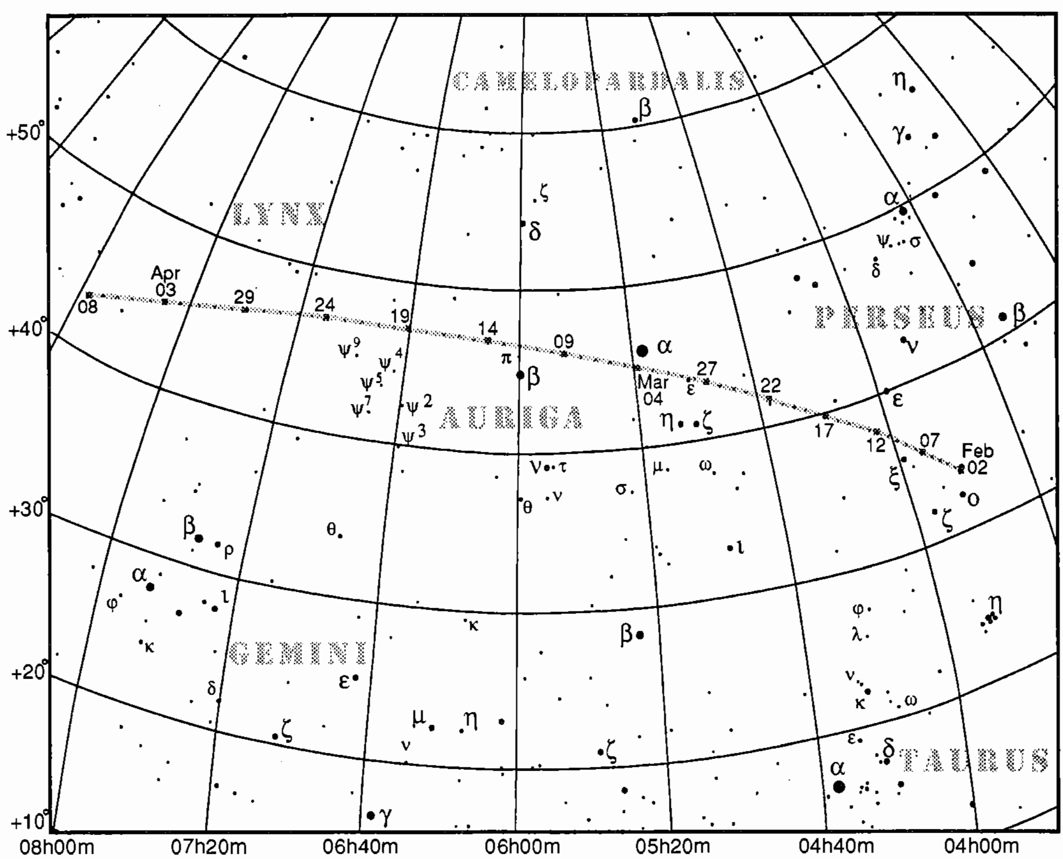

Figure 1. The path of Comet P/Schaumasse (1992x) in the evening sky, 1993 Feb 02-Apr 08. The limiting magnitude for the stars is +5.5 and the coördinates are Epoch 1993.2. The comet is plotted with a 1-day interval for 0h UT, with dates given every 5 days. If viewed in a dark sky, Comet Schaumasse should be a binocular object during this period.

A Sample Study of the Rotation of the 1990 Equatorial Zone Great White Spot on Saturn

By: Walter H. Haas, A.L.P.O. Director Emeritus

Abstract

A simple mathematical determination of the rotation period of the 1990 Great White Spot on Saturn is given as an example of a useful type of non-observing project. The data were 28 of my personal, visual central-meridian transits. The observed longitudes can be fitted well with *two* least-squares regression lines, implying an acceleration on or near 1990 OCT 24. The reduced period of rotation was 10h 13m 59.3s±2.9s for the interval 1990 OCT 04-24 and 10h 13m 29.5s±2.6s for the interval 1990 OCT 24-NOV 20.

Introduction

The Association of Lunar and Planetary Observers, as its name implies, is chiefly concerned with the *observation* of our Solar-System neighbors. Nevertheless, valuable research can be done by amateur astronomers without a telescope or any other sophisticated instrument. Einstein is said to have found pencil and paper sufficient equipment for his advanced studies. This article is intended as an example to our readers of a *non-observing* project: the mathematical determination from observed central-meridian transits of the period of rotation of the 1990 Great White Spot on Saturn. This example is not the definitive treatment of this problem, and it will serve its purpose if it motivates a few imitators.

All dates in this paper are given in Universal Time (UT).

The Observations

Near the end of September, 1990 there erupted in the Equatorial Zone of Saturn a large, brilliant, very conspicuous oval area. Its development and behavior have been described elsewhere **[1,2,3,4,5,7]**. Here attention will be limited to my personal, visual central-meridian transit observations of three points in the Great White Spot: the preceding end in longitude (celestial west or IAU east), the center, and the following end in longitude. In brief, observing the time when a feature is on the central meridian of longitude allows its own longitude to be computed **[8]**. There was a total of 28 such transit observations from 1990 OCT 03 to NOV 20, inclusive. The telescopes employed were 20-cm and 32-cm Newtonian reflectors. The magnifications used were chiefly 321× and 366×. Seeing conditions varied from poor to very bad because Saturn was at a declination of about -22° and thus crossed the meridian only 36° above the horizon at my observing site. Besides, the planet had been at opposition on 1990 JUL 14, well before my first observation on OCT 03.

Longitudes on Saturn will here be given in System I (IAU), which uses a sidereal period of rotation of 10h 14m 00s.

Mathematical Analysis

If the period of rotation of a feature is constant, then its longitude may be regarded as a function of time of the form:

$$Y(est.) = A + BX.$$

In our application, *Y(est.)* will be the estimated longitude by System I. *A* will be the System I longitude on a chosen arbitrary reference date of 1990 OCT 0.00 UT. *B* will be the change in longitude per day, positive when increasing; and *X* will be the number of days since 1990 OCT 0.00.

We are now ready to consider fitting the observed longitudes with a regression line, or "least-squares line." We may regard each observation as a plotted point on a graph that shows observed longitude as a function of time. We shall assume that the error of observation is wholly in the observed longitude. The purist may object that the error in longitude results from an error in the observed time, but the numerical effect of time errors in our analysis is completely negligible. Then the deviation of each observed longitude from the fitting line becomes a residual, *r*, defined as:

$$r = Y - Y(est.),$$

where *Y* is the observed longitude, so that

$$r = Y - A - BX.$$

Using the principles of the calculus, we shall compute the A and B coefficients to make the sum of the squares of the observational residuals a minimum. Incidentally, we shall give each observation the same weight of unity. A measure of how well our regression line fits the observations will be given by the standard deviation, *s*, given by:

$$s = \left\{ \frac{\sum_{i=1}^{n} r_i^2}{(n-1)} \right\}^{\frac{1}{2}}$$

where *n* is the number of observations.

Table 1 (p. 152) presents the results of fitting a straight line to all the accepted observations of each feature; namely, the preceding end, the center, and the following end of the Great White Spot. Two observations were re-

Table 1. Rotation of 1990 Great White Spot (GWS) on Saturn assuming constant period of rotation.

Feature	Terminal Dates (1990, UT)	No. of Obser.	A (System I Longitude, Oct 0.00 UT) ° °	B (Daily Change in Sys. I Long). ° °	s (Std. Dev.) °	Period of Rotation
Prec. End GWS	OCT 04-OCT 30	7	311.87 ±3.25	-0.42 ±0.16	±3.64	10h13m41.8s ±7.1s
Center GWS	OCT 04-NOV 11	9	339.07 ±1.78	-0.34 ±0.07	±2.54	10h13m45.2s ±3.1s
Foll. End GWS	OCT 04-NOV 20	10	001.87 ±1.73	-0.31 ±0.06	±2.74	10h13m46.3s ±2.7s

jected; one of the preceding end on 1990 OCT 03 and one of the following end on 1990 NOV 14, based on large deviations from the regression line, very poor conditions of observation, or both. The results of the regression are shown graphically by the three broken lines in *Figure 1* (p. 154).

The columns in *Table 1* should be largely self-explanatory. The terminal dates are those of the first and last accepted observations of a feature. The A-coefficient of the computed regression line is the longitude on the reference date (1990 OCT 00.00), and the B-coefficient is the change in longitude per day. This change in turn determines the period of rotation. Finally, the "±" quantities are standard deviations, computed for A and B by standard statistical methods **[6]**.

EVIDENCE FOR AN ACCELERATION IN LATE OCTOBER

The fitted straight line assumes a constant period of rotation for each of the three features. But is this assumption the best interpretation of the observations? One may think next of a regression parabola, which assumes a constant change in the period of rotation. Still, the plotted points in *Figure 1* give little encouragement for this idea. Yet may our plot suggest a change, or acceleration, in the rotation on or near 1990 OCT 24? Accordingly, I computed separate least-squares lines for the observations up to and including 1990 OCT 24 and for the ones on that date and later. The results appear in the columns of *Table 2* (below) and are plotted as the solid lines in *Figure 1.*

We would now like to specify the rotation of the Great White Spot as a whole, and it appears reasonable to assume that it did rotate as a whole over the interval 1990 OCT 04-NOV 20. For observations up to and including OCT 24 we shall simply average the period of the three points observed (see *Table 2*). For observations from OCT 24 onward we shall average the values for the center and the following end, ignoring the preceding end as it was observed only three times (see *Table 2*) and had become very ill-defined. The results for the rotation periods are:

OCT 04-OCT 24: 10h 13m 59.3s±2.9s
OCT 24-NOV 20: 10h 13m 29.5s±2.6s.

Again, the "±" quantities are standard deviations. [The 29.8-second difference between the two rates is 7.65 times their combined standard deviation, showing that this difference is highly significant. Ed.]

A very similar acceleration for the Spot's center was noted by Heath and McKim on a reported date of 1990 OCT 21 **[4]**. Their published date actually should have been OCT 24, in surprising agreement with the work discussed in this paper **[10]**. However, this evidence is not really independent because all the post-OCT 26 observations in their data set were made by me.

The idea of an acceleration on or near 1990 OCT 24 may receive incidental other support. A number of drawings and photographs taken between 1990 OCT 02 and 08, inclusive, show the north preceding side of the Great White Spot extending well into the south edge of the North Equatorial Belt **[1,2,4,5,7]**. This dark belt was then the most conspicuous belt on the planet and was located near the middle of the disk.

It then becomes interesting that visual estimates by myself and a few others of the latitude of the North Equatorial Belt show that

Table 2. Rotation of 1990 Great White Spot (GWS) on Saturn assuming an acceleration of rotation on 1990 OCT 24 and constant periods before and after.

Feature	Terminal Dates (1990, UT)	No. of Obser.	A (System I Longitude, Oct 0.00 UT) ° °	B (Daily Change in Sys. I Long). ° °	s (Std. Dev.) °	Period of Rotation
Prec. End GWS	OCT 04-OCT 24	5	308.52 ±2.35	-0.08±0.15	±2.20	10h13m56.6s ±6.6s
Prec. End GWS	OCT 24-OCT 30	3	357.99±24.84	-2.11±0.91	±2.72	10h12m27.8s±39.9s
Center GWS	OCT 04-OCT 24	5	334.99 ±0.56	+0.05±0.04	±0.55	10h14m02.4s ±1.8s
Center GWS	OCT 24-NOV 11	5	352.39 ±2.89	-0.74±0.09	±1.10	10h13m27.7s ±3.8s
Foll. End GWS	OCT 04-OCT 19	5	357.66 ±1.09	-0.02±0.09	±0.92	10h13m59.0s ±4.0s
Foll. End GWS	OCT 27-NOV 20	5	015.28 ±1.84	-0.66±0.05	±0.80	10h13m31.3s ±2.1s

it shifted northward by, say, 10-12° from about OCT 03 to about OCT 30 [**3**]. Was the expanding Spot forcing the Belt northward? One would, of course, prefer to confirm the latitude change with measures of photographs and CCD images; and further study of this matter is planned. Even so, it is tempting to relate an acceleration of the Spot with the ending at about the same date of a northward drift of the North Equatorial Belt.

Also, studies of the rotation period of the similar 1933 Great White Spot on Saturn by Rowland and Peek revealed a similar shortening of the rotation period with the passing of time and probably even a similar sudden acceleration [**9**].

CONCLUSION

It must be stressed that this paper is only a preliminary treatment of the rotation period (or periods) of the Great White Spot. The ideal method would be to combine all data from all observers; including drawings, photographs, and CCD images. Indeed, at least two determinations based upon a larger data set than is here used have already been published [**4,5**]. However, combining longitude determinations made by different observers, obtained with different methods, or both, is not simple. Difficulties will arise due to varying resolution of the structure of the Spot; and, even more troublesome, questions will come up as to what reference point is being used. In fact, the two determinations just cited differ by more than 40 seconds in their rotation periods—10h 13m 45s versus 10h 14m 28s—probably because of the choice of different reference points.

Finally, let me hope that the time spent upon this paper will be as useful as if it had been spent at the eyepiece.

ACKNOWLEDGEMENTS

It is a pleasure to thank Dr. John Westfall for preparing the Spot's drift chart for publication and Mr. David De Poister for providing some mathematical materials.

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Appendix: Central-Meridian Timings of Great White Spot on Saturn by Walter H. Haas

UT Date 1990	Long. (I)	Telescope, Mag.	S/T
	Preceding End		
OCT 03, 05:13?	318°.0	32-cm Rl., 303×	1-2/2.5
OCT 04, 01:29	310°.9	32-cm Rl., 366×	3-4/4.5
OCT 06, 04:31	306°.0	20-cm Rl., 203×	2/1-3
OCT 15, 03:28	306°.7	32-cm Rl., 321×	2-3/2.5
OCT 18, 03:04	305°.2	32-cm Rl., 321×	2-3/2.5
OCT 24, 02:27	308°.6	32-cm Rl., 321×	3/2.5
OCT 27, 01:47	297°.6	32-cm Rl., 321×	3-4/3.5
OCT 30, 01:23	296°.0	32-cm Rl., 321×	3/3.5
	Center		
OCT 04, 02:11	335°.5	32-cm Rl., 366×	2-4/4
OCT 07, 01:48	334°.6	32-cm Rl., 366×	3-5/4
OCT 10, 01:28	335°.5	32-cm Rl., 321×	3-4/3.5
OCT 13, 01:08?	336°.4	32-cm Rl., 321×	3-5/3.5
OCT 24, 03:14	336°.1	32-cm Rl., 321×	2-3/3
OCT 27, 02:44	331°.0	32-cm Rl., 303×	2-3/3
OCT 30, 02:20	329°.5	32-cm Rl., 321×*	2-3/3
NOV 05, 01:31?	325°.6	32-cm Rl., 321×	2-4/3.5
NOV 11, 00:42?	321°.8	32-cm Rl., 321×	3-4/4
	Following End		
OCT 04, 02:50	358°.4	32-cm Rl., 321×	3-4/4
OCT 07, 02:26	356°.9	32-cm Rl., 366×	2-4/4
OCT 10, 02:05	357°.2	32-cm Rl., 321×	3/3.5
OCT 13, 01:47	359°.2	32-cm Rl., 321×	3-4/3.5
OCT 19, 01:02?	357°.8	32-cm Rl., 321×	3-4/3
OCT 27, 03:29?	357°.4	32-cm Rl., 303×	1-2/2.5
OCT 30, 03:06?	356°.4	32-cm Rl., 285×	2/2.5
NOV 05, 02:13?	350°.3	32-cm Rl., 321×	2-4/3
NOV 11, 01:26?	347°.6	32-cm Rl., 321×†	3/3.5
NOV 14, 00:47?	337°.2	32-cm Rl., 321×	3-4/3.5
NOV 20, 00:13?	342°.1	32-cm Rl., 321×	3/3.5

Notes:

? = transit timing considered to be of lower reliability when the observation was made;
Rl. = Newtonian Reflector;
* = also 285×; † = also 366×.
S/T = Seeing/Transparency; Seeing estimated on a scale of 0 (worst) to 10 (perfact); Transparency estimated as the naked-eye, dark-sky limiting stellar magnitude.

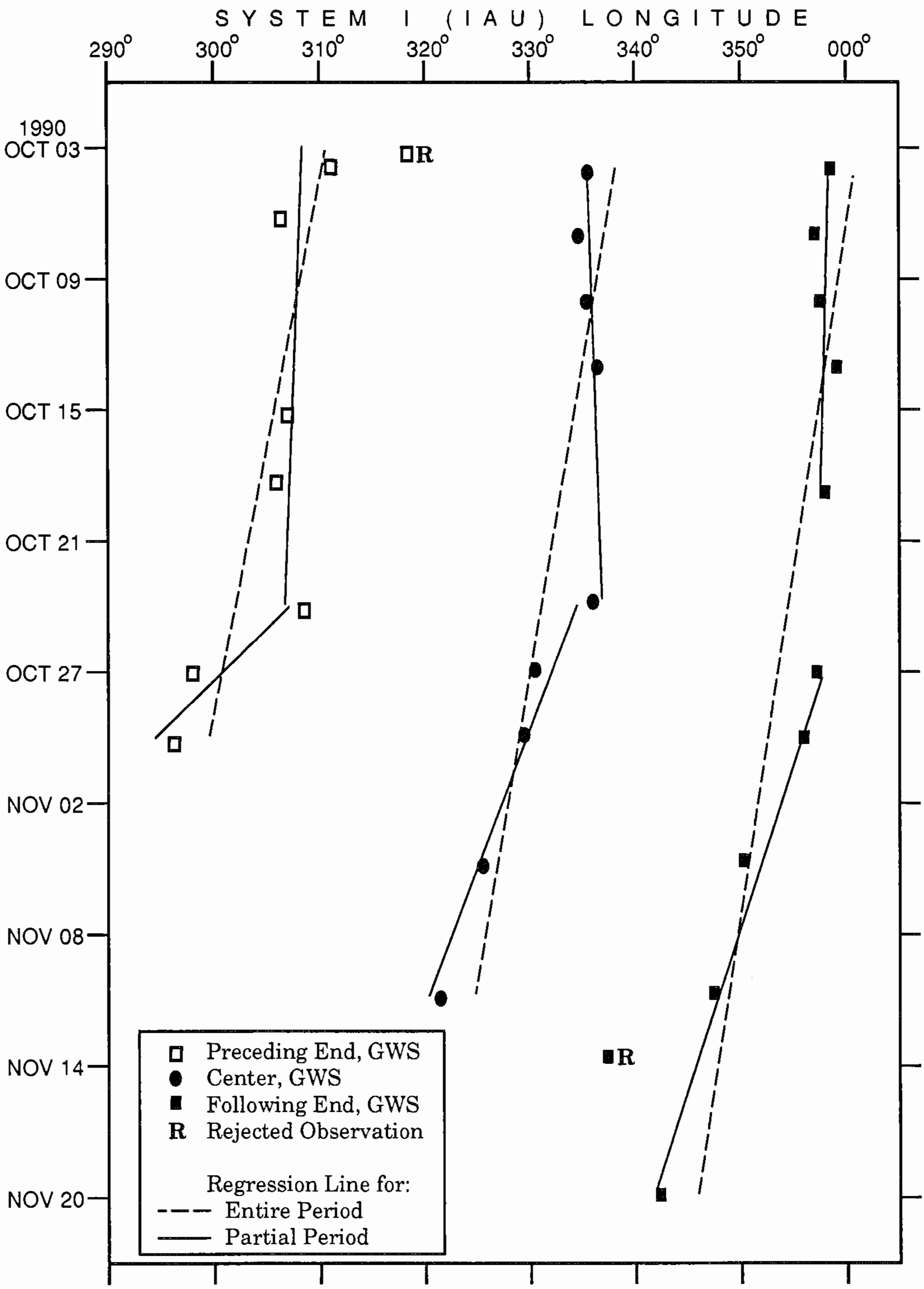


Figure 1. Drift chart of the 1990 Great White Spot (GWS) on Saturn, showing System I (IAU) longitude versus time. The broken lines are regression lines for assumed constant periods of rotation for each feature. The solid lines assume an acceleration on 1990 Oct 24 with constant but different periods before and afterward. See also the text and *Tables 1* and *2*.

GETTING STARTED: CENTRAL-MERIDIAN (CM) TIMINGS OF SATURNIAN ATMOSPHERIC FEATURES

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

Note by Editor: The techniques described below are applicable, not only to Saturn, but to any other planet that has visible surface or atmospheric features and whose rotational period is known. For many years, central-meridian timings have been among the amateur's most valuable contributions in the study of Mars and especially Jupiter. For their applicability to the planet Saturn, see also the article by Walter H. Haas, "A Sample Study of the Rotation of the 1990 Equatorial Zone Great White Spot on Saturn," on pp. 151-154 of this issue. (Paragraphs added by the Editor to help explain general concepts are marked ¶.)

SATURN'S GREAT WHITE SPOT

Considered solely as a globe, there is no doubt that Saturn is a somewhat smaller, dimmer, and relatively quiescent replica of the giant Jupiter. Of course, with its symmetrical Ring System, Saturn emerges as an object of exquisite and unsurpassed beauty. It is inescapable, though, that discrete phenomena in the atmosphere of the planet are rare and usually much less distinct than features seen on Jupiter. Saturn holds a certain kind of attraction for many individuals, however, particularly those who enjoy the challenges of persistent and meticulous visual observations.

Visual observers have come to recognize that their greatest potential for making important contributions to planetary science lies in systematic, simultaneous, and extended observations of variable phenomena at the surfaces and in the atmospheres of moons and planets. On Saturn, when atmospheric features are visible, they are transient, ill-defined, and typically do not lend themselves to successful photography. The persevering observer can take advantage of intermittent times of good seeing, and he or she can record smaller and more delicate details than normally can be captured on film. These are the kinds of individuals who follow Saturn as part of the observing programs of the A.L.P.O. Saturn Section. While they are not necessarily large in number, the dedication, stamina, and enthusiasm they demonstrate, apparition after apparition, is superlative.

The 1990 Apparition of Saturn began no different from many of the past observing seasons. Subtle changes were registered in the intensity of various belts, zones, and Ring components. Observing results were filed for thorough comparative and analytical studies at the end of the apparition by the A.L.P.O. Saturn Section. However, in late September, 1990, observers got a real surprise. In the planet's Equatorial Zone (EZ), for the first time in nearly six decades, a truly spectacular white spot appeared. Saturn's appearance had dramatically changed, even with apertures as small as 5.0 cm (2.0 in)! Walter Haas, the Director Emeritus of the A.L.P.O. and a veteran Saturn observer, said ".. the bright EZ oval now present is the brightest and most conspicuous feature I have ever seen." Haas has been observing Saturn over the interval from 1933 to the present, and his opinion that this was the most spectacular outburst recorded in the EZ since 1933 was confirmed when A.L.P.O. records dating back to 1947, and other records such as B.A.A. data, were examined.

The eruption of activity on Saturn was not totally unexpected, however. Visual observing records maintained by the A.L.P.O. Saturn Section have demonstrated variations in belt and zone intensities related to Saturn's seasons. The emergence of the Great White Spot (GWS) of 1990 fits into a pattern of previous EZ spot activity at intervals of nearly 60 years. [Very likely linked to twice Saturn's 29.5-year period of revolution around the Sun. Ed.]

The historical data suggest a model of spreading, differentiation, and fading of the White Spot over several weeks following the initial observation of the feature. Preliminary results indicate that this is precisely what happened to the Great White Spot during much of October, November, and December, 1990. Originally, the Spot's center was situated at about Saturnian System I longitude 335°, with a length of about 20-25°. However, by mid-October the spot had declined slightly in brightness and had increased its length to 80°. By early November, the Spot had so elongated along the EZ that it almost circled Saturn at that latitude. Also, fulfilling expectations, smaller white spots appeared in the EZ at CM I longitudes 30° and 70°. The emergence of these "secondary" features accompanied a noticeable darkening of other Saturnian zones north of the EZ. The North Equatorial Belt (NEB) adjacent to the EZ did not appear quite so dark as it formerly had, following the start of white-spot activity in September.

CENTRAL-MERIDIAN TRANSITS

In order to determine longitudes on a planet, that body must have one or more defined *Systems* of longitude. Such a System is simply a convention that longitude 000° was centered on the apparent disk at some specific date and time in the past. The System also specifies a constant sidereal rotation rate (expressed in degrees per day) or period (in hours, minutes, and seconds). Such Systems have been defined for all the major planets. Indeed, the atmospheres of the Giant Planets rotate at different rates for different latitudes. To approximately compensate for this difference, both Jupiter and Saturn have been assigned a "System I" applying to low latitudes and "System II" to the higher latitudes.¶

At any given moment, a particular longitude of a System will appear to be at the center of the disk. This longitude is called the *Central Meridian* (CM). Using a published ephemeris, it is simple to calculate the value of that longitude. Such ephemerides take account of the Earth's motion in the planet's sky, the time it takes light to travel to us from the planet, and often even the effect of the planet's phase. Thus the only observation one needs to make to determine a feature's longitude is then to time when it appears to pass across the center of the disk; this observation is called a *central-meridian timing.*¶

Because discrete detail on Saturn is rare, transient, and indistinct, there has been difficulty in establishing rotation rates at different belt and zone latitudes. So, particularly for Saturn, when long-enduring spots or disturbances like the Great White Spot of 1990 appear, the opportunity to obtain accurate CM timings of such features must not be missed. Any spot that can be monitored for a few weeks can yield valuable results, even if the individual CM timings are off by a few minutes. More precise timings, of course, are desirable.

Like Jupiter, Saturn rotates in two Systems of longitude. System I for Saturn refers to equatorial regions of the planet (the NEBs, SEBn, and EZ) and rotates in 10h 14m 00s (844°.3/day). This means that 7 rotations take place in very nearly three terrestrial days; a coincidence useful in planning observations and in monitoring the same feature over a period of several weeks. This rotation period appears to be well-established by long-term visual observation.

Regions to the north or south of the System-I region show longer periods of rotation, centering roughly on a period of 10h 38m 25s (812°.0 per day) that has been adopted by the A.L.P.O. and named *System II.* Nine such rotations occur in close to four Earth days; again a coincidence useful for planning observations and monitoring features for a month or more.

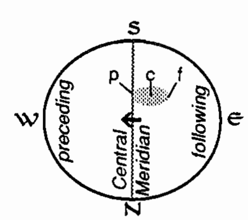
Daily central-meridian System I longitudes for Saturn are published in the annual *Astronomical Almanac (AA).* Both System I and II longitudes are similarly given in the *A.L.P.O. Solar-System Ephemeris (SSE).* In both cases the daily longitudes are for 0h (UT in the *SSE*; TDT in the *AA*), but conversion to other times is simple. ¶

There is no question but that there are actually many rotation rates for Saturn at different latitudes. One important observing project of the A.L.P.O. Saturn Section and other organizations is to establish rotation rates for different latitudes. In order to do so, it is necessary to recover long-enduring spots or disturbances on a large number of CM passages. Thus, when prominent features like the 1990 Great White Spot persist for several weeks, CM timings of them can help improve our understanding of Saturn's atmospheric rotation and circulation patterns.

Making CM transit timings of atmospheric features is really very simple. The observer estimates to the nearest whole minute when the feature appears exactly midway between the East Limb and the West Limb of the planet. Always record such times in Universal Time (UT), obtained by listening to shortwave or U.S. Naval Observatory telephone time signals.

In making such timings, we often use the terms *preceding* (p) and *following* (f). The preceding side of a feature is that side that first touches the CM; it is to the left when the feature is viewed through a simple inverting telescope in the Earth's Northern Hemisphere, with south at the top. The preceding limb of the planet is the side of the planet to the celestial west; or the left side when viewed as above. In either case, a feature or an entire planet, the following side is the side opposite the preceding side. These conventions are diagramed in *Figure 1* immediately below. ¶

Figure 1. Preceding and following directions for a planetary disk and feature, seen with an inverting telescope in the Northern Hemisphere, with south at the top. The preceding edge of the feature is on the CM.



More accurate longitude determinations are obtained by making three separate CM transit timings for each feature. The first time is the final minute when the feature is definitely on the following side of the CM. The second time is the last instant when the feature is exactly centered on the CM. The third and final time is the first minute when the feature is definitely on the preceding side of the CM. The longitude of the feature is then calculated as the mean of these three times.

If the feature has a definite longitudinal extent, it will take some time for it to cross the CM. In such a case, the observer should separately time, in order, the preceding end of the feature (p), the feature's center (c), and the feature's following end (f). The observing notes should also record a description of the feature, including whether it is bright or dark, and which zone or belt it is located in.¶

In addition, all CM transits should be accompanied by a full description of the seeing and transparency conditions, the instrument used, magnification(s), filters, and the observer's name and location. The written description of the feature should be supplemented by a sectional sketch. If possible, the observation should include measures or estimates of the feature's extent and latitude.

The A.L.P.O. Saturn Section will be happy to provide forms for recording these data and submitting them to the Recorder for analysis (his address is on the inside back cover). Central-meridian transit timing is a "low. tech" and uncomplicated observing method, but one that tells us much about the behavior of Saturn's atmosphere.

USING A CCD VIDEO CAMERA FOR GALILEAN SATELLITE ECLIPSE TIMINGS

By: Henk J.J. Bulder

ABSTRACT

Looking for methods more objective than visual timings of the eclipses of Jupiter's Galilean satellites, I tested the MXII CCD video camera for this purpose. Special computer software was developed to track the objects of interest automatically. The first results show that this method is very promising; and, due to its simplicity, is well within the capabilities of many amateur astronomers. Comparison with other objective methods, such as photoelectric photometry, will be necessary to prove the value of this approach.

INTRODUCTION

The results of visual timings of Galilean satellites depend on several conditions beyond the observer's control. Some of these are telescope aperture, background illumination, atmospheric transparency and seeing, and the condition of the eyes and the experience of the observer. Thus, I have been looking for other possible timing methods that would give less subjective results.

One such method is photoelectric photometry, which can be difficult for amateur astronomers. One problem is that the durations of the events are short. A more serious difficulty is due to scattered light near Jupiter, calling for small diaphragm apertures. This requirement in turn leads to the need for very accurate tracking techniques, especially when satellites reappear from Jupiter's shadow.

Another method that has several advantages is video recording of the events. Not only is this method simple to do, but it also gives you all the time you need to analyze the results after the event itself without worrying about losing data. The most obvious advantage over photoelectric photometry is that it is as easy to observe eclipse reappearances as disappearances. Another advantage is that you can replay the events for your friends to show them what you are doing behind the telescope. You also can use the video tape to instruct novice amateur astronomers and others.

The traditional vidicon cameras are not suitable because the flux [electronic signal strength] is not linearly related to the light level. They also produce considerable glare near bright objects, along with geometrically distorted pictures. CCD cameras are more promising in all these respects. Therefore, I have been searching for such a CCD camera to test it for the recording of Galilean satellite eclipses. The HCS Vision Technology firm granted me the use of one of their MXII cameras for such testing.

OBSERVING METHOD

The method of observing is straightforward. First, I used a Barlow lens to obtain a desirable picture scale. Second, in order to get good results, the objects of interest should not be saturated. However, avoid automatic gain control or automatic black level because then the light levels cannot be calibrated.

Because the purpose is to time events accurately, it is necessary to create a time reference. This posed a problem because I had no time inserter available and the camera came without a microphone, which I could then have used to record audio time signals. My solution was to use a standard lens to record the LED display of my DCF77 time receiver before I mounted the camera on the telescope. I left the camera running continuously until the event itself was over. It would be easier, but less accurate, to use a swinging piece of cardboard in front of the telescope to block the light every few seconds at a regular interval. This last was used as a backup provision and proved to be accurate to within 0.3 seconds.

To make certain that the entire event was captured, I recorded for at least 15 minutes. I also assured that at least one satellite other than the one undergoing eclipse was in the field as a reference object. No sophisticated tracking methods are necessary. I used the video monitor to track by drawing a square on the screen around Jupiter or one of its satellites and trying to hold the chosen object within the square. However, such tracking is not really necessary because it is possible to compensate in the reduction process for poor tracking, as explained below.

METHOD OF REDUCTION

The easiest method to obtain the flux values of the subject and comparison satellites is to use a computer with a "frame grabber." [This is a device that converts the analog video image into an array of digital numbers that can be stored and manipulated in the computer. Each number on the array represents the flux of a single picture element ("pixel") on the CCD chip. Ed.] To make flux measurements, you place a set of two windows of different sizes around each object of interest, as shown in *Figure 1* (p. 160). Each window must contain the object throughout the whole recording. The total flux for each window is found by summing the flux values of all its pixels. The difference between the larger and the smaller window is then used to estimate the amount of background light to be subtracted [**1**]. This subtraction of background light is comparable with the method used for conventional photoelectric photometry.

Finally, the flux of the comparison object is used to correct for transparency changes, if any. This correction is necessary when fog is forming or when there are thin clouds. Measurements of both objects are made at short intervals [up to the 30 frames/sec. video scan rate], corrections are applied, and one obtains an S-shaped flux curve with considerable noise superimposed, such as shown in *Figure 4* (p. 161).

The chief problem with this technique is that Jupiter is always near the satellites. Even if they move about only slightly this will cause a changing amount of Jupiter's scattered light to appear in the windows, as shown in *Figure 1a* (page 160). This scattered light is not linearly distributed and is thus difficult to correct for, resulting in discontinuities in the flux curve. Removing such scattered light involves sophisticated image-processing techniques, which would considerably reduce the number of data points.

Attempting to avoid this problem, I used a program produced by the Bureau des Longitudes [**2**] that allows the windows to be moved around during the reduction by using the arrow keys of a computer keyboard. This method allows the windows to be defined as smaller. This program gave good results for the event of 1991 MAR 27 and "reasonable" results for that of 1991 MAR 07. This method proved to be too coarse to obtain continuous flux curves for the remaining four events.

To achieve more reliable results for the remaining four events, it was necessary to use an automatic tracking technique to reduce window sizes even further and to allow perfect centering of the windows around the objects in order to avoid discontinuities completely. I developed a FORTRAN program using the DT-IRIS subroutine library. The basic concept was to define a search window around a reference object and then to use fixed x- and y-offsets for the object to be measured [**3**]. This approach is illustrated in *Figure 1b* (page 160). When this program gave excellent results, I decided to apply it to the 1991 MAR 07 and MAR 27 events as well, so as to be able to compare half-brightness times derived from both methods. [The "half-brightness time" is used to define the midpoint of an eclipse reappearance or disappearance. A small timing bias will be created by albedo variations on the satellite. Ed.] The two results agreed well only for the 1991 MAR 27 event, which can be explained by the relatively large distance of Callisto from Jupiter.

I found half-brightness times from the flux curves by first determining maximum and minimum flux levels by averaging the high and low ends of the curve. Because the flux is linear with respect to light level, a line midway between these two flux levels determines the half-brightness level. This line will intersect the noisy flux curve, and a linear regression fit was used for the points near the half-brightness level to estimate the time of half-brightness.

The accuracy of this approach is estimated as the sum of three errors. The first is the small error in the timings of the individual points, very conservatively estimated as 0.2 seconds. The second error is the formal uncertainty of the linear regression, amounting to 0.2 to 1.0 seconds. Finally, one has the error due to the uncertainty of the maximum and minimum light levels, resulting in an uncertainty in the half-flux value.

These three errors are random in nature, but systematic errors also may be present. For example, if the recording begins too late or ends too early, the half-flux value will be inaccurate because the maximum or minimum fluxes will be wrong. Also, if the sizes of the windows are too small, some of the objects' light will be incorrectly subtracted off as background.

RESULTS

Seven events were recorded with a 30-cm f/5 Newtonian telescope. One event was "lost" because heavy clouds formed during eclipse reappearance. The remaining six eclipses are summarized in *Table 1* below.

Table 1. Reduced half-flux times for observed events.

Type	Predicted Event Date and Time (UT)	Hand Tracking Half-Flux UT	Automatic Tracking Half-Flux UT	Sky Cond. S	T	B
J2 R	1991 MAR 07 20:36:14	20:35:57.8 ±7.5 s	20:35:48.6 ±2.8 s	1	1	0
J1 R	13 20:14:46	---	20:14:40.1 ±1.9	1	1	0
J4 R	27 19:47:32	19:47:37.4 ±3.6	19:47:40.5 ±2.7	1	0	1
J3 R	29 19:14:36	---	19:13:15.3 ±2.9	0	0	1
J1 R	APR 12 22:24:23	---	22:24:19.4 ±1.2	1	0	0
J3 D	23:34:42	---	23:35:03.2 ±3.7	2	0	0

Notes: *Type*; Satellite number, Reappearance/Disappearance. *Predicted UT*; from JPL E-2 Ephemeris. *Sky Cond.*; sky conditions; Seeing, Transparency, Background light; where 0 = condition not perceptible, 1 = condition perceptible, 2 = condition serious. A red filter was used for the 1991 APR 12 events.

Five reappearance curves and one disappearance curve were determined and are shown in *Figures 2-7* (pages 160-162). To help in comparing the figures, the curves have all been normalized so that their mean maximum brightnesses equal 1.00 and their mean minimum brightnesses are 0.00. Some curves (Figures 3 and 7) suggest that observing times may have been too short. To obtain good results, I recommend recording durations of 12, 15, 20, and 30 minutes for the eclipses of Satellites 1 to 4 [in order: Io, Europa, Ganymede, and Callisto], respectively. The predicted eclipse time should be at the middle of the recording periods. [Note that up to several hours may elapse during a "grazing" eclipse of Callisto. Ed.]

Table 1 lists derived half-brightness times and estimates of their accuracy. Automatic tracking yields more accurate results than hand-tracking. The closer the satellite is to Jupiter, the more difficult it is to determine the flux curve without automatic tracking during reduction, and the nosier the data are. This will lead to less accurate half-brightness times. If the light of Jupiter could be blocked out, the form of tracking probably would not matter. This is suggested by the 1991 MAR 27 event, where Callisto was well away from Jupiter.

WINDOW SIZES

Window sizes should be such that the object of interest is completely contained by the inner window. This can be checked by analyzing the difference between the inner and outer windows, correcting for transparency changes. If the difference tends to increase for an eclipse reappearance or decrease during a disappearance, the window size is too small.

On the other hand, window sizes should not be larger than is strictly necessary to obtain the maximum signal-to-noise ratio. It is necessary to experiment to find the best window sizes. The choice also depends strongly on the tracking method that is used. Automatic tracking gives the smallest window sizes and the highest signal-to-noise ratios.

To obtain reliable background-light values, the larger of the two nested windows should contain roughly twice the number of pixels of the smaller window.

Although different window sizes have been tried, more experimentation is needed to find the optimum sizes. Analysis of the differences between the two nested windows showed that most, but sometimes perhaps not all, of the object's light was caught in the smaller window.

CONCLUSIONS

The CCD camera has proven its ability to record these difficult events. The phenomenon of "blooming" [streaks of light caused by saturated pixels] makes it difficult to reduce events near Jupiter, though. To ease reduction, it would be a good idea to block out most of Jupiter's light during the recording with a small strip of black cardboard in front of the rèceptor. I plan to try this procedure during the 1992-93 Apparition. Although the method I have described has clear advantages over photoelectric photometry, its value has yet to be assessed in comparison with visual and photoelectric observations of the same events.

ACKNOWLEDGEMENTS

• I wish to thank Frans Veraart of HCS Vision Technology (Sciencepark Eindhoven 10, NL-5691 PX Son, The Netherlands) for granting me the use of an MXII camera. Anyone needing the camera's technical specifications can address him directly.

• I thank W. Kishna of the Rood BV firm in Rijswijk (Z-H) for the use of one of their DT2851 frame grabbers and the DT-IRIS library for reduction purposes.

• I also thank Jean-Eudes Arlot of the Bureau des Longitudes for sending me their reduction program for mutual events.

• I address a special word of thanks to Rob Wagenaar for his patience during the many hours I used his 80386/387 computer and for helping me in the sometimes tedious reduction process.

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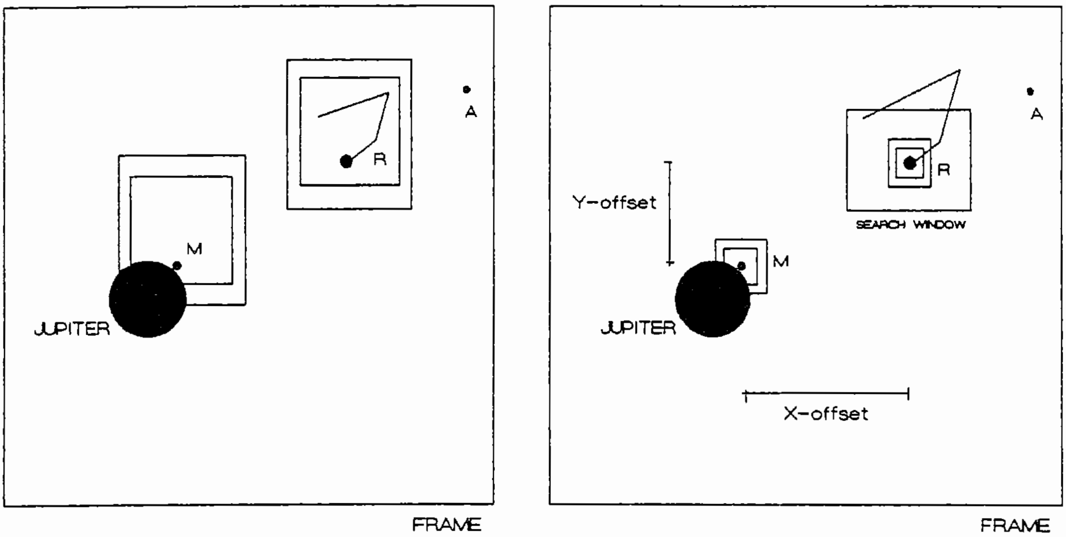
Comments by Editor:

In this article, Mr. Bulder has described a way of timing the eclipses of Jupiter's satellites that avoids the subjectivity of visual timing and which permits easier correction for scattered background light than does photoelectric photometry. His method uses *video* CCD equipment that is owned by a number of our members. However, even his results show considerable scatter. *Digital* CCD photometry, if correctly carried out, allows brightness levels to be measured with greater accuracy yet. Unfortunately, this last method requires a specialized CCD camera and computer interface, both of which are possessed by few amateurs. Both video- and digital-CCD methods are relatively new. Some questions, such as the best window size and shape, are still debated. We welcome letters from our readers expressing their opinions and describing their experiences with CCD photometry, which is becoming an important tool in several branches of Solar-System astronomy.



Figures 1a (left) and 1b (right), comparing two methods of tracking Jupiter's satellites in video images. In Figure 1a the lines at the reference object *(R)* indicate movement due to bad tracking. The windows are defined to be large enough to contain the object throughout the recording. This causes a changing part of Jupiter to appear in the windows around the object to be measured (*M*), resulting in discontinuities in the final flux curve. However, were *A* to be the object measured, this procedure would still give good results. In Figure 1b a search window has been defined around the reference object *R*. When the position of *R* is found, the search window is repositioned. Fixed X- and Y-offsets are used to mark the position of the object to be measured, *M*. Here, small windows centered around both M and R are defined for summing the pixel flux values.

Figures 2-7. Time-flux graphs of Galilean satellite eclipses.

Note that the curves below have been normalized so that the mean maximum flux is 1.00 and the mean minimum flux is 0.00. Times are given in minutes after the hour indicated, and the estimated time of half-flux is shown by a vertical line in each graph.

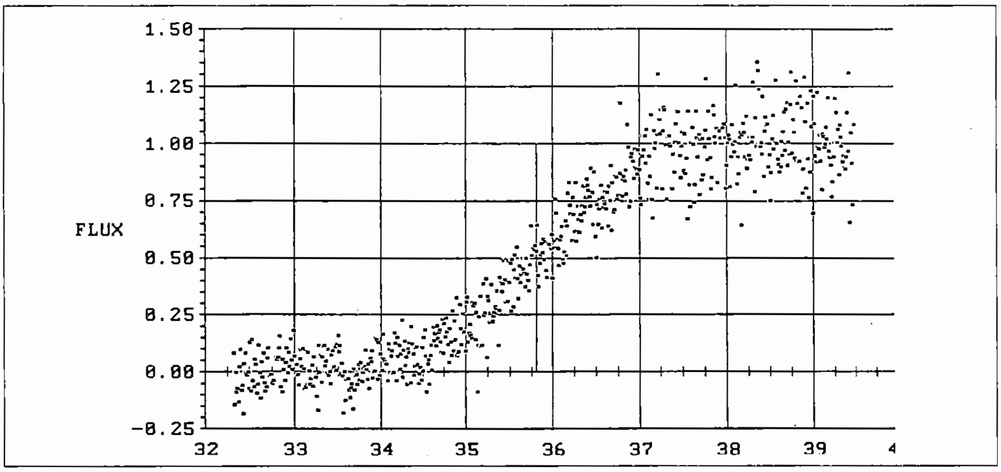


Figure 2. Reappearance of Europa, 1991 MAR 07 with time in minutes after 20 h UT.

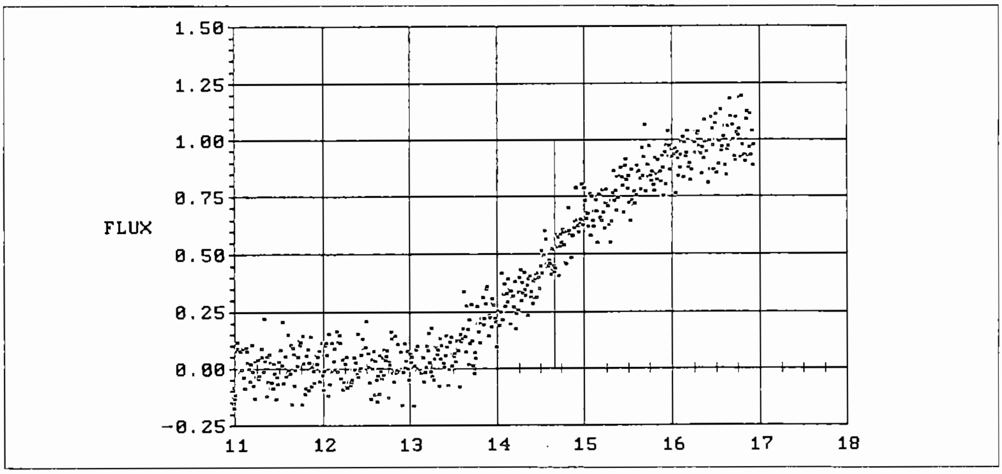


Figure 3. Reappearance of Io, 1991 MAR 13 with time in minutes after 20 h UT.

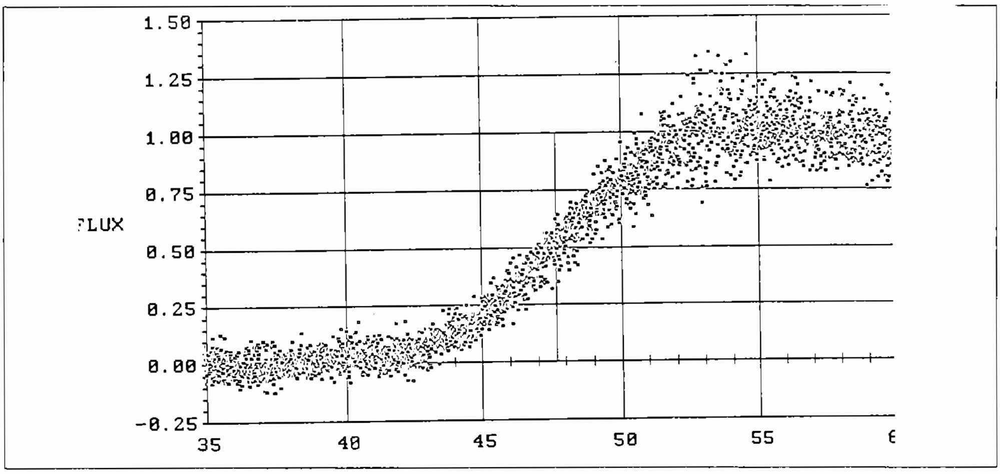


Figure 4. Reappearance of Callisto, 1991 MAR 27 with time in minutes after 19 h UT.

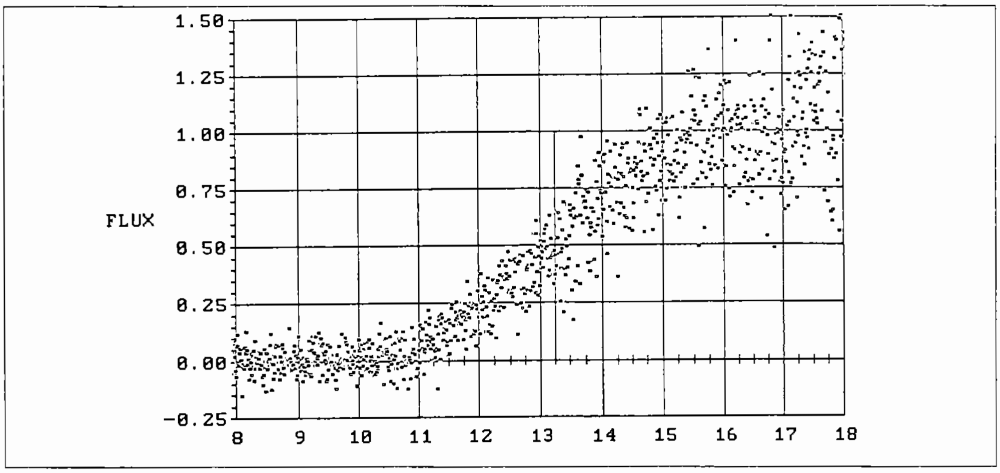


Figure 5. Reappearance of Ganymede, 1991 MAR 29 with time in minutes after 19 h UT.

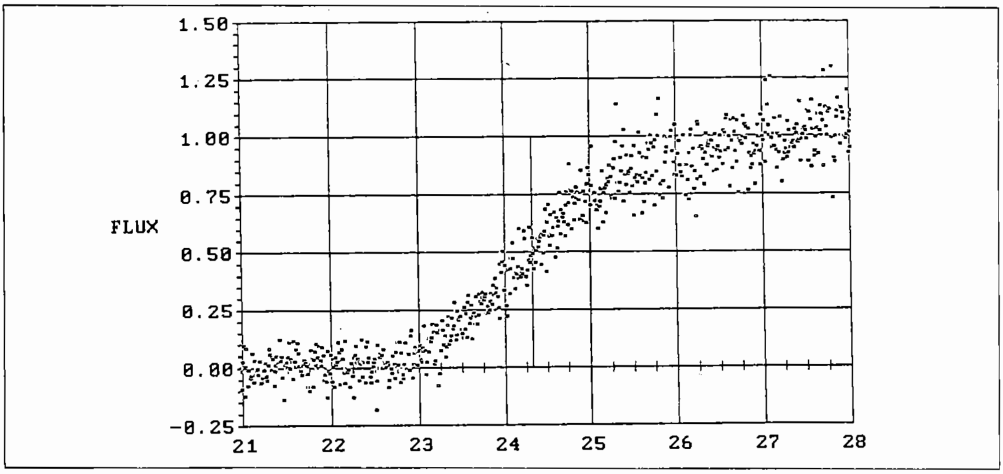


Figure 6. Reappearance of Io, 1991 APR 12 with time in minutes after 22 h UT.

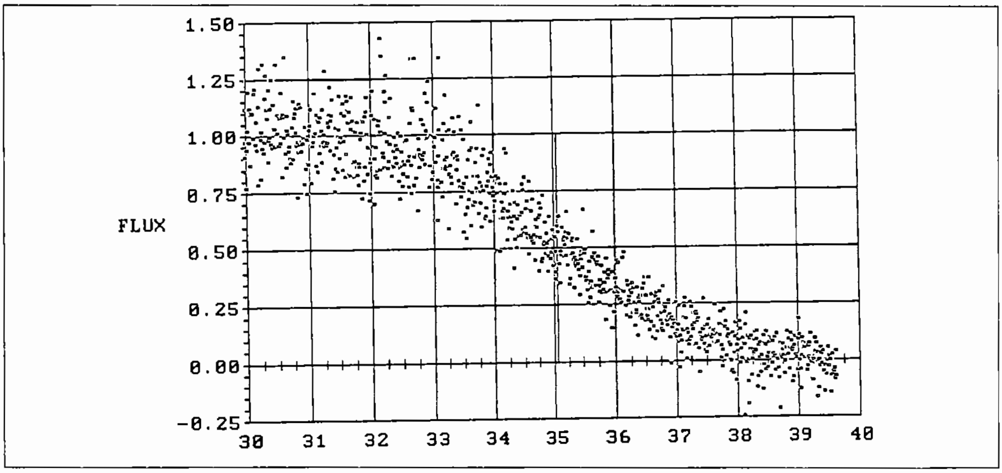


Figure 7. Disappearance of Ganymede, 1991 APR 12 with time in minutes after 23 h UT.

—NOTICE—

A.L.P.O. SOLAR SYSTEM EPHEMERIS: 1993

The *A.L.P.O. Solar System Ephemeris: 1993* is now available. This is our eighth annual edition of this publication; an invaluable guide for the serious observer of the Sun, Moon, planets, asteroids, meteors, and comets. You will need its tables, illustrations, and maps not only to plan your observations, but to reduce them and to provide the background information that is essential to back them up.

Before you send your order, please note:

• Mr. Mark A. Davis continues to supply this publication. However, he has moved to a **new address**: 1700 Whipple Road, Apt. 11A, Mt. Pleasant, SC 29464, U.S.A.

• There has been a **price increase** due to higher printing costs. The new prices are **$7.00** for mailing to the United States, Canada, and Mexico; and **$9.50** to all other countries. Please pay in U.S. funds, by check or money order payable to "A.L.P.O." (Prices include Air Mail postage.)

The contents have reached 129 pages. There have been several other changes since the 1992 edition. We now give data for every day for *all* the bright planets, provide a time-zone chart, and have updated the lunar program. This edition highlights some unusual 1993 events: the Uranus-Neptune conjunctions, a transit of Mercury, two lunar and two solar eclipses, and 38 occultations!

OPTICAL TESTING FOR LUNAR AND PLANETARY OBSERVERS

By: Harry D. Jamieson

ABSTRACT

This paper describes some methods of optical testing and the author's personal experiences with them. It shows the reader how he or she can easily obtain an accurate view of his or her telescope's optical quality.

GENERAL

Most people who purchase a telescope are content to trust the manufacturer to provide them with a high-quality instrument. Unfortunately, every manufacturer has occasionally sold a defective telescope. In this case it is the responsibility of the new owner to detect the defects and then to get the manufacturer to correct them. Some defects are obvious, but many amateurs think that they must be expert opticians to detect optical problems. It is the purpose of this article to help dispel this myth. Although the A.L.P.O. currently is planning to offer an optical testing service to its members, almost anyone can get a very good idea of the optical quality of his instrument by using one or more of the methods presented here.

STAR AND RONCHI TESTS

To some extent, the techniques used to test a telescope's optical quality vary with the type of telescope involved. However, two universal techniques that can be used with any telescope are star testing and the Ronchi Method. With the former, one observes a bright star with an eyepiece yielding a magnification of at least 30-40X per inch of aperture. The goal is to see a bright point surrounded by rings of light. Both inside and outside of focus, the image should show circular and evenly spaced rings of light around the central point (the *Airy Disk)*, but often the seeing will not permit these rings to be seen; and when it does so allow, it still often makes interpretation difficult. Also, the star test is very critical and can often fail even for optics that are good enough for serious lunar and planetary work. Your optics also must be very well collimated. I have personally had little luck with this method, which is also known as the "Diffraction Ring Test," and is well described in references **[14]** and **[16]**.

Another universal method to test your optics is to use a *Ronchi grating.* This is simply a piece of slide film with parallel ruled lines, usually spaced at 100 per inch. To test your telescope with a Ronchi grating, just point the instrument at a bright star and remove the eyepiece. Put the grating where the eyepiece was, with the focuser racked *outside* of the focal plane. Then focus it back and forth until the bright circle of the star image has five or six lines crossing it. If these lines are straight, sharp, and evenly spaced, your optical system is good! With a reflecting system, small outward-facing "hooks" at the end of one or more lines indicate a turned-down edge; while inward-facing hooks indicate an edge that is turned up. Any deviation from a straight line is cause to return the telescope to the manufacturer with a demand for satisfaction.

Remember that, if you own a reflector, you are testing both the main mirror and the secondary at the same time. If the test shows a flawed optical system, try again with a secondary of known good quality. If this solves your problem, then a new secondary is all you'll need. If not, at least you will be able to tell the manufacturer that you have definitely isolated the problem.

Ronchi gratings may be obtained for a few dollars from Willmann-Bell and Company or from the Edmund Scientific Company. If possible, look at your grating under a low-powered microscope to see what the lines will look like when magnified, before using the grating with your telescope. Their appearance in a good microscope and with your telescope should be the same.

The star and Ronchi Tests have the advantage of simplicity and usefulness on any telescope. They also test the entire optical system simultaneously (excluding the eyepiece in the Ronchi Test). If possible, use Polaris as your test star. Because Polaris does not move much during the night, you may clamp your telescope down to reduce vibration and movement. It is also very important to remember to test only when your optics are well-aligned and at the ambient temperature of the surrounding air. Failure to do so will almost certainly give you a misleading and disappointing result. Also try to avoid using stars that are too bright or too near the horizon. A good rule of thumb for brightness is first magnitude for 4- to 6-inch telescopes, second magnitude for 8- to 12-inch apertures, and third magnitude for 16- to 20-inch telescopes.

KNIFE-EDGE NULL TEST

Another easy way to use stars or planets as test objects is with a *knife-edge null test.* Here, one centers a star or planet and removes the eyepiece as in the Ronchi Test. A knife-edge or razor blade is placed at the focal plane, whose location is found by passing the blade over the star's image. If the shadow of the blade appears to move in the *same* direction as the blade, then you are *inside* focus. If the shadow comes from the *opposite* side, then you are *outside*. With the razor blade at the focal plane, the circle of light should darken *evenly and all at once* when the blade cuts the circle. If so, your optics are well- corrected. Any irregularities while the circle is darkening are a sign that your optics are flawed.

As in the Ronchi Test, the flawed element will be your objective if you have a refractor; or your main mirror, secondary, or both if you have a reflector. [If you are testing a compound system, the problem also could be your corrector plate. Ed.] It also may be your star diagonal if your are using one. If the test indicates flawed optics and you are using a star diagonal, repeat the test without it. If you are using a reflector and the test turns out badly, borrow another secondary (diagonal) of known good quality and try again. If your test now turns out well, replace the offending element. If not, then your main mirror or objective needs to be refigured.

Again as with the Ronchi Test, use Polaris and clamp your telescope down. If the seeing is too poor to make the test with a star, Alika Herring recommends Jupiter or another bright planet as an alternative.

FOUCAULT TEST

If you have a reflector and one or more of the tests above indicates a flawed main mirror, you may wish to use the Foucault Test on it before confronting the manufacturer. A Foucault Test is much like the star knife-edge null test, but it is done with the mirror out of the telescope and requires a specially-built tester. When removing your optics, always follow the manufacturer's recommendations.

This test may be used to determine optical smoothness and the exact deviation from a smooth figure. Nearly anyone can construct a Foucault tester out of items found at home or at a hardware store. The basic elements are a light, a razor blade, and some method of keeping track of the blade's location to within 0.001 inches. The latter method is usually a micrometer, which you can make yourself using a screw of known pitch. The bibliography at the end of this article lists books and articles on the subject of building a Foucault tester. Also, a kit to build one may be purchased from University Optics. I built my tester from a University Optics kit, although it has been heavily modified. One of the most important points to remember is that the tester must rest on, and be attached to, something that *will not move* while you are using it! I use 24-by-40-inch plywood and a box of 2-by-4's filled with bricks. [The mirror should be placed on a stand that is similarly sturdy. Ed.] The height of the tester should be whatever is appropriate to have your tester's razor blade at eye level while you are seated. It is also best to do your testing, if possible, in a room with steady air and a concrete floor. As you will be measuring distances between your tester and your mirror with an accuracy of 0.001 inch, you will need a solid surface to work on. Also, if the air is unstable in your testing area, you can see the air currents flowing by your mirror. Many writers advise building a cardboard box tunnel between your tester and mirror in order to stop these currents. Finally, for safety you may wish to mount your razor blade sandwiched between two pieces of wood or styrofoam. Only a small amount of the blade needs to be exposed.

Once you have acquired a tester, the testing procedure itself is fairly simple. Remove your mirror from your telescope and place the mirror on a *secure* stand at a distance twice the mirror's focal length from your tester's razor blade. Now go to your tester and align it with your mirror. It should be aligned so that your blade, when moved back and forth, will follow the optical axis of your mirror. Do a rough alignment now by sighting along your tester to the center of your mirror. Then, with a flashlight located in front of your tester's pinhole light source, move the mirror stand about until the flashlight's reflected beam covers half your tester's razor blade. (Many mirror testers prefer to use a pinhole for seeing detail on the mirror surface and a slit for making zonal measurements, while others use only a slit.)

At this point, allow your mirror to become thermally stable. How long this takes depends upon the mirror's size and how much its temperature initially differs from the ambient room temperature, but a few hours are usually enough. It helps to leave the mirror overnight in the room where the testing will take place, for it then will have only to recover from the effects of your handling. When possible, move the stand instead of the mirror.

After temperature stabilization, turn off the room lights and turn on your tester's light source. Place your eye behind the razor blade, and move it about until you can see the image of the pinhole reflected from your mirror. If you are using a slit, at this time you should carefully align your razor blade vertically with the image of the slit. As you move your eye closer to the mirror (be careful of the razor blade!), the pinhole's image will grow until it fills your mirror. Cut the mirror's image about halfway with your blade and examine its image. Is it straight? If it appears to hook near the edge of your mirror, then the mirror has a turned edge and needs to be reground. When viewed *inside focus*, *outward*-turning hooks indicate a turned-*up* edge, while an *inward*-facing hook indicates that the edge is turned *down*.

You now need to finish aligning your tester with your mirror's optical axis. Moving the blade toward and away from your mirror, note the blade's image. Does it move left or right? If so, your tester is not yet correctly aligned. Move your tester slightly right or left until you can move the blade without noting any blade swing left or right. This alignment is very important for accurate results later.

You are now ready to find your mirror's radius of curvature (ROC). Move the blade so that it cuts the beam of light coming from your mirror. If the image of the blade comes from the *opposite* direction, then the blade is *outside* the mirror's focus. If the blade's image moves in the *same* direction as you are moving it, then the blade is *inside* the focus. As you approach focus, the sharp razor edge will soften until, when you cut the beam, the center one-third of your mirror appears as a soft notch in the edge of the blade. This appearance is unmistakable! For examples of it, see page 79, Figure 37A, of reference **[3]**; page 81, Figure 39B, of reference **[15]**; or page 220 of reference **[16]**, left figure. Another way to find your ROC is to use a mirror mask with a hole in the center one-quarter of the diameter of the mirror (see reference **[16]**, page 226, right figure). The mask with the hole in its center should be a circular piece of heavy dark paper or cardboard equal in diameter to your mirror. Place this mask immediately in front of your mirror, and cut the beam with your blade. The blade shadow within the hole will act just as it did for the whole mirror. Move the blade toward or away from the mirror until the hole darkens evenly and all at once, with no indication of the blade's direction of motion. At this point you have found the ROC and can remove this mask.

Now move the blade away from the mirror by two or three turns of your micrometer screw. Cut the beam with your blade and watch the shadows change. It takes considerable experience properly to interpret these shadows, and some of the references listed in the bibliography below will help you here. At this point, though, it is only important to note whether the mirror appears smooth; without scratches, hills, or valleys. Any deviation from a smooth appearance, such as scratches, an "orange peel," or something similar, means that the mirror has failed this part of the test. It is normal, though, for your mirror to look as if it is depressed in the center at this focus, with a bright ring of light around the edge. After examining the mirror for smoothness, move the blade forward back to the radius-of-curvature point, where the blade appears to have a fuzzy notch at its center.

It is now time to turn your room lights back on. With a tape measure, find the distance from the center of your mirror to the razor blade. The razor blade should be just where it was when you saw the center of your mirror notch the blade. Now, measure the distance from your mirror to your pinhole or slit. Add these two measurements together and divide the result by two. This mean distance is your *radius of curvature*, and is equal to twice your mirror's focal length. We shall need this value for the next step in our test. You also may want to remember it so that you will know your exact focal length to compute magnification and photographic scale and focal ratio.

We are now ready to do a quantitative test of your mirror, which will tell you how close it is—in waves—to a parabola. [A "wave" is a wavelength of light; usually the most visible, at about 5500 Å, 0.00055 mm, or 0.0000216 in. Ed.] Now you can see for yourself whether of not your mirror is as accurate as advertised. We begin by cutting out a mask exactly like that shown by Roger Sinnott in his recent *Sky & Telescope* article (reference **[1]**). It is vital that this mask be equal to the diameter of your mirror and its cut-outs be in the proportions shown by Sinnott.

Place the mask over the mirror. Then cut the beam with the blade and notice the shadows in the two inner cut-outs. The cut-out on the *blade* side of your tester should darken first, showing that you are inside the focus for that mirror zone. Now we want to move the blade away from the mirror until we reach a point where the shadows in the two inner cut-outs behave identically when the blade cuts the beam. If the cut-out on the *light* side of your tester darkens first, then you need to move the blade back toward the mirror again. Both cut-outs should darken evenly and *both at the same time*. Do not make this comparison after the cut-outs have darkened, but instead just as the blade cuts the rays from them. You are looking for the very first indication of darkening in the cut-outs. Thus you will have to contend with some very subtle shadings surrounded by bright diffraction effects around the cut-outs' edges. Ignore these diffraction effects. Your eye must go back and forth between the cut-outs looking for a simultaneous appearance of the shadows, and this refinement will test your judgment. However, with experience, you will get better at judging. When you have reached this point, read the value on your micrometer scale (or whatever other scale you are using to keep track of your blade's location), and write it down. Now, randomize your scale by moving the blade back and forth without reading the scale, and attempt again to find the point of simultaneous darkening for the inner cut-outs. Did you come up with the same reading as before? With practice, you can do so to within ±0.003 inches, although this uncertainty will vary with the focal ratio of your mirror—it is more difficult to obtain consistent results with focal ratios higher than f/8 because they are "flatter." Take four readings for the inner cut-outs and average them. Repeat this process for the other cut-outs. The blade will be moved farther and farther from your mirror as you inspect cut-outs closer to the mirror's edge.

After you have listed the average readings for your cut-outs, take them to your computer and run the values through Sinnott's program (reference **[2]**). If you don't have a computer, I will be happy to run your values through my computer if you will send me (a) your mirror's aperture, (b) its radius of curvature, (c) all of your readings, and (d) a stamped self-addressed envelope.

Knowing your mirror's quality can give you peace of mind if it is good, but what if it is not? You should not be afraid to contact the manufacturer and express your unhappiness. Remember that you can photograph your mirror's appearance while Foucault testing by using any 35mm camera with a time exposure of a few seconds duration. Such a photograph is called a *Foucaultgram.* This provides evidence for your claim, especially if you decide to sue. Remember that defective optics should be treated like any other consumer fraud case. However, if you cannot get any satisfaction from the manufacturer or from the courts, then you may want to send your optics off to be fixed by an independent optician.

In any case, after testing you will know where you stand. Also, you may be able to fix some problems yourself. For example, Richard Wessling suggests that a mirror with a turned edge may often be fixed by simply masking the outside 1/4 inch. While this action will of course cost you 1/2 inch of aperture, the improvement in image quality might more than offset this loss. If you have this problem and have no other recourse, try this masking approach and retest with mirror masks appropriate for your new smaller aperture. For example, you may find that you have traded in a 10-inch 1/2-wave mirror for a 9.5-inch 1/10-wave mirror for the cost of some tape or other masking material.

A.L.P.O. members interested in seeing their organization offer an optical testing service should write to me and express their opinions on this topic. But whether of not the A.L.P.O.can eventually offer this service, you owe it to yourself to acquire the knowledge and skills needed to defend yourself against lazy or unprincipled manufacturers. [Now that the A.L.P.O. has an Instruments Section, it is more likely that we shall be able to provide such a testing service; at least when shipping and liability issues have been settled. You may also wish to write the Instruments Recorder, Mr. Michael Mattei, at the address given on the inside back cover. Ed.]

I wish to express my appreciation to Alika K. Herring, master optician and lunar observer, for his helpful advice while I was learning the art of mirror testing and for his helpful review of this article. I also want to thank Richard J. Wessling, owner of the Pines Optical Shop, and Bob Allen, another long-time and skilled mirror maker, for their reviews of this article and their helpful additions. Of course, any errors in this article are solely my responsibility.

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A Device for Reducing Diffraction Spikes Caused by Secondary Mirror Supports in Reflecting Telescopes

By: Jeff D. Beish, A.L.P.O. Mars Recorder

ABSTRACT

This paper discusses an alternate design for replacing the apodizing screen and presents a new design for an old idea for improving telescope performance and reducing diffraction spikes produced by secondary mirror supports in a reflecting telescope.

INTRODUCTION

During the mid-1980's, *Telescope Making Magazine* published articles about the use of apodizing screens to improve "atmospheric seeing." An apodizing screen is an aperture mask or diaphragm mounted at the entrance to a telescope tube often constructed with several layers of regular household window screening attached to a circular frame. In the popular version, three screens are cut with holes of different sizes in their respective centers, positioned so the square patterns of the screening are at oblique angles to each other around the frame. The proponents of this system claim that it improves seeing.

A lively debate followed the articles in the letter section of subsequent *Telescope Making Magazine* issues, stirring the author's interest. The debate soon ended and no follow-up articles appeared that dealt with this very interesting subject.

Using the materials and dimensions described in the various articles, this author constructed and tested several apodizing screens. The results were not nearly as good as advertised and I found little or no information after an exhaustive search for additional material.

The argument continues in the background about the effectiveness of these screens and other schemes to improve our equipment. In the past, *The Strolling Astronomer* featured great articles about instruments, both informative and educational, for those who observe our Solar System. This brief article will continue with a series of provocative and, I hope, interesting papers about the art of making and improving the "planetary telescope." Ideally, it also will provoke some readers to join in.

OLD IDEAS PAY OFF

Disappointed with apodizing screens, this author set out to find an alternative design. The first prerequisite was to improve telescope performance during bad seeing. It was also desirable to remove the pestilent diffraction spikes caused by the secondary mirror "spider" supports used in some telescopes. Searching through many books, I found a gadget that has produced favorable results; a device first introduced many years ago by A.C. Couder. His description is found in "Dealing with Diffraction Spikes," in *Amateur Telescope Making - Book 2*, pages 620 - 622.

In that article, Couder described two devices he designed to improve astronomical seeing while also reducing the effects of spider diffraction. His first design was an aperture mask or diaphragm containing four bean-shaped holes fitted onto the telescope entrance (see *Figure 1* below) and the other was a system of individual attachments, appearing much like a flower-box decoration, fixed to each of the spider support arms (see *Figure 2* on p. 168). After extensive experimentation with both Couder's designs I selected his second system, the "flower box decoration" design, for its relatively simple layout and easy fabrication.

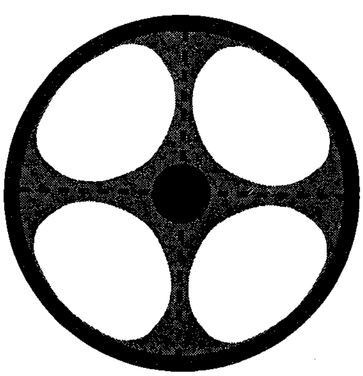


Figure 1. Bean-shaped diaphragm. Circular frame with bean-shaped holes cut into light material and fitted onto the telescope tube entrance.

Couder's article contained no theory nor explanation of either of the designs. His second design suggests he desired to disperse the diffraction spikes throughout the telescope image or to modify the Airy disk in some way. After I made some changes to his original dimensions, I constructed four similar attachments and incorporated them into my 12.5-inch f/30 Classical Cassegrain and 12.5-inch f/7 Newtonian.

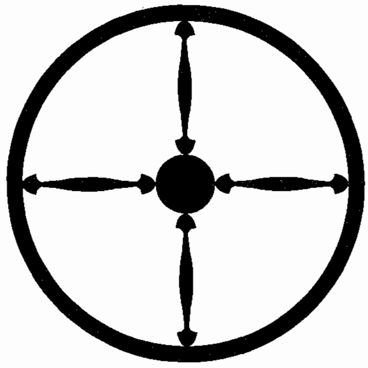


Figure 2. "Flower Box" diaphragm. Individual sections are fitted onto each secondary support arm.

FINISHED DESIGN

Figure 3 (below) illustrates the basic device I call the "Diffraction Spike Suppressors (DSS)." Each section of the device is separated into two identical shapes cut from 1/2-inch 0.030-inch aluminum angles commonly found in hardware stores. Each half section is precisely marked and is cut with a milling machine or simply shaped with a file while several halves are held together in a small vise. Smooth edges are important here.

As illustrated in *Figure 3*, holes are then drilled at each end for 2-56 screws. These screws are used to tighten both halves onto each secondary support so each suppressor is fitted level with the telescope tube entrance.

Telescope optical systems vary considerably in size, so *Figure 4* (p. 169) illustrates the correct ratio of proportions for each section in terms of the total length of each half section. The overall length of the device is the distance from the outer edge of the secondary mirror to the outside edge of the primary mirror (see *Figure 5* on p. 169).

CONCLUSION

The degree to which these devices improve telescope performance depends solely on the perception of the individual observer, his equipment, and his particular seeing conditions. Before you make a final judgment about the usefulness of any of these systems, you should test them over a long period under various conditions. Although my testing methods may be subjective I noticed a definite improvement in image quality using both the apodizing screen and the Couder "bean hole" mask. My testing revealed even more improvement in the telescope image quality by using the "Diffraction Spike Suppressors" as described in this text.

One point should be made. This system is not a cure-all for bad seeing. I have found by using the DSS system the diffraction spikes caused by the spider supports are almost nonexistent—even while observing the bright star Sirius or the planet Mars. A definite improvement in the "astronomical seeing" is also apparent. The resultant dispersion of the diffraction spikes apparently causes no reduction in image contrast by the additional flooding or scattering of light in the image field. While no great theory has been expounded here, it is a pleasure to observe through my Newtonian without those annoying spikes emanating from every star or planet.

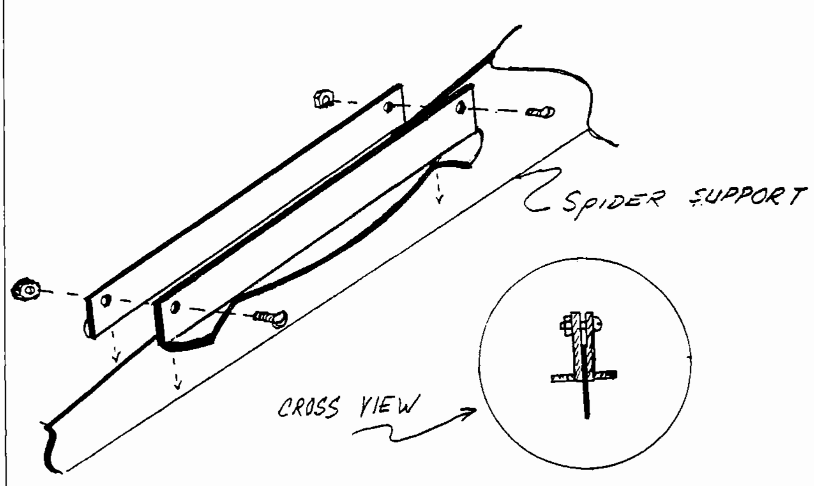


Figure 3. General view of the Diffraction Spike Suppressor design. Shaped from 1/2-inch aluminum angles (0.030-inch stock), each half section is wedged onto each secondary mirror support using 1/4-inch 2-56 screws and nuts.

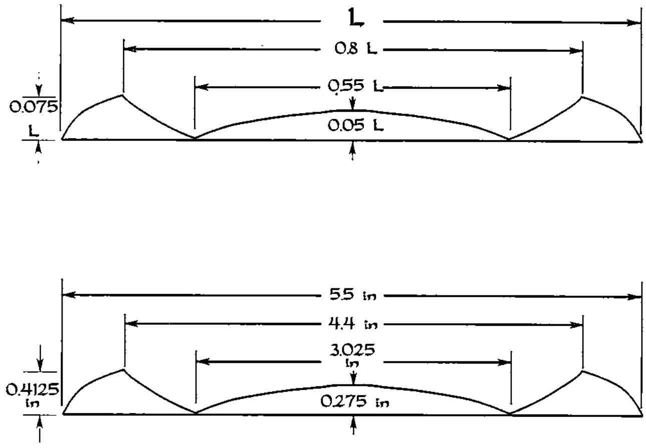


Figure 4. Shown at the top is a diagram of the relative proportions for the "Diffraction Spike Suppressors." All dimensions are relative to the length *L*. At the bottom is an example for a 12.5-inch telescope with a 1.5-inch secondary mirror.

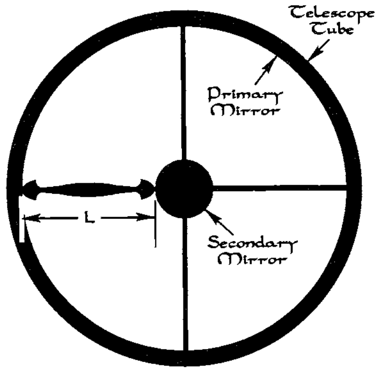


Figure 5. The total length of the device is the equivalent distance from the outer edge of the secondary mirror to the outer edge of the primary mirror. In the case of the 12.5-inch telescope this distance was (D/2 - S/2), here equal to 12.5/2 - 1.5/2 or 5.5 inches.

THE PERFORMANCE OF SCHMIDT-CASSEGRAIN TELESCOPES FOR CRITICAL LUNAR AND PLANETARY WORK

By: Klaus Brasch

Comment by Editor: This essay was originally submitted as a letter, contributing to our ongoing discussion about which optical designs are suitable for lunar and planetary work. However, when a letter runs to several pages and has several illustrations, I believe that it deserves to be set aside as a separate article.

I have enjoyed very much the extended discussion on telescope selection in the past three issues of this Journal. No doubt all the participants, but especially those readers new to amateur astronomy, have learned a great deal about this perennially contentious issue. As Harry Jamieson so aptly points out, the best advice for our novice members is this: join an astronomy club first, try out various telescopes and eyepieces, and only then decide which combination best suits your needs.

Having "suffered some slings and arrows" myself because of my stand on Schmidt-Cassegrains, I now feel compelled once again to write to defend them as telescopes highly suitable for lunar and planetary work. I do this for several reasons: (1) Experience and countless published observations and photographs by amateurs, including many published in the J.A.L.P.O., have proven this argument. (2) SCT's [abbreviation for Schmidt-Cassegrain Telescope. Ed.] are extremely popular and versatile telescopes and their owners should be encouraged, rather than discouraged, to use them for our work. After all, our aim must be to widen the appeal of lunar and planetary observing, not restrict it to users of refractors or long-focus Newtonians. (3) It is always fun to argue with purists—I should know because I tend to be one myself!

As I have stated before and as most observers appear to agree, modern apochromatic refractors [APO's; a three-element refractor design that minimizes chromatic aberration. Ed.] and well-made, long f-ratio Newtonians are clearly excellent telescopes for lunar and planetary work. Large (6-8 in) APO's, however, are bulky to mount and very expensive on a cost-per-aperture basis. Mid-size (8-12 in) Newtonians are a relative bargain in terms of cost per aperture; but their transportation, mounting, and collimation can be deterrents to their frequent use. Ideally, such instruments are permanently housed in an observatory.

Also as I have stated before, commercial SCT's are rarely outstanding either optically or mechanically. They are, however, excellent compromise instruments in terms of portability, sturdiness, affordability, overall optical quality, and generally hassle-free operation. They are suitable for both Solar-System and deep-sky astronomy, visual and photographic work, long- and short-f-ratio operation, and so forth. Besides, all these advantages can be had in a medium-to-large aperture range (8-14 in) and in a compact package. These are powerful attributes in a single telescope design.

But are SCT's optically good enough for really "critical" Solar-System study? Some observers contend "no"; I definitely disagree and hope to demonstrate otherwise. This is the place where issues of "theory" versus "practice" come into play. As Harry Jamieson correctly points out, the 30-35 percent central obstruction found in most SCT's does lower contrast somewhat and can yield "softer" images when compared with unobstructed systems like refractors. Long f-ratio Newtonians are better in this regard because obstruction by the secondary mirror can be as little as 20-25 percent. [These percentages are the ratio of the secondary diameter to the primary diameter. Some "planetary" Newtonians have ratios of 15 percent or less. Ed.] This does not mean, however, that a clean, well-made, and properly collimated SCT is unsuitable for lunar and planetary work just because its optical design is not optimized for such studies. Remember, the SCT is a compromise system; not ideal for any specific application, just good all-round.

Rodger Gordon states that he never recommends SCT's to anyone for lunar and planetary observing. That is most unfortunate for at least two reasons. First, it effectively discourages the many otherwise-happy users of SCT's from participating in this important facet of astronomy. Second, it is an unwarranted generalization, similar to one that many observers make that a long f-ratio telescope is unsuitable for deep-sky observing. Both contentions are simply too extreme and, quite frankly, usually not true.

I do agree with Rodger and Harry that some off-the-shelf SCT's are not optically so well made as they should be. Quality control in complex, mass-produced instruments like these has varied over the years, and one major United States manufacturer has been particularly lax in this regard. The solution to this problem is obvious. Test your newly-acquired instrument, or have it thoroughly inspected by an experienced colleague. If it is found wanting, return it for adjustment or exchange. Most manufacturers today have become very sensitive to this issue and will usually comply.

Finally, as the saying goes (with some poetic license), "the proof is in the telescope." All my serious observing with SCT's has been through instruments made by Celestron, and so my comments must be considered with that in mind. For comparison, I have also had extensive experience in lunar and planetary work with 5- and 6-inch achromatic refractors, an 8-inch f/7 Newtonian, and a 7-inch APO.

Over the years, I have closely examined Jupiter and Saturn through literally dozens of C-8's. Only in a couple of cases was the image quality totally unacceptable in my opinion. Both those instruments had severe mirror-shift problems. This is a mechanical fault only, and is readily corrected at the factory. Most SCT's eventually require such servicing. More to the point, however, most of the above telescopes provided views of Jupiter and Saturn that were entirely acceptable for both photographic and visual purposes. Some C-8's, of course, were better than others, but most readily matched or surpassed the images of typical 6-inch Newtonians or of my 5-inch apochromatic refractor. Remember, too, that those same SCT's also could be used to obtain first-class, high-resolution photographs of globular clusters at prime focus (f/10) and stunning shots of many galaxies and nebulae at f/5, using a telecompressor. The versatility of the SCT is hard to beat. I conclude that the best C-8 that I have used readily matched my excellent 8-inch f/7 Newtonian; though not, however, APO refractors larger than 5 inches aperture and costing several times as much.

I have had the most experience in both photography and visual work with a classic C-10, a C-11, and two C-14's. Although these instruments were fully field tested before their purchase, none were preselected; all were production-line telescopes. The C-10 and one C-14 were late 1970's vintage, and the C-11 and the second C-14 were manufactured in the mid-1980's. While this does not represent a broad survey of telescopes, it does effectively represent a small random sampling.

The accompanying illustrations (*Figures 1-5* on pages 171-172) show what can be done photographically with such instruments under favorable conditions. As with most astrophotographss, some finer detail visible in the original slides and prints is lost through reproduction. Although all photographs were printed for the best contrast and sharpness, no extraordinary measures were taken to enhance image contrast. These methods, such as dodging or masking, or sandwiching several negatives together, can help reveal even subtler atmospheric features and color hues.

The main point is that these images are essentially on par with those taken through other types of telescopes in this aperture range. The resolution, sharpness, and contrast attained with these SCT's is excellent and obviously more than adequate for photographic purposes.

Visually, too, SCT's can be used to good effect under favorable atmospheric conditions and in combination with color filters. See, for example, my article on Mars in *J.A.L.P.O.*, Vol. 34, No. 1 (February, 1990), pages 19-21. Such renowned lunar and planetary observers as Jean Dragesco and John Westfall have successfully used C-14's for many years. For examples of their work, one has only to refer to the countless articles and reports in the *J.A.L.P.O.* and many other publications.

To end, I suggest to our novice members that if they are getting a telescope primarily for observation of the Moon and planets, then they should by all means obtain an instrument optimized for that. A 5-inch or larger APO or an 8-inch or larger long-focus Newtonian would be an excellent choice. However, if you already own a good SCT or want to acquire an extremely versatile instrument that is also highly suitable for Solar-System study, then don't feel excluded. Use your Schmidt-Cassegrain telescope to its fullest potential.

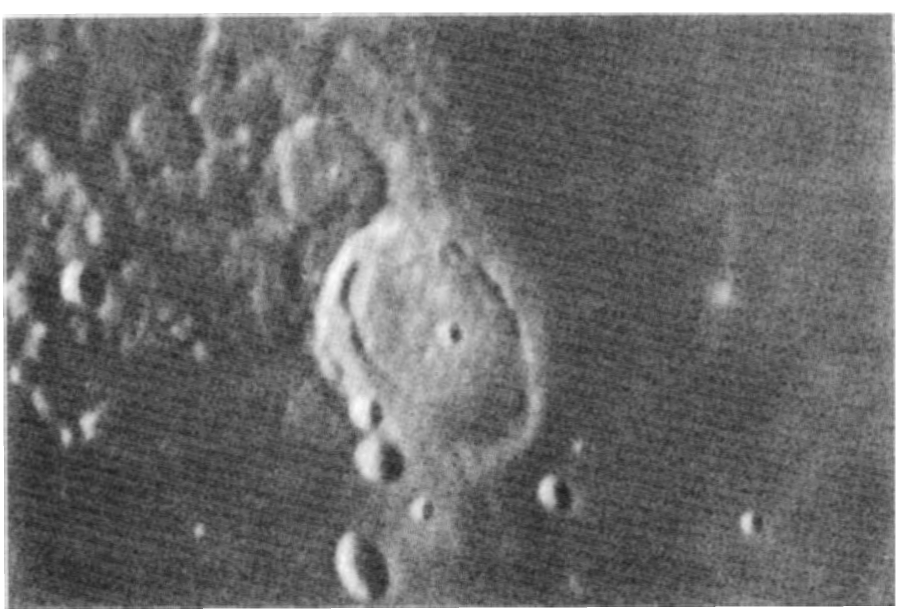


Figure 1. The 100-km lunar crater Posidonius and vicinity. Photographed by Klaus Brasch with a 36-cm Schmidt-Cassegrain (C-14) at f/130 on 1988 Jul 03. Ektachrome 200, 2 sec. South at top.

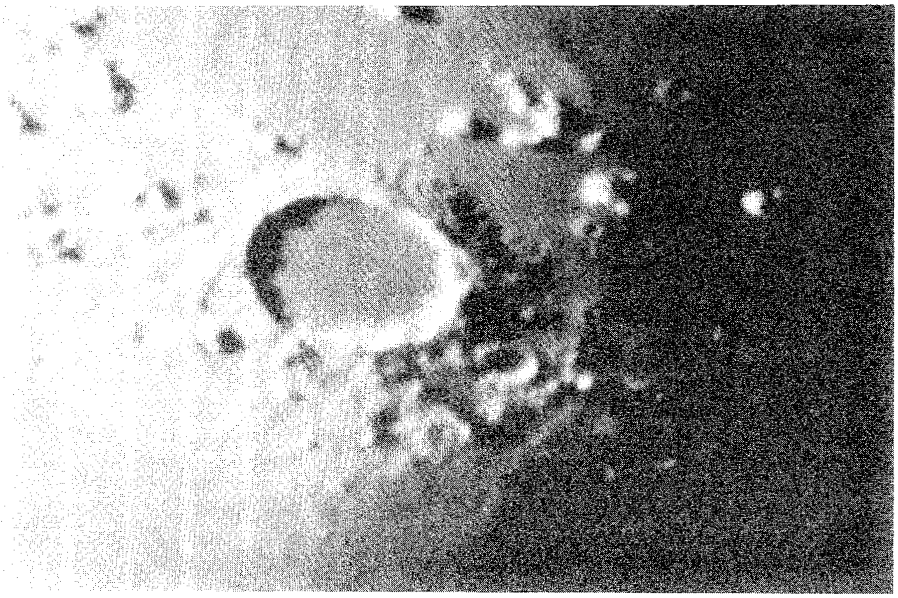


Figure 2. The 100-km lunar crater Plato is near center. Photographed by Klaus Brasch with a 28-cm Schmidt-Cassegrain (C-11) at f/140 on 1989 OCT 09. Fujichrome 100, 4 sec. South at top.

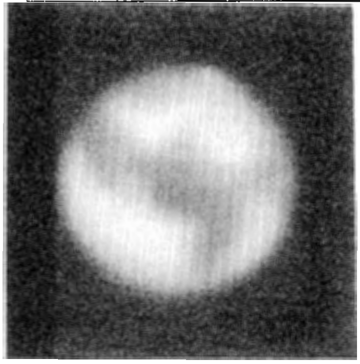
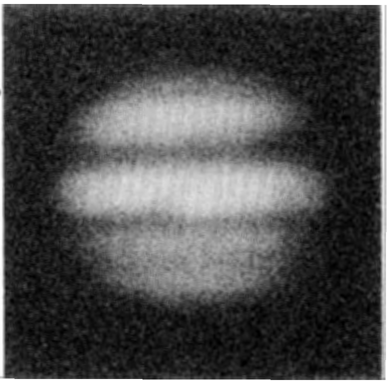


Figure 3. Mars photographed by Klaus Brasch on 1988 OCT 01, 04h50m UT, with a disk diameter of 23".5 and a central meridian of 272°.6. 36-cm Schmidt-Cassegrain (C-14) at f/200. Technical Pan 2415, 3 sec. The south polar cap is visible at top, and Syrtis Major is in the lower right.

Figure 4. Jupiter photographed by Klaus Brasch on 1985 SEP 01. 25-cm Schmidt-Cassegrain (C-10) at f/135. Ektachrome 64, 6 sec. South at top.



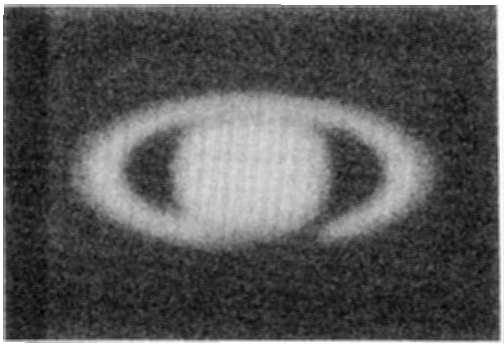


Figure 5. Saturn photographed by Klaus Brasch on 1989 AUG 27. 36-cm Schmidt-Cassegrain (C-14) at f/150. Fujichrome 100, 8 sec. South at top.

Our Readers Speak

(As always, these letters have been slightly edited for style; but not for content ; this means that the letter writers are responsible for their opinions, not the A.L.P.O.)

Dear Dr. Westfall:

I enjoyed Mr. Jamieson's article, "Getting Started: Telescope Selection," and the many letters that have appeared in response. I hope you will continue the letters section.

I second Mr. Bock's suggestion for controlled comparisons between various types of telescopes of similar aperture.

There is a lot of anecdotal evidence cited in favor of one design over another—but such evidence is not very reliable. Side-by-side testing of instruments of high quality under steady skies is needed. The tests should be done by experienced *observers* on a variety of objects. The optical quality of the systems being used should be quantified and should be comparable.

Even with these conditions, it will be difficult to get a truly objective test. The observers will certainly know which telescope is which, and we all have a tendency to see what we expect, or even to ignore evidence that goes against our expectations.

Until a variety of *controlled* tests are done, our knowledge of the telescope hierarchy and the purported advantages and disadvantages of the various designs are little more than guesswork. There are so many factors that affect telescope performance that it will be difficult to put things on a more empirical basis, but it would be nice to stop relying on informal testing and theoretical arguments.

Alan French

R.D. 4, Box 205A, Scotia, NY 12302

September 21, 1992

Dear John:

In response to Dennis di Cicco's letter in *J.A.L.P.O.*, Vol. 36, No. 3, p. 135, I offer the following. I'm glad to know that the baffling problem in the SCT tests done by "Sky Watcher" in 1987 has been corrected. The question arises then: Was this a problem limited to one or two production runs, or are there a decade-and-a-half's worth of SCT's out there with the improper baffling? If the latter, was there a recall offered to consumers to fix the problem? Do manufacturers only respond to problems after there are enough complaints or when documentation is offered? Did the test reports done by "S&T" and *Astronomy* back in 1990 of SCT's prod the manufacturers to improve their product? And why did it take 15-20 years for the major magazines to conduct product reviews of these systems?

Let us assume that Mr. di Cicco is correct in that the current SCT's are the best *general purpose* telescopes available. The *J.A.L.P.O.*, however, caters to a specialist's field in which high image quality is the "sine qua non." Considering the past variations of optical quality of SCT's and the large central obstructions involved, one would still hesitate to recommend them to an individual who has decided that lunar and planetary observing is his particular forte.

I did not mean to imply that S&T's tests of the SCT's a few years back were flawed or were not thorough. They were thorough. However, there are tests like those "Sky Watcher" performed which can be done by any amateur with access to a test chart, light bulb, and 35mm camera. This equipment is far more likely to be found in amateur hands than is semi-sophisticated test equipment.

Manufacturers and dealers "hype" their products to a greater or lesser degree. Some statements are factual, but sometimes overblown; others are correct, but misleading; while still others are false or perhaps difficult to prove or disprove. I will cite two *recent* examples.

First, in the December, 1992 issue of S&T there is an advertisement by an American importer of an excellent-quality 4-inch (100mm) Japanese fluorite apochromat. The ad claims that this particular apochromat has the same image brightness as a 140mm apochromat that used ED-FK01 glass. Now this is absolutely not correct! A 4-inch (100-mm) objective has a surface area of 12.57 square inches; and a 5.6-inch (140-mm) objective has a surface area of 24.63 square inches, based on the formula $A = \pi r^2$. The 140mm gathers almost twice as much light as a 100mm, leading to a limiting magnitude threshold about +0.75 magnitudes fainter than the 100mm. What proof is offered in the ad that the 140mm is losing half its image brightness compared to the 100mm, or that the images in the 100mm are as bright as in the 140mm? None; and there won't be any either because it's impossible.

I caught this baseless claim right away, as did the noted optical designer Dick Buchraeder. Why didn't S&T catch it? Granted, S&T cannot police every ad, but this one was pretty blatant. The quality of the telescope concerned is quite high; and it can stand on its own merits, without resorting to claims like the one above that cannot be validated.

Now for a second example of recent origin:.A reference is made by Celestron on p. 418 of the October, 1992 S&T to the Vixen lanthanum eyepiece: "The rare earth glass lanthanum is used as one of the field lenses in these eyepieces to keep aberrations to an absolute minimum." Just what aberrations are being referred to? They are certainly not distortion or field curvature! My tests of the 4- and 6-mm Vixens in fact show conclusively that they have *more* of these two aberrations than *any* current production eyepieces of similar field angles and focal lengths; greater in fact than any wide-angle 60-80° eyepiece that I'm aware of.

My complete test report for these eyepieces is available in the December, 1992 issue of *The Observer*, published by the Lehigh Valley Amateur Astronomical Society. My tests show that a planet like Jupiter goes from its normal slightly oval shape in the middle of the field to an egg-shaped football near the edge and in a highly curved field to boot!

The Vixen lanthanums do have excellent eye relief. In my opinion, the lanthanum is used to provide this. The use of lanthanum in eyepieces is not new. It was used in many World War II Erfles for the military, where it *was* used to provide excellent aberration control. I have one of these older eyepieces in my collection; it has a 68° apparent field.

Indeed, my 1960's-vintage 7-mm Criterion Achromatic Ramsden gives an excellent account of itself compared to the 6-mm lanthanum in all respects except eye relief. Regarding the latter, why do we get 8 elements with 10 air-to-glass surfaces in a short focal-length eyepiece of standard field, where light and contrast are of paramount concern? The best eyepieces of similar field of view and focal length, using 4 elements and 4 air-to-glass surfaces, are significantly better than the Vixens. Last week I checked out a 6-mm Orthoscopic (classic design) that Vixen provides with their fine 90-mm f/11 refractor and was more impressed with that eyepiece than with their more costly lanthanum equivalent.

A.L.P.O. readers may be interested in knowing that I am writing the first book exclusively devoted to *telescope eyepieces.* In fact, *Sky & Telescope* will be publishing it; I hope by the end of 1993. The book will clear up a lot of myths about eyepieces, yet will be quite fair to all manufacturers wherever it recommends specific eyepieces by design or brand name for various observing pursuits. In other words, I will match their best attributes to the observing situations for which they are best suited.

It would serve everyone better if manufacturers or dealers would stop making unsubstantiated advertising claims and would stick to the facts when selling their products. We would all be better off.

Rodger W. Gordon

637 Jacobsburg Road, Nazareth, PA 18064

November 11, 1992

[Mr. Gordon sent two letters on the same day, in reply to two separate letters in the column in our last previous issue. His second letter follows here.]

Dear John:

This letter is in response to Dr. Goodman's letter in *J.A.L.P.O.*, Vol. 36, No. 3, p. 135. In my opinion, Dr. Goodman is attempting to start a controversy where none exists. Had he researched the matter, using the references in mine and other articles, all of his objections would have been answered.

Mellish described his observations of Martian craters long before the Mariner IV flyby in 1965. Mr. Walter Leight, who corresponded with Mellish for many years, turned over all his material on Mellish to me. Mellish describes his observations of these craters in a letter to Mr. Leight dated January 18, 1935. That's 30 years prior to 1965! Also, in a letter to me in 1975, A.L.P.O. Director Walter Haas told me of a Western Amateur Astronomers meeting he attended, *circa* 1950, where Mellish gave a talk on his crater observations—again, well before 1965.

As to Mellish's reliability as an observer, he discovered five comets and just missed getting credit for several others. In fact Mellish was *anti-canal.* He stated that while observing Mars in 1915 with the 12-inch Yerkes refractor he saw the canals as straight lines. However, when he went to the 40-inch refractor the canals "broke up into other shapes." The great anti-canalist E.M. Antoniadi stated that he saw canals many times with a 9-in refractor, but they were resolved into discrete details with the 33-in Meudon refractor.

Mellish did optical work for Lowell Observatory, and in fact he exchanged drawings with staff members there. Nonetheless, he said that he could never see "the canals on Mars" in the drawings they sent him, while the staff at Lowell was skeptical about the drawings of Martian craters that he sent them. In this context it is interesting to note that the archives at the Lowell Observatory are now being cataloged and it is entirely possible that drawings showing these craters may turn up there. The "Friends of the Lowell Observatory" are planning an auction of the archival and other material to help with the Observatory's finances.

Considering Mellish's statements in this light, he can hardly be called "Lowellian" in his thinking! As to his references to water in the cracks and craters, he probably saw the craters rimmed with frost, or frost or icy haze in the deeper valleys, and assumed it was water. It should be remembered that in 1915 it was still believed that Mars had a substantial atmosphere. Mellish's observations and interpretations are consistent with the then-common belief that the planet's atmosphere was substantial, although less extensive than Earth's.

As to the observations themselves: Difficult—yes! Impossible—certainly not! The view Mellish had of Mars was similar to that one would have of a gibbous Moon 2-1/2 to 3 days before full with low-power binoculars. Even 2X-3X opera glasses will show lunar craters at that phase. Mellish's view of Mars was also obtained in the *best* of circumstances, First, seeing was good enough to allow magnifications of 790X and 1100X . Second, Mars was high in the sky and the observations were conducted in the daylight; two hours *after* sunrise when the glare from the Martian surface would have been greatly reduced. Mellish also stated that he saw the craters on *several* mornings in November, 1915, but that his view on November 13 was the *best.* Mellish also took time to diaphragm the Yerkes 40-in to an aperture of 24 in, thus causing the craters to disappear. It is quite probable that he was thinking of the Lowell 24-in when he did this.

In 1965, Edwin P. Martz, who designed the planetary camera for Mariner IV, thought enough about the Mellish observations to contact Mellish by telephone on the day of the Mariner Mars flyby to discuss his 1915 observations. Martz also asked Mellish to attempt to find some of his drawings that he had sent to others years before in the hope of getting a position for a 200-mile diameter crater that Mellish had described. This conversation resulted in Mellish's June, 1966 letter to *Sky & Telescope.*

Mellish also contacted Walter Leight at the same time because Leight possessed certain Mellish drawings made in 1915-1916. He hoped that one of these drawings would fix the position of the large crater. He apparently succeeded. I quote from Mellish's letter to Leight, dated June 6, 1966: "I just got your valuable letter and it was a valuable letter too as it gave me the photographs of the drawings of Mars that I needed." In the same letter, he wrote: "I am going back to Oregon tomorrow and will send you your pictures in just a few days as soon as I can get them oriented so I can get the position of that big crater I saw. It was about 200 miles diameter and I have to figure out its longitude so I can give the position to the Jet Laboratory ..." (He refers here to the Jet Propulsion Laboratory, which was in charge of receiving the data transmitted by Mariner IV.)

In the same letter, Mellish laments the loss of his Mars crater drawings, his optical shop, telescope under construction, and the pictures and mementos of his family; all of which were destroyed by fire in 1964.

As far as my own "prescience" is concerned, I read about Mellish's observations of craters on Mars in 1957. H.P. Wilkins described Mellish's observations in his book *Mysteries of Space and Time*, published in 1956. Wilkins himself used the 40-in Yerkes refractor at Mars' close opposition in 1954, and described the oases as "resembling craters." Is this prescience? Well, I do read a lot! Also, I was but 16 years old in 1957.

The case of E.E. Barnard's having sighted the craters is nowhere as substantiated as Mellish's. However, A.L.P.O. Director Emeritus Walter Haas remembered a visit he made to Yerkes in 1937, when a staff member told Haas about Barnard's recording craters and other Martian relief features such as hills and cracks. He also said that the Yerkes staff members held Lowell's observations in low regard. It is also evident from Mellish's statements that Barnard saw craters and there is no reason for Mellish to fabricate a story about Barnard or himself.

I believe that there is overwhelming evidence that the Mellish observations are genuine. My original sources, and the source material of others like Gene Cross, who has also written articles about Mellish, would in fact constitute proof in any court of law. It is too bad that Dr. Goodman made conjectures without having done any research into the subject.

Incidentally, I have in my possession drawings Mellish made with the 12-in and 40-in Yerkes refractors in 1915-16. The "canals" that he drew are very irregular and are much wider than anything Lowell showed. In fact, Mellish's "canals" can hardly be called such. They have the appearance of natural features in contrast to the types of markings recorded by Lowell and his followers.

Rodger W. Gordon

637 Jacobsburg Road, Nazareth, PA 18064

November 11, 1992

Dear John:

I am responding to letters written to the Editor about Harry Jamieson's article on telescope selection, that appeared in *J.A.L.P.O.*, Vol. 36, No. 2 (July , 1992).

As much as I respect and admire Don Parker for his work, and Rodger Gordon for his experience, I have to disagree with their viewpoint that some of today's modern, wide-field eyepieces are "high-priced junk," because they have an "excessive" number of elements. What is excessive? Elements are put in for reasons. They correct aberrations. Aberration correction is extremely important in wide-field eyepieces; and a little secret is that it is important in narrow-field eyepieces too. Why would eyepiece elements be considered excessive? These eyepieces are a pleasure to use, with their large eye elements and relatively short focal lengths. I think that Rodger makes too much ado about a little veiling glare and ghosting; and too little about surface accuracy, centering of the elements, barrel design, and fabrication.

These eyepieces *are* high-priced, but I have found all their surfaces to be ML [multi-layer] coated and of very high quality. Of course, we can't really know what brand the letter referred to is discussing. However, using my 20-mm Nagler with my 12-1/2-in f/20 Buchroeder Tri-Schiefspiegler at 318X, the Moon is awesome. The same eyepiece gives superb views in my 18-in f/5.1 Newtonian. Finally, Saturn is excellent on nights of good seeing through my 9-mm Nagler used with the 18-in. The point is that the number of elements isn't important; it's the quality of fabrication that is important.

This brings me to my final point. Many writers stated that "assuming good optics" this or that was true. Well, good optics cannot be assumed, even in a discussion. Our observers know this well, for the whole discussion is really about good optics, isn't it? All telescopes are good if their optics are good and they are aligned. Some may be a bit better due to a smaller percentage of obstruction, or to a lack of obstruction. However, points like obstruction, tube design, alignment, eyepiece design, and seeing conditions become secondary. These criteria are not important unless the optics are good; then and only then a good telescope is possible.

The real question then becomes where to get good optics. They are available today, but it is our responsibility to seek them out and to be prepared to pay for them. Discretion is in order when purchasing optics and telescopes.

I would suggest that our more experienced writers be more appreciative of the wonderful selection of quality products available in our country today, thus providing better leadership for our novices. These writers should stress the optical quality of what is purchased.

Our novices may want to do some reading about optical theory to prepare themselves for searching for good telescopes and optics. Also, learning to test their telescope is in order, either on a star or on a test stand. There is no substitute for knowledge. And finally, it will be their choice as to what telescope to purchase or build; but they should base their decision on optical quality of the type needed for the form of observing they intend to do.

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January 7, 1993

OBSERVING METEOR SHOWERS WITH A MICROSCOPE

By: Charles A. Kapral

ABSTRACT

Approximately 300 metric tons of meteoritic material fall upon the Earth each year. This report describes a project whereby anyone can detect and measure this material, and shows how it is possible to detect meteor showers by monitoring the count of micrometeorites.

INTRODUCTION

The only time that meteors belonging to a stream can be seen is when the ascending or descending node of the stream's orbit intersects the Earth's orbit. This situation produces a meteor shower. The mean daily rate of visual meteors is 9.7±0.7 meteors per hour. Meteors of visual magnitude +2 are the most often seen. Visual meteor observers have a more difficult time distinguishing shower meteors from sporadic meteors when the Zenithal Hourly Rate [ZHR; the rate for a single observer under a dark sky looking toward the zenith. Ed.] of a shower is 5 or less meteors per hour than they would when the ZHR is greater.

Because there are annually approximately 148 recognized meteor showers with durations between 0.28-2.8 days, at least one shower is active on any night. Therefore, the "sporadic" meteor rate is actually a combination of the truly sporadic meteors, whose orbits are truly random, and the meteors belonging to unrecognized minor showers. The latter comprise approximately 20 percent of the meteors seen on a "non-shower" night.

MICROMETEORITES

Each year approximately 300 metric tons of material falls upon the Earth. This material is, micrometeorites; meteoritic dust traveling through space, only to be swept up by the Earth. The formal definition of a micrometeorite is a particle between 0.5 to 200 microns in diameters (a micron is 1/1000 millimeter or .00004 inch) which enters the atmosphere at cosmic velocities without burning up. They survive because they have a surface area-to-volume ratio sufficiently high that energy can be radiated away as fast as it is generated by collision with the molecules of the atmosphere.These particles thus fall unaltered to the Earth's surface.

Another type of micrometeorite that reaches the Earth's surface is caused by larger meteoritic bodies disintegrating as they pass through the atmosphere. Until 1955, a meteoroid [the meteoritic body traveling through space] was thought to be a single solid particle of iron or stone. Then, L.G. Jacchia (1955) proposed that a meteoroid may be a conglomeration of small grains; a dustball. When the dustball enters the Earth's atmosphere, it ablates in the form of progressively fragmenting particles. R.L. Hawkes and J. Jones (1975) expanded on Jacchia's idea and developed a model of a dustball meteoroid by assuming that it contains high-melting point iron or stone particles held together by low-melting point particulate "glue." As the dustball enters the atmosphere and heats up, the "glue" ablates first, without emitting light. The dustball then fragments into higher-melting point particles, which ablate according to the classical theory of meteoroid entry. As the meteoroid burns up, the small spray drops burning off the meteoroid immediately cool and solidify into tiny spherules. The spherules gradually settle on the Earth's surface. These particles are mostly nickle-iron, are highly reflective, and can assume various shapes. *Figure 1* (below) shows the shape classification that I used for this project.

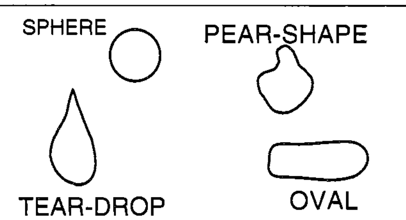

Figure 1. Micrometeorite shape classification.

THE PROJECT

Because these micrometeorites are the result of meteorites burning up in the atmosphere, there should logically be more of them when there is a meteor shower. To verify this, I made a series of measurements on each of 45 mornings in a 48-day period. Each "observation" was made by placing a microscope well-slide (a slide with a circular depression in its center) outdoors, exposed to the unobstructed sky. The next morning, after a full day of exposure, the slide was taken in and replaced by another at the same location. The exposed slide was then inspected with a microscope at 100× in order to count the micrometeorites in the slide well.

I chose my observing period to include the Lyrid Meteor Shower, which occurs between April 16-25 and peaks on April 20-21; and the Eta Aquarid Shower, which is visible April 21-May 12 and peaks on May 4. I began counting on March 30, 1992, to record the number of micrometeorites and to obtain a typical daily count when there was no major shower. I also subdivided each count into the

Table 1. Daily Micrometeorite Counts.

Note: S = Sphere, P = Pear-Shape, T = Tear-Drop, O = Oval.

1992 Date		S	P	T	O	Sum
Mar	30	10	0	0	0	10
	31	11	0	1	1	13
Apr	1	8	0	0	0	8
	2	14	0	0	0	14
	3	12	0	1	0	13
	4	19	0	0	0	19
	5	21	0	0	1	22
	6	26	0	3	0	29
	7	37	0	2	0	39
	8	41	0	1	0	42
	9	42	0	1	1	44
	10	44	0	1	2	47
	11	74	0	0	0	74
	12	74	0	2	3	79
	13	76	0	5	0	81
	14	106	0	6	0	112

1992 Date		S	P	T	O	Sum
Apr	15	115	2	7	2	126
	16	105	0	9	4	118
	17	*(no measurement)*				
	18	125	0	10	2	137
	19	*(no measurement)*				
	20	148	0	8	3	159
	21	163	0	16	0	179
	22	119	3	9	2	133
	23	119	0	7	3	129
	24	91	0	8	4	103
	25	69	1	3	2	75
	26	55	0	4	4	63
	27	47	0	3	2	52
	28	40	1	3	0	44
	29	*(no measurement)*				
	30	34	0	2	1	37

1992 Date		S	P	T	O	Sum
May	1	35	0	0	6	41
	2	28	1	0	2	31
	3	26	0	1	2	29
	4	53	0	3	3	59
	5	23	1	2	0	26
	6	27	2	3	1	33
	7	39	2	4	2	47
	8	20	0	2	1	23
	9	16	1	4	0	21
	10	25	2	4	1	32
	11	35	0	0	0	35
	12	18	0	1	0	19
	13	26	0	2	1	29
	14	51	3	5	0	59
	15	19	0	3	0	22
	16	18	0	1	0	19

four categories, "sphere," "pear-shape," "tear-drop," and "oval" that are shown in *Figure 1*. My micrometeorite counts were made daily through May 16, 1992, except for April 17, 19, and 29; with the results shown in *Table 1* above. The total daily frequency of micrometeorites is graphed in *Figure 2* (p. 178).

An analysis of the daily counts showed that the micrometeorite frequency increased, beginning on April 4. The counts increased each day, peaking on April 21, the predicted maximum of the Lyrid Shower. Other peaks occurred on May 4, 7, 11, and 14. The April, 1992, issue of *Meteor News* stated that the Eta Aquarid Shower peaks on May 4-7, with a secondary peak on May 8-11. It appears that the count maxima coincide with the peaks of the showers, validating that it is possible to track meteor showers with a microscope. [Also implying that the micrometeorites precipitate to the Earth's surface in a relatively short time; perhaps less than one day. Ed.]

A graph of micrometeorites by type is shown in *Figure 3* (p. 178; the spheres are not plotted there because they essentially followed the same pattern as the total shown in *Figure 2*). This, with *Figure 2*, shows that the "Spheres" and "Tear-Drops" peaked with the showers, while the "Pear-Shapes" and "Ovals" did not.

Also, the ZHR at maximum is about 10 meteors for the Lyrid Shower and about 20 for the Eta Aquarid Shower, although these rates can vary widely. Because the periods of the two showers overlap, the counts beginning about April 16 reflect meteorites from both showers. Although the usual visual counts for the Eta Aquarid Shower are greater than for the Lyrid Shower, because the former's maximum is greater, the micrometeorite count was actually lower. This apparent contradiction is probably due to the fact that the Eta Aquarid Shower is a southern shower, with more meteors being visible from the Southern Hemisphere of the Earth than from the Northern. An observer performing this project in the Southern Hemisphere probably would find that the Eta Aquarid count was the higher.

I plan to use the counts by type of micrometeorite to attempt to discover whether meteor showers can be differentiated by their type of micrometeorites. At present, insufficient data are available to do so. I am also now searching for the causes of the May 11 and May 14 peaks.

This project is simple and rewarding. The counting process takes about five minutes per day, and is not hampered by wind or rain. The identification of micrometeorites is easy; but if you are not sure, place a magnet under the slide. Because these particles are nickel-iron, they are affected by the magnet.

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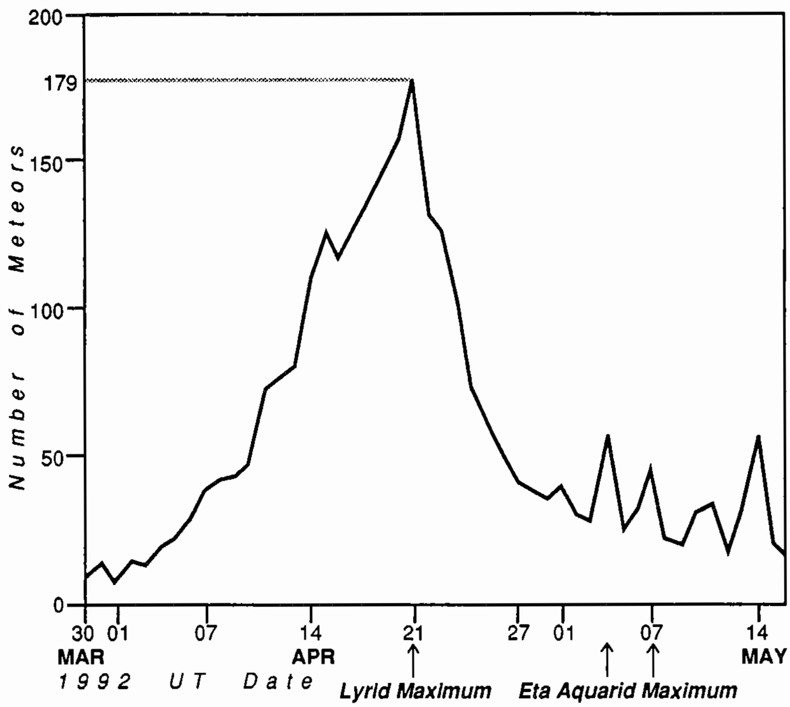

Figure 2. Daily total micrometeorite counts.

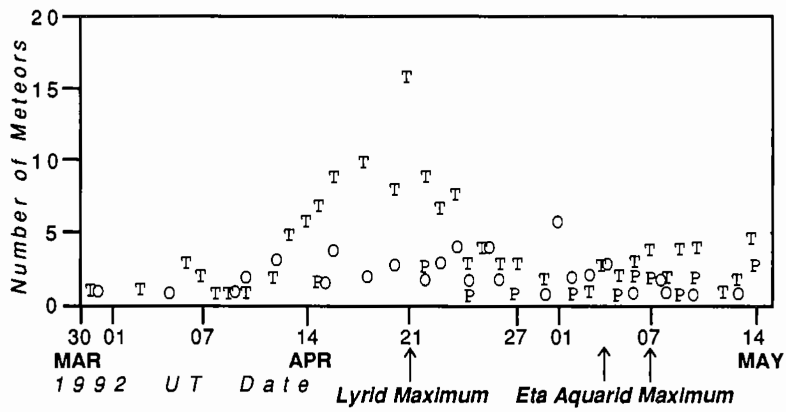

Figure 3. Micrometeorite counts by type of micrometeorite. O = oval; P = pear-shape; T = tear-drop.

METEORS SECTION NEWS

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

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

1992 UT Date	Observer and Location	Universal Time	Number and Type of Meteors Seen*	Comments* (+N = Limiting Magnitude)
JUN 03	J. Kenneth Eakins, CA	06:00-08:00	1 THE, 4 SPO	+5.4
JUL 01	John Gallagher, NJ	05:55-07:03	5 JLY, 3 BCY, 1 JBO, 1 SPO	+5.2
02	" " "	05:05-07:16	2 TAQ, 2 JBO, 6 SPO	+7.0
03	" " "	04:00-06:06	1 JLY, 1 JPE, 2 SPO	+7.0
	George Zay, CA	08:35-11:41	2 TOP, 3 LSA, 3 CAP, 23 SPO	+5.5
04	Mark Davis, VA	03:30-04:30	8 SPO	+5.5
	" " "	04:30-05:30	9 SPO	+5.5
	" " "	05:30-06:30	12 SPO	+5.5
05	George Zay, CA	07:23-11:31	36 SPO	+5.7
08	John Gallagher, NJ	04:25-07:03	2 JSC, 3 JBO, 3 SPO	+7.0
10	" " "	03:25-06:43	1 JBO, 1 ACG, 1 DCE, 1 TCP, 9 SPO	+6.9
11	" " "	04:50-06:10	1 ACG, 1 DCE, 4 SPO	+5.9
15	" " "	05:15-07:21	4 ACG	+5.0
19	George Zay, CA	04:30-05:31	3 SPO	+5.7
	John Gallagher, NJ	04:45-07:23	1 ODR, 1 BAQ, 1 UPG, 1 PER, 3 SPO	+6.5
21	Robert Lunsford, CA	08:54-12:00	1 PER, 17 SPO	+5.5
22	" " "	09:00-12:00	1 PER, 30 SPO	+6.0
24	George Zay, CA	05:32-11:24	1 PAU, 2 CAP, 3 NDA, 1 SIA, 13 SPO	+5.5
26	John Gallagher, NJ	04:30-07:42	9 PER, 1 CAP, 1 PAU, 4 SPO	+6.7
	George Zay, CA	04:45-11:50	13 NDA, 3 CAP, 5 SDA, 1 SIA, 2 PAU, 13 PER, 50 SPO	+6.0
27	" " "	06:59-11:53	1 PAU, 2 CAP, 8 SDA, 5 NDA, 4 SIA, 10 PER, 49 SPO	+5.7
	Robert Lunsford, CA	07:30-12:00	8 CAP, 14 PER, 22 SDA, 3 NDA, 1 BAQ, 1 PAU, 54 SPO	+6.6
28	John King, Mexico	04:18-05:20	3 SPO	+4.8
	Robert Hays, IL	06:50-08:50	11 SDA, 2 NDA, 3 SIA, 2 CAP, 18 SPO	+6.0
	Robert Lunsford, CA	09:00-12:00	3 PAU, 26 SDA, 5 CAP, 22 PER, 1 SIA, 1 BAQ, 2 NDA, 34 SPO	+6.6
29	John Gallagher, NJ	04:35-07:22	2 KCG, 1 SDA, 7 PER, 1 CAP, 12 SPO	+7.2
	Richard Taibi, MD	04:46-08:00	2 PER, 3 SDA, 3 CAP, 8 SPO	+5.6
	George Zay, CA	06:15-11:56	1 PAU, 7 CAP, 13 SDA, 4 NDA, 2 SIA, 21 PER, 57 SPO	+5.7
	Robert Lunsford, CA	07:10-12:00	16 CAP, 8 NDA, 36 SDA, 1 BAQ, 15 PER, 3 SIA, 41 SPO, 2 PAU	+6.5
30	Mark Davis VA	02:10-05:10	3 NDA, 2 CAP, 1 SIA, 5 SDA, 21 SPO	+5.5
	Michael Morrow, HI	12:20-14:20	16 SDA, 5 CAP, 2 PAU, 3 NDA, 2 PER, 25 SPO	+7.0
31	John Gallagher, NJ	04:40-06:19	2 SDA, 2 PAQ, 1 NDA, 2 PER, 1 CAP, 3 SPO	+5.9
AUG 02	" " "	04:50-07:32	1 KCG, 3 ICE, 4 UPG, 3 PER, 4 SPO	+6.5
	Richard Taibi, MD	05:11-07:02	8 PER, 1 CAP, 1 NDA, 2 SDA, 9 SPO	+5.4
	Robert Hays, IL	05:50-07:50	9 SDA, 6 PER, 3 NDA, 13 SPO	+6.0
	George Gliba, VT	05:15-08:12	27 PER, 17 SDA, 4 CAP, 1 KCG, 23 SPO	+6.2
03	John Gallagher, NJ	05:10-08:07	1 KCG, 1 SDA, 1 SIA, 1 ICE, 4 PER, 11 SPO	+6.4
	James Riggs, CA	11:04-12:05	9 PER, 4 SDA, 1 SPO	+6.1

Table 1 continued on pp.180-181 with note on p.181

Table 1—*Continued.*

1992 UT Date	Observer and Location	Universal Time	Number and Type of Meteors Seen*	Comments* (+N = Limiting Magnitude)
AUG 04	John Gallagher, NJ	04:30-05:35	1 ICE, 1 SPO	+5.5
	James Riggs, CA	11:15-12:07	8 PER, 2 SDA	+6.1
05	John Gallagher, NJ	04:35-07:24	10 PER, 1 BAQ, 11 SPO	+6.7
	James Riggs, CA	11:01-12:03	8 PER, 2 SDA	+6.1
06	John Gallagher, NJ	06:15-08:30	1 SIA, 1 ICE, 1 UPG, 9 PER, 1 PAU, 14 SPO	+7.0
	James Riggs, CA	10:51-12:07	19 PER, 6 SDA	+6.1
07	" " "	11:00-12:05	9 PER, 2 SDA, 3 SPO	+6.1
08	Richard Taibi, MD	05:53-08:26	10 PER, 14 SPO	+5.2
	John Gallagher, NJ	06:00-08:40	1 ERI, 1 UPG, 15 PER, 6 SPO	+6.9
	James Riggs, CA	10:45-12:05	21 PER, 3 SDA, 9 SPO	+6.1
09	" " "	10:57-12:03	14 PER, 7 SPO	+6.1
10	John Gallagher, NJ	03:35-05:43	1 ERI, 5 PER, 1 BAQ, 2 SPO	+5.4
	Richard Taibi, MD	07:20-08:55	14 PER, 6 SPO	+5.2
	James Riggs, CA	10:02-12:02	16 PER, 2 SDA, 16 SPO	+6.1
11	Daniel Rhone, NJ	04:00-05:00	4 PER	+4.8
	John Gallagher, NJ	04:30-06:46	6 PER, 1 BAQ, 4 SPO	+6.0
	George Gliba, MD	07:41-08:41	17 PER, 4 SPO	+4.4
	Robert Hays, IL	07:50-09:50	57 PER, 1 UPG, 1 NDA, 19 SPO	+5.4
	Tom Giguere, HI	08:00-11:00	1 SDA, 4 PER, 5 SPO	+4.8
	Michael Morrow, HI	08:00-11:00	3 PER, 5 SPO	+4.8
	Robert Lunsford, CA	09:00-10:00	1 PER, 1 SPO	+4.5; 50% cloudy
	James Riggs, CA	10:32-12:16	27 PER, 2 SDA, 1 SPO	+6.1
12	Robert Lunsford, CA	04:00-05:00	2 PER, 3 SPO	+4.9
	" " "	05:00-06:00	3 PER, 3 SPO	+5.1
	" " "	06:00-07:00	4 PER, 1 SPO	+5.1
	John Gallagher, NJ	06:55-09:24	6 PER	+6.0; 80% cloudy
	John King, Mexico	07:00-08:00	*None Seen*	+3.0; 100% cloudy
	Robert Lunsford, CA	07:00-08:00	14 PER, 3 SPO	+5.2; 10% cloudy
	George Zay, WY	07:35-08:35	16 PER, 2 SPO	+4.9
	John King, Mexico	08:00-09:00	*None Seen*	+3.0; 100% cloudy
	Robert Lunsford, CA	08:00-09:00	16 PER, 1 SPO	+5.2; 25% cloudy
	George Gliba, MD	08:03-09:03	5 PER, 1 SPO	+4.6; 80% cloudy
	George Zay, WY	08:35-10:14	35 PER, 8 SPO	+4.9
	John King, Mexico	09:00-10:00	10 PER	+3.0; 50% cloudy
	Robert Lunsford, CA	09:00-10:00	15 PER, 3 SPO	+5.2; 25% cloudy
	John King, Mexico	10:00-11:00	8 PER, 2 SPO	+3.0; 33% cloudy
	Robert Lunsford, CA	10:00-11:00	14 PER, 2 SPO	+5.2; 50% cloudy
	Michael Morrow, HI	10:45-12:45	11 PER, 4 SPO	+4.7
	John King, Mexico	11:00-11:30	4 PER, 1 SPO	+3.0; 20% cloudy
	Robert Lunsford, CA	11:00-12:00	35 PER, 5 SPO	+5.8; 10% cloudy
	" " "	12:00-12:30	13 PER, 1 SPO	+5.1; 10% cloudy
13	John Gallagher, NJ	03:30-05:11	1 KCG, 1 PER	+5.5; 90% cloudy
	Robert Hays, IL	07:51-08:51	24 PER, 1 KCG, 4 SPO	+4.8; 10% cloudy
	James Riggs, CA	10:50-12:10	12 PER, 3 SPO	+6.1
14	" " "	10:52-12:10	4 PER, 1 SPO	+5.2
19	John Gallagher, NJ	04:10-05:32	2 KCG, 1 NEC	+4.8
20	" " "	05:10-06:54	2 SPO	+6.4
21	George Zay, CA	04:14-06:59	2 KCG, 1 NIA, 9 SPO	+5.7
22	John Gallagher, NJ	05:30-07:32	1 KCG, 1 PER, 1 PAQ, 6 SPO	+6.7
24	" " "	04:05-05:37	3 SPO	+6.5
25	Robert Lunsford, CA	08:45-12:30	2 SEC, 3 PER, 1 SPI, 39 SPO	+6.6
26	" " "	08:30-12:30	1 PER, 45 SPO	+6.3
30	Mark Davis, VA	02:58-06:05	1 AUR, 35 SPO	+5.6
	John Gallagher, NJ	05:30-08:39	1 KCG, 2 AUR, 1 PER, 1 NEC, 6 SPO	+6.8
	Michael Morrow, HI	06:00-09:00	11 SPO	+5.2

Table 1 continued on p. 181 with note

Table 1—*Continued.*

1992 UT Date	Observer and Location	Universal Time	Number and Type of Meteors Seen*	Comments* (+N = Limiting Magnitude)
Aug 31	Mark Davis, VA	07:00-08:00	1 AUR, 7 SPO	+5.1
	George Zay, CA	10:27-12:05	15 SPO	+5.5
	Robert Lunsford, CA	10:30-12:00	3 AUR, 22 SPO	+6.9
Sep 01	John Gallagher, NJ	04:30-07:45	1 SPI, 2 AUR, 1 EDR, 9 SPO	+6.9
	George Zay, CA	03:38-12:25	7 AUR, 2 NIA, 1 KCG, 52 SPO	+5.5
	Robert Lunsford, CA	08:30-12:30	8 AUR, 45 SPO	+6.9
08	" " "	09:30-12:30	1 SPI, 43 SPO	+6.6
10	John Gallagher, NE	06:05-08:11	1 DAU, 5 SPO	+6.1
	George Zay, CA	07:15-08:20	1 DAU, 1 SPO	+5.0
11	John Gallagher, NE	05:40-07:12	1 GAQ	+5.7
22	Robert Lunsford, CA	08:48-12:48	3 SPI, 1 KAQ, 11 SPO	+5.5
23	" " "	09:17-12:47	1 SPI, 2 KAQ, 48 SPO	+6.7
	George Zay, CA	03:08-12:08	2 DAU, 2 KAQ, 1 SPI, 1 OCC, 1 SOR, 40 SPO	+5.6
24	John Gallagher, NJ	04:50-07:58	1 DAU, 1 AND, 7 SPO	+6.1
25	George Zay, CA	05:35-12:40	6 DAU, 3 SPI, 51 SPO	+5.6
28	Robert Lunsford, CA	09:00-13:00	2 SOR, 40 SPO	+6.5
29	" " "	09:00-12:00	1 NPI, 1 NTA, 1 AND, 3 SPI, 2 DAU, 38 SPO	+7.0
30	John Gallagher, NJ	04:45-08:00	1 DAU, 2 NPI, 1 KAQ, 1 GPI, 2 ORI, 11 SPO	+6.6
	" " "	08:00-12:00	2 SPI, 1 KAQ, 2 DAU, 2 SOR, 42 SPO	+6.9

Key to Abbreviations:

ACG Alpha Cygnid
AND Annual Andromedid
AUR Aurigid
BAQ Beta Aquarid
BCY Beta Cygnid
CAP Alpha Capricornid
DAU Delta Aurigid
DCE Delta Cepheid
EDR Eta Draconid
ERI Eridanid
GAQ Gamma Aquarid
GPI Gamma Piscid
ICE Iota Cepheid
JBO June Boötid
JLY June Lyrid
JPE July Pegasid
JSC June Scutid
KAQ Kappa Aquarid
KCG Kappa Cygnid
LSA Lambda Sagittarid
NDA North Delta Aquarid
NEC North Eta Cetid
NIA North Iota Aquarid
NPI North Piscid
NTA North Taurid
OCC October Capricornid
ODR Omicron Draconid
ORI Orionid
PAQ Phi Aquarid
PAU Piscis Austrinid
PER Perseid
SDA South Delta Aquarid
SEC South Eta Cetid
SIA South Iota Aquarid
SOR Sigma Orionid
SPI South Piscid
SPO Sporadic
TAQ Tau Aquarid
TCP Tau Capricornid
THE Theta Herculid
TOP Theta Ophiuchid
UPG Upsilon Pegasid

Erratum:

Alert readers may have noticed that the cover illustration for Volume 36, Number 2 (July, 1992), of this *Journal* was printed upside down. Its caption stated that south was at the top, but the two photographs of Saturn reproduced there were printed with north at the top. Thus, in order to duplicate the usual inverting-telescope view for observers in the Northern Hemisphere, it is necessary to invert the front cover. We apologize for this mistake.

COMING SOLAR-SYSTEM EVENTS: FEBRUARY - APRIL, 1993

WHAT TO LOOK FOR

Although this three-month period includes no spectacular eclipses or conjunctions, it is a good time to view several planets conveniently. There are also two lunar occultations of Venus, one visible from most of North America, six predicted occultations of stars by minor planets and two rare events involving Saturn's satellite Iapetus.

This column is intended to alert our readers about upcoming events in the Solar System; giving visibility conditions for major and minor planets, the Moon, comets, and meteors. You can find more detailed information in the 1993 edition of the *A.L.P.O. Solar System Ephemeris.* (See p. 162 to find out how to obtain this publication.) Celestial directions are abbreviated. All dates and times are in Universal Time (UT). For the time zones in the United States, UT is found by adding 10 hours to HST (Hawaii Standard Time), 9 hours to AST (Alaska Standard Time), 8 hours to PST, 7 hours to MST or PDT, 6 hours to CST or MDT, 5 hours to EST or CDT, and 4 hours to EDT. Note that this addition may well put you into the next UT day!

PLANETS: MARS RECEDING, JUPITER DOMINATING

Mars begins the period as a prominent evening-sky object in Gemini at visual magnitude -0.9, 97-percent illuminated and 13".1 (" = arc-seconds) in diameter. It remains in Gemini until late April, but is moving away from us and growing fainter and smaller. The Red Planet's brightness drops to magnitude +1.0 by MAY 01, while its diameter shrinks to 6".3. As a rule of thumb, you can do useful work on Mars when its diameter exceeds 10"; a condition that persists until MAR 03.

To compensate for Mars' departure, **Jupiter** is drawing nearer. The Giant Planet reaches opposition to the Sun on MAR 30, when its magnitude is -2.4 and its disk measures 44" by 41". Placed in Virgo throughout this period, Jupiter will be the most prominent object in the evening sky.

On FEB 01, **Venus** is a prominent "star" in the western twilight after sunset. Blazing at magnitude -4.5, its disk then appears 44 percent sunlit, located 46° E of the Sun, and spans 28". Venus then appears to approach the Sun, accelerating as it goes. By MAR 01 it is 38° E of the Sun, 42" in diameter, and just 23 percent illuminated. It will be a challenge to follow Venus much longer, as it reaches *inferior conjunction* with the Sun on APR 01. With clear daylight skies you may be able to follow Venus right through conjunction because it will pass some 8° N of the Sun. Venus then pulls away from the Sun as rapidly as it approached it; so by the end of April, the planet will be readily visible in the morning sky.

Saturn is unobservable for some time after its conjunction with the Sun on FEB 09. Located in Capricornus, the Ringed Planet will not be easily visible in the morning sky until late March. By APR 01, it lies 45° W of the Sun, shining at magnitude +0.9 with a disk measuring 16" by 14". Its Ring System is then tilted 11° to our line of sight, measuring 36" by 7".

The Earth and Sun now lie near the plane of Saturn's "two-faced" satellite **Iapetus**. On MAR 22-23, this moon *transits* (passes in front of) Saturn's Globe. This is a rare event, but unfortunately the tiny 11th-magnitude satellite will be hard to spot. It is predicted to *ingress* at Saturn's NE limb at MAR 22, 21h 29m; and to *egress* at the NW limb at MAR 23, 02h 42m. The next Iapetus event is an *eclipse* that is to begin on MAY 01, at 23h 47m; and to end on MAY 02, at 09h 50m. The satellite will be 5.6 Saturn radii WNW of Saturn's limb at eclipse disappearance and 3.8 radii WSW at reappearance. (We thank Brian Loader for sending these predictions. He also informs us that the innermost bright satellite, Mimas, has been undergoing eclipses since July, 1992. The other bright satellites will gradually follow suit as the Sun and the Earth approach Saturn's Ring plane, crossing it in 1995.)

Uranus and **Neptune** are both in Sagittarius, and both were in conjunction with the Sun on JAN 08. Thus they will become observable in the morning sky toward the end of February. Binoculars will be needed to spot Neptune, and for most sites and eyes will also be needed for Uranus. The visual magnitude of Uranus will be about +5.7-+5.8, with a 3".4-3".7 disk. Neptune appears fainter and smaller; +7.8-+7.9 and 2".2-2".3. These two planets appear closer to each other than we have ever seen them since Neptune was discovered in 1846. Indeed, they had a conjunction, just 1°.1 apart on JAN 26. (Sadly, this event was almost unobservable because the two planets then were only 17° W of the Sun.)

Pluto, near the Serpens-Libra border, is well-placed for observation in the late evening and morning hours. At 14th magnitude, it will reach opposition with the Sun on MAY 14.

Two apparitions of **Mercury** occur in these three months. The first is an evening one, favorable for observers in the Northern Hemisphere. It is centered on FEB 21, the date of Greatest Eastern Elongation (18°.1); the planet will be at least 15° from the Sun between FEB 14-28, with *dichotomy* (half-phase) *predicted* for FEB 21, 05h. Mercury's second apparition is a morning one, favorable for Southern-Hemisphere observers. Greatest Western Elongation is on 1994 APR 05, with the planet then 27°.8 from the Sun, and at elongation 15° or greater from MAR 18-MAY 02; and dichotomy is forecast for APR 06, 02h.

MINOR PLANETS

Three of the brighter **minor planets** reach opposition during 1993 FEB-APR, and will be visible in binoculars near opposition. Their 10-day ephemerides are given in the 1993 edition of the *A.L.P.O. Solar System Ephemeris*, and their opposition data are given below:

Minor Planet	Opposition Data: 1993 Date	Stellar Magnitude	Declination& Constellation
6 Hebe	FEB 17.8	+9.2	16°N Leo
7 Iris	MAR 14.3	+9.1	7°S Cra
29 Amphitrite	APR 23.5	+9.4	19°S Vir

Besides the objects above, three of the "Big Four" minor planets, **1 Ceres, 3 Juno,** and **4 Vesta** will be brighter than Mag. +10 during at least part of the current period.

THE MOON

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

New Moon	First Quarter	Full Moon	Last Quarter
JAN 22.8	JAN 31.0	FEB 07.0	FEB 13.6
FEB 21.5	MAR 01.7	MAR 08.4	MAR 15.2
MAR 23.3	MAR 31.2	APR 06.8	APR 13.8
APR 22.0	APR 29.5	MAY 06.1	MAY 13.5

The four lunations listed above constitute Numbers 867-870 in Brown's series.

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

West	North	East	South
FEB 02	FEB 09	FEB 14	FEB 23
MAR 02	MAR 08	MAR 14	MAR 22
MAR 31	APR 05	APR 12	APR 18
APR 27	MAY 02	MAY 10	MAY 15

Our lunar E and W directions follow the convention of the International Astronomical Union, with Mare Crisium near the *east* limb.

If you compare the two tables immediately above, you will see that the librations are not currently well-synchronized with the phases, so that the lunar limbs will not be tilted toward us when there is favorable lighting. The one exception is the lunar N polar area, which can be seen well on FEB 07-11, MAR 06-10, and APR 02-07. Besides the favorable northerly libration on those dates, the Sun will lie about 1°.4-1°.5 N of the Moon's equator during this first period; a condition helpful in illuminating the north polar region. Note also that the librations tabulated in the ephemerides are *geocentric*, and can differ by up to 1° from the *topocentric librations* that one sees from a particular observing location. If the Moon is S of your zenith, you will see even more of the north polar region than the tables predict.

OCCULTATIONS: PRIMARILY OF VENUS

Minor planets will occult six stars. *Table 1* (below) lists the date, occulting object, visual magnitude of planet followed by that of the star, and *possible* zone of visibility for each occultation. (No occultations by major planets are predicted for this period.)

For those lucky observers who happen to lie in the occultation track under a night sky, the MAR 15 event will be visible in binoculars.

The Moon occults Venus twice in our period. The first event occurs on **FEB 25**, at about 05h when Venus is at magnitude -4.6 and 40°E of the Sun. This occultation will be visible from Australia (except the extreme NW) and numerous islands in the SW Pacific Ocean. The approximate circumstances of this event for some selected localities are given below. Disappearance will be at the Moon's dark limb, reappearance at its sunlit limb.

Lunar Occultation of Venus, 1993 FEB 25.

Site	Disappearance UT	Alt.☽	Alt.☉	Reappearance UT	Alt.☽	Alt.☉
	h			h		
Perth	02.7	+17°	+56°	03.7	+28°	+65°
Alice Springs	03.1	+39°	+75°	04.4	+51°	+69°
Melbourne	03.2	+36°	+60°	04.6	+41°	+50°
Sydney	03.4	+43°	+59°	04.9	±45°	+45°
Brisbane	03.5	+50°	+62°	05.2	+50°	+42°
Fiji	05.0	+46°	+22°	06.4	+28°	+2°
Tahiti	05.8	+7°	-19°	(06.8	-8°	-33°)

Table 1. Occultations of Stars by Planets, 1993 FEB-APR.

(For further information, consult the A.L.P.O. Solar System Ephemeris: 1993 or the 1993 Asteroidal Occultation Supplement to Occultation Newsletter, Vol 5, No. 9.)

1993 UT Date	Occulting Object	Visual Mag. Object	Star	Predicted Visibility Zone
FEB 26.21	**3 Juno**	9.0	9.3	NW U.S.A., SW & N Canada
MAR 02.70	**85 Io**	12.1	8.4	N Australia, Arabia
14.02	**88 Thisbe**	12.6	8.3	E North America, NW Africa
15.90	**554 Peraga**	13.0	7.1	Africa
22.75	**3 Juno**	10.3	8.6	Africa, Arabia, S Asia
24.00	**141 Lumen**	12.8	8.9	Africa

The second occultation of Venus is on **APR 19** and should be visible to a large number of our members. Venus is then 26° W of the Sun, at magnitude -4.4. Venus' disk will be 51" across, but only 10-percent illuminated. The planet will disappear behind the Moon's narrow bright limb, and will reappear at the dark limb. Except from Hawaii before sunrise, the Moon will probably not be visible to the naked eye. To see this event, you will probably need to locate Venus by *carefully* offsetting your telescope from the Sun's position. Venus will be 1h 42.6m W of the Sun in right ascension and 5°.8 S in declination.

This event will be visible through most of North America; including Mexico, and the United States and Canada south of a line extending from SW Oregon to northern Hudson's Bay. The northern graze limit passes near Portland, Oregon (at about 16h 00m UT); while the southern limit lies near Miami, Florida (at about 16h 40m UT). Portions of the graze limits are plotted in *Figure A** below. Data for selected locations in the United States, Canada, and Mexico are as follows:

Lunar Occultation of Venus, 1993 APR 19.

	Disappearance			Reappearance		
Site	UT	Alt.☽	Alt.☉	UT	Alt.☽	Alt.☉
	h			h		
Honolulu	(14.5	-2°	-22°)	15.2	+8°	-14°
Los Angeles	15.2	+40°	+22°	16.3	+51°	+36°
Mexico City	15.2	+62°	+41°	16.3	+74°	+56°
Tucson	15.2	+46°	+29°	16.5	+59°	+45°
San Francisco	15.4	+37°	+21°	16.2	+45°	+31°
Houston	15.5	+61°	+47°	16.9	+65°	+63°
Denver	15.6	+49°	+37°	16.9	+55°	+51°
Kansas City	15.8	+55°	+47°	17.2	+55°	+59°
New Orleans	15.8	+64°	+54°	17.1	+63°	+68°
St. Louis	15.9	+56°	+51°	17.4	+54°	+62°
Atlanta	16.0	+62°	+59°	17.4	+55°	+67°
Chicago	16.0	+54°	+51°	17.5	+49°	+59°
Toronto	16.3	+51°	+55°	17.7	+43°	+57°
Washington	16.4	+54°	+61°	17.7	+44°	+61°
Montreal	16.5	+47°	+55°	17.8	+37°	+54°
New York	16.5	+51°	+60°	17.8	+41°	+59°
Boston	16.6	+48°	+59°	17.8	+37°	+56°

More information about these and other occultations can be had from the International Occultation Timing Association (IOTA), 1177 Collins Ave., SW, Topeka, KS 66604, U.S.A.

COMETS

The column by Don E. Machholz, "Comet Corner," on pp. 149-150, and the *A.L.P.O. Solar System Ephemeris: 1993* list nine known comets that will be visible during at least part of this period. Of these, **P/Swift-Tuttle** and **P/Schaumasse** may be as bright as 8th magnitude and thus should be readily visible in binoculars under dark skies.

The above is a conservative statement of comet visibility as it of course does not take into account any discoveries that may be made after this column is written!

METEOR SHOWERS

(Contributed by Robert D. Lunsford, A.L.P.O. Meteors Recorder. Local times are used.)

Although not classed as a major shower, the **Delta Leonids** are the most reliable shower in February. They are most active around the 26th of the month and are visible throughout the night. In contrast to their stronger counterpart in November (the Leonids), this shower produces slower-moving meteors that may last up to one second. If observing near the date of maximum, be sure to wait until the waxing crescent Moon has set to observe them at their best.

The **Lyrids** reach their maximum activity on the morning of April 22, under favorable observing conditions with a New Moon the day before. On the morning of the 22nd up to 20 Lyrids per hour may be seen from a rural location. Decent numbers may also be seen several days before and after this date. This shower is best seen in the early morning hours as Lyra rises higher into the NE sky. [This shower is clearly best seen by Northern-Hemisphere observers.]

Peaking on May 4th, the **Eta Aquarids** are the only major shower of 1993 to coincide with a Moon that is nearly full. Although the best nights may be lost this year, you may see limited numbers of shower members during the last week of April and the first few days of May. Once the bright gibbous Moon has set, face E and watch for swift bluish meteors moving E to W. This shower also provides the highest percentage of trains of the major meteor showers.

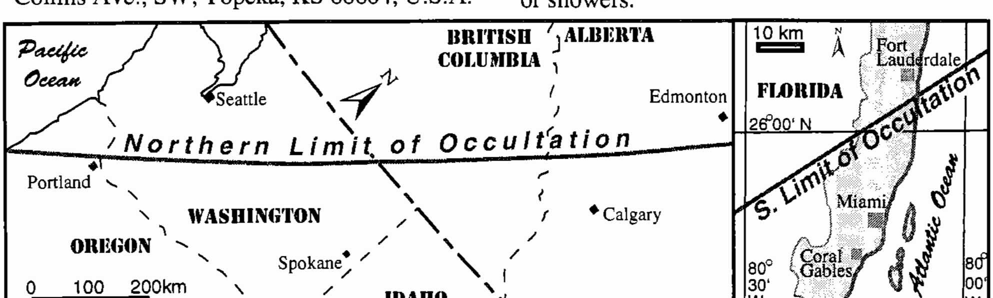

Figure 1. Portion of graze limits of lunar occultation of Venus on 1993 APR 19. The centers of the graze zones are plotted; the zones themselves are approximately 100 km in width. On the right-hand map, the Greater Miami urban area is shaded.

OBSERVATIONS AND COMMENTS

Our members frequently send observations directly to the editor. Such drawings, photographs, and images are not intended to be part of regular A.L.P.O. Section reports, but are often of high quality and should be of interest to our readers. This occasional column allows us to let others besides the editor see these diverse observations.

I. The Brazilian observer, **Nelson Falsarella**, M.D., has forwarded several photographs of the 1992 JUN 30 total solar eclipse, taken by himself and others. This event was not widely observed because the only area where the path of totality passed over land, in Uruguay, was cloudy. Nonetheless we show below one photograph of the partial phase from land and one of totality from an airplane.

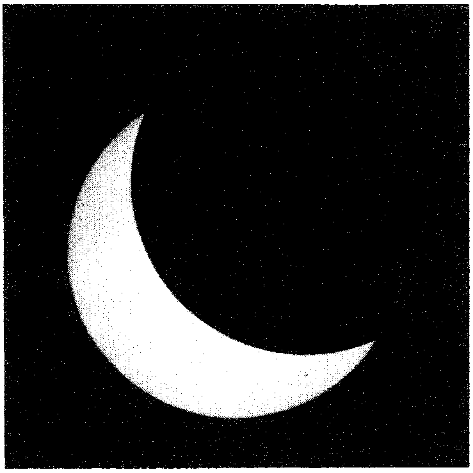

Figure 1. A partial phase of the 1992 JUN 30 total solar eclipse. Photograph taken by Nelson Falsarella near São José do Rio Preto, Brazil, at 10h53m UT with a 60-mm refractor and eyepiece projection.

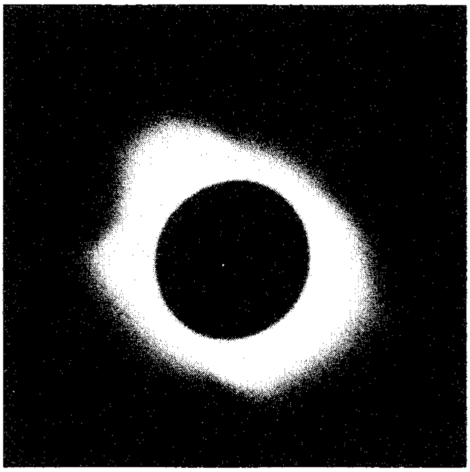

Figure 2. The same eclipse during totality, photographed by Tasso Napoleào and Edvaldo Trevisan from an airplane at 36,000 feel (11,000 meters) altitude. Taken at 11h16m UT, 1/15 sec with a 600-mm f/7 lens.

II. A.L.P.O. Mars Recorder, **Donald C. Parker**, M.D., uses a high-quality 16-in (41-cm) Newtonian reflector to produce dazzling CCD images of the Moon and planets. Admittedly, his work in Miami was interrupted by Hurricane Andrew, which cut out the electricity supply on which CCD camera and their host computers depend. He has resumed full operation, however, and some of his post-Andrew Mars images appear on our front cover.

Figure 3. The lunar crater Plato, showing numerous floor craterlets; the *largest* four are considered test objects! Taken by Donald C. Parker, 1991 SEP 01, 07h 16m UT. 41-cm Newtonian at f/27, 0.50-sec CCD image. Seeing 6-7 on the A.L.P.O. 0 (worst) - 10 (perfect) Scale; Transparency 3-4 on the similar 0-5 Scale. Colong. = 178°.2 (sunset view). South at top, simple inversion.

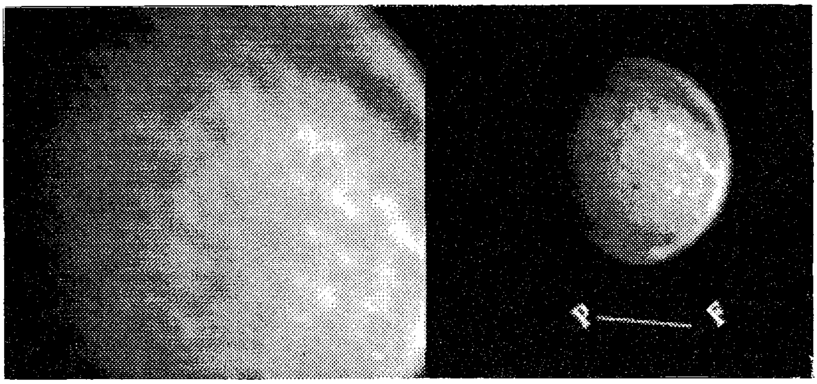

Figure 4. The Tharsis region of Mars, with an enlarged view to the left. Taken by Donald C. Parker on 1992 OCT 17, 10h23m UT. 41-cm Newtonian, f/49, 0.75-sec CCD image with W-25 (red) filter. Seeing = 6-7, Transparency = 4 on the scales noted for *Figure 3.* Central Meridian 119°, Sub-Earth latitude +10°.0, Ls = 341°.8, disk diameter 9".1. South at top. Note the "crater" near the center of the enlarged view, north of Phoenicis Lacus, where no large crater exists. Dr. Parker believes that this feature is "most likely an illusion formed by ridges in [the] Tharsis Bulge—maybe this is what Mellish saw." (Regarding the latter, see our letters column on pp. 172-174 of this issue.)

III. Andrew Johnson observes from North Yorkshire, England. His work appeared in our April, 1992, issue. Another of his lunar drawings appears below.

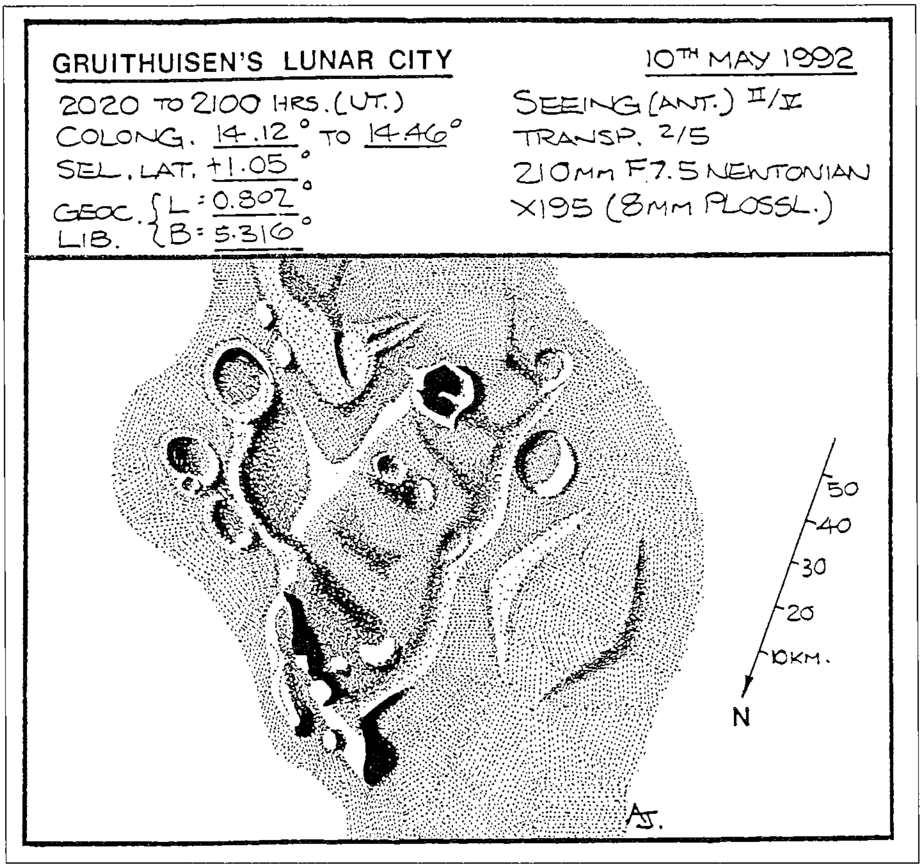

Figure 5. The data for this drawing by Andrew Johnson are at top (the Antoniadi Seeing ranges from very good [I] to poor [V]). The crater Schröter W is at top center. The observer Gruithuisen believed that this area contained a lunar city. Mr. Johnson notes: "First impressions; boosted by expectation, of this feature were much as Gruithuisen observed this strange collection of hills in 1824. However a few moments study soon stripped most of the air of mystery from the scene. Seeing condition were very good, far more detail was visible than could be recorded. (An indication of this was the relative ease with which shadow within Linné could be seen.) Views in earlier lighting ≅ 12° & in opposite lighting ≅ 192° [*sic.*] could prove useful." [Note that "Sel. Lat." should be +1°.03 and the "Geoc. Lib." should be L = 1°.64 and B = 6°.06.]

BOOK REVIEWS

Edited by José Olivarez

The Meteorite & Tektite Collector's Handbook.

By Phillip M. Bagnall.
Willmann-Bell, Inc., P.O. Box 35025, Richmond, VA 23235. 1991. 160 pages, Illus., appendix, glossary, index. Price $24.95 cloth (ISBN 0-943396-31-X).

Reviewed by Mark Davis

The collecting of meteorites and tektites has gained popularity in recent years despite the fact that little has been published about the techniques of collecting them. With the publication of *The Meteorite & Tektite Collector's Handbook*, Bagnall attempts to provide sound guidelines to current collectors and to encourage others to begin this fascinating hobby.

After a short history of meteorite collecting in Chapter 1, Bagnall discusses the acquisition of meteorites. This discussion includes commercial and private sources; as well as falls, finds, and predicted impact sites.

The next three chapters are devoted to the composition, structure, appearance, and classification of meteorites. The author supplements his discussion of these concepts with excellent drawings, tables, and photographs. The minerals found in meteorites, their internal and external features, and a modified classification system are among the topics treated in detail.

Chapter 6, "The Finer Points of Meteorite Collecting," covers preserving them against rust and cracking by methods such as lacquering. It discusses their preparation for display by cutting, polishing, and etching. This chapter also describes the keeping of detailed written and photographic records of a collection.

The final chapter, which discusses tektites, appears to have been included in the book at the last minute. Following the order of the earlier chapters, Bagnall addresses the history, locations, appearance, composition, and collecting of tektites within this single chapter.

In reviewing this book, I was left with one major objection. It is subtitled *A Practical Guide to Their Acquisition, Preservation and Display*; and I expected meteorite and tektite acquisition to be a major portion of the book. In fact it is only a minor portion. Bagnall says little about acquiring specimens other than through private and commercial sources, and no practical advice is given on how one may go out in the field and find a meteorite or tektite for oneself.

Despite this deficiency, this book is of high quality, containing excellent drawings and photographs. Its text is well-supported by a glossary, comprehensive indices, a bibliography, and other useful information. It is doubtful, though, that this book will be useful to the general reader because it has too much technical language in the discussions of composition and classification. There is too little practical information on collecting meteorites and tektites. However, this book would be an excellent addition to the library of a person needing a reference book on meteorite classification and composition.

The Mind's Sky: Human Intelligence in a Cosmic Context

By Timothy Ferris.
Bantam Books, 666 Fifth Avenue, New York, NY 10103. 1992. 281 pages, notes, index. Price $22.50 cloth (ISBN 0-593-02644-6).

Reviewed by Robert D. Hicks

What do the Amazonian rainforest, near-death experiences, the premotor cortex of Joe Montana's brain, belly laughs, and the search for extraterrestrial intelligence (SETI) have in common? Timothy Ferris, author of the acclaimed *Coming of Age in the Milky Way*, *Galaxies*, and *The Red Limit*, has sought correspondences among these topics to support his own version of a Grand Unified Theory. The result is *The Mind's Sky*. Professional and amateur astronomers are both inevitably drawn to speculate on their relationship to the cosmos. Ferris imaginatively jolts our convictions about what is going on Out There.

Ferris offers two similar metaphors to frame his many tales: one of a tree and the other of an hourglass. The roots of the tree represent the human mind, whereas the tree's branches become the cosmos. The tree trunk–the nexus between the upper and lower parts of the hourglass—is the place where the mind perceives and interprets the universe. The cosmos and the mind mirror each other. In fact, as Ferris demonstrates, our notion of having one mind is an illusion because our consciousness comes from many minds. Beholding the cosmos involves the working of our many minds to construct a model. However, this is not New Age talk; this is science. Ferris states:

> "A scientific theory provides a model that enables us to reason about unfamiliar phenomena by translating them into terms with which we are familiar. It is a kind of language, and as such itself exemplifies the dialogue between mind and nature."

The nature of this dialogue can be found in Ferris' romp through apparently diverse topics. These topics force the reader to reflect not only on his or her models of the universe, but on what we construe as reality:

> "We are confronted, then, not with *the* universe, which remains an eternal riddle, but with whatever model of the universe we can build within the mind...[T]he ultimate subject of inquiry is not the outer universe but the nature of its dance with the mind."

Thus *The Mind's Sky* offers original and stimulating views, even though they may run contrary to our supposed certainties about how the universe works. Some of the topics, such as SETI, are familiar terrain for astronomers; but Ferris offers unusual perspectives here. For example, many science writers talk of the explosive change on our world-view that contact with extraterrestrials would bring. Ferris instead points out that, due to the immense inter-stellar distances, such changes are unlikely because simple exchanges could take many millennia. The original message would be lost before a response to it would be received. To Ferris, the solution to this problem would be an intergalactic network of automated, self-replicating stations that could be consulted as libraries, immortal in any practical sense, through which we could explore alien worlds.

Although the book is about the connection between mind and cosmos, readers may argue that some of the topics fail to confirm Ferris' design. They may also note that his treatment of an objective reality is an echo of the so-called *anthropic principle*, much discussed in other books on cosmology. Nevertheless, Ferris stimulates and provokes us, particularly in his contention that our act of observing the universe inevitably limits and reduces our understanding. While not a book on astronomy, *The Mind's Sky* pushes and prods our private models of the universe and of our place in it.

Astronomical Algorithms

By Jean Meeus.
Willmann-Bell, Inc., P.O. Box 35025, Richmond, VA 23235. 1991.429 pages, Illus., tables, glossary, index. Price $24.95 cloth (ISBN 0-943396-35-2). Optional program disk $24.95 (For the IBM-PC; in QuickBasic, Turbo Pascal, or C).

Reviewed by John E. Westfall

Over a decade ago, I bought Jean Meeus' *Astronomical Formulae for Calculators*. It quickly became indispensable. Ironically, when his *Astronomical Algorithms* was published, I didn't buy it because I assumed the latter was just a new edition of the former.

Fortunately, I received a review copy of *Astronomical Algorithms* and found I was very wrong! One major addition is the high-accuracy series calculations for the ephemerides of the Sun, Moon, major planets, and Galilean satellites of Jupiter. These are the same "models" that are used by the U.S. Naval Observatory and the Jet Propulsion Laboratory.

These long algorithms are very accurate, but empirical, models. Look elsewhere for elegant perturbation theory! Instead, Meeus tells us how to find the *physical ephemerides* of the Sun, Moon, and planets—values that describe their brightness, apparent size, lighting and orientation. He includes hard-to-find formulae for calculating not only the Moon's geocentric librations, but its physical and topocentric librations as well. We can also find lunar phases, nodal passages, perigee and apogee, and maximum northerly and southerly declinations. There are formulae for lunar eclipse contact times and magnitudes, as well as for the general and local circumstances of solar eclipses. To use them, we need *Besselian elements* from elsewhere (e.g., other of Meeus' publications).

Astronomical Algorithms covers many topics besides the Solar-System bodies. The first six chapters, for example, cover calculating techniques such as interpolation and curve-fitting methods. Chronological calculations are covered, including Julian Day, the date of Easter, Dynamical and Universal Time, and Sidereal Time. Other "standard" calculations include coordinate transformation; rising, transit, and setting times; atmospheric refraction; the parallactic angle (the angle between one's local "up" and celestial north); the conjunction and angular separation of celestial bodies; and the calculation of precession, nutation, and apparent place.

It is amazing what a large portion of the calculations an A.L.P.O. member might wish to do are included in this book. Indeed, it is difficult to make a "wish list" of what else one would have liked, but was not included. I would have liked to find formulae for calculating the apparent positions of the brighter satellites of Saturn, Uranus, and Neptune. The chapter on eclipses could have been extended to cover occultations of objects by the Moon.

Mr. Meeus is a very careful author, and is quite concerned with correctness and numerical accuracy. I have come to trust him from experience gained by working with his earlier publications. He follows standard professional and International Astronomical Conventions unless he has good reason not to; the latter is the case with defining a planet's north pole, the algebraic sign of longitude, and the degree of umbral and penumbral enlargement in a lunar eclipse. In terms of numerical accuracy I believe that these algorithms will give results accurate enough for nearly all the applications our readers will need. Greater accuracy might be necessary for predicting occultations of stars by planets, and for *refining* orbits; but how many observers do this?

The flaws I found were few and minor. A reference [1] by Bretagnon and Simon is cited at the top of p. 154, but I couldn't find their book listed elsewhere in this book. On p. 202, the last text line should say "Uranus" rather than "Saturn." Page 286 states that the orbits of Io and Europa are "almost exactly circular," which is incorrect; indeed, periodic terms for their radius vectors are listed on p. 294. Finally, the text on p. 368 gives a reference to "E. Silbernagel (1929)," which is not listed elsewhere. Indeed, it would have been very helpful to have a complete bibliography of all his sources cited at the end of Meeus' book.

These are minor complaints given the overall great usefulness of *Astronomical Algorithms*. Even the most spectacular ephemeris programs won't do it all, and not with the accuracy of Meeus' algorithms. If you do astronomical calculations, simple or complex, this book will be an investment you won't regret.

Las Cruces Convention.—Our 43rd Convention will meet on Thursday-Saturday, August 5-7, 1993, in Las Cruces, New Mexico.

Mr. David Levy, the Program Chairman, needs the abstract of any proposed paper no later than June 1, 1993. The normal paper time will be 20 minutes, but indicate on your abstract sheet the amount of time you believe you need if that is differs from 20 minutes. Also state all your audio-visual needs, including "none." At the convention, be prepared to give the J.A.L.P.O. Editor a paper copy of your paper and illustrations, for we plan to publish the convention papers in the *J.A.L.P.O.* in lieu of a separate Proceedings.

The convention will be held at the Best Western Mission Inn, 1765 S. Main St., Las Cruces, NM 88001 (Tel.: 505-524-8591). The Mission Inn will provide rooms to A.L.P.O. members at their corporate rate per room per night: $39.50 + tax for one person, $44.00 + tax for two persons, and $4.00 + tax more for each additional person above two. These rates include full breakfast. When you make reservations, mention that you are attending the A.L.P.O. Convention in order to receive the special rate. If you want to share a room, but don't know with whom, write Elizabeth Westfall at P.O. Box 16131, San Francisco, CA 94116; include your telephone number. She will keep a file of persons seeking roommates and will put them in touch with each other.

Exhibit space will also be available, so bring your best drawings and astrophotos with suitable captions. If you cannot attend, but wish to exhibit, send your material to the A.L.P.O. Executive Director no later than July 20, along with return postage.

We plan two field trips: Thursday afternoon, August 5, to the New Mexico State University Department of Astronomy Observatory on "A Mountain;" and all day Saturday, August 7, to the Apache Point Observatory and White Sands National Monument. A banquet is planned for Friday evening, with Dr. Clyde Tombaugh as speaker. We'll provide more information about these events in the next issue.

1993 Solar System Observers' Workshop. The Chabot Observatory and Science Center and the Association of Lunar and Planetary Observers are co-sponsoring a two-day Solar-System observing workshop, to be held at the Chabot Observatory and Science Center, 4917 Mountain Boulevard, Oakland, California 94619. The dates are Friday, April 30 and Saturday, May 1, 1993.

Lectures and demonstrations will cover the techniques of visual observing, event timing, photography, video and CCD imaging, eclipse observing, comet recovery and observation, and photometry. The participants will gain hands-on experience with the Observatory's 20-in Brashear and 8-in Clark refractors.

The workshop leaders are Don Machholz, José Olivarez, Don Parker, Mike Reynolds, and John Westfall. The registration fee is $20 per person, covering all materials. The number of participants is limited, so sign up early. For more information, telephone 510-530-3480.

A.L.P.O. Solar-System Ephemeris: 1993. The eighth annual edition of our Ephemeris is now available. The 1993 edition has been expanded to 131 pages—now with daily ephemerides for all the bright planets and an improved lunar ephemeris. Tables are also provided for the Sun, the Remote Planets, 9 planetary satellites, 28 asteroids, 12 meteor showers, and 18 comets. There are data on the conjunctions of Uranus with Neptune; the eclipses, transits, and occultations of Saturn's moon Iapetus; the NOV 06 Transit of Mercury; and on 32 occultations of stars by asteroids, six occultations of planets by the Moon, two partial solar eclipses, and two total lunar eclipses.

Please Note: (1) The Ephemeris is still available from Mark A. Davis, but his address is now: 1700 Whipple Road, Apt. 11A, Mt. Pleasant, SC 29464. (2) Due to increased printing costs, the price for the United States, Canada, and Mexico is now $7.00, and is $9.50 in all other countries. These prices include airmail postage. Please make payment to "A.L.P.O." by check or money order.

RETHINKING THE A.L.P.O. TRAINING PROGRAM

Mr. José Olivarez has resigned as the Director of the A.L.P.O. Lunar and Planetary Training Program; a program which he has single-handedly conducted since 1973! We thank Mr. Olivarez for the invaluable training he has supplied to our novice observers for nearly two decades.

At present, his post is vacant. We need a volunteer—possibly more than one—to take over and reorganize this program. The sort of person we need is one who is familiar with those aspects of our field most puzzling to the novice—basic facts and concepts about our Solar System; instrument choice and use; and making drawings, central-meridian timings, and intensity estimates. A background in some aspect of education would also be very helpful.

We think that the Program should ultimately become a regular Section, with a Recorder and perhaps Assistant Recorders, who would work with our Membership Secretary (who supplies novices) and our new network of Volunteer Tutors (see p. 191).

If this is the challenge you have been looking for, please write the A.L.P.O. Executive Director! (Address on inside back cover.)

Universe '93.—Many of our members attended Universe '92 in Madison, Wisconsin. Now there is a Universe '93, a national astronomy exposition and fair to be held Saturday and Sunday, July 10 and 11, in the Aztec Center at San Diego State University in San Diego, California. The sponsors are the Astronomical Society of the Pacific and *Astronomy* magazine; one of the several co-sponsors is the Association of Lunar and Planetary Observers, and we will operate an A.L.P.O. information desk at the meeting. The activities will include talks by Sally Ride, William Hartmann, Jack Newton, Stephen Edberg, and others; panels and workshops, a star party, and exhibits. This public-, student-, and amateur-oriented weekend will be followed by the scientific sessions of the 105th Annual Meeting of the Astronomical Society of the Pacific. To receive a registration package, either: (1) telephone 415-337-1100; (2) FAX 415-337-5205; or (3) write Summer Expo, ASP, 390 Ashton Avenue, San Francisco, CA 94112.

International Solar-System Observers' Fund (ISSOF).—Paul H. Bock, Jr., the ISSOF Coordinator, has submitted a Status Report for this fund through January 25, 1993. This service supplies astronomical literature, supplies, and equipment without charge to deserving amateur Solar-System observers who otherwise would be unable to obtain them. The following persons have generously donated funds to this program in the last year: **Paul H. Bock, Jr.**; **A. Kolodziejczak**, **Andrew Malmed**, **Lee Netzler**, and **Ernest Nussbaum**. We appreciate these contributions; however, because a number of items were acquired and shipped,the fund's current balance is only $25.77. We need donations. Please contribute in funds because contributed items probably cannot be matched with requests (i.e., rather than send an item, sell it and send the proceeds). If you make the check or money order out to "A.L.P.O.", your contribution should be tax-deductible.

Solar Section Staff.—As part of the reorganization of our Solar Section, its staff have now allocated their duties as follows: Paul Maxson—Acting Recorder; Richard Hill—Assistant Recorder, Handbook; Randy Tatum—Assistant Recorder, Publications; and Francis Graham—Assistant Recorder, Eclipses. Their addresses and new titles are given on our inside back cover. Richard Hill has a new address: Lunar & Planetary Laboratory, University of Arizona, Tucson, AZ 85721.

Members Profile Column.—Several persons have told us that they would like to hear more about their fellow members. Thus we would like to start a short "Members Profile" column. What we need is a short paragraph describing how you got interested in astronomy, what sort of observing you like to do, your employment and education, and your telescope. A photograph of you (perhaps posed at your telescope) would also be useful. Don't be shy; our staff and our other members would like to know you better.

ELSEWHERE IN THE SOLAR SYSTEM

Hubble Space Telescope: Amateur Cycle Three.—The program of supplying HST observing time for amateurs is continuing. The "first cycle" of five amateurs is now observing; the second cycle of ten amateurs has been selected; and we are now soliciting amateur proposals for the third annual cycle. The A.L.P.O. is represented on the recommendations committee for this program and we encourage proposals dealing with Solar-System research by amateurs. To obtain a proposal kit, write to: Amateur Astronomers Working Group, c/o AAVSO, 25 Birch Street, Cambridge, MA 02138. The deadline for returned proposals is April 30, 1993, and we hope to make a final selection by late August.

The HST is obtaining unprecedented results already, but don't forget that it should do even better after the Space Shuttle "Repair Mission" scheduled for December 7, 1993. If the upgrade goes as planned, our Cycle Three amateurs will begin to observe in July, 1994, with a significantly improved instrument.

Eight Astronomy Days in 1993.—This year is the twentieth anniversary of the first Astronomy Day. To celebrate, both April 24 and May 1 will be Astronomy Days this year, with the week in between designated as *Astronomy Week.*

The A.L.P.O. is one of the sponsors of Astronomy Day (and Week, too). Take this opportunity to introduce the public and other amateurs to the objects of our Solar System. Typical activities include talks, displays, and public viewing sessions. Note that the Moon will be conveniently placed in the evening sky during this week (First Quarter on April 29), along with the planets Mars and Jupiter. You might also consider taking part in the activities of your local club for Astronomy Day.

Riverside Telescope Makers Conference. This is one of the largest amateur meetings, and it's now 25 years old. The site will be Camp Oakes, 8 mi east of Big Bear City in the San Gabriel Mountains in southern California. The meeting dates are May 28-31, 1993 (Memorial Day weekend). Attendees will have the opportunity to view the first-quarter Moon, Mars, and Jupiter through *large* amateur telescopes; after moonset, the deep-sky objects will be spectacular from this site 7300 feet above sea level. During the day there will be talks and workshops (not just on telescope making), awards, commercial exhibits, and the ongoing swap meet.

You can simply attend the activities; but you can also lodge or camp at Camp Oakes, using the cafeteria (motels are also available in Big Bear). To obtain a registration form, telephone 909-948-2205. Prices will be discounted for all registrations received before May 1.

24th Lunar and Planetary Science Conference.—This professional conference meets in Houston's Lunar and Planetary Institute (LPI) each year; in 1993 on March 15-19. Some of the session topics will be Magellan-Venus results, the Galileo December 1992 lunar flyby and future lunar missions, the "Mars Surface and Atmosphere Through Time" Program (MSATT; see below), and education in planetary science. For more information, contact: Program Services Department, LPI, 3600 Bay Area Boulevard, Houston, TX 77058-1113 (Telephone: 713-486-2166; FAX: 713-486-2160).

Also, telephone LPI at 713-486-2150 for information concerning the following other 1993 conferences: *(1)* ***Workshop on the Analysis of Interplanetary Dust.***—At LPI on May 15-17. *(2)* ***MSATT Workshop on Atmospheric Transport on Mars.***—Corvalis, Oregon, June 28-30. *(3)* ***56th Meteoritical Society Meeting.***—Vail, Colorado, July 19-23. *(4)* ***MSATT Workshop on Early Mars: How Warm and How Wet.***—Also in Colorado, July 26-28. *(5)* ***MSATT Workshop/Field Trips on the Martian Northern Plains: Sedimentologic, Periglacial, and Paleoclimatic Evolution.***—We wish that this were really to be held *on* the Martian Northern Plains; as an approximation it will meet in Fairbanks, Alaska, on August 8-14. *(6)* ***Asteroids, Comets, Meteors 1993.***—At Belgirate (Novara), Italy, June 14-18. (You may also write to: Dr. Vincenzo Zappala, Astronomical Observatory, Strada Observatorio 20, 10025 Pino Torinese (70), Italy.)

Second Solar Astronomy Convention.—To be held at the Los Arcos Hotel in La Paz, Baja California Sur, Mexico, on April 5-7, 1993. Papers report on observations of the 1991 total, and on plans for the 1994 annular, solar eclipses; the coming transits of Mercury and Venus; and other aspects of solar study. For more information, FAX Ing. Luis Farah de Anda at 52-682-2-72-62, or call him via voice telephone at 52-682-1-23-20.

Texas Star Party.—This famous annual dark-sky conclave meets on May 17-23, 1993, at Prude Ranch in the Davis Mountains. For information on registration, contact: TSP Registrar, 1326 Mistywood Lane, Allen, TX 75002. Paper abstracts should be sent to: Philip Kuebler, TSP Scheduling Committee, 1550 Blackstone Drive, Columbus, OH 43235.

Catastrophic Disruptions of Small Solar System Bodies.—This conference is in Gubbio (Umbria), Italy on June 21-23, 1993. For details, write to: Paolo Paolicchi, Departimento di Fisica, Universita di Pisa, Piazza Torricelli 2, I-56126, Pisa, Italy.

Gordon Research Conference on Origins of Solar Systems.—Meeting in New London, Connecticut, on July 5-9, 1993. The contact person is: John A. Wood, Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, Massachusetts 02138 (telephone: 617-495-7278; FAX: 617-495-7001).

Pluto and Charon Conference.—At the Woodlands Plaza Hotel, Flagstaff, Arizona, July 6-9, 1993. The preregistration and abstracts deadline is May 10. Sessions about this "double planet" will include its history; dynamics; bulk properties, surfaces, and interiors; atmosphere; and role in the Solar System. Request a registration form from: Pluto-Charon, c/o Mary Guerrieri, P.O. Box 44221, Tucson, AZ 85733.

A.L.P.O. VOLUNTEER TUTORS

Below are listed experienced A.L.P.O. members who are available to serve as volunteer tutors to correspond with less-experienced members interested in their specialities. There is no better way to learn than by such one-on-one education. If you want to brush up on any of our observing techniques, write to one of them; be sure to enclose a SASE.

Dr. Julius L. Benton, Jr.
305 Surrey Road
Savannah, GA 31410
Instrumentation and Equipment Selection

Mr. Gregory L. Bohemier
E Berkshire Road,
RR1 Box 193
Berkshire, NY 13736
Instrumentation and Equipment Selection

Mr. Richard E. Hill
Lunar & Planetary Lab.,
University of Arizona,
Tucson, AZ 85721 (Internet: rhill@hindmost.lpl.arizona.edu)
Solar

Mr. Harry D. Jamieson
P.O. Box 143, Heber Springs, AR 72543
Lunar; Instrumentation and Equipment Selection; Software—Astronomical Programming

Mr. Andrew Paul Johnson
1 York Lane, Knaresborough, North Yorkshire
HG5 0AJ
United Kingdom
Lunar; Drawing Skills

Mr. Charles A. Kapral
6601 Hana Road
Edison, NJ 08817
Lunar; Photometry

Mr. Michael Mattei
11 Coughlin Road.
Littleton, MA 01460
Drawing Skills; Telescope Making or Enhancement

Mr. Frank J. Melillo
14 Glen Hollow Dr., Apt. E-16
Holtsville, NY 17742
Solar; Photometry

Mr. José Olivarez
1469 North Valleyview Ct., Wichita, KS 67212
Instrumentation and Equipment Selection; General Literature

Mr. Peter Rasmussen
1210 W. Maple, Heber Springs, AR 72543
Instrumentation and Equipment Selection

Mr. Timothy J. Robertson
38121-25th St. E #h-101
Palmdale, CA 93550-1300
Drawing Skills; Comets

Mr. Andrew M. Sorenson
RR 4, Box 4A
Jefferson, IA 50129
Telescope Making or Enhancement

Mr. Brad Timerson
623 Bell Road.
Newark, NY 14513
Instrumentation and Equipment Selection

Mr. Daniel M. Troiani
629 Verona Ct.
Schaumburg, IL 60193
Mars; Video/CCD Imaging

PUBLICATIONS OF THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS

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

◆◆

Order from: Mark A. Davis, 1700 Whipple Road, Apt 11A, Mt. Pleasant, SC 29464, USA

The A.L.P.O. Solar System Ephemeris: 1993. $7.00 in the United States, Canada, and Mexico; $9.50 elsewhere (airmail included). Contains 129 pages of tables, graphs, and maps describing the positions and appearances of the Sun, Moon, each major planet, the brighter planetary satellites, Minor Planets, meteors, and comets. Make payment to "A.L.P.O."

◆◆

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

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

◆◆

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

① ***A.L.P.O. Section Directory--1992/93.*** *Free*; just send a stamped, self-addressed envelope. An 8-page description of each Observing Section's personnel, projects, and publications.

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

◆◆

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

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

1 (1947); 6. ***8*** (1954); 7-8. ***11*** (1957); 11-12.
21 (1968-69); 3-4 and 7-8. ***23*** (1971-72); 3-4, 7-8, 9-10, and 11-12.
25 (1974-76); 1-2, 3-4, 7-8, and 11-12.
26 (1976-77); 3-4, 5-6, and 11-12 [each $1.75].
27 (1977-79); 3-4, 5-6, 7-8, 9-10, and 11-12 [each $1.75].
28 (1979-81); 3-4 [each $1.75]. ***31*** (1985-86); 5-6 and 9-10 [each $2.50].
32 (1987-88); 5-6 and 11-12 [each $2.50].
33 (1989); 1-3, 4-6, 7-9, and 10-12 [each $2.50]. ***34*** (1990); 1, 2, and 4 [each $2.50].
35 (1991); 1, 2, and 3 [each $2.50]. ***36*** (1992); 1 and 2 [each $2.50]
Current Issue [***36***, 4]—$3.00.

KEEPING YOUR MEMBERSHIP CURRENT—

A.L.P.O. memberships include a subscription to the *Strolling Astronomer (J.A.L.P.O.),* the top line of your mailing label gives the volume and issue number for which your membership will expire (e.g., "36.4" means Vol. 36, No. 4). We include a *First Renewal Notice* in that issue, and a ***Final Notice*** in the next one.

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

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

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

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

The Association of Lunar and Planetary Observers

Founded in 1947, the A.L.P.O. now has about 600 members. Our dues include a subscription to the quarterly Journal, *The Strolling Astronomer*, and are $16.00 for one year ($26.00 for two years) for the United States, Canada, and Mexico; and $20.00 for one year ($33.00 for two years) for other countries. One-year Sustaining Memberships are $25.00; Sponsorships are $50.00. Associate Memberships, which do not include a Journal subscription, are $3.00 per year.

There is a 20-percent surcharge on all memberships obtained through subscription agencies or which require an invoice.

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

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