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Photograph of Comet 1996 B2 Hyakutake by Frank J. Melillo, taken on 1996 Mar. 25 at 04h05m-04h14m UT; a 10-minute exposure on hypered Kodak TP2415 Film with an 80-mm f/4.5 lens. North is at the top and the "handle" of the Big Dipper asterism is to the right. Note the dislocation midway in the tail. The field of view is 21° across. Mr. Melillo visually estimated the tail length as 19°, and the total magnitude as +0.6.

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In This Issue

THE 1994-1995 APHELIC APPARITION OF MARS

By: Daniel M. Troiani, Donald C. Parker, and Carlos E. Hernandez

ABSTRACT

The 1994-1995 Apparition of Mars was aphelic, in that the planet's apparent diameter reached only 13.85 arc-seconds at opposition, the smallest since 1980. However, Mars was high in the sky for northern observers. Furthermore, since the Martian North Pole was tilted earthward, observers were able to watch the spring-summer regression of the North Polar Cap and the concomitant increase in meteorological activity. These phenomena were the main subjects of the observational programs of the Association of Lunar and Planetary Observers' International Mars Patrol (IMP). Despite Mars' small angular size, improved instrumentation and observational techniques permitted high-quality work to be done. For the hard-core Mars observer this apparition turned out to be very exciting!

INTRODUCTION

For the 1994-95 Apparition, the A.L.P.O. Mars Section received 2,206 observations from 66 observers, listed in *Table 1* (p. 9) in ten countries as part of the International Mars Patrol (IMP). The was very satisfactory for an aphelic apparition that had Mars at 101 million kilometers from Earth at its closest approach on 1995 FEB 11. However, Mars was at declination 18° North at opposition on FEB 12, favoring observers in our Northern Hemisphere. Observations covered the period from Ls 261° (T. Stryk) to 127° (H. Ishado), corresponding to Martian northern late Fall through early Summer (see *Figure 1*, p. 2). [*Ls* is a measure of the Martian season, where Ls 000° marks the beginning of Northern-Hemisphere Spring, 090° the Northern Summer, 180° the Northern Fall, and 270° Northern-Hemisphere Winter.] Observers submitted 1297 drawings, 41 photographs, and 444 CCD images. In addition, we received 424 measurements of the areocentric latitude of the south edge of the North Polar Cap (NPC), obtained between 022° and 122° Ls from bifilar micrometer, CCD and video red-light images. The NPC displayed numerous rifts and web-like features. Some interesting relationships between Martian meteorology and NPC behavior appear to be emerging, with numerous atmospheric features such as limb clouds and hazes, orographic clouds, equatorial band clouds and the Syrtis Major Blue Cloud increasing in prominence as the NPC regressed.

CAN AMATEUR OBSERVATIONS STILL BE WORTHWHILE?

The answer is definitely YES!! The Mars Section has assisted a number of professional planetary scientists during the present apparition by responding to requests for A.L.P.O. Mars data. One request came from Fred Espenak of the NASA/Goddard Space Flight Center–Planetary Systems Branch. He observed Mars in March, 1995 in the 10-micron band with NASA's 3-meter telescope (IRTF) on Mauna Kea. He was measuring the distribution of ozone in Mars' atmosphere using the Goddard's IR Heterodyne Spectrometer. In his analysis of this data he needed to know the transparency of the Martian atmosphere at the time of his observation. Our data showed him what clouds or haze activities were present before, during and after his observing run on Mauna Kea.

Furthermore, Jim Bell and Jeff Moersch of the NASA Planetary Astronomy program at Cornell University hosted the Mars Telescopic Observations (MTO) Workshop, sponsored by the Lunar and Planetary Institute. The theme of this workshop was to explore the role that current and continuing Earth-based observations play in increasing our understanding of Mars. In addition, it brought together astronomers who work at different wavelengths, both professionals and amateurs, and who do not often have the opportunity to share their ideas with one another. All of the Mars Recorders were invited to present papers on the work of our section. Don Parker gave a talk on the NPC regressions, past and present and on the continuing IMP meteorological survey that Jeff Beish and he have been conducting for many years. Dan Joyce substituted for Dan Troiani, who was unable to attend, and presented the A.L.P.O. Mars Section results from both the 1992-93 and the 1994-95 Martian Apparitions, including numerous drawings, photographs, and videos. All of the A.L.P.O. papers were well received and generated a great deal of interest from the professional astronomers present. Abstracts of the MTO Workshop papers have been published in a professional abstract volume [Bell and Moersch 1995]. The work of the IMP—your observations and hard work—has made an impact upon the professional planetary scientific community. Even in this day of space telescopes and planned space missions, planetary scientists are still interested in using amateurs' data about Mars. In fact, a significant portion of the MTO workshop was devoted to planning ground-based support programs for the upcoming space probes to Mars, and amateur visible-light monitoring was included in these plans. We will keep the readers and our observers informed of these programs as they crystallize, including via an E-mail alert network.

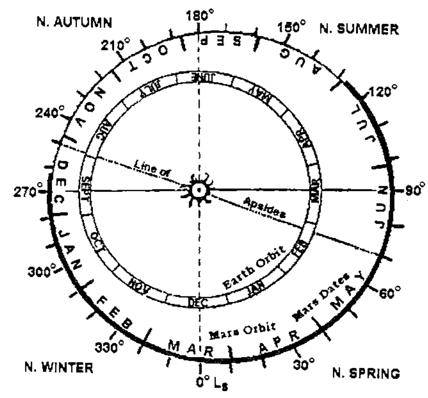

Figure 1. Heliocentric chart of the orbits of Mars and Earth, defining the seasons of both planets in the Martian planetocentric system Ls. The heavy portion of Mars' orbit represents the coverage by IMP observers during the 1994-95 Apparition.

THE MARTIAN ARCTIC

The North Polar Hood (NPH) was conspicuously visible from June, 1994, through late October, 1994 (290°-010° Ls), after which time the hood became fragmented. This agrees well with Ebisawa's finding that the polarization of the north polar region weakened around 009° Ls [Ebisawa 1995]. Whitby, Warell, Niechoy, and Parker reported the NPC largely free of the hood around 358° Ls, but at times high thin arctic clouds were visible in blue light through November (025° Ls) by Will, Stryk, and Schmude. There was an arctic cold front that pushed clouds south of the NPC on the morning limb on 1994 OCT 07, and again on 1994 NOV 03 (359° and 012° Ls respectively). *Lowell's Band*, the dark collar around the NPC, first appeared around mid-October, as reported by Warell, and persisted throughout the apparition.

The NPC Regression

The Martian Northern Spring-early Summer (022°-112° Ls) regression of the NPC was investigated by measuring the areocentric latitudes of the cap's edge from 220 bifilar micrometer measurements, 168 CCD images, and 36 video images (graphed in *Figure 2*, below). In all cases, red filters were employed and the east-west extent of the cap was measured and corrected for phase and Ds (areocentric solar declination). Areocentric latitudes were computed using the formulae derived by Beish [Dobbins, *et al.* 1986]. There were no statistically significant differences between the micrometer, CCD, or video determinations, supporting preliminary data obtained during the 1992-1993 Apparition. This is good news, since micrometric determinations are tedious and require considerable experience. We anticipate obtaining more NPC data in future apparitions as the number of astronomers submitting CCD and video images grows. It must be stressed, however, that observations must be made through red filters, since even thin arctic hazes and clouds will make the cap appear larger than it really is. Perhaps this is one reason that cap sizes derived from drawings are systematically larger than those measured from red-light images. We must also stress that CCD images submit-

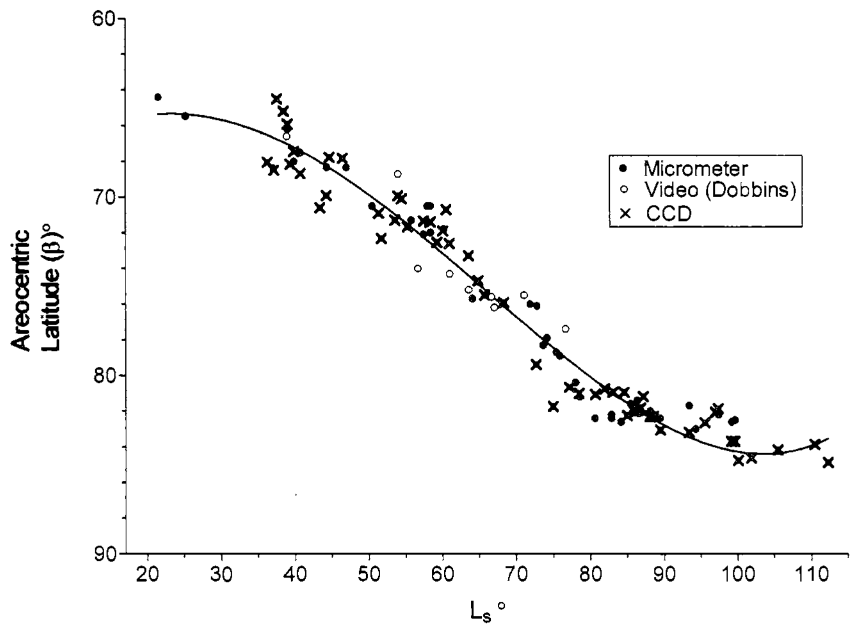

Figure 2. The 1994-1995 Mars North Polar Cap regression based on A.L.P.O.-I.M.P. red-light measurements using bifilar micrometers, and video and CCD images.

ted for NPC measurements must be carefully calibrated; that is, flat fielded and dark-subtracted.

Initially the NPC was significantly smaller than normal but then it exhibited a delayed regression, similar to that observed in the 1992-1993 Apparition. This retardation ceased at approximately 060° Ls, after which the cap's edge retreated rapidly to a latitude of 84°.8 N. by 100° Ls. The tiny summer cap remnant remained at approximately this size into early Northern Summer, when the planet's small apparent size precluded further measurements. A slight transient regrowth of the cap was observed between 065° and 072° Ls, corresponding to the well-known "Aphelic Chill." This phenomenon, first described by Clyde Tombaugh, is a temporary reforming of arctic hazes near aphelion [Capen and Capen 1970]. Overall, the 1994-1995 Spring (024°-090° Ls) NPC was slightly (2°.4) but significantly smaller than those of 1980 and 1982 (0.05>P>0.01, meaning that the probability of this result being due to chance was between .01 and .05), suggesting a continuation of the warming trend first observed in 1980 [Parker *et al.* 1983]. For a comparison of NPC regressions for aphelic apparitions during the last three decades, see *Figure 3*, below. The 1984 North Cap exhibited unusual retardations in regression between 060° and 110° Ls, a period coinciding with the appearances of five localized dust storms [Beish and Parker 1990a]. Inclusion of these 1984 data would make the difference between 1995 and the 1980's even greater but could introduce spurious results. Our 1995 data agree nicely with results obtained by Iwasaki [1995] and with preliminary Hubble Space Telescope (HST) image measurements.

NPC Rifts

1. The Chasma Boreale and NPC Outliers.—Upon emergence from beneath the polar hood, the NPC displays a rather smooth and uniform border. Later, during the rapid-thaw period, the edge of the cap will appear uneven, with numerous small, white, circular detachments along its border. By Martian summer, the NPC retreat slows and three bright projections, termed *outliers*, appear and detach from the cap as its edge retreats above 80° N. latitude. The white remnants may persist throughout Northern Summer and Fall, although this has not been the case in recent apparitions. The outliers are named after the areas on Mars that they occupy. Their averaged center-of-area areographic longitudes according to G. de Mottini's 1941-52 IAU Mars map are as follows: Ierne, 137°; Lemuria (Olympia), 200°; and Cecropia, 297°. [Note that Martian longitudes are measured westward from 000° to 360°.] Lemuria is separated from the cap by a dark conspicuous rift, called the *Chasma Boreale*. The positions of the outliers vary from one apparition to the next, as can be seen in *Table 2* (p. 9).

The outliers and the Chasma Boreale were well observed during the 1994-1995 Apparition. In January, 1995, Hiroshi Ishadoh of the OAA Mars Section (Oriental Astronomical Association, Japan) observed a shadowy streak in the NPC that Masatsugu Minami of the OAA believes to be the early start of the Chasma Boreale. Parker's CCD images from late December through mid February (039°-060° Ls) reveal a concentric dark NPC rift, producing a lifesaver effect on the cap that corresponded in orientation and position to the Chasma Boreale. By 1995 FEB 17 the classical NPC peripheral extensions, or outliers, called

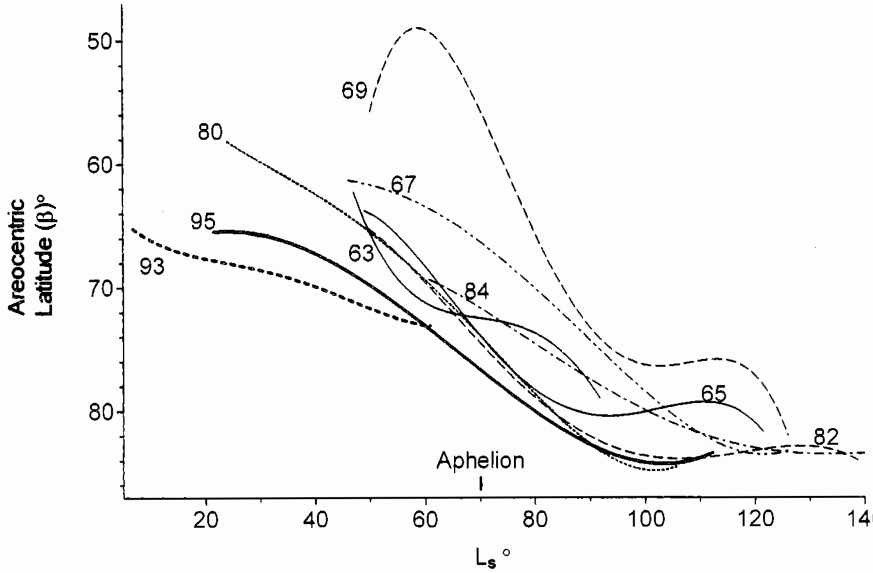

Figure 3. Martian North Polar Cap regressions for the aphelic apparitions from 1963 through 1995 (the years are the dates of opposition). Based on A.L.P.O.-IMP data.

Lemuria and Ierne had become completely detached from the cap. Lemuria persisted until at least late March (078° Ls) and was possibly detected as late as mid June, at 111° Ls. Ierne was imaged well into May (097° Ls). The third classical outlier, Cecropia, was not detected in its established location at 280°W, but a peripheral deposit was noted near 350°W, close to the location of one of two unnamed bright spots observed in 1982 and 1984 [Beish and Parker 1988]. This feature appeared on images taken between late February (064° Ls) and early March, 1995 (068° Ls).

2. The Rima Tenuis.—Giovani Schiaparelli, while using a 9-inch refractor in 1888, noted that the North Polar Cap of Mars was divided in two parts by a dark rift or fissure. This observation was later confirmed by Terby and Perrotin. This rift, crossing the cap at approximate longitudes 135° and 325°, is called the *Rima Tenuis* and was observed many times from 1901 through 1918. Records from the British Astronomical Association (BAA) reveal that the Rima Tenuis had been observed during 1933 and again in 1950. Then it apparently disappeared for nearly 30 years. C.F. Capen searched unsuccessfully for the feature during the 1960's, even though he employed telescopes of 16, 30 and 82 inches in aperture. The Rima also eluded the Viking Orbiters during the 1970's. It was not until late 1979 that the Rima Tenuis reappeared, when D. Troiani detected a dark notch at the south edge of the NPC near 335° areographic longitude. R. Robotham, J. Dragesco, J. Beish and D. Parker observed the Rima Tenuis within days of the first observations of the notch. Later, on 1980 FEB 22, P. Moore and C.F. Capen observed the complete Rima Tenuis while using the Lowell Observatory's 24-inch refractor [Capen, 1980]. The first photograph of this elusive feature was obtained by A. MacFarlane on 1980 FEB 22. Visibility of the Rima Tenuis has increased since 1979. While this may be due in part to improved instrumentation and greater awareness of the feature, there is evidence that the Rima is intrinsically more conspicuous, since observers are detecting it with instruments as small as 6 inches in aperture.

The 1994-1995 Apparition is the fifth consecutive aphelic apparition during which this feature was observed. It may have been detected as early as 1994 DEC 02 (026° Ls), when D. Niechoy of Germany observed a NPC rift corresponding in position to the Rima. A number of reports were made between 1994 DEC 20 and 1995 JAN 02 (034°-040° Ls), when S.R. Whitby, D. Troiani, D. Parker, G. Cameron, T. Stryk, and M. Schmidt (CCD images) independently observed both notches and the rift itself. The notches in the cap edge were located at 080° and 332° areographic longitudes. The next observations of this rift were reported on 1995 JAN 26 (051° Ls) by D. Joyce and D. Troiani using the Cernan Space Center (Triton College) 10-in f/8 Newtonian. Troiani made a drawing showing the complete rift with his 17.5-in f/4.5 reflector on 1995 JAN 27, when M. Schmidt and C. Tobias obtained CCD images at the Racine Observatory (Wisconsin) that clearly showed the Rima Tenuis notch in the south edge of the NPC. Over the next two nights a number of midwestern observers, including D. Drake, Jesse Carroll, Troiani, and Joyce, saw the Rima Tenuis with telescopes ranging from 6 inches to 17.5 inches in aperture. On 1995 JAN 30, M. Schmidt obtained excellent CCD images showing the Rima Tenuis starting at the small notch in the NPC at 332° and cutting across the cap. Images from the HST reveal a faint streak in the cap at the right longitude. After opposition D.L. Lehman obtained high-quality CCD images of the Rima Tenuis on 1995 MAR 08 (069° Ls), and D. Parker imaged the feature between 1995 MAY 09 and MAY 23 (096°-102° Ls).

METEOROLOGY

Clouds, clouds and more clouds. That's what many observers reported on Mars from January through March of 1995. It is most gratifying that most observers employed blue filters and thus were able to make high-quality observations of Mars' atmosphere. This study is a most important part of the A.L.P.O. Mars program and one that provides a valuable source of data for professional astronomers. The following meteorological results for the 1994-1995 Apparition are still qualitative only, because several hundred blue-light observations are being measured and statistically analyzed by Beish and Parker for inclusion in their ongoing study of Martian clouds [Beish and Parker 1990b]. The study now includes over 24,000 drawings, photographs , and CCD images obtained since 1965! The major Martian clouds, as reported during the 1994-95 Apparition, are mapped in *Figure 5* (p. 10).

Limb Clouds and Hazes.

1. Limb Brightenings.—Also called limb arcs, these are caused by scattered light from dust and dry ice particles high in the Martian atmosphere. They are often brilliant in blue light but can also be bright in all wavelengths. They were reported throughout the apparition.

2. Morning Clouds.—These are bright, isolated patches of surface fog or frosty ground near the morning limb (Mars' western edge as seen on Earth's sky). The fogs usually dissipate by mid-morning, while the frosts may persist most of the Martian day, depending on the season.

3. Evening Clouds.—These have the same appearance as morning clouds but are usually larger and more numerous than morning clouds. They appear as isolated bright patches over light desert regions in the late Martian afternoon and grow in size as they rotate into the late evening. Morning and evening limb clouds are distinguished from localized clouds in that they do not rotate with the planet. Limb clouds tend to cluster in the Martian tropical regions, whereas limb hazes or arcs usually extend from pole to pole.

There were frequent morning and evening limb clouds throughout most of the apparition, with some of them being very bright at times. They became particularly prominent during late Northern Spring, around 075° Ls, and were still detected during early summer (100° Ls), after which observations became difficult due to Mars' small apparent diameter. A bright evening limb cloud appears on Parker's tricolor CCD images taken from 1995 MAR 28 through APR 05 (077°-081° Ls). It was interesting to watch the Acidalium and Nilokeras albedo features disappear as they rotated under this cloud. A particularly unusual morning cloud was imaged by Parker between 1995 MAY 09 and MAY 19 (096°-100° Ls). This cloud had a "peanut" shape and appeared quite blue in color. Unlike a localized cloud, however, it did not rotate with the planet.

Localized Clouds, Topographic

Topographic clouds are intense bright patches of limited extent that occur seasonally over certain regions of Mars. Appearing white in integrated light, these features are best viewed and photographed through blue and blue-green filters. Occasionally they become more prominent in green and even yellow-orange light, suggesting that they may be combinations of water-ice and dust.

During the 1994-1995 Apparition, bright localized clouds became prominent over Libya, Chryse, and Moab starting in late January, 1995, around 050° Ls. These clouds persisted and perhaps increased in size and intensity well into Northern Summer. On 1995 FEB 18 (061° Ls), Beish reported a localized cloud formation over Xanthe-Memnonia that he called the "Capen wedge-cloud". By late February (064° Ls), discrete clouds over Xanthe, Amazonis, Argyre I and Arabia-Moab had become very conspicuous. On 1995 FEB 24 (063° Ls) Cameron saw a small bright spot in the Solis Lacus region and clouds over Tharsis. Hellas had some light fog in early March. On 1995 MAR 16 (072° Ls), there were a few very small bright spots in Cebrenia and Utopia.

A specialized type of topographic cloud is the famous "Syrtis Major Blue Cloud." This is a very localized cloud that had been traced for over a century by C.F. Capen. It appears every Martian year around the Northern-Hemisphere Summer Solstice and persists through early Summer. This cloud circulates around the Libya Basin and then crosses over to the Syrtis Major, where it changes the color of this albedo feature to an intense blue. When Syrtis Major is viewed through a yellow filter it turns a vivid green (yellow + blue = green). This cloud was first observed in 1858 by Father Angelo Secchi, who called it the "Blue Scorpion." The cloud was next seen by J. N. Lockyear in 1862 and again in 1911 by members of the BAA. C. W. Tombaugh and Capen observed the cloud early in the Martian Northern-Hemisphere Summer during the 1950 Apparition. It was seen regularly in the 1960's and it was most prominent in 1982.

D. Parker and J. Beish first reported the Syrtis Major Blue Cloud on 1995 JAN 28 (051° Ls), and it was imaged on both morning and evening limbs several times until 1995 APR 20 (087° Ls). By 1995 MAY 23 (102° Ls) Libya still displayed bright cloud cover with wispy tendrils extending over Syrtis Major, but no coloration was detected. On 1995 MAY 30 (105° Ls), however, Parker again noted the distinctive coloration. The 1996-97 Apparition will again be favorable for viewing the Syrtis Major Blue Cloud. Since this is one of the most spectacular features on Mars, we hope that observers avail themselves of this opportunity.

Localized Clouds, Orographic

Orographic clouds, like those that form on Earth, are white discrete clouds that are condensed from the moisture-laden air which is uplifted over a mountain or volcano. They appear bright on Mars when viewed through a blue (W80A) or a dark blue (W47) color filter.

Orographic clouds are discrete white clouds which develop as moisture-laden air is uplifted over the peaks of the great volcanoes in the Martian Tropics. They form when the Martian atmosphere is high in water vapor content, especially in late Spring or early Summer of the Northern Hemisphere. They assemble as local noon approaches, when they are best seen and photographed in blue and violet light. They continue to expand and brighten throughout the the Martian afternoon, and by nightfall are best discerned in violet and ultraviolet wavelengths, suggesting that they are carried further aloft by convection. The most spectacular orographic clouds occur over the volcanoes of the Elysium Shield and the Tharsis Bulge. The latter clouds sometimes appear to coalesce to form the famed "W-cloud," first reported by E.C. Slipher in 1954 [Slipher, 1962]. In 1971 the Mariner-9 spacecraft showed them to be water clouds near the large volcanoes Olympus Mons (longitude 133°, latitude 18°N.), Ascraeus Mons (104°, 11°N.), Pavonis Mons (112°, 0°N.), and Arsia Mons (120°, 9°S.).

The Elysium cloud usually forms first, as was the case in the 1994-95 Apparition. Early in December, 1994 (025° Ls) some brightening over Elysium was reported, and by the month's end (039° Ls) bright orographic clouds were conspicuous over this volcanic shield. This is rather normal for this region, unlike in the 1992-93 Apparition, when the Elysium cloud was very well formed by 028° Ls. Interestingly, this pattern appears to parallel the behavior of the NPC, which was considerably smaller during the early Northern Spring of the 1992-93 Apparition.

By mid-January, 1995 (045° Ls), orographic clouds were beginning to appear over the Tharsis volcanoes and had become very conspicuous by mid-February (057° Ls). By 1995 FEB 19 (061° Ls) these clouds had coalesced to form the W-Cloud. The Tharsis and Elysium orographic clouds persisted and became larger and brighter well into Northern Summer.

Polar Clouds, Hazes, and Hoods

During Northern Winter a thick mantle of cloud covers the Martian Arctic. Termed the *North Polar Hood* (NPH), this dull shroud usually breaks up around the time of the Vernal Equinox, revealing the bright pearly-white Spring NPC. It is uncertain whether the NPC is formed from the dissolving hood or was lying fully formed beneath the cloud layer during Northern Winter. Near-infrared CCD images taken by Parker in October, 1992, suggest the former state of affairs. These images, taken during late Northern Winter (346° Ls), reveal established albedo features beneath the NPH with no evidence of the large Spring Cap which appeared a few weeks later when the hood dissipated [Parker and Berry 1993]. Similar evidence was obtained from infrared observations from Tokyo and from the University of Arizona's Catalina Telescope during the period 347°-354 Ls° [Ebisawa 1995b]. These investigators also imaged the tiny permanent cap remnant beneath the hood, but found no trace of the large spring surface cap that was to emerge only a few weeks later.

During the 1994-95 Apparition the NPH became variable and thin near the Northern Vernal Equinox. Both Whitby and Niechoy reported a large, dull hood between 346-347° Ls; but, by 354° Ls (1994 SEP 28), Niechoy detected the cap largely free of the hood. By 356-358° Ls, Whitby, Warell, and Parker all observed the NPC clear of the NPH, bordered by the dark Lowell's Band. As the NPC retreated, a number of observers spotted polar clouds, especially on the morning side of the cap. These were reported on 1994 DEC 01 (025° Ls), 1995 FEB 03-06 (054°-055° Ls), and on 1995 MAR 08 (068° Ls). J. Beish saw a light haze over the cap, possibly the start of the "aphelic chill" on the 1995 FEB 08. Micrometer and CCD measurements revealed a small but significant regrowth of the NPC around the time of aphelion at 070° Ls.

Equatorial Cloud Bands (ECB's)

Perhaps the most interesting formations, however, are the equatorial cloud bands (ECB's). These are faint veils of wispy white clouds with variable shapes and transparencies that extend across the Martian disk within 20° of the equator. Residing at high altitudes and probably composed of CO_2 ice crystals, ECB's are best detected with dark blue (W47 or W47B) filters.

Until recently, cloud bands were thought to be exceedingly rare phenomena that were most likely to occur during the Martian Northern Summer. However, systematic tricolor CCD imaging has uncovered evidence that these wisps of cloud bands may be more frequent and may occur in all Martian seasons. They were seen and imaged on numerous occasions during the latter half of the 1992-93 Apparition, being much more prominent on CCD images than they were visually or photographically. The ability of the CCD camera to reveal subtle cloud structures that are only 1-2 percent brighter than the background demonstrates the power of electronic image processing. This did create a problem, however, since it was uncertain whether the increase in ECB's during the last apparition was real or merely due to better imaging techniques.We hoped that the 1994-95 Apparition would clarify the matter.

While ECB's were not usually specifically mentioned, they do appear on a few blue-light drawings from a number of observers, including J. Beish, C. Hernandez, D. Lehman, R. McKim, D. Niechoy, R. Schmude, T. Stryk, and S. Whitby. Parker's CCD images again revealed them on several occasions. These delicate features were most prevalent over Tharsis and Amazonis during February and March, 1995. More information on ECB prevalence awaits Beish's statistical analysis.

Dust Clouds

As expected, no major dust clouds were reported during this apparition; but some very minor dust activity was observed in 1994. Stryk reported a small, transient dust cloud over Argyre on 1994 JUN 05 (290° Ls) [Stryk, 1994]. On 1994 OCT 05 (358° Ls), it appears that there was dust in the atmosphere over Chryse making the area very bright at times in red light. In addition, a small thin dust cloud in Xanthe was first observed by Whitby on 1994 NOV 03 (012° Ls). It was again seen on 1994 NOV 13 and 14 by Ted Stryk, who reported some expansion on 1994 NOV 14. Analysis of color-filter observations suggests that there was some dust mixed in the clouds over the Chryse region in March, 1995, and a small dusty spot near Solis Lacus. This admixture of dust with the prevalent water-ice crystal clouds was verified by polarization measurements of Ebisawa [1995], who detected dust present in the Chryse-Xanthe-Tharsis clouds in late January, 1995 (050° Ls). In addition, a bar-like dust cloud was seen at the same time over Arcadia-Tempe, similar to the more conspicuous one observed in 1982 near 122° Ls [McKim 1985]. Finally, Ebisawa's polarization data revealed dust mixed with the Elysium shield clouds in mid-January (045° Ls). It should be noted, however, that the phase angle (the Earth-Sun angle as seen from Mars) in mid-January was about 25°. This is where the signs of polarization of both water-ice clouds and dust clouds change, making differentiation of cloud types nearly impossible with this method at such times.

SURFACE FEATURES

The albedo markings of Mars, as reported during the 1994-95 Apparition, are mapped in *Figure 4* (p. 10).

Region I: Longitude 250°-010°

Syrtis Major was dark throughout the apparition, exhibiting little change from 1992-93. It displayed an average width, with a blunted northern border. Osiridis Promontorium, at the northeast border of Syrtis Major was again prominent. Moeris Lacus, a short streak just south of Osiridis, was again seen jutting into Libya. The Thoth-Nepenthes "canal", so conspicuous from 1954 to 1967, was not seen. The Nodus Laocoontis-Nubis Lacus complex was also absent, as it has been since 1982, although Seigel and Falsarella drew it faintly in March, 1995. Nodus Alcyonius, northeast of Syrtis Major, was extremely dark and elongated NE-SW. To the south, Hellas was bright with cloud or fog both before and after opposition. In February, 1995, however, the floor of this great basin was cloud-free, revealing the "Hellas Cross", consisting of Peneus, Alpheus, and Zea Lacus. West of Syrtis Major, Astaborae Sinus was faintly seen by Cave, Schmude, and Stryk. To the north, Nilosyrtis and Astusapes were faint or absent, although the former was reported after opposition by Cameron, Haas, Teichert, and Niechoy. Boreosyrtis and Umbra were dark. Moving westward, Protonilus, Ismenius Lacus, and Deuteronilus were fairly well defined on both CCD images and drawings from several observers, including Cameron, Fabian, Teichert, and Troiani. Sabaeus Sinus was quite dark, and its eastern end, which had previously faded since 1990, resumed a more normal aspect, as reported by Cave, Lehman, and Cameron. Despite the markedly positive De (areocentric declination of the Earth), Pandorae Fretum was very well seen by most observers. It was very dark and appears to have shifted southward from its usual position. In late January, 1995 (052° Ls), however, Hernandez found only the eastern half of Pandorae Fretum to be dark, with the western portion intermediate in tone. He also detected the dark Vulcani Pelagus projecting from the eastern border of Erythraeum Mare.

Classically, Syrtis Major broadens after Northern Summer Solstice (090° Ls). No significant changes in its breadth were observed during this apparition, agreeing with HST data [Lee et al. 1995]. This feature demonstrated a high degree of variability during the 1970's and early 1980's, but it has remained fairly stable since the 1984 Apparition.

Region II: Longitude 010°-130°

Margaritifer Sinus and Aurorae Sinus were well defined and of normal intensity. Oxia Palus was prominent, as it has been for several years. The delicate filament Cantabras, joining the western fork of Meridiani Sinus with Oxia Palus, was seen on CCD images. At least four small, dark, round features were seen in southern Chryse-Xanthe, including Hydapsis Sinus, Iamunae Sinus, Hydrae Palus, and Clytaemnestrae Lacus. These markings were also conspicuous in the 1992-1993 Apparition. These features do not correspond well with those on classical maps (it would appear that the areography of the northern Chryse-Xanthe region is somewhat inconsistent). To the west, in Candor, Juventae Fons was again prominent and Ganges was broad but only dusky. McKim reported that Lunae Lacus, so noticeable in the early 1980's, was again faint. Several observers found western Nilokeras to be faint, while at its eastern end it appeared double (Nilokeras I and II). Idaeus Fons and Achillus Fons appeared as two dark nodules west of Niliacus Lacus. Prior to opposition, Niliacus Lacus was darker than Acidalium Mare; but by March, 1995, Crocker and Parker found that it had lightened somewhat.

To the south, Agathadaemon, Melas Lacus., and the Tithonius Lacus. Complex were distinct. Solis Lacus was dark and elongated E-W. It has undergone little change since the 1986 Apparition. Gallinaria Silva was a distinct dark dot west of Solis Lacus. The "canal" Phasis, joining Gallinaria to Aonium Sinus, was not imaged or reported. This variable feature had resumed prominence in May, 1984, darkened in 1986, but had faded during the 1988 Apparition. Then, in 1990, it became very prominent after the early November dust storm [McKim 1992], but was barely perceptible during the 1992-93 Apparition. Acampsis, linking Solis Lacus to Gallinaria was drawn and imaged by several observers, and the unnamed dark streak running west from Gallinaria to near Gomer Sinus was seen and imaged in December and in March. Near opposition it had faded but was still barely perceptible on CCD images. This streak, running along the northern borders of Sirenum Mare and Cimmerium Mare was first detected in August, 1988 by S. O'Meara and D. Parker and has been reported sporadically since. Like Eumenides to the north, this feature seems to be most prominent when Mars' phase angle is greatest, and may thus be linked to shadow effects.

In addition to the numerous clouds in Tharsis, some albedo feature changes were reported. In early December (028° Ls) Teichert recorded a darkening of Ascraeus Lacus. Again, in late March (075° Ls) Siegel, Warell, Teichert, Lehman found this feature dark, with Cameron and McKim reporting Uranius to be broad and dark. Whitby also observed a darkening in Ceraunius in late January (048° Ls).

Region III: Longitude 130°-250°

T. Cave and W. Haas reported Laestrygonum Sinus well-detached from Cimmerium Mare in March, when Haas also sighted the canals Cyclops and Cerberus II. The dark patch in eastern Aetheria, prominent since 1977 and termed the Hyblaeus Extension by C. Capen, remained dark during 1994-95.

Cerberus I, forming the southern border of the Elysium Shield, displayed some interesting changes, proving that it is a highly variable feature. In fact, this was one of the features targeted for intensive study by the HST. It was a dark and conspicuous feature throughout the 1950's and early 1960's, weakening in 1965 and more in 1967, but returning as a thin but dark feature in 1969. It remained conspicuous until the 1975 Apparition, when it reached near invisibility. It recovered somewhat in 1977 and darkened dramatically after opposition in 1980. After the February and May dust storms of 1982, Cerberus faded, a trend that continued after the 1984 dust events. Since 1984, Cerberus has remained faint, although there have been some variations in its intensity.

In 1994-95 Cerberus was fairly dark and conspicuous early in the apparition. However it became fainter by late November and early December, 1994 (023-025° Ls) when Trivium-Cerberus appeared on CCD images as a halftone streak with two or three diffuse nuclei. From 1995 JAN 02-12 (040-044° Ls) it had weakened considerably, becoming a faint thin streak with Trivium a small dark dot. During mid-February, 1995 (057-060° Ls) the complex was barely visible, appearing as only three small dots. Parker's 1995 MAR 18-25 CCD images (both tricolor and red light) showed Cerberus still weak, as just three small dots, especially after local noon. Interestingly, however, several very experienced A.L.P.O. observers independently reported that Cerberus became quite dark and streak-like near 1995 MAR 14. During April the feature darkened considerably as noted on both drawings and CCD images. It maintained that aspect for the remainder of the apparition, but was still not as conspicuous as it had been during the 1970's.

CONCLUSIONS

Despite the unfavorable aspect that Mars presented during the 1994-1995 Apparition, much useful information was obtained, due largely to the high quality of the observations submitted. Many IMP astronomers systematically observed Mars when it was less than 6 arc-seconds in apparent diameter, thus significantly extending the seasonal coverage. Over 50 percent of the observers, both visual and photographic, regularly employed color filters; this is the highest proportion to date, and we hope that the trend continues. In addition, the vast majority of the observations submitted were properly documented as to image orientation, Universal Time and date, central meridian, and so forth. Also, the quality of the reports was, on the average, the highest we have seen. Despite the "high-tech" contributions of CCD imaging, and the use of active optics to assist photography, the visual drawing remains the backbone of Mars observations. Cases in point are Troiani's 1994-95 Mars maps (*Figures 4 and 5*, p. 10) that were highly praised by a number of professionals at the MTO Workshop. Even though Troiani generated these on a computer, they were produced entirely from the amateur observations submitted to the A.L.P.O. Mars Section. Many thanks to all our observers!

ACKNOWLEDGEMENTS

The Mars Section of the Association of Lunar and Planetary Observers wishes to express its gratitude for the contributions of fellow A.L.P.O. members as well as those of the British Astronomical Association and the Oriental Astronomical Association.

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Table 1. Members of the A.L.P.O. International Mars Patrol for the 1994-1995 Apparition.

Observer	Location	Observer	Location
Makoto Adachi	Ohtsu City, Japan	Frank Melillo	Holtsville, NY
Oscar Arnal	Ontario, Canada	Masatsugu Minami	Fukui, Japan
Greg Banialis	Arlington Hts., IL	Patrick Moore	Selsey, UK
Jeff Beish	Miami, FL	Yukio Morita	Hatssuka, Japan
Phillip Budine	Walton, NY	Mike Morrow	Ewa Beach, HI
Gary Cameron	Des Moines, IA	Masami Murakami	Fujisawa, Japan
Lawrence Carlino	Lockport, NY	Takashi Nakajima	Fukui, Japan
Jesse Carroll	Chicago, IL	Detlev Niechoy	Goettingen, Germany
Jim Carroll	Chicago, IL	Gary Nowak	Essex Jct., VT
Thomas Cave	Long Beach, CA, Mt. Wilson, CA	Yoshio Ohba	Yamagata, Japan
		Don Parker	Coral Gables, FL
Vanessa Cave	Long Beach, CA	Cecil Post	Las Cruces, NM
John Crocker	Chicago, IL	Phil Plante	Poland, OH
Brian Cudnik	Flagstaff, AZ	Terry Platt	Binfield Berks, UK
Tom Dobbins	Coshocton, OH	Robert Robinson	Morgantown, WV
Darren Drake	Indian Head Pk., IL	Mark Schmidt	Racine, WI
Garry Dymond	St. John, Canada	Richard Schmude	Barnesville, GA
Karl Fabian	Hickory Hills, IL	Elisabeth Siegel	Agertoften, Denmark
Nelson Falsarella	San Jose, Brazil	Robert Smith	Huntville, AK
Vincent Giovannone	Latham, NY	Chester Spell	Woodstock, GA
David Graham	N. Yorkshire, UK	Robert Soltis	La Jolla, CA
David Gray	County Durham, UK	Ted Stryk	Bristol, VA
Bob Gunnerson	Loveland, CO	Gérard Teichert	Hattstatt, France
Walter Haas	Las Cruces, NM	Greg Terrance	Lima, NY
David Hanon	Chattanooga, TN	Chris Tobias	Racine, WI
Carlos Hernandez	Miami, FL	Daniel Troiani	Schaumberg, IL
Richard Hill	Tucson, AZ	Robert Young	Harrisburg, PA
Hiroshi Ishado	Okinawa, Japan	Johan Warell	Uppsala, Sweden
Tohru Iwasaki	Morodomi, Japan	John Westfall	San Francisco, CA
Chuck Jacobson	Puyallup, WA	Samuel Whitby	Hopewell, VA
Daniel Joyce	Chicago, IL	Matthew Will	Springfield, IL
David Lehman	Pinedale, CA	Pat Winemiller	Terre Haute, IN
Michael Mattei	Littleton, MA	Gene Witkowski	Buffalo, NY
Richard McKim	Oundle, UK	Mike Zweifel	Yorkville, WI

Table 2. North Polar Cap Residual Features ("Bright Projections," "Outliers").

		Feature Longitudes		
Observer(s)	Years	Ierne	Lemuria	Cecropia
Schiaparelli	1879-88	121°	208°	310°
Lowell	1901-05	122	206	311
Antoniadi	1903-29	122	208	309
Maggini	1918-35	136	213	278
de Mottoni	1941-52	137	200	297
Dollfus	1946-52	142	227	292
Capen	1962-68	140	196	290
Beish, Parker, Capen, and Dragesco	1981-82	132	205	280
Beish, Parker, Hernandez, and Dragesco	1983-85	142	205	294
	Mean	133°	208°	294°
	Range	121°-142°	196°-227°	278°-311°
	Standard Error	±2°.9	±2°.9	±4°.4

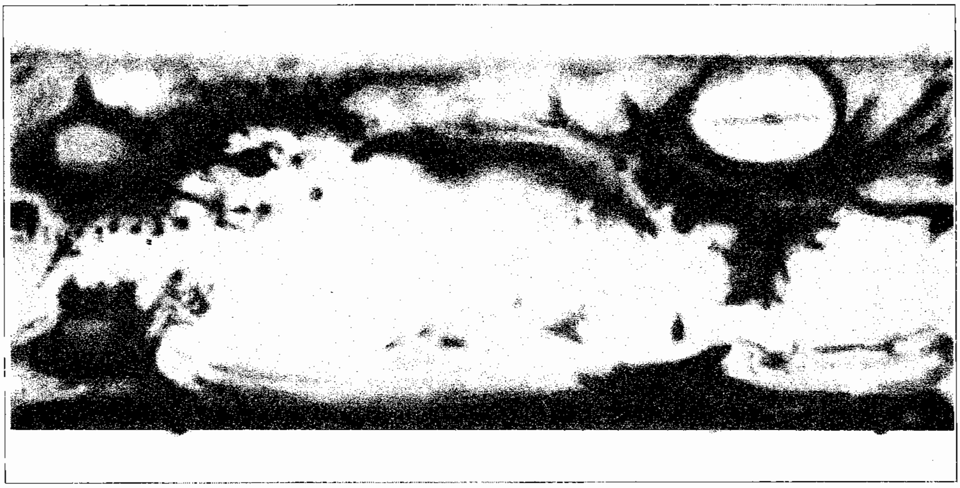

Figure 4. Cylindrical equidistant projection map of Martian albedo features in 1994-95. Prepared by Dan Troiani, Jim Carroll, and Dan Joyce using International Mars Patrol drawings, photographs, and video and CCD images. Martian south is at the top and east to the right. The right and left margins are at longitude 000° and the Martian poles are at the top and bottom margins.

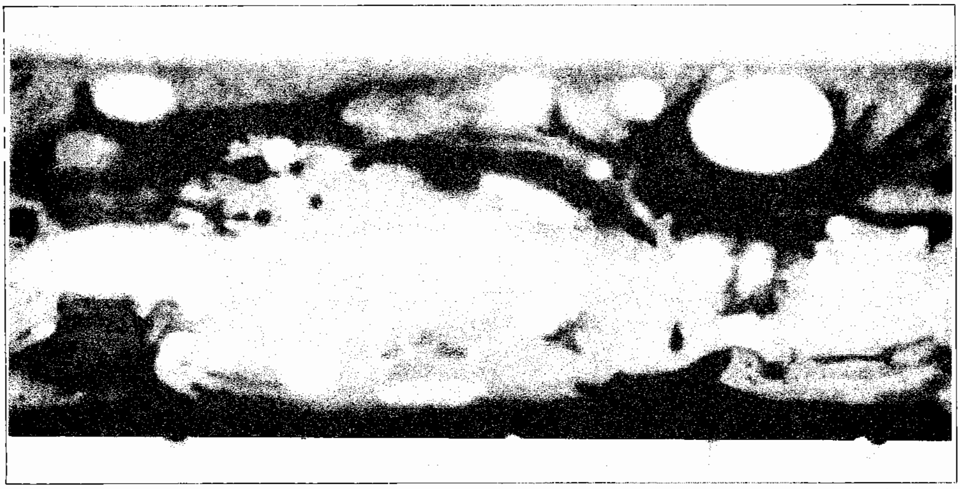

Figure 5. Map showing major Martian clouds reported by International Mars Patrol observers during the 1994-95 Apparition. The map shown in Figure 4 (top) has been used as a base.

Table 3. Captions for Observations 1-56 (on Figures 6-8 on pp. 13-15).

(Abbreviations: Newt. = Newtonian, Refr. = refractor, SCT = Schmidt-Cassegrain; B = blue, G = green, M = magenta, O = Orange, R = red, Y = yellow; lt = light)

1. 1994 Jun 07, 09:55 UT, CM: 127°, Ls: 290°, 10-in (25-cm) Newt. Filter: None. Ted Stryk. First observation of the apparition showing prominent southern maria. Areocentric Declination of Earth: -17°. Diameter only 4.45 arc-sec.

2. 1994 Nov 02, 08:15 UT, CM: 106°, Ls: 012°, 16-in (41-cm) Newt. Filter: W47 (B). Don Parker. Prominent evening limb cloud with terminator projection; bright morning limb haze.

3. 1994 Nov 03, 10:45 UT, CM: 133°, Ls: 012°, 7-in. (17.8-cm) Refr. Filter: W21 (O). Samuel Whitby. N. Polar collar dark in orange light; morning limb haze.

4. 1994 Dec 01, 08:31 UT, CM: 194°, Ls: 025°, 16-in (41-cm) Newt. Don Parker. From tricolor CCD image showing dark streak along northern border of Cimmerium Mare Hyblaeus extension prominent; Trivium-Cerberus halftone. Lynxx PC camera.

5. 1994 Dec 26, 06:40 UT, CM: 294°, Ls: 037°, 17.5-in (44-cm) Newt. Filter: W25 (R). Dan Troiani. Rima notch at edge of NPC , bright spot in Hellas.

6. 1994 Dec 30, 09:20 UT, Cm: 296°, Ls: 039°, 14.25-in (36-cm) Newt. Gene Witkowski. From video image showing faint Rima Tenuis.

Table 3—Continued.

7. 1995 JAN 01, 07:30 UT, CM: 251° Ls: 039°, 8-in (20-cm) Newt. Filter: W30 (M). Carlos Hernandez. Elysium cloud on evening limb. Hyblaeus extension, N. Alcyonius, and Cerberus prominent.

8. 1995 JAN 06, 08:40 UT, CM: 223°, Ls: 042°, 12.8-in (32.5-cm) Newt. Filters: R, O, B. Thomas Cave. Trivium-Cerberus still dark but thin.

9. 1995 JAN 10, 05:45 UT, CM: 144°, Ls: 043°, 8-in (20-cm) Newt. Filter: W30 (M). Carlos Hernandez. Tractus Albus noted over Tempe-Tharsis. Propontis complex prominent.

10. 1995 JAN 10, 05:55 UT, CM: 146°, Ls: 043°, 8-in (20-cm) Newt. Filter: W38A (B). Carlos Hernandez. Equatorial Cloud Band (ECB) over Memnonia-Tharsis. Refer to Observation 9.

11. 1995 JAN 20, 06:00 UT CM: 058°, Ls: 048°, 4.25-in (11-cm) Schiefspiegler. Filters: W23A (lt R), 80A (lt B). Gary Cameron. Chryse-Xanthe bright. Lunae Lacus dusky, not discrete.

12. 1995 JAN 21, 00:25 UT, CM: 328°, Ls: 048°, 15-in (38-cm) Newt. Filters: None. Patrick Moore. Hellas light; Pandorae Fretum noted.

13. 1995 JAN 26, 09:10 UT, CM: 052°, Ls: 051°, 8-in (20-cm) Newt. Filters: None. Robert Smith. Idaeus Fons dark; Lunae Lacus not noted.

14. 1995 JAN 27, 09:10 UT, CM: 043°, Ls: 051°, 10-in (25-cm) Newt. Filters: None. Daniel Joyce. Rima Tenuis visible. Again, Lunae Lacus not noted.

15. 1995, JAN 28, 02:45 UT, CM: 300°, Ls: 051°, 8-in (20-cm) Newt. Filters: R, O, G, B. Nelson Falsarella. Sabaeus Sinus dark along its length; Pandorae Fretum prominent.

16. 1995 JAN 29, 05:30 UT, CM: 332°, Ls: 052°, 17.5-in (44-cm) Newt. Filter: None. Dan Troiani. Rima Tenuis prominent.

17. 1995 FEB 02, 23:26 UT, CM: 199°, Ls: 054°, 12.5-in (32-cm) Tri-schiefspiegler. From color CCD camera (Starlight Xpress). Terry Platt. Orographic clouds Arcadia-Tharsis on evening limb. Propontis complex prominent.

18. 1995 FEB 02, 07:20 UT, CM: 324°, Ls: 054°, 14-in (36-cm) Newt. Filters: W25 (R). Richard Hill. Numerous canals, including Astaboras, and Hiddekel noted.

19. 1995 FEB 03, 05:35 UT, CM: 289°, Ls: 054°, 16-in (41-cm) Newt. Filters: Tricolor CCD image. Lynxx PC camera. Don Parker. Hellas Cross noted. Boreosyrtis prominent.

20. 1995 FEB 05, 05:05 UT, CM: 265°, Ls: 055°, 11-in (28-cm) SCT. Filters: R,O,G.B. Gérard Teichert. Casius dark on CM; Nasamon seen extending from northeastern Syrtis Major. Bright cloud over Aethiopis.

21. 1995 FEB 06, 03:50 UT, CM: 238°, Ls: 055°, 10-in (25-cm) Newt. Filter: W23A (lt R). John Crocker. Hyblaeus Extension dark, broad; Trivium-Cerberus very weak.

22. 1995 FEB 07, 03:45 UT, CM: 228°, Ls: 056°, 10-in (25-cm) Newt. Filters: R, G, B, Y. Ted Stryk. Detail of NPC outliers, Rima Borealis.

23. 1995 FEB 02, 02:59 UT, CM: 260°, Ls: 053°, 16-in (41-cm) Newt. Greg Terrance. Filters: None. Lynxx PC CCD image showing Hyblaeus extension broad and dusky. Cerberus very weak on evening limb.

24. 1995 FEB 11, 06:37 UT, CM: 235°, Ls: 058°, 16-in (41-cm) Newt. Filters: Tricolor CCD image. Lynxx PC camera. Don Parker. Trivium-Cerberus now very weak.

25. 1995 FEB 12, 06:45 UT, CM: 228°, Ls: 058°, 14-in (36-cm) Newt. Filter: W23A (lt R). Richard Hill. Trivium-Cerberus more prominent.

26. 1995 FEB 18, 03:03 UT, CM: 122°, Ls: 061°, 16-in (41-cm) Newt. Tricolor CCD image. Lynxx PC camera. Don Parker. Prominent orographic clouds over Tharsis.

27. 1995 FEB 20, 04:20 UT, CM: 123°, Ls: 062°, 10-in (25-cm) Newt. Filter: W25 (R), W38A (B). David Lehman. Clouds over Tharsis. Possible polar cloud on CM (Ierne region).

28. 1995 FEB 22, 19:47 UT, CM: 332°, Ls: 063°, 11-in (28-cm) SCT. Filters: R, O, Y, G, B. Gérard Teichert. Sabaeus Sinus dark throughout its length; Pandorae Fretum strong, broad.

29. 1995 FEB 22, 03:40 UT, CM: 096°, Ls: 062°, 12.8-in (32.5-cm) Newt. Filters: R, O, B. Thomas Cave. Clouds over Xanthe, Arcadia, Tempe, and near Olympus Mons. Lunae Lacus weak.

30. 1995 FEB 26, 01:40 UT, CM: 031°, Ls: 064°, 4.25-in (11-cm) Schiefspiegler. Filters: W23A (lt R), 80A (lt B). Gary Cameron. Clouds over Candor on morning limb; clouds over Chryse, Arabia-Moab, and south limb. Lunae Lacus weak.

31. 1995 FEB 26, 04:30 UT, CM: 073°, Ls: 064°, 14-in (36-cm) Newt. Filters: W25 (R). Richard Hill. Lunae Lacus very weak; Ganges prominent. Acidalius Fons dark at S. border of NPC with Issedon joining it to Nilokeras. Lunae Lacus not discrete. Blue-light observation reveals morning and evening limb clouds.

32. 1995 FEB 28, 02:48 UT, CM: 030°, Ls: 065°, 16-in (41-cm) Newt. Don Parker. From tricolor CCD image. Lynxx PC camera. Bright cloud on morning limb over western Tempe. Hazes across Chryse and Moab. Nuclei in Idaeus Fretum. Lunae Lacus weak.

33. 1995 MAR 01, 01:58 UT, CM: 009°, Ls: 065°, 7-in (18-cm) Refr. ST-5 camera CCD image. David Hanon. Achillis Pons light. Ismenius Lacus, Deuteronilus, Dirce Fretum, and Gehon detected!

Table 3—Continued.

34. 1995 MAR 04, 21:00 UT CM: 261°, Ls: 067°, 8-in (20-cm) SCT. Filters: None. Report with W25 (R), W15 (deep Y), W58 (G), W80A (lt B), W47 (B). Elisabeth Siegel. Hyblaeus Extension prominent. Aeria, Ausonia, and evening limb brightest with W80A.

35. 1995 MAR 04, 00:40 UT, CM: 324°, Ls: 067°, 6-in (15-cm) Refr. Filter: W23A (lt R). Lawrence Carlino. Aeria bright (see observation No. 34); Sabaeus Sinus and Hellespontus dark.

36. 1995 MAR 11, 01:45 UT, CM: 277°, Ls: 070°, 7-in (18-cm) Newt. Filters: W25 (R), 23A (lt R). Gary Cameron. Rima Tenuis noted. Hellas bright in red and blue light. Clouds reported over Moab, Aethiopis, and Elysium.

37. 1995 MAR 13, 03:00 UT, CM: 278°, Ls: 071°, 100-in (2.5-M) Mt. Wilson Coudé focus. Filters: R, M. Thomas Cave. Bright evening limb cloud (Elysium). Numerous small white areas in desert regions. Edge of NPC scalloped.

38. 1995 MAR 14, 02:25 UT, CM: 260°, Ls: 071°, 6-in (15-cm) Refr. Filters: W25 (R), 12 (Y), 80A (lt B), 38A (B). Phillip Budine. Nilosyrtis prominent. Cerberus darkening.

39. 1995 MAR 14, 01:55 UT, CM: 253°, Ls: 071°, 6-in (15-cm) Refr. Filter: Y8, Phil Plante. Aeria very bright on morning limb; Trivium-Cerberus reported as dusky.

40. 1995 MAR 14, 03:00 UT, CM: 269°, Ls: 071°, 12.8-in (32.5-cm) Newt. Filters: R, O. Vanessa Cave. Trivium-Cerberus darkened. Albor bright in NE Elysium.

41. 1995 MAR 21, 20:00 UT, CM: 094°, Ls: 074°, 8-in (20-cm) SCT. Filters: None for drawing. Report with W25 (R), 15 (deep Y), 58 (G), 80A (lt B), 47 (B). Elisabeth Siegel. Ascraeus Lacus and Ceraunius prominent near CM.

42. 1995 MAR 21, 04:45 UT, CM: 231°, Ls: 074°, 12.5-in (32-cm) Newt. Filter: W25 (R). Walter Haas. NPC peanut-shaped. Cerberus II extending between Pambotis Lacus and Gomer Sinus. Symplegades Insula bright.

43. 1995 MAR 22, 22:32 UT, CM: 122°, Ls: 075°, 12.5-in (32-cm) Trischiefspiegler. From color CCD camera (Starlight Xpress). Terry Platt. Numerous orographic clouds over Tharsis.

44. 1995 MAR 23, 03:55 UT, CM: 201°, Ls: 075°, 16-in (41-cm) Newt. Tricolor CCD image. Lynxx PC camera. Don Parker. Trivium-Cerberus strengthening. Tharsis orographic clouds on evening limb.

45. 1995 MAR 31, 01:28 UT, CM: 092°, Ls: 078°, 16-in (41-cm) Newt. Tricolor CCD image. Lynxx PC camera. Don Parker. Bright cloud on morning limb over Memnonia. Cloud wisps over Tharsis.

46. 1995 MAR 31, 01:15 UT CM: 089°, Ls: 078°, 16-in (41-cm) Newt. Filters: W47 (B), 47B (deep B). Jeff Beish. Band cloud and numerous discrete clouds over Tharsis, Xanthe.

47. 1995 APR 09, 20:05 UT CM: 281°, Ls: 083°, 6.3-in (16-cm) Refr. Filters: W21 (O). Johan Warell. evening limb haze. Hellas bright. Pambotis Lacus noted adjacent to bright evening limb.

48. 1995 APR 12, 20:00 UT, CM: 252°, Ls: 084°, 8.5-in (21.6-cm) Newt. Filters: None. Richard McKim. Trivium-Cerberus darkened. Brightening over Libya-Isidis Regio-Neith Regio-Aeria (Blue Syrtis Major Cloud?). Evening limb bright.

49. 1995 APR 13, 20:40 UT, CM: 252°, Ls: 084°, 16-in (41-cm) Dall-Kirkham. Filters: Integrated light, W15 (deep Y). David Gray. Cerberus I and II visible. Elysium complex well-defined.

50. 1995 APR 28, 21:10 UT, CM: 119°, Ls: 091°, 16-in (42-cm) Dall-Kirkham. Filters: Integrated light, W15 (deep Y). David Gray. Tharsis features noted: Nodus Gordii, Eumenides, Ascraeus Lacus, Ascuris Lacus, and dusky bands.

51. 1995 MAY 13 21:20 UT, CM: 339°, Ls: 098°, 16-in (42-cm) Dall-Kirkham. Filters: Integrated light, W15 (deep Y). David Gray. Hellas, Chryse bright; Protonilus, Ismenius Lacus, Deuteronilus, Hiddekel, and Gehon noted.

52. 1995 MAY 30, 02:05 UT, CM: 255°, Ls: 105°, 16-in (41-cm) Newt. Filter: W47 (B). Don Parker. ECB over Aethiopis-Isidis. Bright limb clouds. Syrtis Major covered with the Blue Syrtis Major Cloud.

NPC Outliers:

53. 1995 FEB 18, 03:15 UT, CM: 124°, Ls: 061°, 16-in (41-cm) Newt. Filters: Red light (Schott RG-610) CCD image. Lynxx PC camera. Don Parker. Outliers Ierne and Lemuria south of NPC, separated from it by the Chasma Borealis.

54. 1995 FEB 18, 01:50 UT, CM: 104°, Ls: 061°, 16-in (41-cm) Newt. Filters: W25 (R), W22 (deep O). Don Parker. Ierne west of the NPC; small outlier glimpsed on evening limb.

55. 1995 FEB 25, 02:33 UT, CM: 053°, Ls: 064°, 16-in (41-cm) Newt. Filters: Red light (Schott RG-610) CCD image. Lynxx PC camera. Ierne west of NPC. Small outlier in northern Ortygia east of NPC.

56. 1995 MAR 23, 01:56 UT, CM: 172°, Ls: 075°, 16-in (41-cm) Newt. Filters: Red light (Schott RG-610) CCD image. Lynxx PC camera. Lemuria southwest of NPC.

Figures 6, 7, and 8 appear on pages 13, 14, and 15; and contain Observations number 1-20, 21-40, and 41-56, respectively.

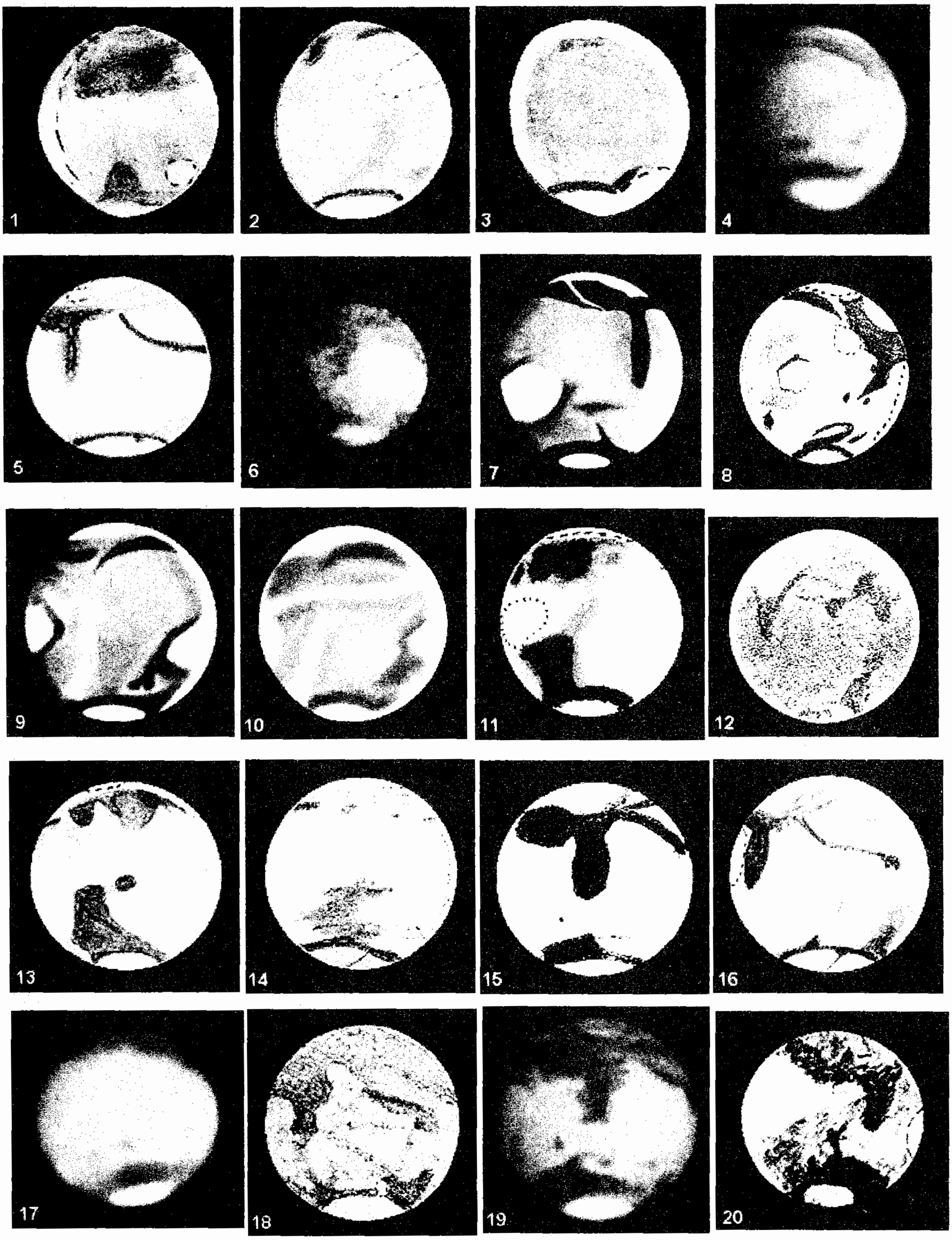

Figure 6. Drawings and video and CDD images of Mars; Observations 1-20 (1994 JUN 07-1995 FEB 05). The captions for these observations are given on pp. 10-11.

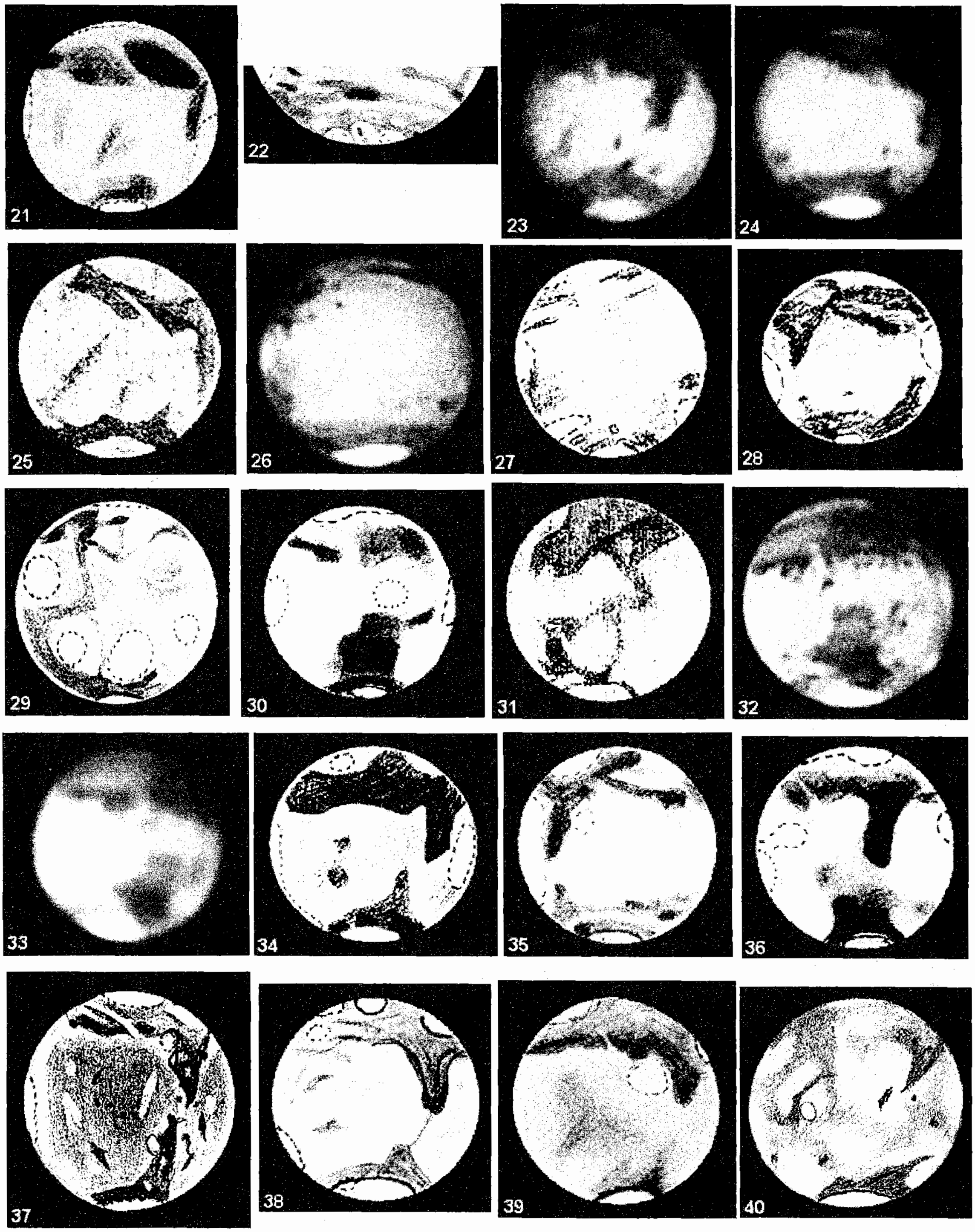

Figure 7. Drawings and CDD images of Mars; Observations 21-40 (1995 Feb 06-1995 Mar 14). The captions for these observations are given on pp. 11-12.

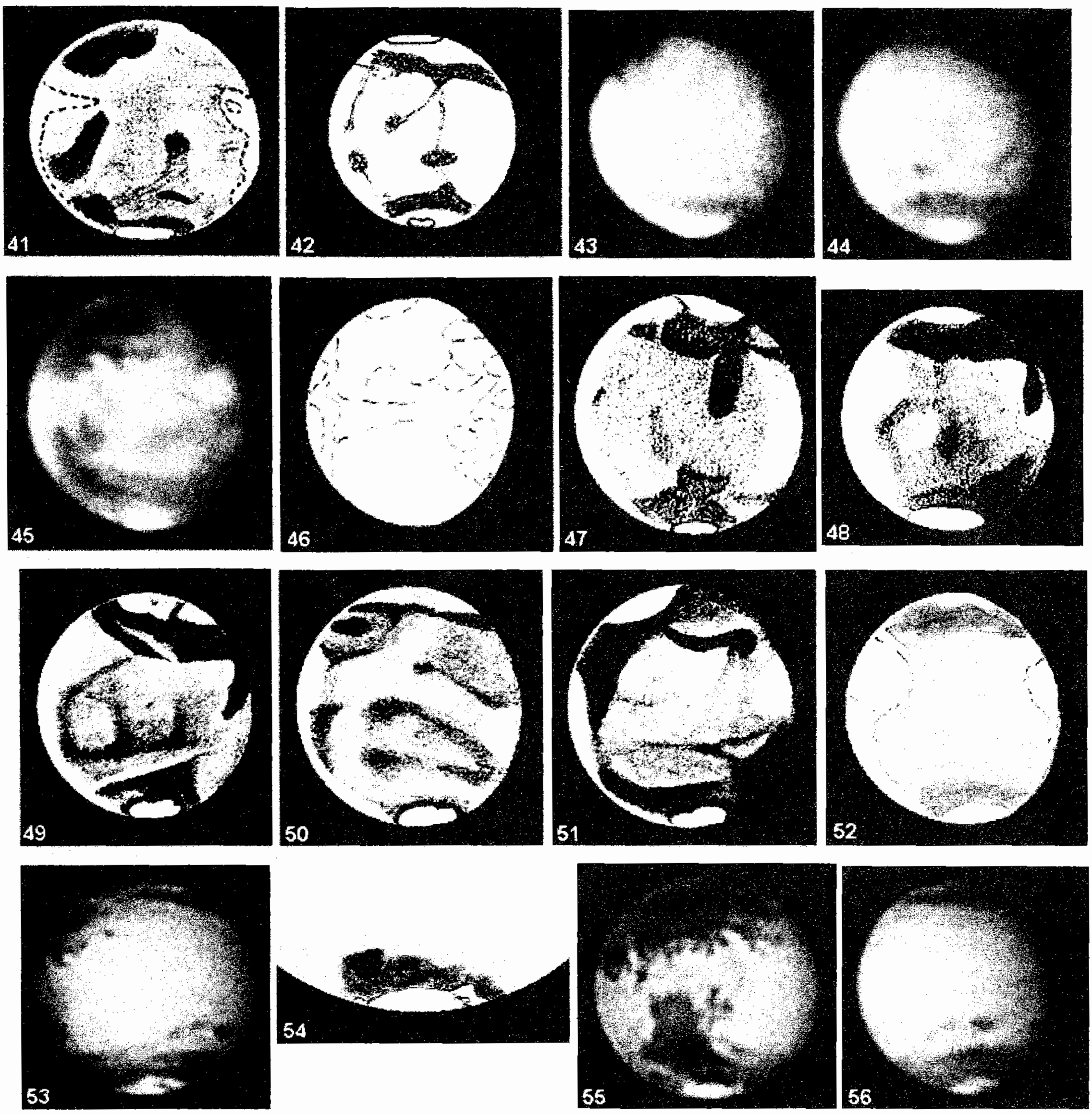

Figure 8. Drawings and CDD images of Mars; Observations 41-56 (1995 MAR 21-MAY 30; Observations 53-56 show NPC Outliers, 1995 FEB 18-MAR 23). The captions for these observations are given on p. 12.

GALILEAN SATELLITE ECLIPSE TIMINGS: THE 1991/92 APPARITION

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

ABSTRACT

The A.L.P.O. Jupiter Section received 855 visual timings of the eclipses of Jupiter's four Galilean satellites from 104 observers for the 1991/92 Apparition. For each satellite, eclipse visual disappearance and reappearance timings were adjusted for telescope aperture and were then combined for comparison with the Jet Propulsion Laboratory's "E-2" Ephemeris. The observed positions of Europa, Ganymede, and Callisto fitted the ephemeris well. Io appeared to be about 8 seconds "late" in its orbit; a statistically significant difference.

INTRODUCTION

The 1991/92 Apparition of Jupiter was the sixteenth studied by the A.L.P.O. Jupiter Section's Galilean Satellite Eclipse Timing Program. This was our second-most successful apparition, with 855 visual timings received. The satellites timed were Io (*1*), Europa (2), Ganymede (*3*); and Callisto (*4*). Visual observers timed the "first speck" visible when the satellite reappeared from Jupiter's shadow (*reappearance*), or the "last speck" seen when the satellite disappeared into the shadow (*disappearance*). Reports for previous apparitions are listed under "References" (p. 21). [Westfall 1983-84, 1986a, 1986b, 1987, 1988, 1989, 1991, 1992, and 1994]

Table 1 (below) lists some significant dates for the 1991/92 Jupiter Apparition.

Table 1. 1991/92 Jupiter Apparition Chronology.

			d	*h*
Conjunction with the Sun	1991	Aug	17	22
First Eclipse Timing	1991	Sep	19	05
Opposition to the Sun	1992	Feb	29	00
Closest Approach to Earth	1992	Feb	29	03
Last Eclipse Timing	1992	Aug	11	07
Conjunction with the Sun	1992	Sep	17	19

An *apparition* is the period between successive conjunctions, while an *observing season* covers the period of actual observation. The observing season began 33 days after conjunction, with Jupiter 24° west of the Sun; it ended 37 days before the next conjunction, at solar elongation 28° east. The jovicentric declination of the Sun was such that all four Galilean satellites underwent eclipses throughout the apparition.

At closest approach, Jupiter's distance from the Earth was 4.4118 AU [astronomical units; 1 AU = 149,597,870 km], with an equatorial diameter of 44".64, and a visual magnitude of -2.45. Its geocentric declination at opposition was +9°.2, so that observers in the Earth's Northern Hemisphere continued to be favored in this apparition, although not so favorably as in the previous three.

OBSERVATIONS

The timings received for 1990/91 bring our sixteen-apparition total to 6979 visual timings. Slightly over half the timings were submitted to the A.L.P.O. directly, or by a coordinating individual (438; 51.2 percent of the total of 855). We were fortunate to also receive 304 timings (35.6 percent) by 21 New Zealand and Australian observers coordinated by Brian Loader of the Royal Astronomical Society of New Zealand and 113 timings (13.2 percent) by 17 Spanish observers from the Agrupación Astronòmica de Sabadel. All in all, 104 individuals or teams made observations. The timings themselves are listed in *Table 9*, followed by the list of observers (pp. 22-27). We wish here to single out those observers for the 1991/92 Apparition who have contributed observations for at least five apparitions. *Table 2* (below) gives their names, nations and number of apparitions.

Table 2. Long-Term Participating Observers, Galilean Satellite Eclipse Timing Program.

William Abrahams (Australia, 7)
Colin Bembrick (Australia, 6)
J.L. Blanksby (Australia, 5)
Henk Bulder (Netherlands, 8)
Roberto Di Luca (Italy, 5)
Januário Fernandes (Portugal, 5)
Joaquim Garcia (Portugal, 5)
Rui Gonçalves (Portugal, 5)
Walter Haas (United States, 8)
Robert Hays (United States, 6)
Alfred Kruijshoop (Australia, 6)
Brian Loader (New Zealand, 11)
Malcolm MacDonald (New Zealand, 5)
Craig MacDougal (United States, 7)
Juan Grados Moreno (Spain, 6)
Jens Østergaard Olesen (Denmark, 5)
R. Parmentier (United States, 5)
John Priestly (New Zealand, 8)
Dennis Rowley (United States, 5)
Benita Ruiz Ruiz (Spain, 5)
Charlie Smith (Australia, 5)
G. Smith (Australia; 5)
Joaquim Vidal (Spain, 5)
Colin Ward (Australia, 5)
John Westfall (United States, 15)

Timings for the 1991/92 Apparition were made by observers in 17 countries, as shown in *Table 3* (below), giving us wide geographical distribution. We welcome the increased participation of Chinese observers. However, there remain longitude gaps in our coverage, such as most of the Pacific Basin and Asia. The number of American observers has increased but Australia still holds first place.

Table 3. Nationalities of Observers and Observations, 1991/92 Apparition.

Nation of Residence	Number of Observers		Number of Observations	
Australia	17	(16 %)	248	(29 %)
Spain	16	(15 %)	63	(7 %)
United States	14	(13 %)	82	(10 %)
Italy	14	(13 %)	60	(7 %)
P. R. of China	11	(11 %)	81	(9 %)
Portugal	6	(6 %)	66	(8 %)
Hungary	5	(5 %)	13	(2 %)
Brazil	4	(4 %)	70	(8 %)
New Zealand	4	(4 %)	56	(7 %)
Germany	3	(3 %)	49	(6 %)
Denmark	3	(2 %)	22	(3 %)
Argentina	2	(2 %)	5	(0.6 %)
Poland	1	(1 %)	27	(3 %)
The Netherlands	1	(1 %)	5	(0.6 %)
Israel	1	(1 %)	4	(0.5 %)
Sweden	1	(1 %)	1	(0.1 %)
Austria	1	(1 %)	1	(0.1 %)

Table 4 (below) gives summary statistics for the timings in terms of the satellite and the type of event. Note that the "Number of Events Total" refers to the number of events that occurred during the observing season.

Table 4. Summary Statistics By Event Type, 1991/92 Apparition.

(1 = Io; 2 = Europa; 3 = Ganymede; 4 = Callisto; D = Disappearance; R = Reappearance)

Event Type	Number of Timings	Number of Events* Total	Timed	
1D	159	93	53	(57 %)
1R	254	94	65	(69 %)
1	413	187	118	(63 %)
2D	74	46	26	(57 %)
2R	130	47	34	(72 %)
2	204	93	60	(65 %)
3D	72	38	26	(68 %)
3R	91	37	24	(65 %)
3	163	75	50	(67 %)
4D	46	19	12	(63 %)
4R	29	19	11	(58 %)
4	75	38	23	(61 %)
D	351	196	117	(60 %)
R	504	197	134	(68 %)
TOTAL	855	393	251	(64 %)

* During observing season.

As always, the closer a satellite is to Jupiter, the greater the number of timings made of its eclipses, chiefly because the frequency of satellite eclipses decreases outwards from Jupiter. Reappearances comprised the majority of timings for all satellites but Callisto. About two-thirds of the eclipses that occurred for all four satellites were actually timed.

As is usual, the number of timings varied considerably from month to month, as shown in *Table 5* (below) and *Figure 1* (p. 18).

Table 5. Number of Timings by Month, 1991/92 Apparition.

(Solar elongation range in parentheses; restricted to observing season)

1991	SEP	(024-033°W)	4	Timings
	OCT	(033-058°W)	16	
	NOV	(059-084°W)	31	
	DEC	(085-114°W)	62	
1992	JAN	(115-147°W)	89	
	FEB	(147-179°W)	132	
	MAR	(178-145°E)	137	
	APR	(144-115°E)	126	
	MAY	(114-086°E)	140	
	JUN	(085-061°E)	92	
	JUL	(060-037°E)	23	
	AUG	(036-028°E)	3	
Before Opposition			323	(37.8 %)
After Opposition			532	(62.2 %)

The most intense observing was during the four months including and after opposition, when Jupiter was easily viewed in the evening sky. We have an ongoing bias toward post-opposition timings; observers should make more pre-opposition timings in the future, even though this means observing after midnight.

The one remaining significant factor in the observations was the size of telescope used. Most observers used a single telescope, but a few used two or three instruments. The 137 telescopes used are tallied by aperture in *Table 6* (below); apertures within a few millimeters of each other have been grouped together.

Table 6. Number of Telescopes Used, By Aperture, 1991/92 Apparition.

Aper. (cm)	No.Tele.	Aper. (cm)	No.Tele.
5.0	5	17.0	1
5.5	1	18.0	1
6.0-6.3	12	20.0-20.5	33
7.0	1	21.0	3
7.5	3	21.6	1
8.0	9	25.0-25.4	6
9.0	2	26.0	1
10.0-10.2	12	30.0	2
11.0-11.5	11	31.75-32.0	2
12.0	3	35.0	1
12.7	1	40.0	2
13.5	1	41.0	2
14.0	3	45.0	1
15.0	14	50.0	1
16.0	1	65.0	1
		75.0	1

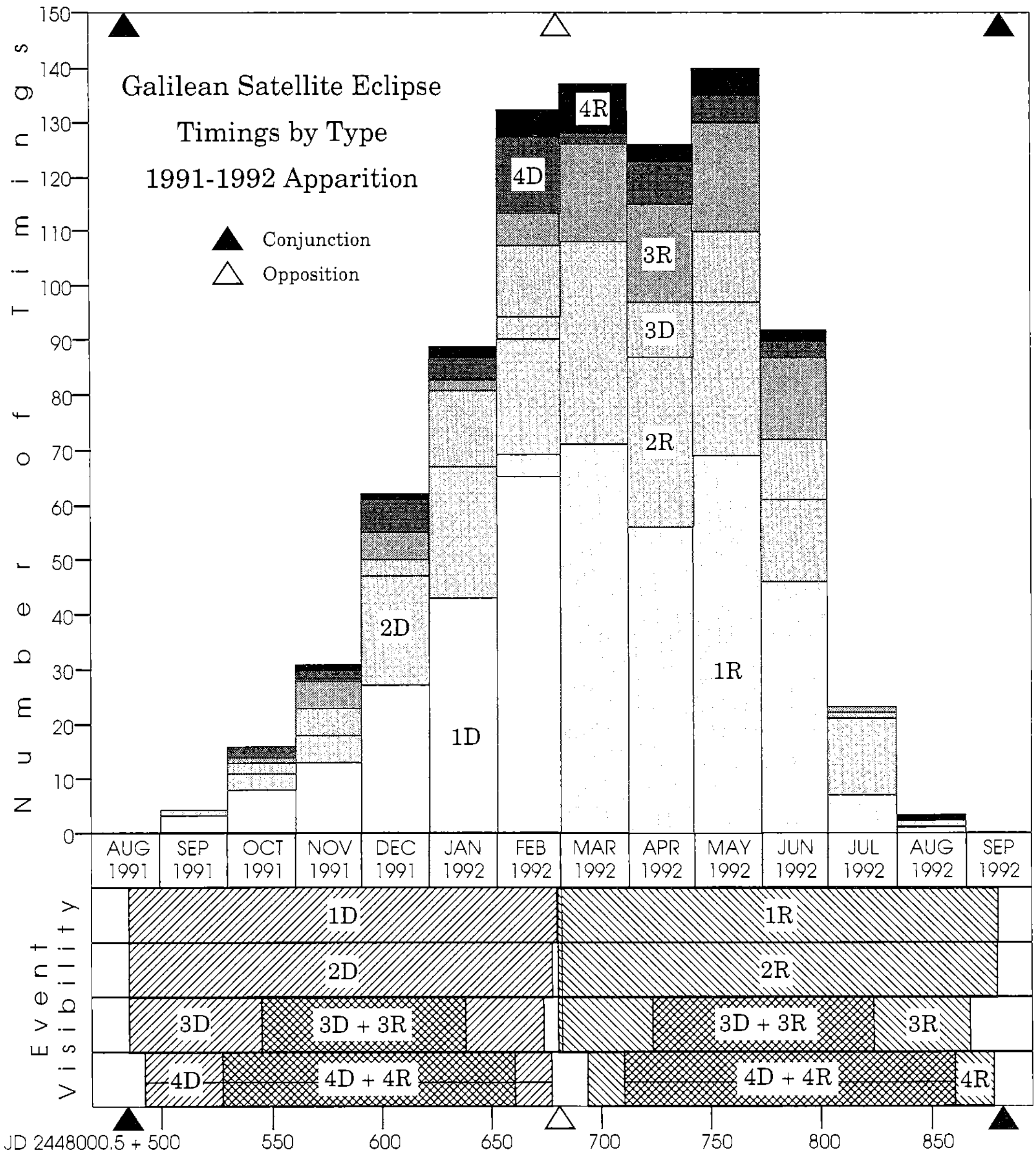

Figure 1. Histogram of the number of eclipse timings by type and month for the 1991/92 Apparition of Jupiter, where: 1 = Io, 2 = Europa, 3 = Ganymede, 4 = Callisto, D = Disappearance, and R = Reappearance. The bars at the bottom show when eclipse events of each type occurred.

The most popular aperture continues to be 20 cm, with the median somewhat less; 15.0 cm. Thirteen small telescopes, 5.0 to 6.3 cm in aperture, were used, comprising 9 percent of the instruments. The twelve fairly large telescopes, 30 cm or larger in aperture, constituted 9 per cent of those used. The range of apertures continues to be large; from 5.0 to 75 cm, showing that almost any size of telescope can be used in our program.

REDUCTION

The first step in reduction was to segregate the timings by satellite and by the type of event; disappearance versus reappearance. Observations were compared with the predictions of the "E-2" Ephemeris developed by Dr. Jay H. Lieske of the Jet Propulsion Laboratory. [Lieske, 1981] The predicted time of each event was then subtracted from the observed time; a positive residual meant that an event was "late"; a negative residual, that it was "early." These residuals are given in the right-hand column in *Table 9*. The next step was to correct for aperture with a linear regression model in which the dependent variable was the residual (**y**) and the independent variable was the reciprocal of the telescope aperture, measured in centimeters (**x**). The form of the model is:

(1) $y = A + Bx$,

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

Two statistics describe how well equation (1) fits the observed residuals. One, the *standard error* (S.E.), measures how different the average residual was from that predicted. The other, *R-Square*, measures what proportion of the variance (squared differences among the residuals) is removed by equation (1).

A few timings were not used because they differed by many minutes from the predictions and could not be reconciled. A number of timings were rejected because of differences from the regression model that were significant at the 5-percent level (i.e., would occur due to chance less than 5 percent of the time) as measured in terms of the standard error (given in *Table 7*). For the 1991/92 Apparition, 91 timings (10.6 percent) were rejected, and are shown by italicized residuals in *Table 9*.

As a check of the method described above, the writer estimated the diameter of each satellite by taking the differences between its predicted disappearance and reappearance residuals, which should give the amount of time it took Jupiter's shadow edge to cross the satellite's disk. Then, taking into account each satellite's velocity and average angle of entry or exit from the shadow, the diameter in kilometers was calculated and is shown in *Table 7* (p. 20).

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

LONG-TERM RESULTS

The orbital residuals for Io, Europa, Ganymede, and Callisto for the fifteen apparitions from 1976/77 through 1991/92 are graphed in *Figure 2* (below; there were too few timings made in the 1975/76 apparition to determine its orbital deviations). In that figure, the error bars represent a ±1 standard-error range, and a deviation from the ephemeris significant at the 5-percent level would have to be at least about ±2 standard errors.

The diagram shows that the widths of the error bars have tended to diminish over time, chiefly due to the greater accuracy caused by an increasing number of timings submitted to the program. There are hints of cyclical variations for some of the satellites, particularly for Europa and Ganymede, perhaps in a 12-year cycle associated with Jupiter's orbital period. We hope that we will receive sufficient timings for enough future apparitions to investigate this question.

1991/92 RESULTS

Details for the 1991/92 Apparition follow in *Table 7* (p. 20). This table gives results for each of the four Galilean satellites in a separate column. Each column is divided into four parts, "Disappearance," "Reappearance," "Orbital Residual," and "Diameter." For both disappearances and reappearances, the number of timings is given first, followed in parentheses by the number finally used in the regression analysis after aberrant timings had been deleted. The next item is the mean residual for the timings that were retained, followed by the coefficient of variation ("R-squared"), which is the proportion of the variance among the timings that is explained by the aperture model.

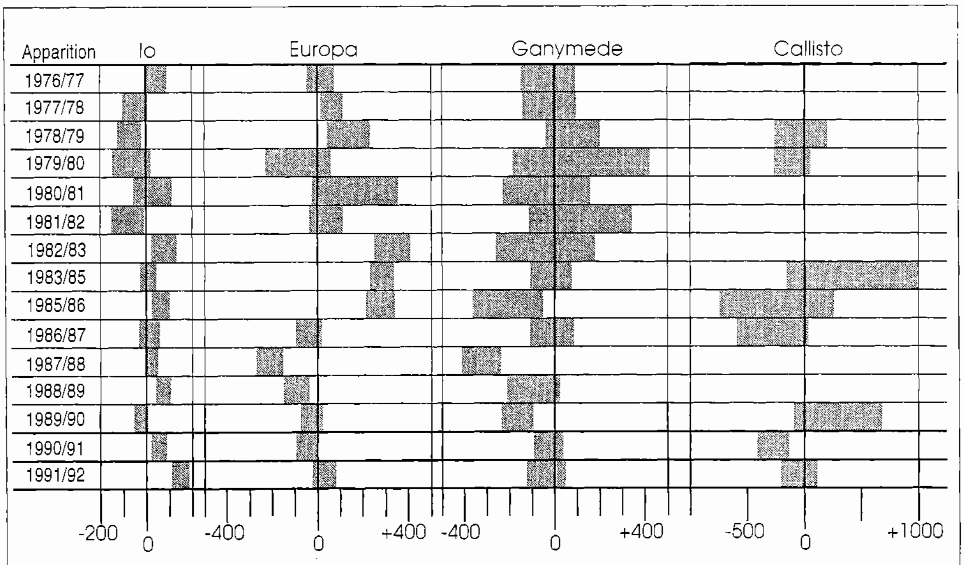

Figure 2. Graph of deviations of the Galilean satellites from the E-2 Ephemeris for the 1976/77 through the 1991/92 Apparitions. Units are in kilometers. The width of each bar represents ±1 standard error. Note the different scale for Callisto, which was not eclipsed in every apparition.

Table 7. Galilean Satellite Timings Compared With E-2 Ephemeris, 1991/92.

Satellite:	Io	Europa	Ganymede	Callisto
Disappearance				
Number of Observations	159 (141)	74 (66)	72 (64)	46 (41)
Mean Residual (seconds)	+75.2±1.9	+71.7±3.5	+197.4±6.0	+351.0±13.4
Coefficients:				
R-squared	.2318**	.3305**	.2139**	.1908**
A (seconds)	+93.9±3.3	+100.5±5.9	+238.7±11.4	+414.4±24.2
B	-250±39	-375±67	-558±136	-828±273
Standard Error (seconds)	±19.4	±23.7	±42.9	±78.5
Aperture Residual (seconds):				
6-cm	+52±4	+38±7	+146±14	+276±28
10-cm	+69±2	+63±3	+183±6	+332±14
20-cm	+81±2	+82±3	+211±6	+373±14
40-cm	+88±3	+91±5	+225±9	+394±17
Reappearance				
Number of Observations	254 (229)	130 (117)	91 (81)	29 (25)
Mean Residual (seconds)	-64.1±1.4	-84.8±2.4	-215.4±5.6	-294.8±18.7
Coefficients:				
R-squared	.1101**	.0596**	.1023**	.4061**
A (seconds)	-77.2±2.8	-96.3±4.8	-245.5±11.4	-402.7±30.9
B	+170±32	+153±57	+367±122	+1343±339
Standard Error (seconds)	±19.4	±25.3	±48.5	±73.6
Aperture Residual (seconds):				
6-cm	-49±3	-71±6	-184±12	-179±33
10-cm	-60±1	-81±3	-209±6	-268±16
20-cm	-69±2	-89±3	-227±7	-336±18
40-cm	-73±2	-92±4	-236±9	-369±24
Orbital Residual				
Seconds	+8.4±2.2**	+2.1±3.8 (ns)	-3.4±8.1 (ns)	+5.8±19.6 (ns)
Orbital Arc (degrees)	+0.0198±.0051	+0.0025±.0045	-0.0020±.0047	+0.0015±.0049
Kilometers	+145±38	+29±52	-37±88	+48±161
Diameter				
Seconds	171.1±4.3	196.8±7.6	484.2±16.1	817.0±39.3
Kilometers	2939±74	2607±101	5042±168	5431±261
Compared with Standard (km)	-691±74** (-19.0 %)	-531±101** (-16.9 %)	-220±168 (ns) (-4.2 %)	+631±211** (+13.2 %)

Fourth, the two regression coefficients are given with their 1-standard error uncertainty ranges; in *Table 7*, all such uncertainty ranges are preceded by the "±" symbol. Next is the standard error of estimate for the regression model. Following this are the predicted residuals for four commonly used telescope apertures.

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

The results of the satellite diameter estimation described above are given at the bottom of each column, where the calculated satellite diameter is given in seconds of time and in kilometers. The latter value is corrected for the mean cosine of the angle of entrance into or out of Jupiter's shadow. This quantity is then compared with the "standard" Voyager-derived satellite diameter (Io, 3630 km; Europa, 3138 km; Ganymede, 5262 km; and Callisto, 4800 km).

Table 7 also shows the statistical significance of the differences of the following values from zero: "R-squared," the orbital residual (in seconds of time only), and the difference between the estimated and the standard satellite diameters. The statistical significance is shown by "(ns)" for not significant, "*" for significant at the 5-percent level, and "**" for significant at the 1-percent level (these percentages give the probability of such results having occurred due solely to chance).

There are eight types of events listed in *Table 7*; eclipse disappearances and reappearances for each of the four satellites. As shown by the R-square values, in all eight cases the aperture-regression model significantly reduced the variance among the timings.

Nonetheless, the majority of the variance among the timings remained unaccounted for in our simple residual-aperture model. Naturally, the uncertainties in our timings represent the combined effect of a plethora of variables that are not considered in our analysis, which takes only aperture into account. We have not considered, for example: type of instrument, magnification, optical quality, atmospheric conditions, distance or phase angle of Jupiter, distance of the satellite from Jupiter's limb, keenness of the observer's eyes, or possible use of an occulting bar (an object placed at the focus of a positive eyepiece to block out Jupiter itself). Clearly, only some of these variables are quantifiable, and for some we have no data at all. Nonetheless, with the large number of timings we are now receiving each apparition, a more complex statistical analysis, which might reduce the amount of uncertainty, is possible.

The average uncertainty of the timings is indicated by the standard error which was roughly the same for disappearance and reappearance timings, but increased going outward in distance from Jupiter; about ±19 seconds for Io, ±24-25 seconds for Europa, ±43-48 seconds for Ganymede, and ±74-78 seconds for Callisto. This trend is not surprising because the satellites move more slowly, and Jupiter's shadow penumbra becomes broader, as one moves away from the planet. These factors also are reflected in the mainly increasing numerical values of the B-coefficients with distance from Jupiter; these values measure the effect of aperture variations on the reported times of events.

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

The timing results for only one of the four Galilean satellites differed significantly from the E-2 Ephemeris; Io was reported as being eclipsed about 8 seconds later than predicted. The difference was about 3.87 times the standard error of that value, significant at a 1-percent level.

The accuracy of our method of analysis can be assessed approximately by using the A-coefficients to estimate the diameters of the satellites, and then to compare these estimates with the diameters that were derived from the Voyager Missions. In the cases of Io, Europa, and Callisto there were significant differences, but of different signs. Io and Europa were estimated as too small, but Callisto as too large. The estimated diameter of Ganymede did not differ significantly from the standard values. These diameter differences follow the trend found for most previous apparitions and may be an effect resulting from the increase in the size of Jupiter's penumbral shadow zone as one moves outwards in the satellite system.

CONCLUSION

We encourage suitably-equipped observers to use their CCD or video cameras to time the eclipses of Jupiter's four major satellites (Mallama, 1991); conventional photometers are difficult to use accurately because of the effect of scattered light from Jupiter. For example, Henk J.J. Bulder reported that he had timed video records of 12 Galilean satellite eclipses during the 1991/92 Apparition, and that Jean Bourgeois had similarly timed another three. Electronic measures allow us to determine these bodies' orbits more accurately than do individual visual timings, although the latter's accuracy is improved by combining different observers' visual timings. However, visual timings remain the mainstay of our program and provide comparability with the body of similar visual timings that goes back to the Seventeenth Century.

Naturally, we hope that the present observers will continue and new ones will join us. For information on this program, please contact the writer, whose address is given on the inside back cover. Along with instructions, he can send you a timing report form, which should be returned at the end of the current apparition (*not* of the calendar year). You will also need predictions of these events, which are published each year in the *Astronomical Almanac*, *Observer's Handbook of the Royal Astronomical Society of Canada*, *The Handbook of the British Astronomical Association*, and other places.

We thank the many observers who participated in our project for the 1991/92 Apparition of Jupiter. Remember that your results become more accurate as you accumulate experience. Likewise, the more visual timings that are made, the more accurate our results. Thus we hope to hear from you again!

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Table 9. Galilean Satellite Eclipse Timings, 1991-92 Apparition.

UT Date mmdd	Geometry r	°	Ob. No.	Con. stb	Res. sec.
-------- Io Disappearances -------					
1991					
0926	0.5	-3	38	001	+28
			36a	201	+51
			31	110	*+192*
1010	0.7	-4	80	111	+48
1012	0.7	-4	9	122	+39
1013	0.7	-4	65a	122	*-30*
1017	0.8	-4	43	100	+79
			57	201	+90
1028	0.9	-4	27	112	+92
1029	0.9	-4	71	012	+51
			60	011	+66
1111	1.0	-5	92	000	+74
			39	000	+76
			36a	101	+83
			31	000	+96
			35	111	+99
1114	1.0	-5	6	000	*+2*
			7	202	+50
			48	210	+89
1120	1.0	-5	9	122	+83
1121	1.0	-5	60	001	+57
			65a	012	+72
1125	1.0	-5	80	000	+95
1127	1.0	-5	64	112	+72
1204	1.0	-5	36a	000	+88
1207	1.0	-5	7	102	+51
			65a	010	+82
			50	000	+89
			1	- - 2	+97
			98	102	+107
1213	1.0	-5	31	001	+88
1214	1.0	-5	60	000	+85
			65a	011	+88
1216	1.0	-5	25	201	+69
			54a	000	+87
			98	211	+88
			88	101	+89
1218	1.0	-5	57	101	+86
1220	1.0	-6	79	- - -	+23
1223	1.0	-6	7	102	+69
			6	000	+91
			88b	102	+94
			98	012	+102
			2	000	+104
1225	1.0	-6	43	000	+94
1227	1.0	-6	16	000	+48
			36	001	+69
1228	1.0	-6	73	100	*-31*
			46	001	+58
			31	002	+70
			27	000	+94
1992					
0103	0.9	-6	31	002	+83
0105	0.9	-6	9	122	+71
0106	0.9	-6	65a	011	+87
0108	0.9	-6	7	210	+72
			54a	000	+93
0112	0.8	-6	82	200	+72
			80	110	+82
0113	0.8	-6	71	002	+52
0115	0.8	-6	14	000	+66
0115	0.8	-6	71	002	+69
			89	020	+93
			2	100	*+144*
0119	0.8	-6	3	111	*+11*
			73	001	+54
			43	000	+86
			57	211	+91
			31	001	+99
0121	0.7	-6	38	000	+72
			64	112	+81
			91a	212	+81
			31	001	+89
			27	112	+99
0122	0.7	-6	50	120	+56
			89	112	+100
0124	0.7	-6	7	101	+75
			50	000	+80
			88	122	+85
			25	101	+94
0126	0.6	-6	38	012	+58
0128	0.6	-6	3	111	*-62*
			38	000	+78
0129	0.6	-7	72a	011	*-13*
			46	211	+51
			69	010	+61
			14	000	+72
			60	000	+86
			65a	011	+88
0131	0.6	-7	72a	101	0
			52	000	+26
			14	000	+73
			15	000	+80
			65a	010	+82
			54a	000	+94
0202	0.5	-7	82a	100	+93
			43	000	+104
0204	0.5	-7	20	200	+16
			38	100	+79
			40a	010	+82
			57	221	+82
			19	000	+89
			27	000	+92
			8	001	+94
			79	- - -	*+100*
			3	111	*+124*
0205	0.5	-7	16	001	+11
			71	012	+32
			38	101	+72
			69	000	+81
			19	000	+90
			9	222	+93
			27	000	+95
			95	101	+105
0207	0.4	-7	56	020	*-156*
			7	000	+66
			60	000	+82
			65a	020	+84
			88b	120	+87
			50	100	+88
0209	0.4	-7	4a	000	*-5*
			43	000	+101
			82a	100	+102
0213	0.3	-7	38	100	+75
0214	0.3	-7	7	201	+60
			27	111	+80
			50	000	+80
			88b	221	+88
0216	0.3	-7	7	001	+70
			6	000	+79
			48	000	+90
			50	001	+91
			88b	211	+91
0220	0.2	-7	20	222	+2
			12	- - -	+50
			8	121	+58
			10	011	+107
0221	0.2	-7	63	012	+20
			45	201	+48
			99a	211	+67
			23	000	+78
			92a	100	+80
			16	011	+84
			40	121	+84
			23a	000	+101
0223	0.1	-7	71	102	*+1*
			14	100	+56
			7	010	+57
			34a	220	+64
			88b	020	+75
0225	0.1	-7	4a	000	*0*
0227	0.0	-7	47	22 -	*-81*
			27	101	+87
0228	0.0	-7	73	001	*-69*
			79	- - -	+9
			64b	11 -	*+31*
			9	212	+68
			46	021	+69
			23a	000	+79
			24	020	*+183*
-------- Io Reappearances -------					
1992					
0227	-0.0	-7	97	101	*+86*
0229	0.0	-7	64b	11 -	-59
			46	011	-28
			79	- - -	-5
0301	0.0	-7	9	122	-47
			46	101	-35
			10	220	-31
			27	000	-31
			60	010	-31
			40	222	*+77*
0303	0.1	-7	50	000	-80
			65a	010	-65
0307	0.2	-7	10	010	-83
			58	210	-74
			79	- - -	-30
			38	110	-28
0308	0.2	-8	92a	000	-85
			9	112	-66
			27	000	-66
			40a	111	-43
			81	101	-24
			24	000	*+7*
			16	000	*+83*
0310	0.2	-8	65a	110	-86

Table 9. Galilean Satellite Eclipse Timings, 1991-92 Apparition—Continued.

UT Date mmdd	Geometry r	°	Ob. No.	Con. stb	Res. sec.
--- Io Reappearances-Cntd. ---					
1992					
0310	0.2	-8	50	000	-68
			7	100	-41
			17	110	-36
0312	0.3	-8	54	220	-19
			56	220	*+95*
0315	0.3	-8	9	122	-85
			40a	001	-73
			79	000	-71
			27	001	-66
			64a	122	-66
			23a	101	-65
			38	101	-60
			29	002	-50
			81	101	-45
			24	010	*+6*
0317	0.4	-8	88b	222	-67
			65a	112	-32
0319	0.4	-8	88b	002	-103
			89	000	-64
			50	020	-51
			22a	201	-49
			4a	010	*+5*
0321	0.4	-8	75	000	-74
			12	---	-46
0323	0.5	-8	75a	000	-103
			43	000	-88
			58	210	-85
			97	212	-62
			85	---	-51
			79	000	-36
0324	0.5	-8	9	212	-52
			16	121	*+107*
0326	0.5	-8	88b	001	-97
			48	200	-87
			60	000	-82
			65	010	-74
			6	000	-71
			56	200	-71
			84	001	-66
			55	001	-65
0328	0.6	-8	82	010	-92
			43	100	-85
			88	002	-84
			54a	210	-63
0330	0.6	-8	12	---	-59
			27	100	-58
0331	0.6	-8	27	000	-81
			9	122	-72
			81	101	-50
			91a	112	-48
			3	011	-17
0402	0.6	-8	84	101	-66
			50	010	-65
			55	101	-61
			7	200	-45
0404	0.7	-8	48	100	-94
			86	000	-76
			7	100	-75
			22a	000	-71
			50	010	-67
			89	010	-66

UT Date mmdd	Geometry r	°	Ob. No.	Con. stb	Res. sec.
0404	0.7	-8	6a	010	*-18*
			56	000	*-9*
0407	0.7	-8	27	100	-79
			9	122	-73
			79	000	-67
			64	111	-55
			85	---	-52
0409	0.7	-8	65	010	-82
0411	0.8	-8	53	001	-99
			22a	200	-85
			60	001	-84
			84	001	-84
			50	000	-79
			54	000	-66
			55	001	-66
			7	021	-63
			71	011	-16
0413	0.8	-8	56	000	-101
			78	000	-98
			22a	202	-86
0415	0.8	-8	8	001	-75
0416	0.8	-8	40a	121	-40
			3	111	*+57*
0418	0.9	-8	53	002	*-116*
			102	000	-57
			84	101	-56
			101	221	*+42*
0420	0.9	-8	88b	110	-99
			22a	101	-90
			56	000	-74
0422	0.9	-9	79	000	-54
0423	0.9	-9	36a	100	-87
			92	110	-77
			81	001	-72
			79	000	-66
			3	111	-49
0425	0.9	-9	84	100	-65
			101	000	*-2*
0427	0.9	-9	54a	000	-88
0430	1.0	-9	27	111	-72
			9	122	-67
			12	---	-67
			64a	211	-66
			31	200	-59
			26	000	-22
			79	000	-17
0504	1.0	-9	88b	100	-94
			50	010	-75
			14	000	-74
			7	120	-69
			72	021	0
0506	1.0	-9	56	000	-44
0508	1.0	-9	32	000	-76
0509	1.0	-9	68	111	-86
			36a	202	-80
			81	001	-76
			93	001	-67
			33	111	-59
			70	001	-58
			83	001	-57
			13	000	-53
			3	111	-48
			26	000	-46

UT Date mmdd	Geometry r	°	Ob. No.	Con. stb	Res. sec.
0509	1.0	-9	62a	000	-35
			74a	000	-29
0511	1.0	-9	14	001	-70
			17a	112	-67
			72	001	-48
0513	1.0	-9	2	101	-103
			50	000	-84
0515	1.0	-9	43	100	-84
0516	1.0	-9	9	212	-82
			27	002	-81
			41a	011	-81
			79	000	-78
			62a	000	-72
			81	011	-70
			92	100	-68
			69	010	-61
			70	011	-59
			93	101	-58
			91	200	-56
			85	---	-54
			74a	000	-47
			46	022	-46
			62	000	-45
			26	010	-43
			31	111	-42
			83a	010	-41
			19	011	*-5*
0518	1.1	-9	51	121	-35
0520	1.1	-9	60	000	-93
			50	000	-88
			65a	021	-84
			7	000	-72
0522	1.1	-9	100a	100	-48
			100	000	-29
0523	1.1	-9	27	000	-63
			79	000	-62
0525	1.1	-9	68	010	-67
0527	1.1	-9	84	001	-80
			17a	101	-61
			55	001	-55
			71	002	-55
			6	000	-14
			101	000	*+6*
			102	220	*+37*
0529	1.1	-9	88a	112	-98
			54a	000	-88
			48	002	-67
			50	002	-61
			56	000	-48
0531	1.1	-9	43	001	-78
			58	210	-73
			5	220	-25
0601	1.1	-9	31	012	-77
			9	121	-76
0603	1.1	-9	14	001	-72
			51	110	-56
0605	1.1	-9	2	100	-101
			22a	201	-61
0607	1.0	-9	57	221	-80
			21	201	-79
			8a	001	-45
			44	121	-40
0608	1.0	-10	31	011	-82

Table 9. Galilean Satellite Eclipse Timings, 1991-92 Apparition—Continued.

UT Date mmdd	Geom-etry r	°	Ob. No.	Con. stb	Res. sec.
--- Io Reappearances-Cntd. ---					
1992					
0608	1.0	-10	74a	110	-78
			41a	100	-71
			26	101	-44
			62a	220	-27
			3	211	*+14*
			62	220	*+34*
			70	121	*+72*
0612	1.0	-10	65a	111	-80
			88b	202	-73
			4	222	*-8*
0614	1.0	-10	78	000	-92
			22a	000	-75
			94	101	-37
0616	1.0	-10	79	000	-36
0619	1.0	-10	65a	110	-71
			84	001	-64
			104	001	-52
0621	1.0	-10	48	002	-89
			88b	102	-88
			54a	000	-84
			86	001	-78
			7	002	-73
			50	001	-70
			56	000	*-6*
			4a	111	*0*
0624	1.0	-10	9	121	-70
			92	100	-54
			70	112	-25
			31	012	-22
0628	0.9	-10	48	000	-86
			7	000	-77
			88b	210	-76
			61	000	-61
			4a	000	*+1*
0630	0.9	-10	42	22 -	-57
0714	0.8	-10	88b	112	-92
			50	000	-70
			22a	101	-63
			87	001	-58
0716	0.8	-10	97a	111	-83
			43	101	-81
			21	201	-76
0806	0.6	-11	4a	010	*0*
---- Europa Disappearances ---					
1991					
0919	0.7	-8	38	211	*-36*
1021	1.3	-9	92	100	+51
1024	1.4	-9	6	000	+33
1031	1.5	-10	103	012	*-273*
1122	1.7	-11	38	000	+64
			9	222	+66
1125	1.7	-11	65a	111	+58
			88b	112	+96
			25	001	+104
1202	1.7	-11	14	001	+48
			65a	012	+70
			60	011	+75
1209	1.7	-11	27	111	*+134*
1220	1.6	-12	7	111	+56
			48	200	+91
1220	1.6	-12	88	112	+91
1224	1.6	-12	73	100	-3
			79	- - -	+62
			92	000	+88
			36b	101	+103
			31	101	+111
1227	1.6	-12	52	000	+16
			65a	011	+82
			7	111	+84
			25	001	+104
1231	1.5	-12	36	000	+26
			9	121	+49
			40a	- - 2	+106
			31	000	+113
1992					
0103	1.5	-12	65a	011	+88
0107	1.4	-13	80	000	+106
0110	1.4	-13	16	100	+48
			71	002	+61
			69	010	+67
			9	122	+85
			27	101	*+127*
0118	1.2	-13	79	- - -	+7
			9	212	+80
0121	1.1	-13	56	011	+44
			14	001	+76
			88b	112	+107
0125	1.1	-13	3	101	*+5*
			16	000	+61
			9	212	+66
			27	111	+71
			57	210	+93
			80	000	+96
0128	1.0	-13	72a	012	+16
			7	100	+76
			50	000	+79
			60	000	+83
			14	221	+90
			48	000	+122
0201	0.9	-14	24	- - 0	*-172*
			73	000	+59
			31	001	+106
0204	0.8	-14	69	010	+29
			9	122	+69
			65a	010	+80
			60	000	+98
			27	000	*+135*
0211	0.6	-14	9	212	+44
			19	010	+79
			69	110	+91
0215	0.4	-14	50	001	+85
			48	100	+89
0219	0.3	-14	12	- - -	+24
			85	- - -	+36
			38	212	+57
			36a	001	+103
0222	0.2	-15	102a	100	*+4*
			65a	021	+32
			34a	100	+68
0226	0.1	-15	27	112	+118
---- Europa Reappearances ----					
1992					
0229	0.0	-15	10	200	-69
			65a	010	-26
			4a	110	*-2*
			46	211	*+122*
0307	0.3	-15	24	020	*-397*
			23a	010	-120
			11	010	-94
			46	011	-60
			92	000	-55
			9	112	-45
			81	121	-25
			39a	111	*+14*
			79	- - -	*+59*
			83	112	*+71*
0311	0.4	-15	88b	210	-108
			6	000	-71
			65a	221	-62
			22a	200	-34
0315	0.5	-16	28	001	-80
			79	000	-69
			81	101	-67
			85	- - -	-64
			30	001	-54
			12	- - -	-23
0318	0.6	-16	88b	102	-110
			65a	012	-95
			6	000	-87
0322	0.7	-16	80	000	-119
			12	- - -	-100
			27	111	-97
			20	100	-80
			79	000	-51
0325	0.8	-16	88b	111	-127
			65a	011	-104
			60	000	-85
			50	010	-80
			7	210	-77
			4a	000	*-4*
0329	0.9	-16	80	100	-100
			8	100	-94
			12	- - -	-45
0405	1.1	-17	54a	000	-130
			82a	000	-119
			43	100	-115
			22a	000	-111
			6a	000	-105
			88b	102	-105
0408	1.2	-17	9	222	-118
			27	000	-106
			69	110	-78
			79	000	-77
			81	201	-47
0412	1.2	-17	60	100	-107
			65a	011	-104
			50	021	-82
			54	100	-82
			22	101	-81
			84	002	-79
0416	1.3	-17	79	000	-88
0419	1.4	-17	53	001	-133
			54a	100	-107
			60	101	-106
			22a	201	-99

Table 9. Galilean Satellite Eclipse Timings, 1991-92 Apparition—Continued.

UT Date mmdd	Geom-etry r	°	Ob. No.	Con. stb	Res. sec.
Europa Reappearances–Cntd.					
1992					
0419	1.4	-17	101	011	-83
			56	010	-43
0423	1.4	-17	43	000	-122
			79	000	-105
			32	000	-99
0426	1.5	-17	14	001	+42
			101	020	*+154*
0430	1.5	-18	43	010	-114
			32	000	-86
0503	1.6	-18	77	010	-93
0507	1.6	-18	88b	202	-129
			56	100	-75
0510	1.6	-18	31	101	-107
			27	102	-91
			76	111	-91
			13	111	-89
			74a	000	-89
			33	110	-88
			62a	000	-86
			36a	211	-85
			3	111	-74
			46	001	-65
			26	000	-63
			62	000	-62
			70	122	-62
0514	1.6	-18	88b	221	-101
			89	010	-59
			60	000	-46
0517	1.7	-18	58	220	-111
			27	102	-96
			31	101	-91
			85	- - -	-68
			81	111	*+11*
0521	1.7	-18	55	001	-79
0525	1.7	-19	75a	000	-133
			97a	001	-132
			43	000	-113
0604	1.7	-19	68	010	-100
0608	1.6	-19	88b	202	-110
			89	000	-104
			4a	111	*-8*
0611	1.6	-19	10	202	-126
0615	1.6	-19	78	220	-83
			61	112	-77
			50	020	-71
			7	- 2 -	*+6*
0618	1.6	-20	79	010	-57
0622	1.5	-20	65a	010	-114
			84	001	-95
			55	001	-90
			14	001	-82
			60	000	-68
0710	1.3	-20	22a	201	-112
0713	1.3	-21	74	101	-81
			66	011	-76
			76	112	-68
			62a	101	-64
			33	000	-59
			70	121	-26
			31	212	*-11*
			62	101	*+60*
0717	1.2	-21	48	110	-104
			86	000	-78
			50	100	-77
			60	011	-66
0720	1.2	-21	85	- - -	-20
0811	0.8	-22	22a	101	-83
- Ganymede Disappearances -					
1991					
1009	1.8	-7	69	010	*+85*
			27	100	+198
1106	2.4	-8	65a	010	+171
			14	000	+201
1121	2.6	-9	38	000	+197
			9	222	+257
1128	2.7	-10	80	010	+210
1205	2.7	-10	80	000	+286
1219	2.6	-11	14	222	+227
			65a	011	+249
1992					
0110	2.2	-12	31	001	+154
0117	2.0	-13	57	100	+249
0124	1.7	-13	103	000	*-231*
			52	000	+135
			50	011	+180
			56	000	+200
			65a	121	+224
			88b	012	+247
			25	001	+261
			48	000	+261
0131	1.4	-13	65b	020	+179
			14	000	+187
			71	001	+225
			60	000	+244
0207	1.1	-14	73	011	+105
			46	011	+192
			45	000	+215
			29	000	+221
			59	000	+231
			31	000	+255
			95	111	+258
			96	111	+259
0215	0.7	-14	3	001	+132
			38	100	+199
			12	- - -	+209
			80	011	+247
0222	0.4	-15	12	- - -	+156
0412	0.1	-18	65a	012	*+73*
			54	100	+88
			60	101	+131
			22a	101	+153
			88	112	+166
			50	010	+196
0419	0.4	-18	101	011	*-21*
			60	001	+198
			53	001	+236
0426	0.5	-18	92	001	+113
0503	0.7	-19	77	121	+138
			99	100	+151
			79	000	+193
			9	222	+217
			31	101	+228
0511	0.8	-19	79	000	+166
0511	0.8	-19	43	000	+211
			32	000	+214
			8a	001	+235
0518	0.8	-20	54a	000	+205
0525	0.9	-20	65a	011	+201
			88b	110	+232
			60	000	+271
0601	0.9	-20	71	011	+102
			84	011	+102
			55	001	+128
			17a	211	+157
			65a	110	+164
			53	211	*+346*
0608	0.8	-21	68	112	+230
0615	0.8	-21	74a	000	*-95*
			79	020	+143
0623	0.7	-22	57	211	+242
0630	0.6	-22	56	000	*+82*
0707	0.4	-22	86	120	*-56*
- Ganymede Reappearances --					
1991					
1030	0.4	-8	98	002	*-31*
1114	0.6	-8	91	211	-152
			38	110	-106
1121	0.7	-9	28	002	-198
			38	000	-165
1128	0.8	-9	80	000	-247
1212	0.8	-10	65a	010	-199
			60	000	-173
1227	0.6	-11	36	001	-189
			39	000	-98
			29	201	*-92*
1992					
0103	0.5	-11	31	001	-146
0117	0.1	-12	14	222	*+52*
0229	0.0	-15	88b	100	-262
			65a	010	-189
			6a	000	*-99*
			60	000	*-67*
			22a	100	*-48*
			4a	110	*-3*
0307	0.4	-15	60	000	-251
			65a	220	-242
			50	100	-142
			9	112	-129
0314	0.8	-16	29	001	-237
			92	100	-228
			81	001	-221
			27	101	-159
			79	000	-131
			73	010	*+59*
0322	1.1	-16	80	000	-293
			83	211	-288
			20	100	-199
			12	- - -	-197
			79	000	-197
0329	1.5	-17	80	100	-261
			8	100	-243
			12	- - -	-191
0405	1.7	-17	22a	100	-263
			88b	210	-239
			6a	200	-226

Table 9. Galilean Satellite Eclipse Timings, 1991-92 Apparition—Continued.

UT Date mmdd	Geom-etry r	°	Ob. No.	Con. stb	Res. sec.
Ganymede Reap.–Continued.					
1992					
0412	2.0	-17	65a	011	-279
			50	011	-268
			60	000	-267
			84	001	-252
			54	100	-206
			71	011	-134
			101	012	-118
0426	2.4	-18	37	011	-290
			31	100	-283
			26	000	-278
			92	000	-239
			81	001	-233
			46	021	-231
			79	000	-211
			3	111	-182
0504	2.5	-19	57	010	-301
			8a	100	-270
			79	000	-207
0511	2.6	-19	100a	220	-161
			100	210	-140
0518	2.7	-19	78	100	-295
			88b	102	-282
			34	000	-255
			54a	010	-250
			6	000	-232
			60	001	-224
			86	110	-202
			7	011	-190
0525	2.7	-20	60	000	-265
			84	001	-247
			53	001	-244
			65a	010	-244
			102	010	-176
			53	121	-128
			101	121	*+2*
0608	2.7	-21	3	212	*-687*
			41a	100	-284
			62a	110	-238
			26	101	-224
			69	001	-221
			81	011	-213
			79	000	-211
			62	110	-205
			41	100	-202
			30	000	-163
			70	121	-116
0616	2.6	-21	80	000	-241
0630	2.4	-22	48	000	-274
			87	010	-231
			61	110	-226
0721	1.9	-23	79	000	-162
--- Callisto Disappearances ---					
1991					
1031	4.1	-20	80	100	+314
			57	201	+343
1117	4.6	-22	31	111	+287
			35	122	+476
1203	4.8	-23	71	001	+256
			14	001	+334
1220	4.6	-25	7	111	+305
1220	4.6	-25	50	000	+308
			88	112	+379
			48	100	+422
1992					
0123	3.1	-29	79	- - -	+364
			19	000	+384
			40a	000	+390
			27	102	+392
0208	1.8	-31	36	001	+204
			46	001	+207
			67	- - -	+212
			91	110	+254
			99b	101	+413
			90	100	+435
0225	0.3	-33	4a	000	*-2*
			7	100	+237
			60	000	+259
			14	000	+270
			34a	220	+296
			50	000	+307
			65a	010	+307
			48	000	+409
0330	1.0	-38	12	- - -	*-51*
			57	221	+443
0415	2.1	-40	12	- - -	*+52*
			3	111	*+152*
			27	112	+332
			29	002	+417
			36a	101	+462
			31	101	+471
			37	011	+492
			96	101	+527
0502	2.9	-42	14	121	+232
0519	3.3	-44	34	100	+364
			88b	120	+408
			60	010	+425
			78	100	+446
0621	3.0	-49	49	111	*-3*
			41a	210	+257
			79	010	+351
---- Callisto Reappearances ---					
1991					
1117	2.8	-21	43	200	-292
1204	3.0	-23	31	001	*-149*
1992					
0106	2.3	-27	7	200	-228
			50	120	-166
0209	0.2	-31	91	100	-172
			36	001	-130
			46	100	*+25*
			8	211	*+130*
			67	- - -	*+160*
0313	1.2	-35	78	100	-444
			60	000	-338
			65	111	-336
			88b	120	-333
			7	100	-320
			50	010	-283
			6a	000	-276
			14	000	-274
0330	2.5	-37	54	000	-305
0416	3.6	-39	37	011	-403
0416	3.6	-39	8	010	-322
			79	000	-189
0502	4.3	-42	47	011	-338
			18	- - -	-231
			77	121	-187
0519	4.6	-44	65a	010	-469
			60	000	-367
0605	4.6	-46	22a	101	-482
			22	101	-227
0811	1.9	-57	22a	101	-258

The Key to the above table and List of Observers follow on p. 27.

Key:

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

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

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

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

E. *Res.* (residual): The time difference in seconds, found by subtracting the eclipse UT as predicted by the E-2 Ephemeris from the observed eclipse UT. The former, originally given in Ephemeris Time, was converted to UT using an assumed ΔT value of +58 seconds prior to 1992 MAR 27 and +59 seconds thereafter. Italicized residuals denote timings that were not used in the regression analysis, because they differed from the regression model at the 5-percent significance level.

Participating Observers

(In Parentheses: Aperture followed by number of timings)

1 *Anonymous* (25; 1)
2 Abrahams, W. (20; 4)
3 Aquilar, J. (14; 14)
4 Ayme, A. (20.2; 1)
4a " (20.5; 11)
5 Barroso, N. (20; 1)
6 Bembrick, C. (7.5; 9)
6a " (25; 5)
7 Blanksby, J. (15; 27)
8 Bock, P. (10.2; 7)
8a " (12.7; 3)
9 Brylowski, Z. (15; 27)
10 Bulder, H. (30; 5)
11 Busi, L. (12; 1)
12 Campos, A. (18; 14)
13 Catalano, A. (25; 2)
14 Chen, D.-h. (11.4; 20)
15 Cheng, Jie (14; 1)
16 Cilleruelo, L. (6; 7)
17 Cui, Z.-m. (10.0; 1)
17a " (10.2; 3)
18 Cziniel, S. (15; 1)
19 Darnell, P. (15; 5)
20 Davis, M. (6; 4)
21 Dickens, T. (20; 2)
22 Dickie, R. (9; 2)
22a " (20; 18)
23 Di Luca, R. (12; 1)
23a " (35; 4)
24 Dueñas, M. (10; 5)
25 Elsworth, G. (20; 5)
26 Escaramís, J. (20; 7)
27 Ewald, D. (8; 29)
28 Fernande, J. (21; 1)
29 Fernandes, J. (15; 6)
30 Foglia, S. (5; 2)
31 Garcia, J. (40; 26)
32 Garey, P. (20; 4)
33 Garoni, M. (10.2; 3)
34 George, M. (11.3; 3)
34a " (17; 3)
35 Gómez, J. (41; 2)
36 Gonçalves, R. (5; 5)
36a " (15; 8)
36b " (20; 1)
37 González, M. (21; 3)
38 Gracias, N. (13.5; 16)
39 Grilo, A. (11.4; 2)
39a " (11.5; 1)
40 Grunnet, C. (6.3; 2)
40a " (20; 6)
41 "Grupo A. del Jolón" (8; 1)
41a " (21; 4)
42 Haas, W. (20.3; 1)
43 Hays, R. (15; 16)
44 Himes, D. (30; 1)
45 "I.B.C. Arenal" (8; 2)
46 Kerber, F. (11.4; 13)
47 Kiss, L. (10; 1)
48 Kruijshoop, A. (20; 15)
49 Lacruz, R. (8; 1)
50 Larkin, P. (20; 32)
51 Li. T.-j. (8; 2)
52 Li, Y.-j. (6; 3)
53 Liu, T.-L. (8; 6)
54 Loader, B. (10; 5)
54a Loader, B. (20; 11)
55 Lü, D.-D. (6.3; 8)
56 MacDonald, M. (20; 14)
57 MacDougal, C. (15; 11)
58 Mackintosh, R. (21.6; 4)
59 Martins, P. (20; 1)
60 Matthews, T. (20; 32)
61 McCrohan, P. (11.4; 3)
62 Milanesi, A. (6; 5)
62a " (15; 6)
63 Millán, M. (8; 1)
64 Molau, S. (5; 3)
64a " (6.3; 2)
64b " (50; 2)
65 Moller, H. (20; 3)
65a " (20.3; 39)
65b " (20.5; 1)
66 Moreno, J. (20; 1)
67 Nagy-Mélykuti, A. (5; 2)
68 Ofek, E. (20; 4)
69 Olesen, J. (20; 9)
70 Orietta, C. (11.4; 7)
71 O'Yiang, T.-j. (15; 12)
72 Pan, X.-q. (5.0; 2)
72a " (5.5; 3)
73 Panivino, A. (6; 7)
74 Paolucei, M. (6; 1)
74a " (11.4; 5)
75 Parmentier, R. (15; 1)
75a " (75; 2)
76 Pasolini, D. (20; 2)
77 Patak, A. (6.3; 3)
78 Priestley, J. (20; 6)
79 Roque, M. (6; 35)
80 Rowley, D. (20; 15)
81 Ruiz, B. (12; 13)
82 Samolyk, G. (32; 2)
82a " (65; 3)
83 Sampedro, T. (8; 3)
83a " (11; 1)
84 Shi, Q.-D. (10; 12)
85 Silvestre, R. (11.4; 7)
86 Skilton, P. (15; 5)
87 Skilton, R. (15; 2)
88 Smith, C. (7.5; 6)
88a " (20; 1)
88b " (25; 32)
89 Smith, G. (20; 4)
90 Sterzinger, P. (20; 1)
91 Szabó, S. (7; 5)
91a " (11; 1)
92 Testa, L. (20; 10)
92a " (40; 2)
93 Tozzi, F. (9; 2)
94 Underhay, E. (7.5; 1)
95 Urbano, J. (26; 2)
96 Vidal, J. (41; 2)
97 Waraczynski, S. (25.4; 3)
97a " (31.75; 2)
98 Ward, C. (20.5; 4)
99 Warrell, J. (14; 1)
99a " (15; 1)
99b " (16; 1)
100 Westfall, J. (10.2; 2)
100a " (25.4; 2)
101 Yiang, H.-t. (8; 8)
102 Zhang, D.-q. (10; 3)
102a " (20; 1)
103 Zhang, X.-j. (10; 2)
104 Zhou, Y.-h. (6.3; 1)

IMPROBABLE JOVIAN IMPACT CANDIDATES

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The spectacular dark spots created on Jupiter by the impacts of Comet Shoemaker-Levy 9 naturally led people to wonder whether similar things had been observed before. Having then just completed a thorough review of the Jovian literature [1], my opinion was that there were no outstanding historical records of prominent, sudden-onset dark spots on Jupiter that were not recognizable as recurrent meteorological features [2].

Richard Hill [3] has performed a useful service by searching through BAA (British Astronomical Association) Jupiter *Memoirs* looking specifically for possible examples of comet impact spots, and he described several candidates. I argue here that these are much more likely to have been meteorological features like other Jovian spots. So the value of Hill's search lies in putting an upper limit on the frequency of comet impacts.

In the following text, figure and page references are to the BAA *Memoirs* for those apparitions. Note that in these years, most observers used GMAT and called it GMT; thus "Oct. 24, 17h 40m" means Oct. 25, 05h 40m UT. Central meridian is abbreviated as CM, and standard Jovian abbreviations are used.

CANDIDATE SPOTS ON THE NORTH EQUATORIAL BELT (NEB)

Hill [3] proposed six candidate spots in five apparitions. The most interesting was on the SEB north edge in 1921, and original observations of this will be discussed after the others. I have inspected the records of the other spots in the BAA *Memoirs*. They all appear to be just very dark examples of normal NEB/NTrZ features. These include "projections" on the NEBs edge, and "barges," which are cyclonic dark spots on the NEBn edge; both types can become very dark, as for example during the Voyager encounters. These spots were as follows, using Hill's numbering:

1. 1895 (NEBn). Lunt's observation [3] coincided with a drawing by T.H. Foulkes on Oct. 24/25 (Memoir Fig. 23), which shows the spot as a black wedge 25° following the CM. This must have been the "Garnet Spot," although not accurately positioned. It should have been on the CM, according to direct estimates of its System II longitude on Oct. 27/28 by H. McEwen and Oct. 15/16 by E. Antoniadi [also see Plate P4.3 of Ref. 1]. As Hill noted, the Garnet and Violin spots were two very dark spots tracked for many months. Although the Oct. 24/25 drawing made the Garnet Spot look like a "barge," from other data I concluded that these were actually the first observed examples of Little Red Spots in the NTrZ [p.117 of Ref.1].

2. 1909 (NEBn). In Newbegin's drawing (*Memoir* Fig.8), this appears to be an unremarkable small barge.

4, 5. 1932 (NEBn, NEBs). The NEBn dark spot was described in the *Memoir* (pp. 6, 23) and is tabulated therein as No. 7, tracked for three months. Apart from Phillips' one record of its being very dark on Jan. 31, it was treated as a typical NEBn dark spot, and there were others of these. There was no evidence for a sudden onset.

Williams' NEBs dark spot description resembles a large but common NEBs projection.

6. 1941 (mid-NEB). As Hill said, this did not resemble a comet impact. (The "rings" around S-L9 impact sites were controversial.) It was a transient feature in an active NEB rift region (*Memoir* Plate IV), probably a small but intense cyclonic eddy.

CANDIDATE SPOT ON THE SOUTH EQUATORIAL BELT (SEB) IN 1921

This dark spot on the SEBn edge was the most promising candidate because in Sargent's description it sounds rather like the S-L9 impact sites, and the slow motion would be appropriate for a high-altitude cloud over the equatorial region [p. 147 of Ref. 1]. This dark spot was described by Sargent in *Monthly Notices* [4] and was cited in the BAA *Memoir* only for its rotation period. The question is: Was it just a very dark example of the SEBn spots which were numerous in that apparition? At Hill's request, I have checked the BAA Jupiter archives for original records of this feature, and found some more details which were not available to him.

The SEB had undergone a vigorous "Revival" in 1919/20, and such Revivals are often followed by conspicuous bright and dark spots on the SEBn that persist for up to a year, often with increasing System I longitude (i.e., slow drift for the latitude) [see pp. 162 and 171f of Ref. 1], like Sargent's spot. Indeed, short-lived SEBn dark spots were common in early 1921 (*Memoir* p. 77, and many drawings therein). In the *Memoir*, the motion of the SEBn edge is described (p. 81 section 4; "NEB" is a misprint). Sargent's spot was particularly dark and slow but not necessarily exceptional. Sargent's observations (May 16 - June 3) were late in the apparition (opposition was March 4) when observations were infrequent. In the *Memoir*, nothing else was tracked after May 10 except for the large, long-lived circulations in the South Tropical and Temperate regions.

The BAA Jupiter archives before 1950 are fragmentary, mainly because in that pre-photocopier age, people used to lend their observations to the Section Director who would return them later. However, there are quite a lot of observations for some years and 1921 happens to be one of them. Although I have not found observations by Phillips or Peek, several other observers recorded this turbulent SEBn region just before, during, and after Sargent's spot. (Dates and times below are all given in GMAT. L1 is System I longitude; CM1 is L1 of CM; p. and f. are preceding and following.)

Phillips' chart of the BAA longitude data still exists, on which Sargent's data are plotted, showing that the spot moved from L1 = 236° (May 16) to 269° (June 3), a rate of +56°/month. Also, on April 25 at L1 = 165°, some 35° preceding the later track of Sargent's spot, a "very dark" spot is plotted, with white spots following it—possibly precursor activity of Sargent's spot.

T. Brindley (Sydney, Australia) used only a 3-inch (7-cm) refractor, so had low resolution, but he sent a set of nicely tinted drawings starting in 1880! In late 1921 they included: May 4, 01:30, CM1 = 210°. Very dark purple spot on SEBn/EZs 40° preceding CM (L1 = 170°). This is 40° preceding the later track of Sargent's spot.

M. du Martheray (Brussels, Belgium), using a 5-inch (13.5-cm) refractor, observed up to July 14, and sent an overall report and many drawings. His report on the SEB does not mention anything very dark but describes it as "Region changements rapides." Relevant drawings are as follows: (1) April 30, CM1 = 195°. Nothing prominent near CM (centered on the later track of Sargent's spot), but a dark streak on following side. (2) May 5, 08:45, CM1 = 273° (Fig. IV.4 of *Memoir*; *Figure 1a* on p. 30 herein). Shows typical complex disturbance on SEBn with streaks into SEB, including a very dark "step-up" on preceding side, which is probably Sargent's "angle" feature (transited at L1 = 197°.5 the previous evening) although it should be even nearer the preceding limb. This must be a precursor of Sargent's spot. (3) May 21, CM1 = 269° (*Figure 1b*, p. 30). The very dark streak on the SEBn is Sargent's spot.

E.A.L. Attkins (Squirrel's Heath, England), using an 8.5-inch (22-cm) reflector, made the following relevant notes: (1) "April 6, 09:10-30: The three spots on N. edge SEB almost black." (So at least one observer thought SEBn spots other than Sargent's were extremely dark.) (2) "May 14, 08:45: Black spot on N. edge SEB just p. CM." (CM1 = 253°—so this was Sargent's spot.) (3) "June 6, 08:48-09:10: One of the finest white spots I've ever seen on Jupiter now on N. edge SEB–almost splitting the belt completely. Another smaller w.s. [white spot] p. the first, and between [is] a dark spot." (First white spot transit at 08:54, L1 = 286°. Final stage of Sargent's spot.) (4) "June 24, 08:40-09:40: Same white and dark spots N. edge SEB as seen on 6th; seem wider apart; too late for transit." (Illustrated by a drawing; *Figure 1c*, p. 30). The longitude seems too low for these to be the same spots, but the drawing at least illustrates what those of June 6 looked like.]

To summarize these 1921 observations, there appears to have been strong disturbance in this longitude range as early as 1921 April 25 (a point on Phillips' chart), April 29 (Brindley), and April 30 (Du Martheray). By May 4-5 (Brindley, Sargent, Du Martheray) there was a dark sector with a "step-up" 20° preceding the track of the later black spot— a typical but very dark disturbance in the SEBn. Sargent [4] timed the transit of this step-up on May 4 (L1 = 197°.5) and May 9 (209°.3), so it had about the same drift rate as the later spot.

Sargent's spot itself (May 16 - June 3) was independently recorded as a black spot on May 14 (Attkins) and drawn as a very dark streak on the SEBn on May 21 (Du Martheray); in this drawing, also, it looks like an intrinsic SEB feature.

Subsequently, two white spots (one of them spectacular) appeared near the site of the former black spot, as noted on June 6 and 24 (Attkins).

Prominent disturbances at other longitudes on the SEBn were also drawn; for example, by Brindley (April 21, *Memoir* Fig. III.6) and Porthouse (May 15, Fig. IV.5).

Therefore it appears likely that Sargent's spot was just part of a region of enhanced meteorological activity within the SEBn, which was continuing to produce slow-moving, short-lived, conspicuous spots, as the final fling of the 1919/20 SEB Revival.

CONCLUSION

Almost all dark spots observed on Jupiter are of recurrent types in fixed latitudes belonging to permanent currents. The typical forms, circulations, and lifetimes of these spots are well established. Very dark spots almost all belong to the following classes of feature [2]:

- South Tropical Disturbances (points of recirculation).
- SEBn dark spots (in SEB Revivals).
- SEBn dark "projections" (in the 19th century).
- NEBs dark "projections" (bluish hot-spots).
- NEBn "barges" (cyclonic) (and dark spots in NEB Revivals in the 19th century).
- NTeBs jetstream spots (small, anti-cyclonic).
- NTeBn dark spots (cyclonic).

Also, very dark spots may appear briefly in cyclonic disturbances within the SEB and NEB, especially in SEB Revivals and NEB Revivals. I have argued that all Hill's candidate spots belonged to these categories, except for that of 1895 which was probably a Little Red Spot.

There are no records of spots which appear likely to have been impacts. Therefore we can put upper limits on the frequencies of impacts of different sizes.

In the continuous record of observations of Jupiter from 1878 to 1994, a span of 116 years, there were no outstanding records of large black sudden-onset spots like the largest S-L9 impact sites G or L. Allowing for about one third of the time being lost due to unobservability during solar conjunction, the frequency of such large impacts is less than one per 80 years.

In the detailed BAA records of 1891-1943 searched by Hill, and also 1972-1994 for which the author has been responsible, giving a total of 74 years, anomalous black spots could have been picked out at a smaller scale, comparable to impacts E or Q1. Again, it appears likely that none were detected. As these smaller impacts would be shorter-lived, let us assume that two-thirds might be missed due to solar conjunction, poor observing conditions, or confusion with other spots; then the frequency of these smaller impacts is less than one per 25 years.

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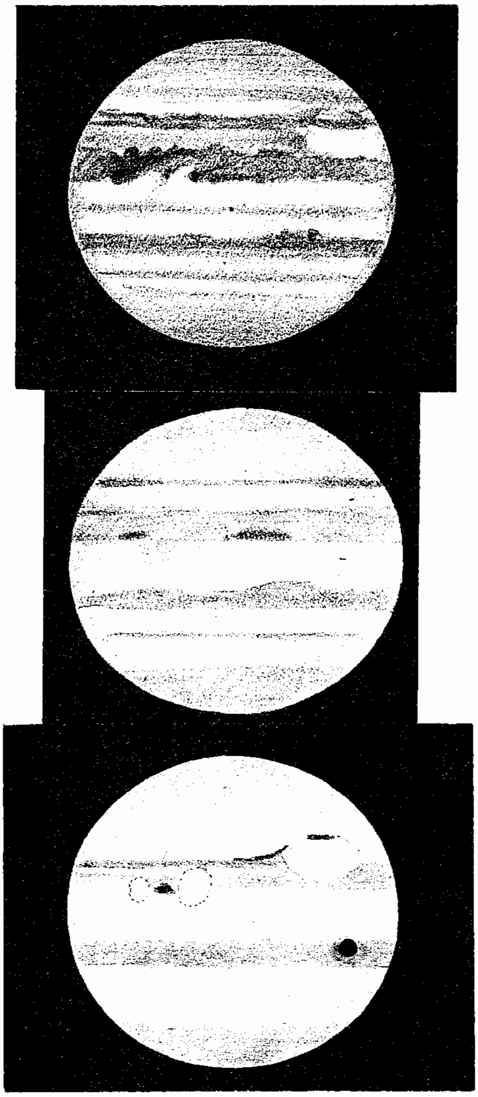

Figure 1. Drawings of Jupiter in 1921 (south is up):

a (top). 1921 MAY 05, 08h45m GMAT, CM1 = 273°; Du Martheray. On the SEBn edge, the very dark "step-up" on the p. side is probably Sargent's "angle" feature, a precursor of Sargent's spot.

b (middle). 1921 MAY 21, 08h30m GMAT, CM1 = 269°; Du Martheray. The very dark streak on SEBn is Sargent's spot.

c (bottom). 1921 JUN 24, 09h GMAT, CM1 = 250°; Attkins. The two bright spots, flanking a dark one, resembled a cluster seen on JUN 06 which was the final stage of Sargent's spot.

J.H. SCHROETER'S "SMALL DARK BLACK SPOTS" ON JUPITER IN 1785-1786

By: Thomas Dobbins and William Sheehan

While doing research on the German astronomer J. H. Schroeter (*Figure 1*, lower right), the writers were able to obtain a copy of Schroeter's rare publication *Beobachtungen verschiedener schwarzdunkler kleiner Flecken des Jupiters*. The term "schwarzdunkler kleiner Flecken" [black dark small spots] is unusual, and aroused our suspicion. We were finally able to track down this essay, which is most remarkable–it describes Schroeter's observations made in October/November 1785 and also in February 1786 of small dark circular spots which appear uncannily like the impact features which appeared in July 1994 when Comet Shoemaker-Levy 9 struck Jupiter.

Here are some excerpts translated from Schroeter's admittedly rather convoluted German:

> "On October 26, 1785, at 8h 25m 11s Sidereal Time, in steady air, using 150× on my 4-foot Herschelian telescope, I saw while awaiting the exit of the first satellite from the disk, and with entire distinctness, two small dark black spots, one close beside the other ... the larger was as large almost as the shadow of the first satellite itself; their diameters were therefore 1".5. Both were approximately 7/12 of the distance from the limb, north of the middle of the long ago observed belt [SEB] and moving westward in the rotation period assigned by Cassini." (See *Figure 2*, p. 32)
>
> "On November 15 ... I was astonished to find two different sized large round black shadow-spots....Both were jet-black and had the same strongly-defined round shape, and moved to the west, though because of my surprise, and the fact that they were already past the middle of the disk, and the seeing was indifferent, I could not absolutely determine their rotations." (See *Figure 3*, p. 32)
>
> "November 21. Two similar, but somewhat smaller round black shadow-points." (See *Figure 4*, p. 32)

The observations of February 1786 are even more remarkable (*Figures 5-8*, p. 32).

We believe that we have found the most compelling evidence yet culled from the historical record of events like the impacts of Shoemaker-Levy 9 in July 1994.

Certainly a first reading of Schroeter's monograph evoked powerful memories of the authors' first glimpse of the "A" impact site on the evening of July 19, 1994.

We caution readers that a more mundane explanation is possible. Since 1911, the southern edge of the North Equatorial Belt (NEBs) has been the site of an entire family of dark spots and associated festoons extending well into the Equatorial Zone (EZ). Jose Olivarez noted in examining the historical record that a mysterious south-to-north inversion occurred on Jupiter in 1911, in which the projections and festoons migrated from the SEBn (South Equatorial Belt, north component) to the NEBs. During the nineteenth century, the projections and festoons emanated from the SEBn. Given the location of Schroeter's spots in the EZ adjacent to the SEB it does give pause that unusually dark blue festoons could have been responsible for Schroeter's observations.

On the other hand, such an explanation is seemingly at odds with Schroeter's depictions of round spots completely detached from the adjacent SEB. Also, Schroeter failed to record similar features in later series of observations made in the 1780s and 1790s. Olivarez's blue spots and festoons are persistent, quasi-permanent features—one has been followed for more than eleven years now; Schroeter's spots of 1785-86 appear to have dissipated in a matter of days.

Impact sites or blue festoons? At the moment, we cannot decide; the whole question, in our view, remains open. Whatever the final verdict, Schroeter's records are, in our opinion, of more than passing interest; they are the only eighteenth-century records of intensely dark spots on the planet, and whether serendipitously observed impacts or an early outbreak of SEBn festoons, they should be carefully weighed by students of the planet, its meteorology, and its possible encounters with cometary matter.

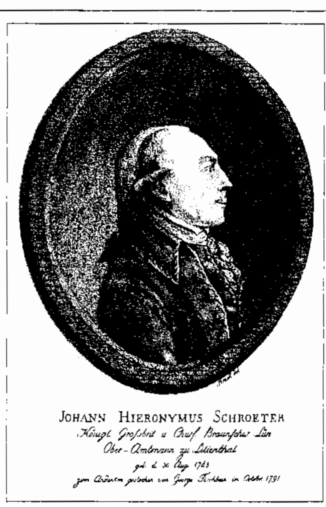

Figure 1. Portrait of Johann Hieronymus Schroeter, made in 1791.

Figures 2-8. J.H. Schroeter's Drawings of Jovian dark spots in 1785-1786.

(These are normal inverted views, with celestial directions given as follows: Süd = South; Nord = North; West = West; and Ost = East)

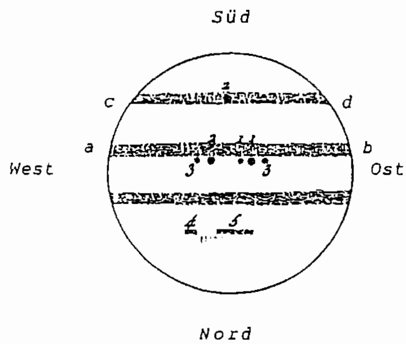

Figure 2. J.H. Schroeter's original engraving of his observation of Jovian spots on October 26, 1785.

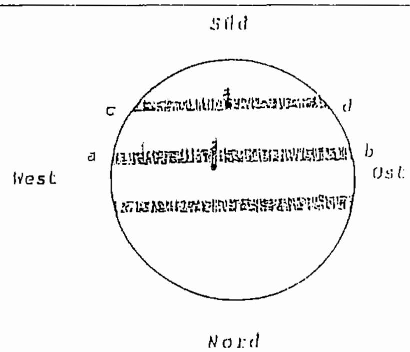

Figure 3. J.H. Schroeter's drawing of Jovian spots on November 15, 1785.

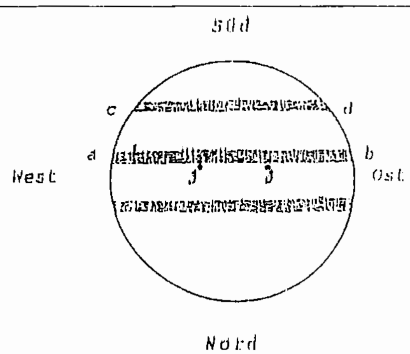

Figure 4. J.H. Schroeter's drawing of Jovian spots on November 21, 1785.

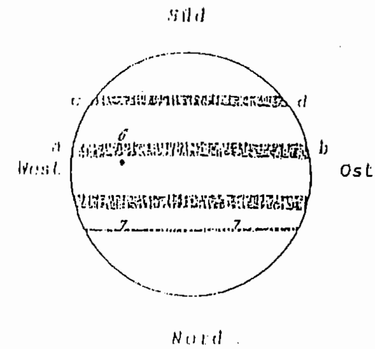

Figure 5. J.H. Schroeter's drawing of Jovian spots on February 9, 1786.

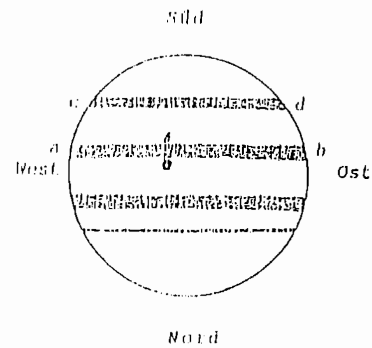

Figure 6. J.H. Schroeter's drawing of Jovian spots on February 11, 1786.

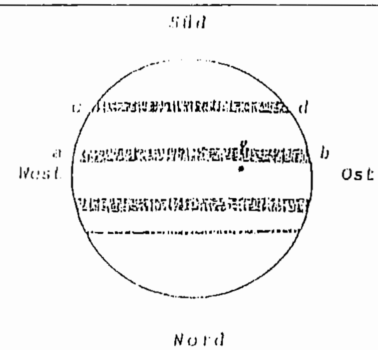

Figure 7. J.H. Schroeter's drawing of Jovian spots on February 17, 1786.

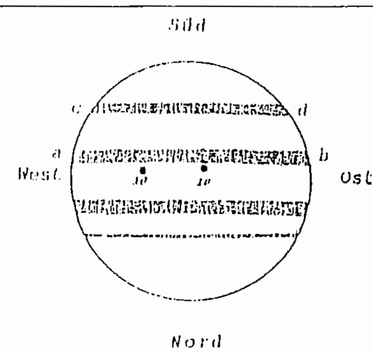

Figure 8. J.H. Schroeter's drawing of Jovian spots on February 26, 1786.

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METEORS SECTION NEWS

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

Table 1. Recent A.L.P.O. Meteor Observations; April - June, 1995.

1995 UT Date	Observer and Location	Universal Time	Number and Type* of Meteors Seen	Comments (+*N* = Limiting Magnitude)
APR 01	John Gallagher, NJ	09:05-09:52	2 SPO	+7.4
02	Graham Wolf, New Zealand	07:00-08:00	*None Seen*	+4.3
	Pierre Martin, Ont., Canada	07:54-08:54	3 VIR, 3 SPO	+5.9
	Graham Wolf, New Zealand	09:00-18:00	3 ASC, 10 SPO	+4.6
03	John Gallagher, NJ	03:30-05:34	1 MLE, 2 SLE, 1 VIR, 1 EDR, 5 SPO	+7.5
	Graham Wolf, New Zealand	07:00-09:30	1 BPA	+4.2
	Pierre Martin, Ont., Canada	07:19-08:19	4 SPO	+5.8
04	George Zay, CA	03:25-12:35	5 VIR, 2 ASC, 32 SPO	+5.8
	Robert Lunsford, CA	06:00-12:30	3 VIR, 4 ASC, 1 SLE, 56 SPO	+6.4
05	John Gallagher, NJ	03:45-05:50	1 VIR, 2 SPO	+7.5
	Pierre Martin, Ont., Canada	04:35-12:35	8 VIR, 1 ASC, 33 SPO	+5.9
	Robert Lunsford, CA	07:15-12:30	2 VIR, 3 KSE, 2 ASC, 1 NSC, 46 SPO	+6.7
06	Pierre Martin, Ont., Canada	04:37-12:31	7 VIR, 2 ASC, 36 SPO	+5.9
	Graham Wolf, New Zealand	07:00-15:00	6 BPA, 1 ASC, 22 SPO	+4.3; 5% cloudy
08	John Gallagher, NJ	04:50-06:52	1 EDR	+7.4
	Graham Wolf, New Zealand	11:30-14:00	2 ASC, 2 BPA, 1 VIR, 10 SPO	+6.6
09	Graham Wolf, New Zealand	12:00-14:00	2 ASC, 4 BPA, 1 VIR, 5 SPO	+4.4; 5% cloudy
10	Pierre Martin, Ont., Canada	08:10-09:10	1 ASC, 3 SPO	+5.8
11	Pierre Martin, Ont., Canada	08:32-09:12	1 ASC, 2 SPO	+5.8
13	Graham Wolf, New Zealand	07:00-11:00	2 ASC, 1 BPA, 9 SPO	+4.7
14	Graham Wolf, New Zealand	07:00-11:00	3 ASC, 2 BPA, 11 SPO	+4.5
15	Graham Wolf, New Zealand	07:00-11:00	3 ASC, 1 VIR, 9 SPO	+4.3
16	Graham Wolf, New Zealand	07:00-11:00	3 ASC, 1 PPU, 1 VIR, 8 SPO	+4.2
17	John Gallagher, NJ	04:15-06:02	2 SPO	+6.8
	Graham Wolf, New Zealand	07:00-14:00	8 ASC, 3 PPU, 4 VIR, 21 SPO	+4.2
18	Graham Wolf, New Zealand	07:00-10:00	3 ASC, 2 PPU, 1 VIR, 11 SPO	+4.2
22	Wanda Simmons, FL	03:26-04:38	1 LYR, 1 FBO, 5 SPO	+5.5
	Daniel Simmons, FL	03:26-04:38	1 LYR, 1 FBO, 5 SPO	+5.5
	Karl Simmons, FL	03:26-04:38	1 LYR, 1 FBO, 3 SPO	+5.6
	Milton Hays, FL	03:26-04:38	1 FBO, 3 SPO	+5.5
	George Zay, CA	04:25-12:10	17 LYR, 1 ASC, 4 VIR, 26 SPO	+5.8
	Richard Taibi, MD	05:25-08:11	4 LYR, 6 SPO	+5.3
	Robert Lunsford, CA	05:30-12:30	34 LYR, 3 MVI, 4 VIR, 1 ASC, 1 ASC, 3 ETA, 31 SPO	+6.2
	James Riggs, CA	05:30-11:00	6 LYR, 24 SPO	+4.5
	Norman McLeod, FL	06:15-07:30	5 SPO	+5.5
	J.Kenneth Eakins, CA	07:00-11:00	11 LYR, 0 SPO	+5.2
	George Gliba, MD	07:35-08:45	5 LYR, 5 SPO	+5.0
23	Robert Lunsford, CA	03:00-05:00	1 SPO	+5.0
	Norman McLeod, FL	06:11-07:42	7 LYR, 3 VIR, 2 SPO	+6.8
	John Gallagher, NJ	08:37-09:12	2 LYR,	+7.0
	Robert Lunsford, CA	09:00-12:00	1 ASC, 7 SPO	+5.7
25	Pierre Martin, Ont., Canada	05:04-06:07	1 ABO, 1 ASC, 2 SPO	+5.9
	Robert Lunsford, CA	08:00-11:30	6 SPO	+5.6
26	John Gallagher, NJ	04:25-06:33	1 ABO, 1 DDR, 1 NOP, 1 SPO	+7.3
	Robert Lunsford, CA	08:55-12:10	3 ABO, 1 ASC, 4 ETA, 1 WCA, 29 SPO	+6.8
27	Graham Wolf, New Zealand	07:00-08:30	1 ASC	+4.8

Table 1 continued on pp. 38-40 with notes on p. 40.

Table 1—Continued.

1995 UT Date	Observer and Location	Universal Time	Number and Type* of Meteors Seen	Comments (+N = Limiting Magnitude)
APR 28	George Zay, CA	05:24-12:08	5 VIR, 3 ETA, 3 ASC, 1 NOP, 15 SPO	+5.8
	Graham Wolf, New Zealand	07:00-09:00	1 ASC, 2 VIR, 2 SPO	+4.7
29	John Gallagher, NJ	04:40-05:43	5 ABO, 1 AVB, 2 SPO	+7.2
	Richard Taibi, MD	06:50-09:05	3 SPO	+5.5
	George Zay, CA	10:21-12:08	4 ETA, 1 SPO	+5.4
30	John Gallagher, NJ	04:35-06:39	2 ABO, 3 SPO	+7.5
	George Zay, CA	10:00-12:08	3 ETA, 10 SPO	+5.8
MAY 01	George Zay, CA	03:53-11:47	5 VIR, 2 ASC, 1 ABO,	
			1 ETA, 1 NOP, 19 SPO	+5.7
	Graham Wolf, New Zealand	07:00-10:00	1 ASC, 2 VIR, 1 SPO	+4.5
02	David Holman, CA	04:21-11:12	1 ABO, 2 VIR, 4 ETA, 16 SPO	+6.3
	George Zay, CA	06:20-11:11	4 ETA, 2 NOP, 1 VIR, 5 SPO	+5.9
	Robert Lunsford, CA	06:30-11:15	8 ETA, 2 ASC, 2 MVI, 1 ACA, 17 SPO	+6.5; 30% cloudy
	Graham Wolf, New Zealand	07:00-12:00	7 ASC, 4 VIR, 4 SPO	+4.8
	Mark Davis, SC	07:41-08:41	1 ETA, 1 ASC, 9 SPO	+5.4; 10% cloudy
	Norman McLeod, FL	07:51-09:30	3 ETA, 1 VIR, 1 ABO, 5 SPO	+6.8
	James Riggs, CA	11:15-12:35	4 ETA, 20 SPO	+4.0
	Graham Wolf, New Zealand	15:00-17:00	3 CAU, 18 ETA, 7 SPO	+4.8
03	Robert Lunsford, CA	04:00-12:00	21 ETA, 4 ASC, 7 MVI,	
			2 ABO, 1 NOP, 28 SPO	+6.4
	David Holman, CA	04:00-11:55	15 ETA, 3 VIR, 1 ASC, 40 SPO	+6.3
	George Zay, CA	04:03-12:00	3 VIR, 3 NOP, 2 ASC, 32 SPO	+6.0
	Mark Davis, SC	06:08-09:23	8 ETA, 3 ASC, 14 SPO	+5.9
	Felix Martinez, Cuba	06:30-07:30	1 ETA, 3 SPO	+6.0
	Graham Wolf, New Zealand	07:00-10:00	5 ASC, 1 VIR, 4 SPO	+4.6
	Norman McLeod, FL	07:36-09:35	11 ETA, 2 VIR, 8 SPO	+6.8
	James Riggs, CA	09:05-12:15	18 ETA, 43 SPO	+6.0
04	John Graddon, Cuba	06:00-08:30	6 ETA, 9 SPO	+6.0
	Pierre Martin, Ont., Canada	06:02-08:02	3 ETA, 1 NOP, 5 SPO	+5.6
	David Holman, CA	07:15-11:55	16 ETA, 1 ABO, 1 ASC, 2 VIR, 33 SPO	+6.4
	George Zay, CA	07:17-11:15	6 ETA, 2 NOP, 1 ABO, 1 VIR, 18 SPO	+6.0
	Robert Lunsford, CA	07:30-12:00	21 ETA, 2 ASC, 1 MVI,	
			1 ABO, 1 NOP, 1 GCA, 24 SPO	+6.4
05	Mark Davis, SC	07:45-08:30	2 ETA, 6 SPO	+5.6
	Robert Hays, IL	08:00-09:40	4 ETA, 12 SPO	+6.5
	Felix Martinez, Cuba	08:15-08:30	1 ETA	+6.0
06	John Gallagher, NJ	06:20-08:48	6 ETA, 5 SPO	+7.5
	Norman McLeod, FL	06:53-09:38	17 ETA, 4 VIR, 3 ASC, 10 SPO	+6.7
	Richard Taibi, MD	07:29-09:00	4 ETA, 10 SPO	+5.8
	Mark Davis, SC	07:33-09:15	12 ETA, 2 ASC, 20 SPO	+5.5
	Robert Hays, IL	08:00-09:35	5 ETA, 14 SPO	+6.5
07	John Gallagher, NJ	06:25-08:33	2 ETA, 1 LYR, 6 SPO	+7.5
	Norman McLeod, FL	07:15-09:42	14 ETA, 3 ASC, 11 SPO	+6.5
08	Graham Wolf, New Zealand	07:00-11:00	2 ASC, 1 VIR, 4 SPO	+4.0
	Norman McLeod, FL	07:17-09:44	14 ETA, 2 VIR, 1 ASC, 6 SPO	+6.8
	Mark Davis, SC	07:40-09:10	7 ETA, 16 SPO	+5.7
09	Norman McLeod, FL	07:02-08:50	7 ETA, 2 ASC, 2 ABO, 2 SPO	+7.2
	George Zay, CA	08:43-11:54	15 ETA, 1 NOP, 1 ASC, 20 SPO	+5.8
	Graham Wolf, New Zealand	09:00-11:00	2 ASC, 4 SPO	+4.8
10	Graham Wolf, New Zealand	07:00-10:00	4 ASC, 1 VIR, 7 SPO	+4.4
	Graham Wolf, New Zealand	17:00-18:00	7 ETA, 2 SPO	+4.5
11	Graham Wolf, New Zealand	07:00-10:00	2 ASC, 5 SPO	+4.3
	George Zay, CA	08:29-11:52	11 ETA, 1 ASC, 1 NOP, 15 SPO	+5.6
	Robert Lunsford, CA	08:45-11:45	10 ETA, 2 ASC, 1 MVI,	
			3 IAA, 1 NOP, 20 SPO	+5.9
	Graham Wolf, New Zealand	15:00-16:00	6 ETA, 3 SPO	+4.3

Table 1 continued on pp. 39-40 with notes on p. 40.

Table 1—Continued.

1995 UT Date	Observer and Location	Universal Time	Number and Type* of Meteors Seen	Comments (+*N* = Limiting Magnitude)
MAY 12	George Zay, CA	09:28-11:50	3 ETA, 14 SPO	+5.5
13	Graham Wolf, New Zealand	15:00-16:00	4 ETA, 2 SPO	+4.0
16	Graham Wolf, New Zealand	07:00-08:00	*None Seen*	+4.2
	Graham Wolf, New Zealand	15:00-17:00	5 ETA, 4 SPO	+4.1
17	John Gallagher, NJ	04:25-05:00	1 SPO	+6.4
	Graham Wolf, New Zealand	07:00-12:00	3 ASC, 1 VIR, 4 SPO	+4.4
	Graham Wolf, New Zealand	15:00-18:00	8 ETA, 7 SPO	+4.4
18	Graham Wolf, New Zealand	07:00-09:00	2 ASC, 3 SPO	+4.7
	Graham Wolf, New Zealand	07:00-10:00	2 ASC, 1 VIR, 4 SPO	+4.5
	Graham Wolf, New Zealand	15:00-18:00	3 ETA, 8 SPO	+4.7
20	Graham Wolf, New Zealand	06:00-12:00	3 ASC, 1 VIR, 9 SPO	+4.6
	Graham Wolf, New Zealand	15:00-16:00	1 ETA, 2 SPO	+4.8
21	Graham Wolf, New Zealand	06:00-10:00	1 ASC, 1 SPO	+4.5
	Graham Wolf, New Zealand	15:00-18:00	2 ETA, 7 SPO	+4.7
23	John Gallagher, NJ	04:50-06:55	1 NOP, 1 SOP, 3 SPO	+7.4
	Graham Wolf, New Zealand	15:00-18:00	1 ETA, 5 SPO	+4.6
24	Graham Wolf, New Zealand	15:00-18:00	9 SPO	+4.8
26	George Zay, CA	07:34-11:32	1 NOP, 1 KSC, 1 CSC, 16 SPO	+5.8
28	Mark Davis, SC	02:57-03:57	4 SPO	+5.1; 15% cloudy
29	Damien Mathew, ND	04:02-05:02	4 SPO	+6.3; 30% cloudy
	Graham Wolf, New Zealand	06:00-11:00	1 ASC, 2 SPO	+4.6; 5% cloudy
	George Zay, CA	07:33-11:32	1 NOP, 3 OSC, 3 GSA	+5.7
	Robert Lunsford, CA	08:30-11:30	1 NOP, 1 OSC, 26 SPO	+6.7
30	Robert Lunsford, CA	07:30-11:30	2 NOP, 4 CSC, 34 SPO	+6.9
	Graham Wolf, New Zealand	08:00-18:00	4 ASC, 8 SPO	+4.5; 5% cloudy
31	John Gallagher, NJ	04:45-06:49	4 SPO	+7.2
	Graham Wolf, New Zealand	06:00-14:00	3 ASC, 5 SPO	+4.8
	Robert Lunsford, CA	07:30-11:30	3 NOP, 3 CSC, 1 GSA, 30 SPO	+6.7
JUN 01	Robert Lunsford, CA	08:00-11:30	4 NOP, 1 OSC, 32 SPO	+6.6
05	George Zay, CA	06:00-11:28	1 TOP, 31 SPO	+5.8
	Graham Wolf, New Zealand	06:00-14:00	3 ASC, 3 TOP, 8 SPO	+4.3
	Robert Lunsford, CA	07:45-11:30	2 TOP, 3 GSA, 40 SPO	+6.6
06	George Zay, CA	05:28-08:11	1 GSA, 1 CSC, 12 SPO	+5.8
	Robert Lunsford, CA	09:30-11:30	1 CSC, 19 SPO	+6.4
07	Mark Davis, SC	05:04-07:04	2 SAG, 15 SPO	+5.6
	Norman McLeod, FL	06:57-09:26	1 ASC, 17 SPO	+7.2
	Robert Lunsford, CA	08:00-11:35	3 GSA, 1 TOP, 34 SPO	+6.7
	Graham Wolf, New Zealand	10:00-14:00	1 TOP, 1 SPO	+4.5
15	John Gallagher, NJ	05:25-07:06	1 JLY, 1 DCG, 1 SPO	+6.6
16	John Gallagher, NJ	05:10-07:43	1 JLY, 4 SPO	+7.1
17	John Gallagher, NJ	07:05-08:23	2 SPO	+6.2
18	John Gallagher, NJ	05:15-06:47	1 TOP, 1 BCG, 1 SPO	+5.7
19	John Gallagher, NJ	03:50-05:56	1 TAQ, 1 JAQ, 3 SPO	+7.1
	Graham Wolf, New Zealand	06:00-12:00	2 CSC, 7 TOP, 12 SPO	+4.6
	Robert Lunsford, CA	09:15-11:30	2 JLY, 11 SPO	+5.9
20	John Gallagher, NJ	04:50-06:52	1 DCG, 1 SPO	+7.1
	Graham Wolf, New Zealand	06:00-14:00	8 TOP, 23 SPO	+4.6
	Robert Lunsford, CA	07:30-11:30	1 JLY, 1 LSA, 24 SPO	+5.9
21	Robert Lunsford, CA	07:30-11:30	3 JLY, 1 LSA, 1 TAQ, 39 SPO	+5.9
22	Pierre Martin, Ont., Canada	04:36-05:37	6 SPO	+5.8
	Graham Wolf, New Zealand	06:00-14:00	5 TOP, 26 SPO	+4.6

Table 1 continued on p. 40 with notes.

Table 1—Continued.

1995 UT Date	Observer and Location	Universal Time	Number and Type* of Meteors Seen	Comments (+N = Limiting Magnitude)
JUN 23	George Zay, CA	04:09-11:23	1 TOP, 39 SPO	+5.8
	Pierre Martin, Ont., Canada	04:57-05:55	5 SPO	+5.6
	Graham Wolf, New Zealand	06:00-14:00	4 LSA, 4 TOP, 22 SPO	+4.5
24	David Holman, CA	04:54-07:54	1 LSA, 7 SPO	+6.3
	Graham Wolf, New Zealand	06:00-14:00	2 LSA, 1 TOP, 23 SPO	+4.8
25	David Holman, CA	04:48-11:20	2 TOP, 32 SPO	+6.4
	Graham Wolf, New Zealand	06:00-12:00	3 LSA, 2 TOP, 18 SPO	+4.5
26	John Gallagher, NJ	04:20-04:51	*None Seen*	+6.0
	Graham Wolf, New Zealand	06:00-14:00	3 LSA, 2 TOP, 23 SPO	+4.6
	Robert Lunsford, CA	08:30-11:30	3 LSA, 1 TAQ, 37 SPO	+6.8
27	Graham Wolf, New Zealand	06:00-14:00	2 LSA, 27 SPO	+4.5
	Robert Lunsford, CA	06:30-07:30	*None Seen*	+6.3; 75% cloudy
28	George Zay, CA	04:02-11:30	5 TOP, 1 JBO, 1 LSA, 44 SPO	+5.9
	Robert Lunsford, CA	07:30-11:30	3 TAQ, 48 SPO	+6.4
29	John Gallagher, NJ	04:50-07:00	1 JLY, 1 BCG, 1 JPE, 1 RSA, 1 SPO	+7.4
	Robert Lunsford, CA	07:30-11:30	35 SPO	+6.5
	James Riggs, CA	10:10-11:40	25 SPO	+5.7
30	George Zay, CA	04:03-11:29	3 LSA, 2 TOP, 27 SPO	+5.9
	Graham Wolf, New Zealand	15:00-18:00	1 LSA, 6 SPO	+5.3

**** Key to Abbreviations***

ABO	Alpha Bootids	GCA	Gamma Capricornids	NOP	North Ophiuchids
ACA	Alpha Cor. Australids	GSA	Gamma Sagittarids	NSC	Nu Scorpids
ASC	Alpha Scorpids	IAA	Iras-Araki-Alcock	OSC	Omega Scorpids
AVB	Alpha Virginids "B"	JAQ	June Aquarids	PPU	Pi Puppids
BCG	Beta Cygnids	JBO	June Bootids	SAG	Sagittarids
BPA	Beta Pavonids	JLY	June Lyrids	SLE	Sigma Leonids
CAU	Corona Australids	JPE	July Pegasids	SOP	South Ophiuchids
DCG	Delta Cygnids	KSF	Kappa Serpentids	SPO	*Sporadics*
DDR	Delta Draconids	LSA	Lambda Sagittarids	TAQ	Tau Aquarids
EDR	Epsilon Draconids	LYR	Lyrids	TOP	Theta Ophiuchids
ETA	Eta Aquarids	MLE	March Leonids	VIR	Virginids
FBO	Phi Bootids	MVI	Mu Virginids	WCA	Omega Capricornids

IN MEMORIAM: KERMIT RHEA, 1919-1994

Notes by Jeff Beish

Kermit Rhea, a long-standing A.L.P.O. member, passed away in December, 1994 at the age of 75. Kermit previously had a stroke while preparing for the impact of Comet Shoemaker-Levy 9 with Jupiter and was recovering when he suffered heart failure.

Kermit was born on November 30, 1919 near Walcott, Arkansas. He was a veteran of World War II, in which he lost his right eye. In his later years Kermit was involved in therapy for the seeing-impaired and was Assistant Field Director (ARC) with the Veteran's Administration. He also was President of the American Corrective Therapy Association (1969-70).

Kermit Rhea's interest in astronomy began as a teenager while reading of the exploits of Percival Lowell and Clyde Tombaugh. He gained his B.S.E.E. degree from Arkansas State College and his Master's from the University of Arkansas.

Kermit was an A.L.P.O. member for nearly 25 years, making his own telescopes from homemade lenses and mirrors. He took part in the International Mars Patrol since the early 1970's and made many friends among our. members. Even though he had sight in only one eye, he regularly contributed to several programs; besides Mars, they included lunar eclipses, meteors, comets and others. He will indeed be missed.

HYAKUTAKE HARVEST

The surprise event of Spring, 1996, was the sudden passage through our skies of Comet 1996 B2 Hyakutake. Below, and on the front cover, is a selection of observations of this spectacular object submitted to Comets Recorder Don E. Machholz.

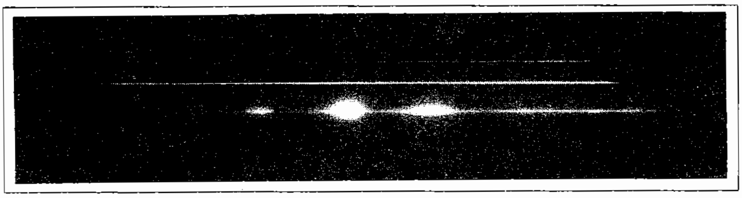
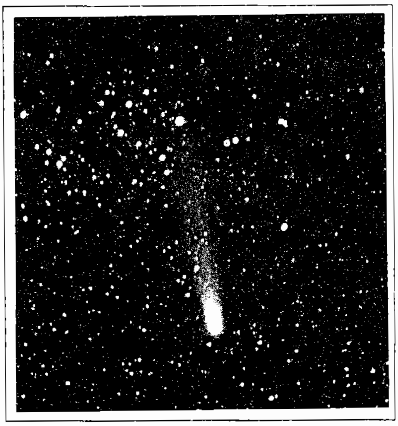


Figure 1. A slitless spectrum of Comet Hyakutake, by Tom Buchanan, 1996 MAR 23, 05h10m UT, with a blazed diffraction grating, 600 grooves/mm, 135-mm f/1.9, Kodak 2415TP Film, 4-min exp. Violet to left, red to right.

Figure 2 (right). Photograph of coma of Comet Hyakutake by John D. Sabia, 1996 MAR 28, 03h10m UT. 9.5-in (24.13-cm) Alvan Clark refractor, f/15, 30 sec. on Kodak Royal Gold ISO 1000 Film. North to upper left; the star in upper left is SAO 5036, magnitude +8.6. Note the sharp "spike" extending to the left of the nucleus region.

Figure 3 (below). Tail of Comet Hyakutake, photographed by Gus Johnson, 1996 APR 04, 01h00m UT, during a total lunar eclipse. 135-mm f/2.8, 2.5 minutes on ISO 400 film. North is to the upper right and the tail extends to Alpha Persei (Mag. +1.8). The field of view is approximately 6°.5 on a side.



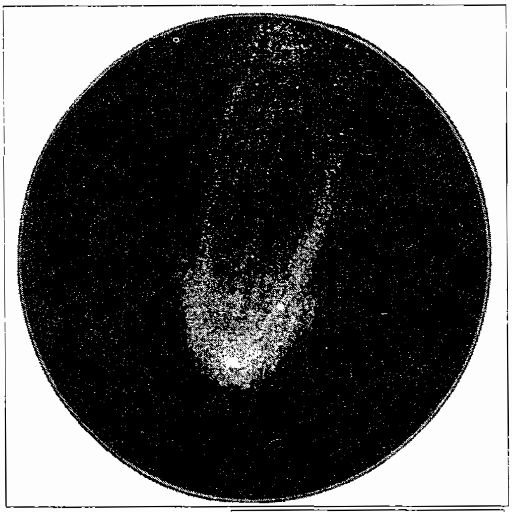
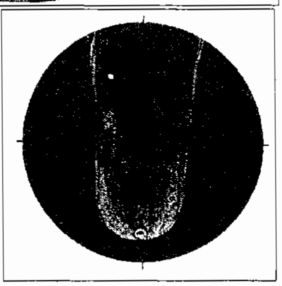


Figure 4 (right, upper). Drawing of Comet Hyakutake by Detlev Niechoy of Göttingen, Germany. 1996 APR 16 , 19h54m UT. 2.4-in (6-cm) telescope, 33X. The star to the upper right of the nucleus region is probably SAO 56000, magnitude +7.5. North is to the upper right. (Originally a negative drawing, converted here to a positive.)

Figure 5 (right, lower). Drawing of Comet Hyakutake by Gérard Teichert of Hattstatt, France, on 1996 APR 16, 20h23m UT, just 29 minutes after Figure 4; the comet's motion is shown by the apparent shift of the star. 28-cm Schmidt-Cassegrain, 112X, 165X, and 224X. North is to the upper right. (Originally a negative drawing, converted here to a positive.)



Book Reviews

Edited by Jose Olivarez

To a Rocky Moon, A Geologist's History of Lunar Exploration.

By Don E. Wilhelms.

The University of Arizona Press, 1230 North Park Avenue, Suite 102, Tucson, AZ 85719-4140. 1993. 477 pages. (ISBN 0-8165-1443-7).

Reviewed by Jose Olivarez

The "story behind the story" of the lunar landings is eloquently described in this definitive account of how we learned the geological history of the Moon. Dr. Wilhelms was a member of a scientific team responsible for assembling an overall picture of the Moon's structure and history during the "Apollo Era" in order to recommend where on the Moon field work should be conducted. In this book, he details the site-selection process, and draws in related events concerning mission operations to show how the events affected the course of the scientific program. Wilhelms discusses all six landing sites in detail and tells the behind-the-scenes story of telescopic and spacecraft investigations of the Moon before, during, and after the manned landings.

To a Rocky Moon leaves the reader interested in the space program, the history of science, or the application of geology to planetology, with a better understanding of how the Apollo landing sites were selected. The book is also replete with revealing statements about what has made the Moon what it is today. For example, this reader learned that the Moon's famed Alpine Valley is a *graben* (fault valley); that if there is a volcanic caldera on the Moon, the crater Vitello ought to be it; and that the youngest prominent crater on the Moon is probably Tycho at 109 million years old. These include Dr. Wilhelms' views that "the moon is not a primordial object but an evolving one"; that "the moon is neither cosmic exotica nor a little earth"; and that "cosmic impacts rule the Moon".

To a Rocky Moon contains 47 small black-and-white photographs, but it would benefit by many more. Also, a second edition of this book would be greatly enhanced by the inclusion of a larger version of the ACIC photomosaic map of the lunar near side, perhaps in the form of a folding plate. This map appears as the frontispiece of the current edition, but is too small to serve as an adequate guide to the location of the many lunar sites discussed in the book. Two good companion books to *To a Rocky Moon* are Peter Cadogan's *The Moon: Our Sister Planet* (Cambridge University Press, 1981) and Dr. Wilhelms' other massive publication, *The Geologic History of the Moon* (U.S. Geological Survey Professional Paper 1348).

In conclusion, *To a Rocky Moon* is both fascinating and easy to read.

Pauper and Prince: Ritchey, Hale, & Big American Telescopes.

By Donald E. Osterbrock.

The University of Arizona Press, 1230 North Park Avenue, Suite 102, Tucson, Arizona 85719-4140. 1993. 359 pages. Price: $45.00 cloth (ISBN 0-8165-1199-3).

Reviewed by Jose Olivarez

This readable and fascinating book by a well-known historian of astronomy focuses on the career of George Willis Ritchey, who perfected the methods of making parabolic mirrors for giant reflecting telescopes and who pioneered their use for astronomical photography. A genius at building large telescopes, Ritchey, like all telescope makers, believed he knew everything about his business. He was an artist and a perfectionist, but these traits made him temperamental and difficult to work with and did not endear him to George Ellery Hale, his employer and observatory director. Rather, they led to tension, estrangement, and finally to Ritchey's dismissal and banishment from the "Big Telescope" scene by Hale.

Using interviews with people who knew Ritchey and letters preserved in archives, Osterbrock reveals the impact of human pride, ambition, and character on the development of scientific knowledge, technology, and "big science". He also details the telescope-building aspects of Hale's life at Yerkes, Mount Wilson, and Palomar Observatories and shows how the relationship between Ritchey and Hale helped the United States to develop the world's premier astronomical facilities.

Osterbrock's willingness to reveal everything about Hale's and Ritchey's pride and character—warts and all—helps to make this book engrossing reading. Indeed, I was left with a changed opinion of the "father of big American astronomy" and more sympathetic towards George Ritchey, whose character prevented him from receiving the honor and renumeration in his lifetime that his genius deserved. Now, thanks to this book, Ritchey, the unsung pauper of his time, can take his place among the giants of American astronomy where he richly deserves to be.

The only drawback to this book is the lack of examples of Ritchey's photographs. Although his spectacular lunar and celestial photographs taken with the 40-inch Yerkes refractor, a 24-inch reflector of his own making, and the 60-inch reflector at Mt. Wilson are mentioned repeatedly in the text, none are included! Indeed, the University of Arizona Press would do well to include examples of his famous photographs in future editions.

Pauper and Price: Ritchey, Hale, & Big American Telescopes is sure to become a classic on the history of American astronomy . Get your copy now.

Edwin Hubble: the Discoverer of the Big Bang Universe.

By Alexander S. Sharov and Igor D. Novikov. Translated by Vitaly Kisin.

Cambridge University Press, 40 West 20th Street, New York, NY 10011-4211. 1993. 187 pages, Illus., bibliographical references and indices. Price $34.95 cloth (ISBN 0-521-41617-5)

Reviewed by Thomas Pinkney Davis

It is ironic that the only popular biography of American astronomer Edwin Hubble was written by Russian authors to commemorate the centennial of his birth. This book is the English edition of a work first published by Nauka Publishing House, Moscow, in 1989. It is by neither professional biographer, nor historians of science, who will not like its non-academic style. Rather, it is a labor of love by professional astronomers fascinated by the history of their science and with an open admiration of Hubble and his accomplishments.

Hubble is a difficult subject, though. His scientific writing, some 70 papers and books, chronicles his professional life well enough. But his private life is harder to reconstruct since he was not given to extensive personal correspondence. (The papers in the Hubble archives in Pasadena were collected by his widow who decided what should be preserved.) Hubble was, as his former student and colleague Alan Sandage observed, "a very private man." Combine this fact with the situation of Russian researchers working far from what primary sources are extant and one sees the formidable challenge the authors faced.

Edwin Hubble was one of the great observational astronomers of this century (Sandage says since Copernicus). In this book he appears utterly dedicated to his calling, somewhat aloof, stern and paternalistic toward younger colleagues, and possessing a passion for his pipe, fishing, books, and the stars.

The authors have done a creditable job given the constraints of distance and the paucity of primary sources. The book, illustrated with 17 black-and-white plates of Hubble from boyhood through his later years, includes a bibliography of Hubble's publications, reprinted from Nicholas Mayall's brief biographical essay. Three-fourths of the text is devoted to the biography *per se*. The final quarter places Hubble's work on the red-shift in perspective along with a brief survey of modern astronomy and astrophysics.

Occasionally, however, the translation falters, along with the editing. On page 44 the Royal Astronomical Society is referred to as the "Royal Society". On page 80 we read "..the absolute luminosity of a star is higher, the shorter the time needed for the star to drop in brightness by three magnitudes." Also, the index frequently refers the reader to the wrong page in the text.

As the authors note in their preface to the Russian edition, Hubble's definitive biography has yet to be written.

Atlas of Neptune.

By Garry E. Hunt and Patrick Moore,

Cambridge University Press, 40 West 20th Street, New York, NY 10011-4211. 1994. 84 pages, Index, Appendices. Price $27.95 cloth (ISBN 0-521-37478-2).

Reviewed by Richard W. Schmude, Jr.

Atlas of Neptune is divided into 14 chapters describing three areas: Introductory and historical aspects, the Voyager spacecraft, and current knowledge of the Neptune system. It contains over 60 photographs, almost half in color, fourteen other illustrations, six tables, two appendices and a 270-item index.

The first six chapters are "Introduction", "Neptune in the Solar System", "The discovery of Neptune", "Pre-discovery observations", "Early theories of Neptune" and "Neptune before Voyager", covering introductory and historical aspects. After a brief introduction, we read the fascinating story of Neptune's discovery. Several pre-discovery observations of Neptune, including one probable one by Galileo in 1612, are described. A few of the best Earth-based images of Neptune appear in the sixth chapter. Early attempts at determining Neptune's rotational period and the nature of its interior are also reported.

The seventh chapter, "The Voyager Mission", describes the Voyager-2 spacecraft. The reader is introduced to the different instruments on Voyager-2 which include scientific instruments and related equipment. The Deep Space Network is also described, with its modification made just before the Neptune encounter. The book describes some of the problems of the Voyager-2 spacecraft along with their solution. Hunt and Moore describe well both the engineering and scientific aspects of the Voyager-2 Neptune encounter.

The next five chapters describe our current understanding of the Neptune system. In the eighth chapter, "The Structure of Neptune", we discover that there are two models of Neptune's interior. The structure, temperature, dynamics and chemical composition of Neptune's atmosphere are treated in "The atmosphere of Neptune", along with the Great Dark Spot and several bright clouds. Chapter 10, "The Magnetosphere of Neptune", describes the magnetic field and magnetic interactions with the solar wind. The nature of Neptune's rings are the topic of "Rings of Neptune", while Chapter 12 summarizes our current understanding of Triton and the other satellites. The remaining two chapters, "Beyond Neptune" and "Farewell, Voyager 2", tell the story of Pluto's discovery and the fate of the Voyage- 2 spacecraft respectively.

Atlas of Neptune is well-written and well-illustrated, and I recommended it for those interested in Neptune or the engineering aspects of the Voyager-2 encounter with Neptune. Educators, wishing to show youngsters the appearances of Neptune and Triton, will also find this book and its large color photographs to be of great value.

ANNOUNCEMENTS

ASSOCIATION AFFAIRS

STAFF CHANGES.

As a result of the A.L.P.O. Board Meeting in July, 1995 (see pp. 184-185 of the previous issue) and more recent events, there are several staff changes to report:

Mercury Section.—Richard Baum is no longer in charge of the Mercury Section. The Executive Director welcomes hearing from members interested in working to make this Section active once again.

Lunar Section.—William Dembowski has been appointed as an Acting General Lunar Recorder. Mr. Dembowski will coordinate all lunar observations not made in connection with any of our existing lunar programs, as well as offer additional training in lunar observation to graduates of our regular Training Program.

Guido E. Santacana has been appointed as an Acting Assistant Lunar Recorder for the Dome Survey. He will handle most correspondence and report writing while Harry Jamieson continues to computerize the existing observations and clean up the dome catalog.

Meteors Section.—Mark Davis has been added to our Staff as an Acting Assistant Meteors Recorder. Mr. Davis will continue to serve the A.L.P.O. as our Solar System Ephemeris publishing and distribution person.

Computing Section.—David Weier has resigned from his post in the Computing Section due to a change in his job situation.

Mars Section.—Daniel Joyce has been appointed as an Acting Assistant Mars Recorder. Dan is now the editor of the Section newsletter, *The Martian Chronicle*. He also helped with the writing of the 1994-95 apparition report (in this issue).

Jupiter Section.—Jose Olivarez has resigned from his posts as a Jupiter Recorder and A.L.P.O. Associate Director. The A.L.P.O. Board of Directors has also voted to terminate his seat on that body. Mr. Olivarez remains as our Book Review Editor.

Phillip W. Budine has resigned from the A.L.P.O. Board of Directors, as the personal situation that caused him to resign as Director has not changed. Fortunately, Phil remains with us as an Assistant Jupiter Recorder in charge of central-meridian transit timings.

We are pleased to announce the appointment of Wynn Wacker as a provisional Jupiter Recorder and head of the Jupiter Section. Mr. Wacker, a long-time A.L.P.O. member and Jupiter observer, has written about Jupiter in *Astronomy* and the *Journal* of the A.L.P.O.

Dr. Sanjay S. Limaye, of the Space Sciences and Engineering Center of the University of Wisconsin-Madision, has agreed to be Scientific Advisor to the Jupiter Section. He has worked extensively on tracking the movements of cloud features in Jupiter's atmosphere, including work with Voyager images that revealed previously unknown jetstreams.

A.L.P.O. Publicist.—In addition to changes within our existing observing Sections, we are happy to announce the addition of Ken Poshedly to our staff. Mr. Poshedly's responsibilities will include working with our staff and members to publicize the A.L.P.O. in the major astronomy magazines and regular press. He has a degree in journalism and has worked in media relations and as a reporter for two Cleveland area newspapers.

New A.L.P.O. Committees.—Finally, we announce the formation of two committees of A.L.P.O. members. The first committee will focus on bringing young people into the organization, and we need your ideas on this topic. This committee could form the nucleus of a future Junior Section, such as exists in the British Astronomical Association.

The second committee of A.L.P.O. members will focus on ways to help get the A.L.P.O. Journal out on a more regular schedule, and could form the nucleus of a future Publications Section. Members interested in joining the youth committee should contact the Executive Director, while members wishing to join the Journal committee should contact the Editor.

A.L.P.O. 1996 Convention.—As this goes to press, the A.L.P.O. Program for our 1996 Convention is being finalized.

We are meeting with the Astronomical League at Rockford College in Rockford, Illinois, on July 25-27 (Thursday-Saturday). Besides amateur papers and exhibits, several professional astronomers will be speakers. Preregistration should be addressed to Astro-Con'96 c/o RAA, Inc., 6804 Alvina Rd., Rockford, IL 61101. The post-June 15 registration fee is $45 for the first person and $40 for each additional person. Tours will visit Yerkes Observatory (July 24 or 25; $10.00 per person), Astro-Physics (no fee; July 24 or 25), the Time Museum ($4.00; July 24, 25, or 26) and the Discovery Center ($3.00, July 26). The Friday Night Star-B-Q is $7.00 for each person, while the Saturday Evening Banquet is $18.00 per person (specify prime rib or orange roughy). Dormitory fees at Rockford College are $16.00 per night per person (double occupancy) plus a $6.00 linen fee. Meal tickets are $28.50 per person (Th. lunch and dinner; Fri-Sat. breakfast and lunch). The AL Convention Proceedings are $7.00 (the A.L.P.O. will also publish its own Proceedings).

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.

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

Gregory L. Bohemier
RR2 Box 1306
Canton, MO 63435
Instrumentation and Equipment Selection

Bill Dembowski
219 Old Bedford Pike
Windber, PA 15963
Lunar Photography

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

Harry D. Jamieson
P.O. Box 16882
Memphis, TN 38186-0882
Lunar; Instrumentation and Equip. Select.; Software—Astron. Programming

Andrew Paul Johnson
1 York Lane, Knaresborough, North Yorkshire
United Kingdom HG5 0AJ
Lunar

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

Robert D. Lunsford
161 Vance Street
Chula Vista, CA 91910
Meteors

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

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

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

Fred Pilcher
Illinois College,
Jacksonville, IL 62650
Minor Planets

Zac Pujic
23 Attungan St.
Kingston 4114
Queensland, Australia
Drawing Skills

Timothy J. Robertson
2010 Hillgate Way, Apt. L
Simi Valley, CA 93065
Lunar; Comets; Jupiter

John Sanford
2195 Raleigh Avenue
Costa Mesa, CA 92627-2940
CCD images; Photography

Andrew M. Sorenson
RR 4, Box 4A
Jefferson, IA 50129-9701
Drawing Skills

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

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

Matthew Will
2112 Austin Drive
Springfield, IL 62704
Mars; Saturn

PUBLICATIONS OF THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS

(All Section Publications on p. 48 must be ordered directly from the appropriate Recorders.)
(Checks must be in U.S. funds, payable to an American bank with bank routing number.)

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Order from: Mark A. Davis, 7304 Doar Rd. Awendaw, SC 29429 USA

The A.L.P.O. Solar System Ephemeris: 1996. $8.00 in the United States, Canada, and Mexico; $10.00 elsewhere (airmail included). Contains 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, 1996.

◆◆

Order from: A.L.P.O. Membership Secretary, P.O. Box 16882, Memphis, TN 38186-0882, U.S.A:

① ***A.L.P.O. Section Directory—1995.*** *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 North America; $6.00 elsewhere. Continuously-updated list of members on MS-DOS diskette; specify 3.5-in or 5.25-in disk and whether DBASE or ASCII format. Make payment to "A.L.P.O." *Provided at the discretion of the Membership Secretary.*

◆◆

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. ***7*** (1953); 2, 3, 4, 5, 7, and 8. ***8*** (1954); 3-4, 5-6, and 7-8. ***9*** (1955); 1-2.
10 (1956); 5-6, 9-10, and 11-12. ***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, and 11-12.
26 (1976-77); 3-4, 5-6, and 11-12 [each $1.75]. ***27*** (1977-79); 3-4, and 7-8 [each $1.75].
31 (1985-86); 5-6 and 9-10 [each $2.50]. ***32*** (1987-88); 5-6 [each $2.50].
33 (1989); 4-6, 7-9, and 10-12 [each $2.50]. ***34*** (1990); 2 and 4 [each $2.50].
35 (1991); 3 [$2.50]. ***37*** (1993); 1, 2, 3, and 4 [each $2.50].
38 (1994-); 1, 2, 3, and 4 [each $2.50]. ***Current Issue*** [***39,*** 1]—$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., "39.1" means Vol. 39, No.1). 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, although we do not wish material that has been published or submitted elsewhere. Please submit double-spaced copy, either typewritten or printed; MS-DOS or Macintosh 3.5-inch diskette text (ASCII) files are very helpful as well. Gray-scale graphics may also be sent on disk, but should be uncompressed and in a common format such as TIFF, GIF, or PICT. 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, exaggerate contrasts on drawings, photographs, and CCD images. Be sure to indicate the direction of 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.

Publications of the Sections of the A.L.P.O.

Order the following directly from the appropriate Section and person; use the address on the inside back cover unless another address is given below.

Venus (Benton): (1) *The ALPO Venus Observing Kit*, $17.50. Includes introductory description of ALPO Venus observing programs for beginners, a full set of observing forms, and a copy of *The Venus Handbook.* **(2)** *Observing Forms Packet,*, $10.00. Includes observing forms to replace the quantity provided in the Observing Kit above. Specify the *Venus Forms. (To order the above, send a check or money order made out to "Julius L. Benton, Jr." All foreign orders should include $5.00 additional for postage and handling; for domestic orders, these are included in the prices above. Shipment will be made in two to three weeks under normal circumstances. NOTE: Observers who wish to make copies of observing forms have the option of sending a SASE for a copy of forms available for each program. Authorization to duplicate forms is given only for the purpose of recording and submitting observations to the A.L.P.O. Venus, Saturn, or Lunar SAP Section. Observers should make copies using high-quality paper.)*

Mars (Troiani): (1) *Martian Chronicle*; send 8-10 SASE's; published approximately monthly during each apparition. **(2)** *Observing Forms*; send SASE to obtain one form which you can copy; otherwise send $3.60 to obtain 25 copies (make checks out to "J.D. Beish").

Mars (Astronomical League Sales, 1901 South 10th St., Burlington, IA 52601): *ALPO's Mars Observer Handbook*, $9.00.

Jupiter (Westfall): *Timing the Eclipses of Jupiter's Galilean Satellites*; send a SASE with 55 cents in stamps. This is the project "Observing Kit" and includes a report form.

Saturn (Benton): (1) *The ALPO Saturn Observing Kit*, $20.00. Includes introductory description of ALPO Saturn observing programs for beginners, a full set of observing forms, and a copy of *The Saturn Handbook.* **(2)** *Observing Forms Packet*, $10.00. Includes observing forms to replace the quantity provided in the Observing Kit above. Specify the Saturn Forms. *(See note for Venus.)*

Solar (Maxson): (1) *Solar Rotation Reports*; send SASE's to receive this monthly newsletter. **(2)** *ALPO Solar Section Catalog of Data Vol. II*, $5.00. A list of over 6000 solar observations, observer profiles and Section history in the Solar Section available to aid in professional or amateur research. The first printing was in March, 1991; a second printing is based on demand.

Solar (Graham): *Solar and Lunar Eclipse Observations 1943-1993*; $25.00 postpaid. (A *Handbook for Solar Eclipses* is under preparation.)

Lunar (Benton): (1) *The ALPO Lunar Section's Selected Areas Program (SAP)*, $17.50. Includes a full set of observing forms for the assigned or chosen lunar area or feature, together with a copy of the *Lunar Selected Areas Program Manual.* **(2)** *Observing Forms Packet*, $10.00. Includes observing forms to replace the quantity provided in the Observing Kit above. Specify the *Lunar* Forms. *(See note for Venus.)*

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