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Clyde W. Tombaugh (1906-1997) making a point (and very likely a pun) as Banquet Speaker at the 1993 A.L.P.O. Convention in Las Cruces, New Mexico. Dr. Tombaugh, best known as the discoverer of the planet Pluto in 1930, always maintained strong ties with amateur astronomy and was a charter member of the Association of Lunar and Planetary Observers. We regret that he will not be joining us at our Fiftieth Anniversary Convention in Las Cruces, June 25-29, 1997.

THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS
Editor, John E. Westfall

Director and Membership Secretary,
Harry D. Jamieson
P.O. Box 171302
Memphis, TN 38187-1302

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In This Issue

A COLLISION IN THE SOLAR SYSTEM: THE IMPACT OF COMET SHOEMAKER-LEVY 9 WITH THE PLANET JUPITER

By: Carlos E. Hernandez, Phillip W. Budine, Donald C. Parker, and Jeffrey D. Beish

ABSTRACT

During the week of 1994 JUL 16-22, the planet Jupiter was impacted by the fragments of Comet Shoemaker-Levy 9. This report summarizes the discovery of the comet, the realization that it would impact Jupiter, and the observations of the impact and post-impact events and features as reported by amateur observers in the A.L.P.O. and cooperating organizations.

In July, 1994 humanity witnessed a cataclysmic event when the fragments of a rogue comet, Comet Shoemaker-Levy 9, impacted the planet Jupiter over a period of nearly six days. Members of the Association of Lunar and Planetary Observers (A.L.P.O.), among many other amateur and professional astronomers worldwide, witnessed this rare event and recorded it for posterity. The following is a summary of the impact event witnessed by A.L.P.O. members and contributing observers.

A CELESTIAL ENCOUNTER

News services around the world reported that Comet Shoemaker-Levy 9, or specifically fragment A (21), had produced an impact debris ring the size of planet Earth (12,756 km diameter) upon the Southern Hemisphere of the planet Jupiter on 1994 JUL 16. This impact of the first fragment of Comet Shoemaker-Levy 9 marked the beginning of a remarkable period of nearly six days of similar impacts which left an indelible mark upon the memory of humanity. The Comet Shoemaker-Levy 9 impact sites, or "scars", were so prominent as to be visible with instruments as small as 2 inches aperture. Amateur and professional astronomers everywhere, used to observing the normally pastel banded atmosphere of the planet Jupiter, now were witnessing a scar-laden Southern Hemisphere. This series of events all began with the discovery of a fragmented comet in March, 1993 atop Palomar Mountain.

A SHATTERED COMET

David H. Levy, noted comet discoverer and author, and his colleagues, Carolyn and Eugene Shoemaker, well-known astronomers of the United States Geological Survey (U.S.G.S.), were not having much luck during the first few months of 1993 in their search for near-Earth asteroids and comets, a search program initiated by Eugene Shoemaker and Eleanor Helin (JPL) in 1973. The weather had been so poor that they observed only one hour of one night during the January, 1993 observing run of seven days! They were hoping that the March, 1993 observing session would be different; they were in for a large surprise. Using the 18-in (0.46-m) Schmidt telescope on Palomar Mountain, made famous by American astronomer Fritz Zwicky (1898-1974) in his study of supernovae and other exotic objects in the universe, the observing team, joined at this time by visiting French astronomer Philippe Bendjoya, began the March, 1993 observing session with high hopes. Unfortunately, some film sheets had been inadvertently exposed to light since their last observing session the month before. After they photographed for two nights, the weather changed dramatically, becoming cloudy with intermittent thunderstorms, effectively ending the session. Carolyn Shoemaker, the most prolific comet hunter to date with 31 discoveries to her credit, then proceeded to examine the exposed plates with a stereomicroscope on March 25th. Reviewing an exposed plate of the Beta Virginis region, which included brilliant Jupiter in the field, she noted an odd-looking object in the field that appeared to be, in her words, "a squashed comet." Eugene Shoemaker and David Levy reviewed the unusual comet themselves and obtained confirmation, with the help of James V. Scotti (University of Arizona Observatories) using the 36-in (0.91-m) Spacewatch telescope at Kitt Peak National Observatory (KPNO) in Arizona. Their discovery was then announced to the world, in *Circular 5725* of the International Astronomical Union (IAU), on March 26, 1993 as Comet Shoemaker-Levy 9 (1993e) by Brian Marsden of the Central Bureau for Astronomical Telegrams (CBAT) in Cambridge, Massachusetts, a clearinghouse for astronomical discoveries established by the International Astronomical Union (IAU) (see *Figure 1*, p. 98).

A STRING OF PEARLS

Shortly after its discovery, Comet Shoemaker-Levy 9, also known as S-L9 and Comet P/1993e, was found by the Hubble Space Telescope (HST) on 1993 JUL 01 to consist of 21 fragments. It now appears, from theoretical models, that the comet passed within 1.3 Jovian radii of Jupiter's center, or just 13,300 mi (21,400 km) above its cloud tops, on 1992 JUL 07, when it was broken into multiple fragments by enormous tidal forces. Depending whether the comet was disrupted at perijove,

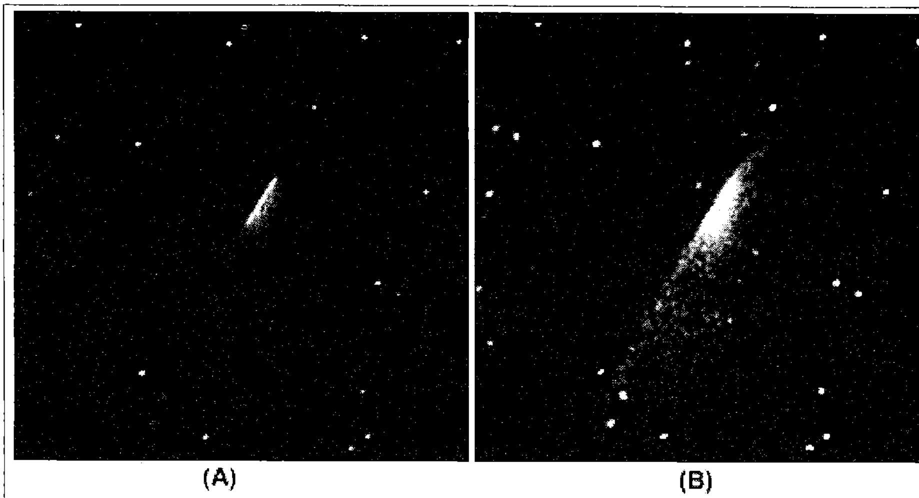


Figure 1. CCD image of the newly discovered shattered comet Shoemaker-Levy 9 (S-L9 or 1993e). Taken by noted astroimager Jack Newton of Vancouver, British Columbia on 1993 MAR 28; 25-inch (64-cm) f/5 Newtonian reflector, SBIG ST-6 CCD camera, 5-min exposure. The image on the left (a) of the comet displays 11 nuclei, later shown by the Hubble Space Telescope (HST) to total at least 21. The image on the right (b) has been enhanced to show the individual nuclei's dust tails and wings.

its closest to Jupiter, or some time afterward, the progenitor comet may have measured either 5.6 miles (9 km), with fragments between 1.2-2.5 mi (2-4 km); or 1.2 mi (2 km), with fragments between 0.3-0.6 mi (0.5-1.0 km) in diameter, respectively. The comet then entered a highly elliptical (e≥0.99) jovicentric orbit that would ultimately take it as far as approximately 30 million mi (48 million km) at apojove, or farthest from Jupiter, on 1993 JUL 16; or slightly less than the mean distance of the planet Mercury from the Sun (36 million mi or 58 million km). It appears from current theoretical models that the comet was captured by the planet Jupiter before 1960 and most likely between 1920-1930; it appears fitting that Carolyn Shoemaker was born in 1929. The Jet Propulsion Laboratory (JPL) team of Donald K. Yeomans, Paul W. Chodas, and Zdenek Sekanina designated the S-L9 fragments with letters, A through W excluding I and O (which could be confused with the numbers 0 and 1), in order of predicted impact times: S-L9 fragment A was closest to Jupiter whereas fragment W was farthest. David Jewitt (University of Hawaii) numbered the fragments 1 through 21, but with number 1 being farthest from the planet Jupiter and 21 the closest to it. The comet train, or aligned fragments, was initially 50 arc-seconds (106,000 mi or 170,000 km) in length at the time of discovery (March, 1993) increasing to approximately 360 arc-seconds (approximately 1-2 million mi or 1.6-3.2 million km) by late-April to mid-May, 1994 and finally reaching nearly 900 arc-seconds (5 million mi or 8 million km) just prior to the impacts (mid-July, 1994). As the fragments of Comet Shoemaker-Levy 9 hurled through space towards their encounter with Jupiter in July, 1994 astronomers on Earth were preparing for the event.

PREPARING FOR THE EVENT

After the excitement of discovering that this unusual comet would crash into the planet Jupiter in mid-July, 1994, which was announced in *IAU Circular 5800* on May 22, 1993, both the amateur and professional astronomical communities began preparing for this spectacular event. Astronomers around the world monitored the comet (S-L9) prior to the impacts in July, 1994, including a team established by Stephen M. Larson and James V. Scotti (University of Arizona Observatories) designated the Comet-Impact Network Experiment (CINE). This group used professional instruments of various apertures, 36 to 157 in (0.9 to 4 m), specially fitted with coronograph-type apertures to block out the disc of Jupiter in order to follow the comet fragments as close to the limb of the planet as possible. Planetary astronomers John Spencer (Lowell Observatory) and John Rayner (University of Hawaii) used NASA's 118-in (3-m) Infrared Telescope Facility at Mauna Kea, Hawaii to study the planet Jupiter at thermal-infrared wavelengths (5 microns), that allows deeper penetration into the Jovian atmosphere, to later compare with their observations after the impact of the S-L9 fragments for any significant changes (refer to "Jupiter's Warm Glow" in the May, 1994 issue of *Sky & Telescope*, p.11). The University of Maryland, under the guidance of Dr. Michael F. A'Hearn and Dr. Lucy A. McFadden, established a special electronic messaging (e-mail) system dubbed "exploder" that would instantaneously distribute highlights of each researcher's observations to hundreds of others worldwide (this later proved to be crucial for warning of unexpected events to monitor at observatories in more favorable locales worldwide). Respected amateur astronomical organizations worldwide such as the Association of Lunar and Planetary Observers (A.L.P.O.), the British Astronomical Association (BAA), and the Oriental Astronomical Association (OAA) prepared their members for the event in order to maximize the data obtained. Both amateur and professional astronomers readied for the event with high hopes of being able to witness at least a minor change in the Jovian atmosphere from the impacts. Comet Shoemaker-Levy 9 and the planet Jupiter did not let them down.

Eighty-four A.L.P.O. observers submitted observations of the S-L9 impact events, and have previously been listed (Budine, 1996).

THE FIRST IMPACT (1994 JUL 16)

Anticipation of the upcoming impacts of the Comet Shoemaker-Levy 9 fragments with the planet Jupiter was felt throughout the world as depicted in media broadcasts of documentaries, interviews, and special events held in honor of the impacts. The media had gathered at the unofficial center for the event, the Space Telescope Science Institute (STScI) in Baltimore, Maryland, where the images from the Hubble Space Telescope (HST) would ultimately be downloaded. Impact fever was in the air! The first fragment was predicted to impact the farside of Jupiter, approximately 10° behind the terminator as seen from the Earth, at approximately 19h55m UT (3:55 P.M. EDT). Telescopes throughout the world had been trained upon the king of the planets who was about to give humanity a royal show.

Amateur and professional astronomers around the world had been preparing for this once-in-a-lifetime event by monitoring the planet Jupiter months before the predicted impact of the S-L9 fragments. Co-authors Beish and Hernandez had honed their eyes to the nuances of faint ovals in the higher latitudes and deep blue festoons near the equator, while their colleague, Parker, had imaged the planet extensively with his telescope and CCD camera in order to be able to later compare the impact zone before and after the impacts for any changes. Near the jovicentric (measured from Jupiter's center) latitude of the impacts, about 45° south, or approximately at the South South Temperate Belt (SSTB) alone there were 23 ovals of various sizes that had been measured by this team along with then A.L.P.O. Jupiter Recorder Phillip W. Budine, now Assistant Coordinator. This was accomplished in order to later avoid confusion between a "new impact site" and an oval that had been there previously; it was believed by the majority of scientists that the S-L9 impact sites would appear as small, white ovals similar to the ones that normally inhabit the impact zone. It was thought, according to data available at that time, that the early impacts (S-L9 fragments A [21] through E [17]) would probably not produce any significant activity, and none would be seen, until the mid-portion of the impact period (G [15] or Q [7a and 7b]), but this prediction was luckily proven wrong.

Saturday the 16th of July, 1994 began like any other hot, muggy day in South Florida. Beish and Hernandez had been practicing finding the planet Jupiter in the daytime sky for some time before the impact event since the first impact, S-L9 fragment A (21), had been predicted to impact at 19h55m UT (3:55 P.M. EDT) and they wanted to be prepared. Beish had opened up his 16-in (0.41-m) f/7 Newtonian reflector in order to let it cool off. Shortly after 4:00 P.M. EDT (20h00m UT) he found the planet Jupiter in his finder and then proceeded to center it in his field of view. The image was wavering a great deal due to the time of observation and the heat. Beish spotted a faint, black smudge over the right (following) half of the planet at the approximate latitude of the impact (45° S) at approximately 5:00 P.M. EDT (21h00m UT), but he dismissed it as dirt on his eyepiece lens (see *Figure 2*, below; it must be noted that a white, not a dark, oval-shaped feature had been predicted prior to the impacts). Beish later had to reverse the telescope to the other side of the pier as Jupiter crossed the meridian, due to the German equatorial mounting. The atmosphere began to steady at approximately 7:00 P.M. EDT (23h00m UT), when Beish recovered the

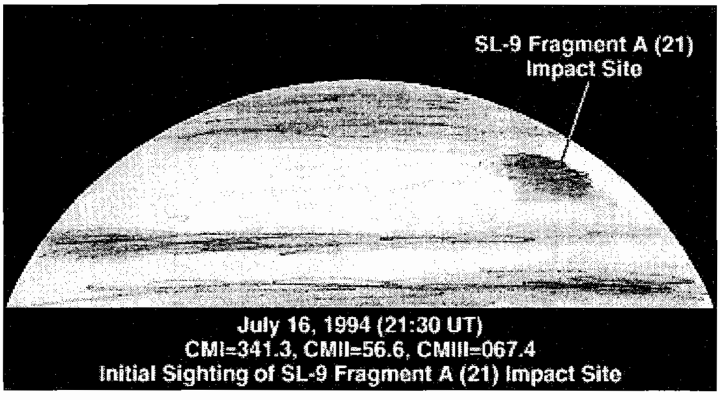


Figure 2. Sectional sketch of Jupiter's Southern Hemisphere by Jeffrey D. Beish. 1994 JUL 16, 21h30m UT (CMII=056.6, CMIII=067.4). 16-in (41-cm) f/6.9 Newtonian; 225X, 360X. The approximately 1.3 hours-old, S-L9 fragment A (21) impact site is visible towards the f. limb as a dark, elliptical albedo feature comprising both the impact site and resultant impact debris ejecta, oriented toward the direction of the incoming fragment (Sf. or southeast). CBAT credited Beish as the first observer, amateur or professional, to report the fragment A impact site. South is at the top in this and subsequent figures.

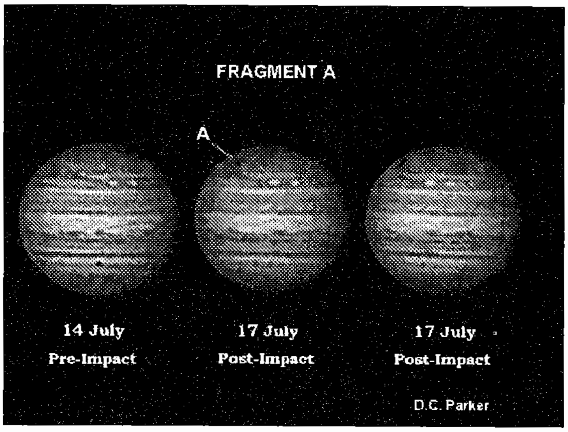


Figure 3. A composite of CCD images by Donald C. Parker prior to and after the impact of S-L9 fragment A; 16-in (41-cm) f/6 Newtonian, SpectraSource Lynxx CCD camera. **Left:** 1994 JUL 14 (two days prior to fragment A's impact), 02h22m UT (CMI=045°.9, CMII=142°.6, CMIII=212°.4). Note the appearance of the Southern Hemisphere (top), particularly the area between the South Polar Region (SPR) and the South South Temperate Belt (SSTB, especially preceding the small, bright oval located along its northern border just past the central meridian (CM). **Center**: The first amateur image of the A (21) impact site, 1994 JUL 17, 00h11m UT (CMI=079°.4, CMII=153°.9, CMIII=224°.5), showing the approximately 4 hour-old, S-L9 fragment A (21) impact site as a dark, elongated albedo feature towards the p. limb just south of the SSTB and preceding the small, bright oval previously described within it. A dark fan of material is visible Sp. the A impact site; which on HST images proved to be the impact debris ejecta. **Right:** 1994 JUL 17, 00h33m UT (CMI=092°.8, CMII=167°.2, CMIII=237°.8), showing the S-L9 fragment A impact site nearly on the p. limb.

black smudge over the southern half of Jupiter, but by this time it was past the central meridian. He continued to observe it for some time until it finally struck him that this was the impact site produced by the first S-L9 fragment, A or 21, when he shouted "jumping Jupiter, I see it, I see it! The impact has left a great hole in the clouds of Jupiter!" His daughter, Natalie Kay, was nearby and she proceeded to look in the field of view and described what she saw to her father, as she had done countless times before, "I see a dark smudge in the bright region of Jupiter just above one of the southern belts." Beish's observing partner, Carlos E. Hernandez (an A.L.P.O Assistant Jupiter Coordinator), had by then come out of the house as he had been cooling off from the summer heat and began to study the image before him. Hernandez then stated "I've never seen anything like this on Jupiter before, especially over the Southern Hemisphere! This has to be the impact site of S-L9 fragment A (21)!" In the excitement Hernandez nearly fell off the high observing platform and thus almost produced his own impact zone on the ground below. Beish's wife, June, was now called to share in the excitement of this historic moment and viewed the impact site herself as well (See *Figure 5*, p. 102, top sectional sketch).

Beish and Hernandez immediately contacted their observing partner Donald C. Parker, who then proceeded to image Jupiter with his telescope, a 16-in (0.41-m) f/6 Newtonian reflector, and CCD camera, a Lynxx PC CCD camera by SpectraSource Instruments (see *Figure* 3, to left). Phillip W. Budine (then A.L.P.O. Jupiter Recorder) was also notified and also confirmed the sighting. Beish and Hernandez immediately contacted Dr. Brian Marsden at CBAT to let him know that the site had been observed by the South Florida group. At no time did Beish or Hernandez believe that they were the first ones to have reported the impact site as it was assumed that some major observatory in Europe, or most probably the HST, had beaten them to the punch. To their surprise Dr. Marsden called back shortly and informed Beish that he was officially the first observer in the world to have reported the A impact site (see *Figure* 4, p. 101, top sketch). Although the Hubble Space Telescope (HST) had imaged the plume, as well as the impact site, of S-L9 fragment A (21) shortly after it impacted (20h13m UT, 4:13 P.M. EDT), as well as a team led by Tom Herbst [Max-Planck-Institut fur Astronomie] who reported detecting the plume at 20h18m UT at 2.3-microns in the infrared, using the 3.5-m [138-in] reflector at Calar Alto Observatory in southern Spain, the HST was unable to download its images until later that night. However, astronomical discoveries are credited by CBAT only by visual confirmation of an image and order of reporting (eg., the planet Pluto had been imaged and observed on various occasions prior to its official discovery in 1930). It is rumored that a goldfish experiment aboard the shuttle prevented the HST's download of its images and if this is true then Beish and Hernandez will forever love goldfish!

Meanwhile, the media had gathered at the Space Telescope Science Institute (STScI) in Baltimore, Maryland, to inform the world of the Hubble Space Telescope's (HST) view of the first, and subsequent, impact earlier that afternoon. The comet discoverers, Eugene and Carolyn Shoemaker and David H. Levy, had been sobering the crowd gathered there for this spectacular event by informing them that we might see little, if any, effect on the atmosphere of Jupiter by the comet fragments. They were happily proven wrong! The crowd was gathered in an auditorium in a subdued, but anxious, atmosphere when Heidi B. Hammel (MIT), a member of the blue-ribbon Hubble Space Telescope Comet Team (HSTCT), suddenly rushed in with a near-infrared image

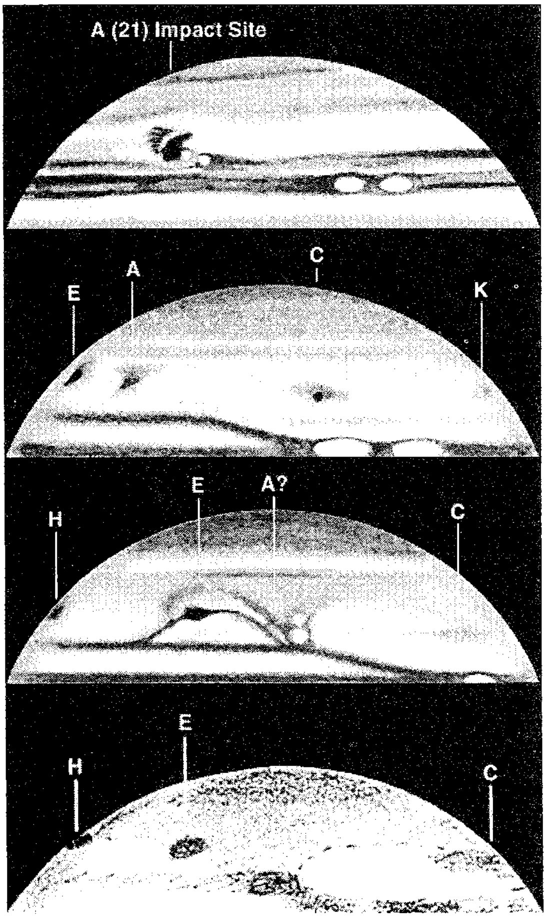


Figure 4. Sectional sketches of Jupiter's southern hemisphere showing the evolution of the S-L9 fragment A (21) impact site. **Top:** The discovery observation of the S-L9 fragment A impact site, 1994 JUL 16, 23h35m UT (CMII=132°.6, CMIII=202°.7) by Jeffrey D. Beish, 16-in (41-cm) f/6.9 Newtonian, 225X ,382X (Wratten 25, 30, 57, 64, 80A, 47 filters). The S-L9 fragment A impact site,within the South South Temperate Zone (SSTZ), appears dark (1-2/10) and "comma-shaped" with a dark ray system visible Sp. the impact site. Two small, bright (8-9/10) ovals are visible f. the A impact site within the South South Temperate Belt (SSTB). Note the indentation (southward) along the northern border of the South South South Temperate Belt (SSSTB). **Second:** Sketch by Carlos E. Hernandez, 1994 JUL 19 (3 days after impact), 01h25m UT (CMII=139°.4, CMIII=210°.0), 16-in (41-cm) f/6.9 Newtonian, 360X (Integrated light), showing the S-L9 fragment A impact site towards the preceding limb as a dark (3/10), biconvex-shaped (especially towards the south) albedo feature with a very dark (1-2/10) nucleus. In only 3 days it has diminished in overall intensity (compare to top image). The S-L9 fragment E (17) impact site is visible adjacent to the preceding limb as a very dark (1-2/10) elongated nucleus with a dark (3-4/10) "fan-shaped" system toward the south. The S-L9 fragment C (19) impact site is visible just following the central meridian (CM) and appears as a dark (3/10), elliptical (elongated east-west) albedo feature with a very dark (1-2/10) nucleus. The S-L9 fragment K (12) impact site appears as a dark (3/10) nodule on the f. limb. **Third:** sectional sketch by Carlos E. Hernandez, 1994 JUL 31, 00h20m UT (CMII=101°.6, CMIII=175°.4), 16-in(41-cm) f/6.9 Newtonian, 382X (Integrated light). The S-L9 fragment A impact site is not clearly visible in this image on the CM but now appears as a dark (3/10) streak extending in a Sp. to Nf. direction. Two very bright (8/10) ovals are visible following the A impact site. The S-L9 fragment E impact site is visible preceding the A impact site as a very dark (1-2/10), elongated albedo feature with projections noted from it's p. and f. borders (the following projection appears to connect to the A impact site). A dark to dusky (3-4/10) curvilinear albedo feature is visible Sp. the E impact site (possibly comprised of the E impact explosion debris ejecta material). The S-L9 fragment H (14) impact site is visible on the preceding limb as a dark (3/10) nodule. The S-L9 fragment C impact site is visible towards the following limb as a dusky (4/10), elongated albedo feature without a dark nucleus. **Bottom:** Sketch by John H. Rogers (BAA Jupiter Section Recorder), 1994 AUG 05, 19h33m UT (CMII=108°.3, CMIII=184°.2), 12-in (30-cm) Northumberland Refractor, 230X (polarizer employed). The A impact site is no longer visible as all that remains is a dark patch within the SSTB, timed at 104°.0 (SII). The E impact site is visible past the CM as a dark, elongated albedo feature. The H impact site is visible on the preceding limb as a dark nodule. The long-lived South South Temperate Zone (SSTZ) is visible following the CM as a bright, elongated albedo feature. The S-L9 fragment C impact site is visible on the following limb as a dusky, elongated albedo feature.

from the Hubble Space Telescope showing the S-L9 fragment A (21) impact site that had just rotated into view from the backside on the following limb. The comet had delivered and the crowd shouted with glee, especially the comet discoverers. Champagne corks flew across the room as history was made across the chasm of space on the king of the planets. Not since Neil Armstrong and Edwin "Buzz" Aldrin stepped upon the lunar surface twenty-five years earlier had the human race celebrated such a spectacle!

EVOLUTION OF THE IMPACT SITES (1994 JUL 16-SEP 18)

Mankind had just witnessed the death of an object, or rather its fragments, that may have originated shortly after the birth of the solar system. An incredible amount of energy was released by the impact of S-L9 fragment A (21), as well as by the other fragments, which affected the surrounding Jovian atmosphere. We detected different compounds re-

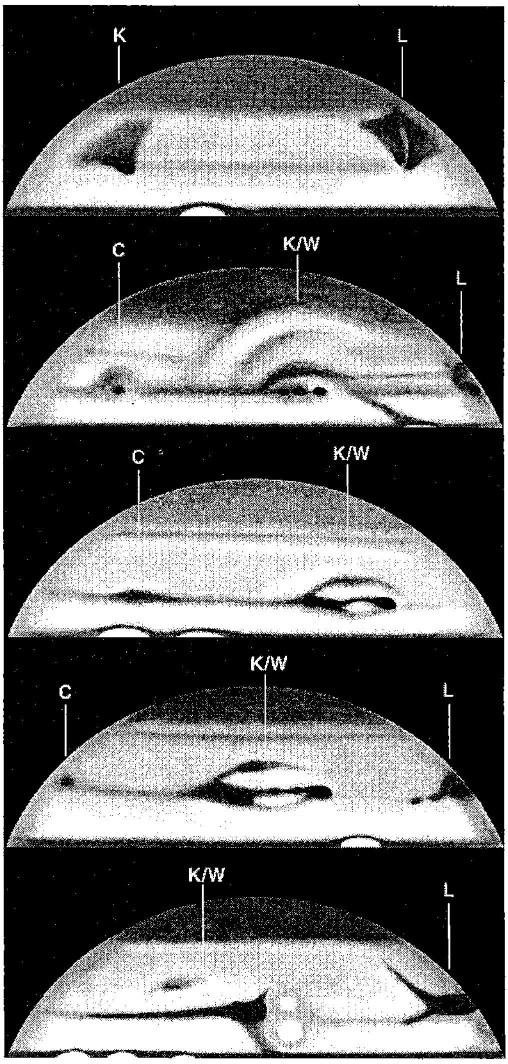


Figure 5. Five sectional sketches of Jupiter's Southern Hemisphere showing the development of S-L9 fragment site C (19), the K (12)/W (1) impact site complex and the L (11) impact site between 1994 JUL 19-AUG 17, drawn by Carlos E. Hernandez with a 16-in (41-cm) Newtonian, except for the last sketch with an 8-in (20-cm) f/7.5 Newtonian. All views are in integrated light (no filter). **One:** 1994 JUL 19, 23h53m UT (CMII=233°.4, CMIII= 304°.8, 382X . The 13.5 hour-old K impact site is visible toward the p. limb, consisting of a very dark (1-2/10) "tear drop-shaped" condensation (the actual impact site) with a dark (3/10) ray system Sp. the impact site. The 37 minute-old S-L9 fragment L impact site is on the f. limb and appears asf bi-lobed, very dark (1-2/10) nuclei (not reported by other observers) with prominent ray systems emanating from their Sp. and f. borders with a bright (7/10) strip separating the two components (this appearance may be due to the perspective of the impact site and/or mediocre seeing conditions, i.e. 3-4/10). The long-enduring oval FA is visible within the STB just p. the CM (timed at 238°.8 [SII] or 309°.7 [SIII]). **Two:** 1994 JUL 22, 00h10m UT (CMII= 184°.5, CMIII=255°.9), 360X and 382X. This sketch shows the S-L9 fragment C impact site toward the p. limb appearing to consist of a very dark (1-2/10), slightly elliptical condensation with a dark to dusky (3-4/10) semicircular arc south of the impact site. The K impact site, f. the CM along the SSTB, appears to consist of three very dark (1-2/10) condensations connected by thin, very dark (1-2/10) bridges. A dark (3/10), semicircular arc is visible Sp. the K impact site. South of this arc is a larger, duskier (4-5/10) arc extending above the SSTZ and SSSTZ. Part of a dusky (4/10) arc is p. the CM projecting north from the South Polar Region (SPR) which itself appears indented along its northern border to the south of the K impact site. This series of arcs may be a combination of the K impact ejecta and seismic waves produced by the impact (this appearance was confirmed by two other experienced observers at the same site, but by no other observers elsewhere). The large, very dark to dark (1-3/10) L impact site is visible on the f. limb. **Three :** 1994 July 24, 01h55m UT (CMII= 188°.2, CMIII=260°.1), 382X. The C impact site, toward the p. limb, has faded significantly since the previous sketch and now appears as a dark (3/10), elongated albedo feature without an arc to the south. The K/W impact site complex is visible f. the CM and now has the appearance of a "scorpion"; the body of the scorpion is formed by the very dark (1-2/10) impact sites which have merged (a dusky [4/10] bridge is above the STZ between the f. sections of the body) and the tail consisting of the impact ejecta south of the impact site complex. The long-enduring ovals BC and DE are visible p. the CM within the STB. **Four:** 1994 July 27, 00h00m UT (CMII=209°.1, CMIII=281°.8), 382X . It shows the much faded (3-4/10) C impact site on the f. limb f. by the prominent K/W impact site complex on the CM now appearing more like a "scorpion" (compare to the sketch above) but now extending 30° in longitude (184°.9-213°.9 [SI] or 258°.1-287°.1 [SIII]), or 36,000 km across! The L impact site is visible on the f. limb with a small, dark (3/10) condensation p. it (timed at 245°.3 [SII] or 318°.6 [SIII]). **Five:** 1994 AUG 17, 02h00m UT (CMII=193°.6, CMIII=272°.0) at 213X . The very dark to dark (2-3/10), elongated K/W impact site complex is visible extending from the CM to nearly the p. limb! A "spike-like" projection extends from its Sf. border. A dark (3/10), curvilinear column extends from its Nf. border, appearing to connect with the STB. The remnant of its ejecta (the "scorpion's tail"of the previous sketch) is visible south of the center of the complex over the SSTZ. Two large, bright (8-9/10) ovals are visible f. the complex (largest oval above STZ and the smaller above the SSTZ). The L impact site is shown on the f. limb as a very dark to dark (2-3/10) rectangular albedo feature with dark (3/10) projections extending from its Sp. and Np. borders.

sulting from the impacts representing the comet (S-L9) and Jupiter itself. The dark bands and light zones on Jupiter represent alternating zonal, or jet, currents similar to those on Earth (such as the jet stream), but of much greater magnitude. For example, Jupiter's Great Equatorial Current was measured by the Voyager spacecraft to flow eastward at over 380 mi/h (611 km/h). By monitoring the eastward and westward flow of the S-L9 impact debris we could learn a great deal about the zonal currents at the latitude of the impacts (45°S). Therefore even after their destruction the fragments would help us answer questions about the dynamics of Jupiter's atmosphere, including the microcirculation patterns of the upper Jovian atmosphere at mid-temperate latitudes.

Although it appears logical to describe the evolution of the impact sites (complexes) in alphabetical order, Comet Shoemaker-Levy 9 (S-L9) appears to have been truant from school as its fragments impacted the planet Jupiter out of sequence, causing much confusion to observers monitoring the events back on the Earth. The evolution of the impact sites (complexes) will instead be described, starting with the first impact site (A or 21), according to increasing Jovian longitude (westward), using the rotation systems encompassing the impacts (System II [SII], rotating with a period of 9 h 55 m 40.632 s; and System III [SIII], the Jovian magnetic field rotation period of 9 h 55 m 29.711 s). Although many additional observers contributed useful observations of the various impact sites (complexes) throughout the impact period (1994 JUL 16-22) and afterward, Figures 4-10 (pp. 101, 102, 104, 106-109) are used to show the development of these sites over approximately a two-month period (JUL 16-SEP 18, 1994).

This selection of sectional sketches summarizes the appearance of the minor and major S-L9 fragment impact sites (complexes), but what about the S-L9 fragments that failed to produce impact sites?

THE MISSING FRAGMENTS (B, F, P2, T, U, AND V)

Shortly after Beish, his family, and Hernandez finished celebrating their discovery of the S-L9 fragment A (21) impact site on 1994 JUL 16, they then prepared to await the impact of S-L9 fragment B (20) later that night, calculated to impact at 02h53m UT on 1994 JUL 17 (UT). Beish was the first to recover, on the following limb, what he believed to be the expected impact site at 03h35m UT on 1994 JUL 17, 1994, 42 minutes after the calculated impact time, and he then proceeded to make a drawing of his observation of the supposed site, which consisted of a very dark (1-2 on the A.L.P.O. Scale, where 0 is black and 10 is the brightest possible), elongated albedo feature preceded by a dark (3/10) semicircle. Beish did not discuss his observation with Hernandez until the latter made his own observation as standard procedure. Thus Hernandez shortly afterward, at 03h50m UT, made his own observation of the supposed B impact site and recorded it (see Figure 11, p. 109). They both recorded, independently of one another, what appeared to be a dark (2-3/10), elongated albedo feature adjacent to the following limb, representing the supposed B impact site, surrounded by a dark to dusky (3-4/10) semicircular ring, possibly representing ejecta material (debris) or less likely a shock wave. Members of the Pomona Valley Amateur Astronomers, an amateur astronomer group in southern California, reported detecting a "dark impact scar" shortly after the calculated impact time of fragment B while using the venerable 100-in (2.54-m) Hooker reflector (refer to "The Scarlet Belt", January, 1995 issue of *Sky & Telescope*, p.104). Members of the Berks County Amateur Amateur Astronomical Society, located in Pennsylvania, even reported a flash reflected from the Galilean satellite Io (I) at approximately 03h07m UT, about 14 minutes after the calculated impact (refer to "The Great Dark Spots", November, 1994 issue of *Sky & Telescope*, p.30).

Why did only a few individuals report a phenomenon, impact scar or flash, while the majority of observers, as well as the HST and most major observatories failed to detect the B impact? (A significant exception was the 10-meter Keck reflector, detecting a plume between 3.27-3.44 microns wavelength shortly after the calculated impact time.) This is certainly a mystery, although it must clearly be stated that it was considered a non-event by most astronomers, with no detectable impact site or scar produced.

S-L9 fragment F (16) was calculated to impact the farside of Jupiter on 1994 JUL 18 at 00h33m UT and astronomers worldwide anxiously awaited the moment. Beish and Hernandez, along with an experienced observing partner, Tippy D'Auria, were among the anxious astronomers monitoring Jupiter prior to the F impact. The three observers took turns observing the planet after the predicted event and recorded their impressions between 01h06m-02h30m UT. They noted a bright (8/10), elliptical ring adjacent to the following limb containing a very dark (1-2/10) condensation at its core exhibiting a prominent "ray system" toward the south. A similar description was provided by Roger Venable of Augusta, Georgia in a magazine account of the event (MacRobert, 1994). A plume had been detected by both the 2.2-m (87-in) and 3.6-m (142-in) reflectors of the European Southern Observatory (ESO) atop La Silla, Chile. It is presently believed possible that S-L9 fragment F (16) overlapped S-L9 fragment E's (17) impact site, therefore not producing a separate impact site (see *Figure 12*, p. 110). This impact was also considered a non-event by most astronomers.

S-L9 fragment P (8) was clearly visible adjacent to the brighter Q (7) fragment when the Hubble Space Telescope (HST) first imaged the comet on 1993 JUL 01. When the HST again imaged the comet on 1994 JAN 24, the P fragment appeared to have further sub-

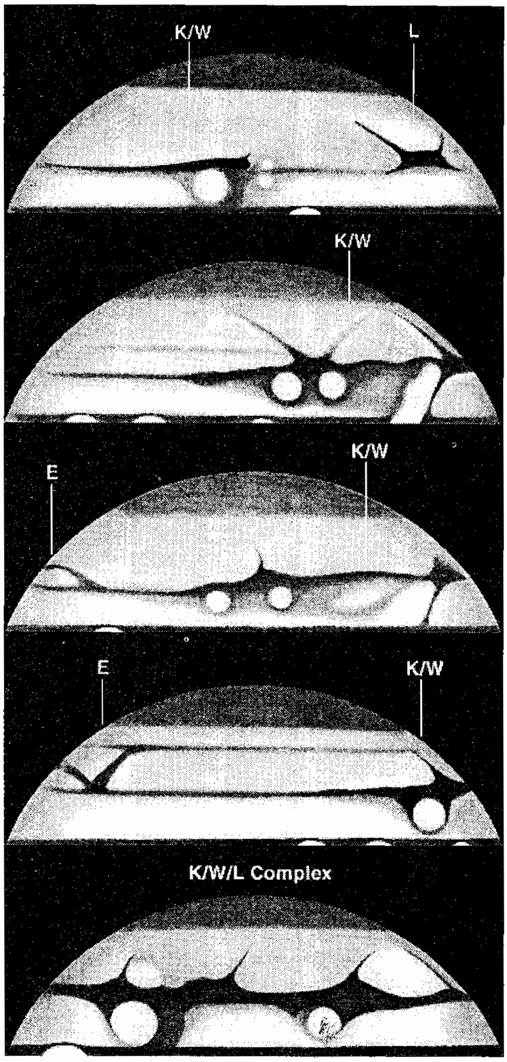


Figure 6. Ssectional sketches of Jupiter's southern hemisphere showing the development of the S-L9 fragments E (17), and C (19) impact sites, the K (12)/W (1) impact site complex, and the L (11) impact site between 1994 AUG 22-SEP 17, drawn by Carlos E. Hernandez using an 8-in (20-cm) f/7.5 Newtonian, except for the1994 AUG 22, drawing, made with an 11-in (28-cm) f/10 Schmidt-Cassegrain. **One:** 1994 AUG 22, 01h30m UT (CMII=205°.8, CMIII=285°.6), 270X and 440X (Wratten 23A and 80A filters). The K/W impact site complex is visible extending between the CM and the p. limb, giving it a "snake-like" appearance with a short projection from its Sf. border. A large, very bright (8/10) oval is noted above the STZ N. of the f. end of the complex surrounded by a dark (3/10) ring. The two bright (8/10) ovals, described above, are again noted f. the complex. The L impact site is visible toward the f. limb as a rhomboidal albedo feature with projections from its p. and f. borders (these projections are probably due to a contrast effect; or less likely to impact ejecta in motion, primarily to the S., contrasting with the bright material surrounding the impact sites). **Two:** 1994 SEP 03, 00h20m UT (CMII=164°.2, CMIII= 235°.2), 356X and 440X (Integrated light). The K/W impact site complex now has a "roach-like" appearance as it stretches from just p. the CM to the f. limb (timed between 144°.8-206°.5 [SII] or 228°.2-290°.0 [SII]). Its center exhibits two dark (3/10) projections from its S. border extending over the SSTZ and SSSTZ nearly reaching the dull (5/10) SPR. Two very bright (8-9/10) large ovals lie within a dark to dusky (3-4/10) section of the STZ north of the center of the complex (these ovals may be very high, bright ammonia-ice clouds surrounded by the dark impact ejecta). The very dark (1-2/10), expanded f. end of the complex also contains two very dark to dark (2-3/10) projections from its Np. and S. borders, over the STZ and SSTZ/SSSTZ, respectively. A very bright (8/10) undulating strip lies above the STZ, p. the expanded f. end of the complex. **Three:** 1994 SEP 05, 00h30m UT (CMII= 110°.3, CMIII= 194°.0), 213X and 285X (Integrated light). The E impact site is on the p. limb, consisting of a dark (3/10) curved projection extending from the E impact site's f. border; the E impact site now appears above the SSTZ. The K/W impact site complex appears as in the previous drawing except that only one dark (3/10) projection extends from its S. border, a bright (7/10) patch lies within the STZ dusky (4/10) section, and only the N. projection extends from the expanded f. end of the complex. **Four:** 1994 SEP 09, 23h50m UT (CMII=116°.3, CMIII=201°.4), 213X, 285X and 356X (Integrated light). The E impact site is seen on the p. limb as a V-shaped very dark (1-2/10) albedo feature, its Sf. end appearing to connect with the SSSTB. The K/W impact site complex is visible toward the f. limb, appearing very dark (1-2/10) with a dark (3/10) projection extending from its S. border and a very bright (8/10) oval N. of it, above the STZ, apparently encircled by a very dark to dark (2-3/10) ring. **Five:** 1994 SEP 17, 23h45m UT (CMII=233°.6, CMIII=320°.9). The K/W impact site complex has apparently merged with the L impact site, forming a continuous very dark to dark (2-3/10) belt across the visible disk with dark (3/10) projections from both its N. border, across the STZ, and its S. border, above the SSTZ. A very bright (8/10) oval f. the Sp. projection, above the SSTZ, as well as two other large, very bright (8/10) ovals above the STZ; the p. oval has a f. dark (3/10), curved column visible above the STZ. The very bright (8/10) long-enduring oval FA is visible within the dark (3/10) STB toward the p. limb.

divided into two fragments, namely P1 (8a) and P2 (8b); the Q fragment had also divided. By 1994 MAR 30, the P1 (8a) fragment had disappeared and the P2 (8b) fragment had once again subdivided into two fragments. The reason for the further fragmentation of this and other fragments was probably due to the fact that they were held loosely together, and easily pulled apart by stresses due to rotation and possible outgassing of gas and dust.

By the time the P2 (8b) fragment reached Jupiter it may have further fragmented, or diffused, to dust as no impact site, or plume at infrared wavelengths, was observed on the calculated impact date and time (1994 JUL 20, 15h23m UT). The same fate may have affected the S-L9 T (4), U (3), and V (2) fragments as no impact plumes or scars were visible over their calculated impact sites (fragment U preceding the K impact site and T and V preceding the E impact site) on their calculated impact dates (T [4]: 1994 JUL 21, 18h11m UT. U [3]: 1994 JUL 21, 21h56m UT. V [2]: 1994 JUL 22, 04h23m UT).

S-L9 fragments J (13) and M (10) were initially imaged by the HST in July, 1993 within the comet train but disappeared from view upon its subsequent observation in January, 1994. These fragments most likely further fragmented and diffused apart during that period.

The appearance of Jupiter at the conclusion of the impact period is shown in *Figure 13* (p. 110).

A DARK BELT AND HOOD

The dust debris resulting from the explosion of the S-L9 fragments during the impact period (1994 JUL 16-22) was initially thought to lie at an elevation defined by an atmospheric pressure between approximately 1 mbar to 200 mbar, or approximately between 60 to 100 mi (100 to 160 km) above the visible cloud tops; and possibly down to 500 mbar or the visible cloud layer. As evidenced by the accompanying figures, as well as by a multitude of images obtained by the HST and ground-based observatories, the impact debris material shortly after impact began to disperse within the upper Jovian atmosphere, primarily to the east (decreasing jovicentric longitude or retrograde) direction. By September, 1994 the dust material from the impact sites and complexes had apparently coalesced, as predicted by models by R. A. West *et. al.*, into a global impact belt which would later coagulate and settle down toward the visible cloud layer.

One of the first observations of Jupiter after conjunction with the Sun, occurring on 1994 NOV 18, was by David H. Levy, co-discoverer of the comet. He described his observation as: "This morning from 13:40 to 14:00 UT I observed Jupiter visually with my 20-cm f/7 reflector, through poor seeing. The dark material left from the impacts of S-L9 is still there, and still obvious. Crossing almost the correct latitude [45°S] is a dark bar which widens into a large spot about a third of the way from the western limb. With the exception of the North Equatorial Belt [NEB], these features, are the most conspicuous on Jupiter." Similar descriptions of Jupiter's Southern Hemisphere were made by P. Devadas (India) and David Gray (BAA Jupiter Section) shortly before the above observation. An image obtained by the Reta Beebe (NMSU) using the Hubble Space Telescope (HST) on 1995 FEB 13 failed to show a solid belt at the approximate latitude of the impacts, but instead showed clumps, due to coagulation of impact debris material, at the appropriate latitude. Observations made by ground-based observatories, the IRTF Facility at Mauna Kea and Calar Alto Observatory in Southern Spain, at infrared wavelengths (2.3 microns) showed the impact debris material to have spread south of the impact latitude, including the South Polar Region (SPR). By mid-1995 the S-L9 impact debris remnants had faded significantly and it then became difficult to distinguish possible impact debris material from the normal South South Temperate Belt (SSTB); see *Figure 14* and *Figures 17w* and *17x* (p. 117).

REFLECTIONS ON IMPACTS

The demise of a fragmented comet (S-L9) over the Southern Hemisphere of the largest planet in the Solar System provided mankind its first opportunity to witness cataclysmic events only previously theorized from craters produced long ago upon the surfaces of the Moon, the terrestrial planets, and their satellites. All observers, no matter what size instrument they used, should consider themselves fortunate to have witnessed such a historic event and can tell future generations of observers: "I witnessed the death throes of a fragmented celestial wanderer upon the face of a gas giant at the close of the 20th century."

ACKNOWLEDGMENTS

The authors, and the A.L.P.O. Jupiter Section, here thank all participating observers for their scientifically useful, and well-executed, observations which made this synopsis possible. Special thanks goes to John H. Rogers (BAA Jupiter Section Director), Isao Miyazaki (OAA Jupiter Section Recorder), and Mark Bosselaer (VSS Group, Belgium) for relaying observations made by members of their respective organizations. We apologize that this report was not published sooner and appreciate all contributing observers' patience. Co-author Hernandez would like to personally thank Daniel Fischer for his support and media reports throughout the event and review of this report as well as Dr. Sanjay Limaye (University of Wisconsin, Madison) for technical support. Last but not least, this article is a synopsis of observations made by amateur astronomers worldwide.

(Figure Key is given on p. 109; References are given on p. 111)

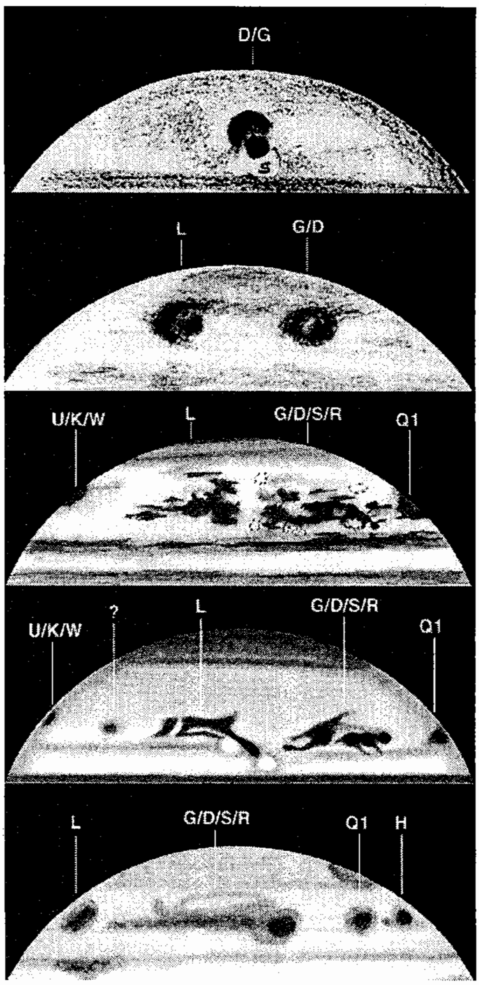


Figure 7. Sectional sketches of Jupiter's Southern Hemisphere showing the development of the L (11), G (15)/D (18)/S (5)/R (6), and Q1 (7a) impact sites between 1994 Jul 20- Aug 06. **One:** Sketch by John H. Rogers on 1994 Jul 18, 20h07m UT (CMII=306°.7, CMIII=017°.8) using the Northumberland 12-in (30-cm) Refractor at 230X (yellow and polarizer filters) showing the 12.6 hour-old G/D impact site complex. The G/D impact site complex was described by Dr. Rogers as "the darkest feature on the disk" as well as "exactly like a satellite shadow", normally given an intensity of 0-1/10. The impact ejecta are prominent Sp. the impact sites. The complex appears to be surrounded by a bright periphery, especially north of the complex. **Two:** Sketch by Jean-Francois Viens on 1994 Jul 20, 01h20m UT (CMII=286°.0, CMIII=357°.4), 10-in (25-cm) f/5.6 Newtonian, 189X (Integrated light). This drawing shows the newly formed (3.1-hour old) L impact site just past the CM displaying the classic appearance of the impact sites, at least the major ones, consisting of a very dark (1-2/10) central core, or condensation, representing the actual impact site, and the dark 3/10), curved impact ejecta Sp. the impact site, representing the impact debris material. The G/D impact site complex is visible f. the CM and appears to consist of a very dark (1-2/10) core (or condensation, actually the merged impact sites of G and D) located along the Nf. sector of a dark (3/10) ring. **Three:** Sketch by Jeffrey D. Beish, made on 1994 Jul 25, 00h22m UT (CMII=282°.1, CMIII=354°.3), 16-in (41-cm) f/6.9 Newtonian, 382X and 585X (Wratten 23A, 25, 30, 33, 38A, 47, and 57 filters). The K/W impact site complex is visible as a very dark (1-2/10), elliptical albedo feature on the p. limb with a dusky (4/10) projection extending from its Sf. border. The L impact site is visible just p. the CM and appears to consist of a very dark (1-2/10) elongated nucleus with very dark to dark (2-3/10) expanding projections noted to extend from its p. and S. borders. A thin, dark (3/10) strip is visible S. of the impact site above the SSTZ. The G/D/S/R impact site complex is visible f. the CM as a large, very dark (1-2/10), irregular albedo feature with very bright (8/10) ovals noted surrounding it over the SSTZ and SSSTZ. The Q1 impact site is visible on the f. limb, consisting of a very dark (1-2/10) core, or impact site, with very dark to dark (2-3/10) material to the S. above the SSTZ. **Four:** Sketch by Carlos E. Hernandez, 1994 Aug 01, 01h00m UT (CMII=275°.9, CMIII=350°.0), 16-in (41-cm) f/6.9 Newtonian, 382X (Integrated light). The f. end of the K/W impact site complex is visible on the p. limb as a very dark (1-2/10) condensation. The L impact site is on and just p. the CM and it appears to be rectangular in shape with its p. end nearly divided by a very bright (8/10) strip and another thin, very bright (8/10) strip along its N. border. A very dark (1-2/10), elongated "club-shaped" projection extends from its Nf. border, appearing to connect with the STB. A very bright (8/10) oval is noted p. the club-like projection and another one is visible over the STZ at the f. border of the club-like projection. The G/D/S/R impact site complex is visible f. the L impact site and the CM, and appears to consist of four large, very dark (1-2/10) condensations (the last three having nearly merged into one long elliptical albedo feature). The p. condensation exhibits a very dark to dark (2-3/10) "trunk-like" projection from its p. border and another dark (3/10) "cap-like" projection from its Sp. border. The first and second condensations appear to be separated by a very bright (8/10) strip. Two thin, dark (3/10), curved projections extend from the N. borders of the second and third condensations above the SSTZ, appearing to connect with the SSTB. The Q1 impact site is visible on the f. limb as a very dark (1-2/10) elliptical albedo feature. **Five:I** Sketch by Daniel M. Troiani (A.L.P.O. Mars Coordinator), 1994 Aug 06, 01h34m UT (CMII=326°.5, CMIII=042°.4), 8-in (20-cm) f/6 Newtonian,280X (Integrated light). The L impact site appears as a very dark (1-2/10) condensation towards the p. limb, followed by an elongated, very dark to dark (2-3/10) G/D/S/R impact site complex with its f. end appearing very dark (1-2/10) and a dark (3/10) "festoon-like" projection along its S. border. The Q1 impact site is visible f. the G/D/S/R complex and appears as a very dark (1-2/10) condensation. The H impact site appears as the Q1 site toward the f. limb. The dark section along the southern limb, south of the Q1 impact site, is most probably not impact-related but is a contrast effect.

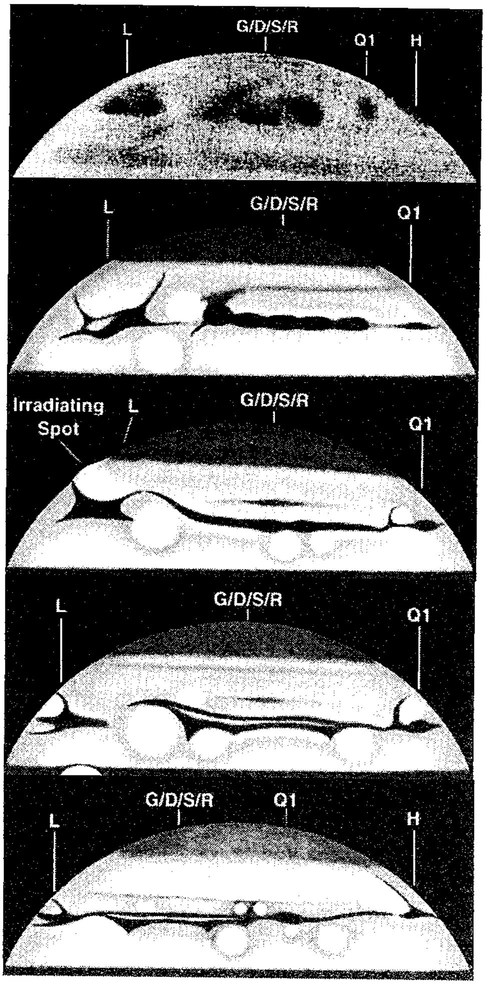


Figure 8. Sectional sketches of Jupiter's Southern Hemisphere showing the continued development of the L (11), G (15)/D (18)/S (5)/R (6), and Q1 (7a) impact sites between 1994 AUG 11-SEP 04. **One:** Sketch by Jean-Francois Viens, 1994 AUG 11, 00h05m UT (CMII=303°.1, CMIII=020°.4), 10-in (25-cm) f/5.6 Newtonian, 189X (Integrated light). The L impact site is vis. near the p. limb as an dark (1-2/10) elongated feature with a dusky (4/10) shading S. of the impact site. The G/D/S/R impact site complex on the CM appears as a very dark (1-2/10), undulating feature with a dusky (4/10), curved projection from the p. portion of the complex extending above the SSTZ. The Q1 impact site, f. the G/D/S/R complex, is a very dark (1-2/10) condensation. The H impact site is a dark (3/10) indentation on the f. limb. (Sketches Two-Five are by Carlos E. Hernandez with an 8-in [20-cm] f/7.5 Newtonian.) **Two:** 1994 AUG 18, 00h40m UT (CMII=295°.3, CMIII=014°.0), 252X (integrated light), showing the L impact site as a very dark (1-2/10), rectangular feature with very dark to dark (2-3/10) projections extending from both p. and f. borders (the Nf. projection nearly reaches the p. border of the G/D/S/R complex), nicknamed by the observer as "the amoeba." Very bright (8/10) regions lie N. and S. of the impact site. The brilliant (10/10) projection S. of the L impact site appears to extend beyond the S. limb of the planet. Named an "irradiating spot", this feature is probably due to very high clouds that are very brilliant, thus giving the appearance, due to irradiation, of projecting beyond the limb. The prominent G/D/S/R impact site complex is seen on the CM as a very dark (1-2/10), elongated feature consisting of five large, elliptical condensations with the p. condensation having a thin, dark (3/10) projection from its Np. border and a dark (3/10) "cap-like" projection extending from its Sp. border; a thin, dusky (4/10) "streamer-like" projection extends above the SSTZ from the f. border of this projection. The G/D/S/R complex appears like a "giant alien centipede." The S. border of the complex is rimmed by a very bright (8/10) undulating strip extending to the f. limb S. of the Q1 impact site. Two very large, very bright (8-9/10) ovals lie between the L and G/D/S/R impact sites above the STZ and the SSTZ (these ovals may be dark impact ejecta surrounding bright ammonia-ice clouds next to the impact sites, present before the impacts, or less likely arising after the impacts). The Q1 impact site is vis. near the f. limb as a very dark (1-2/10), elongated feature. **Three:** 1994 AUG 30, 00h15m UT (CMII=280°.9, CMIII=002°.9),t 213X and 285X (Integrated light), again showing the L impact site, which now appears smaller. The G/D/S/R impact site complex appears on the CM as a very elongated, very dark (1-2/10) feature, looking like a "giant earthworm." The complex is surrounded by a very bright (8/10) border (probably a contrast effect); a dark (3/10), elongated feature lies S. of the complex above the SSTZ. Several large, very bright (8/10) ovals are N. of the complex above the STZ. A very bright (8/10) oval is near the f. limb, above the SSTZ, with the f. end of the G/D/S/R complex curving around its p. border. The Q1 impact site appears near the f. limb as a very dark (1-2/10), elongated albedo feature. **Four:** 1994 SEP 01, 01h50m UT (CMII= 278°.4, CMIII=001°.0), 285X and 356X (Integrated light). The L impact site is seen near the p. limb as a very dark (1-2/10) "arrowhead-shaped" feature with very dark to dark (2-3/10) projections extending from its p., N., and S., borders. A very bright (8/10) zone is Sp. the L impact site's p. border above the SSTZ. The G/D/S/R impact site complex is vis. on the CM as a very dark (1-2/10), elongated feature surrounded by a very bright (8/10) rim (probably a contrast effect) as well as several large, very bright (8/10) ovals to the N. and S. of both ends of the complex. A dark (3/10), elongated feature is S. of the complex above the SSTZ. A very bright (8/10) oval lies near the f. limb, above the SSTZ, with the f. end of the G/D/S/R complex curving around its p. border. The Q1 impact site appears next to the f. limb as a very dark (1-2/10) elongated feature that connects with the f. end of the G/D/S/R complex. The very bright (8/10) long-enduring oval FA falls within the dark (3/10) STB, N. of the L impact site. **Five**: 1994 SEP 04, 00h00m UT (CMII=302°.1, CMIII=025°.5), 213X (Integrated light). The G/D/S/R impact site complex has grown longitudinally since the previous sketch and all impact sites and complexes appear connected, except for the p. end of the H impact site on the f. limb, appearing as a single very dark (1-2/10) belt. Several variable-sized, very bright (8/10) ovals lie to the N., above the STZ, and to the S., above the SSTZ, of this new belt. A dark (3/10) projection extends from the S. border of the H impact site along the f. limb.

Figure 9. Sectional sketches of the Southern Hemisphere of Jupiter showing the development of the S-L9 fragment H (14) impact site and surrounding sites (i.e., G/D/S/R, Q1, and E) between 1994 JUL 18-SEP 18. All drawings were made in integrated light (no filter). **One:** Sketch by Carlos E. Hernandez, 1994 JUL 18, 22h30m UT (CMII=033°.6, CMIII=104°.2), 16-in (41-cm) f/6.9 Newtonian, 305X, showing the approximately one hour-old (impact occurred at 19h31m59s UT) H impact site just p. the CM. The H impact site appears to consist of a large, very dark (1-2/10) condensation at the approximate latitude of the SSTB (approximately -45°) with a prominent (3/10) ray system to the south above the SSTZ. **Two:** Sketch by John H. Rogers, 1994 JUL 23, 21h25m UT (CMII=024°.5, CMIII=096°.9) using the Northumberland 12-in (30-cm) Refractor at 230X. This sketch shows the 5.1 day-old H impact site on the CM now displaying a broad, very dark (8/10) projection from its N. border across the STZ, unlike the rest of the impact sites which display impact ejecta dispersed toward the south. A bright (7/10) spot, or oval, is vis. p. the H impact site above the STZ. The G/D/S/R impact site complex is vis. on the p. limb as a large, dark elliptical patch followed by the Q1 impact site and finally the E impact site on the f. limb. **Three:** Sketch by Carlos E. Hernandez, 1994 AUG 11, 01h25m UT (CMII=352°.0, CMIII=068°.7), 8-in (20-cm) f/7.5 Newtonian, 213X and 284X. The H impact site is vis. f. the CM and the N. projection, across the STZ, appears to have largely dissipated over a period of nearly three weeks, except for a possible remnant above the S. edge of the STB. The H impact site itself appears to have shifted southward above the SSTZ with broad, dark (3/10) projections from all of its borders. The G/D/S/R impact site complex is vis. on the p. limb followed by the Q1 impact site (with a small, very bright [8/10] oval Sf. it), and finally the E impact site on the f. limb. **Four**: Sketch by Carlos E. Hernandez, 1994 AUG 16, 00h45m UT (CMII=358°.2, CMIII=076°.3), 16-in (41-cm) f/6.9 Newtonian, 289X . The H impact site is vis. f. the CM and it now appears to consist of a very dark to dark (2-3/10), elongated albedo feature above the SSTZ with a broad, dusky (4/10) veil projecting from its N. border appearing to connect with the SSTB (a CCD image obtained by Isao Miyazaki on the same date shows the shape of the H impact site to be somewhat different, proving the difficulty in making these low-contrast observations). **Five:** Sketch by Carlos E. Hernandez, 1994 SEP 02, 01h30m UT (CMII=056°.4, CMIII=139°.3), 8-in (20-cm) f/7.5 Newtonian, 213X and 285X. The H impact site is vis. on the p. limb as a very dark (1-2/10), elongated albedo feature above the SSTZ with a broad, dark (3/10) curved projection emanating from its f. border to apparently connect with the SSTB. The surrounding areas N. and S. of the H impact site f. projection appear bright (7/10, possibly a contrast effect). The E impact site is vis. f. the CM as an "hourglass-shaped" albedo feature with a very dark (1-2/10) central core and very dark to dark (2-3/10) N. and S. Projections, the N. projection being broader and apparently terminating just N. of the SPR whereas the S. Projection apparently connects with the SSTB. The region of the SSTZ f. the E impact site appears bright (7/10), but this may be a contrast effect as well. **Six**: Sketch by Carlos E. Hernandez, 1994 SEP 18, 23h05m UT (CMII=359°.5, CMIII=087°.0), 8-in (20-cm) f/7.5 Newtonian, 213X and 285X. This sketch represents the last observation received by the A.L.P.O. Jupiter Section for the 1993-94 Apparition and the S-L9 event as well, completing an observational coverage of over two months. A thin, very dark to dark (2-3/10) undulating belt is now formed by the merging of impact ejecta from the impact sites of this region (i.e., the G/D/S/R, Q1, H, and E impact sites). The remnant of the H impact site is vis. on the CM as a very dark (2/10), elongated albedo feature above the SSTZ with dark (3/10) projections emanating from its p. and f. borders to apparently connect with the SSTB. This complex encloses a dusky (4/10), triangular region between the H impact site and the SSTB which contains a very bright (8/10) oval Nf. the impact site. The remnant G/D/S/R impact site complex is vis. on the p. limb whereas the E impact site lies adjacent to the f. limb, appearing as a "festoon-like" albedo feature whose f. end appears enclosed by a very bright (8-9/10) f. limb oval, or patch.

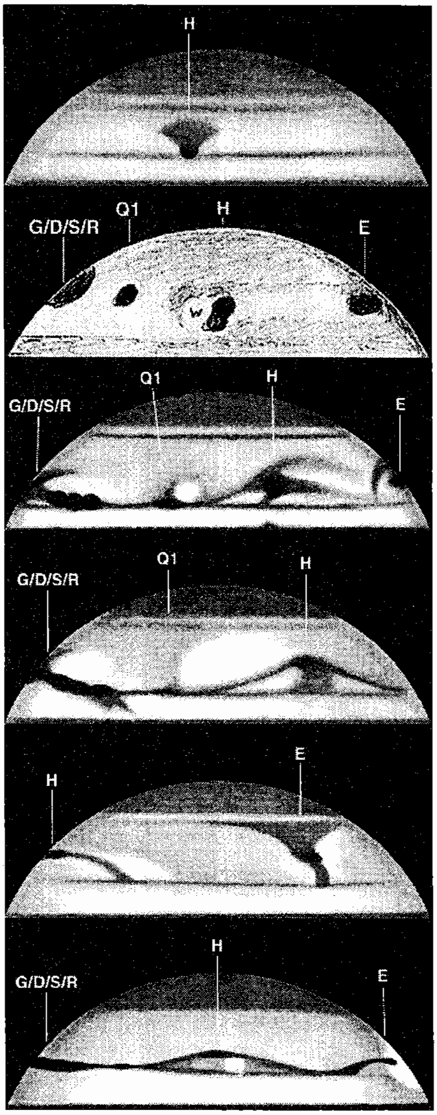


Figure 10 (right). Drawing of Jupiter's Southern Hemisphere, by Frank J. Melillo, 1994 JUL 20, 01h30m UT (CMI=240°.9, CMII=292°.0, CMIII=003°.4), 8-in (20-cm) f/10 Schmidt-Cassegrain, 220X (Integrated light). From left to right, the K (15.1 hr old), L (3.2 hr old), and G/D (3.4 and 2.3 days old, respectively) impact sites are vis. near the latitude of the South South Temperate Belt (SSTB; -45°). Note the general pattern of a very dark central core surrounded by a lighter penumbra-like shading (predominantly Sp. the dark core) in the impact sites. The dark South Equatorial Belt (SEB) is vis. to the north. Mr. Melillo made many such high-quality sectional sketches during and after the impact period.

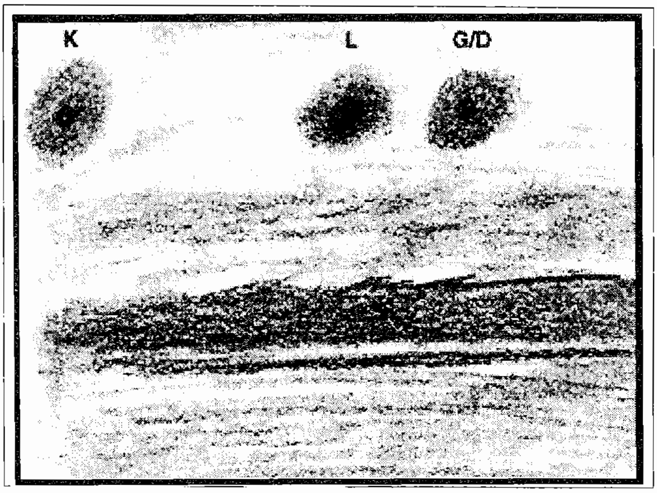


Figure 11 (below). Sectional sketches depicting the possible S-L9 fragment B (20) impact site. S-L9 fragment B was predicted to impact the farside of Jupiter on 1994 JUL 17, at 02h53m00s UT. Although many instruments were turned toward the planet for the event the vast majority of observers failed to note evidence of the impact over Jupiter's Southern Hemisphere after the fact. These sketches by A.L.P.O. observers show a mysterious feature at first believed to be the B impact site. **Left (a):** Drawing by Jeffrey D. Beish, 1994 JUL 17, 03h35m UT (CMII=277°.2, CMIII=347°.8) at 360X (Wratten 25, 30, 47, 57, 64, and 80A Filters), showing what appears to be a very dark to dark (2-3/10), elongated albedo feature adjacent to the f. limb above the SSTZ. A dark (3/10), V-shaped albedo feature is vis. p. the dark spot, appearing to have separated the South South Temperate Belt (SSTB) into N. and S. Components. **Right (b):** Drawing by Carlos E. Hernandez on the same date but slightly later, at 03h50m UT (CMII=286°.2, CMIII=356°.9) using the same instrument and filters as above. In this rendition a very dark to dark (2-3/10), elliptical albedo feature is noted adjacent to the f. limb above the SSTZ p. by a semicircular, dark (3/10) ring-like albedo feature; again apparently separating the SSTB into two components. The observers did not discuss their observations until after they were both made, but they obviously obtained similar results. The B impact site was not recorded by major ground-based observatories, as well as the HST, so that the event is considered to have not occurred (a "dud impact").

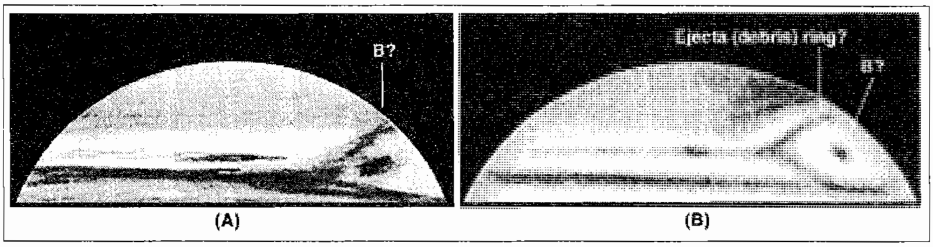


Figure Legend: In all the figures that accompany this report (*Figures 1-17*), Jovian south is shown at the top, with celestial east (preceding) to the right and celestial west (following) to the left; in normal unreversed inverted views as seen with inverting telescopes when near the meridian in the Northern Hemisphere. "vis." indicates "visible." Directions are indicated as follows: N. = north, S. = south, p. = preceding, f. = following, Np. = north-preceding, Nf .= north-following, Sp. = south-preceding, and Sf. = south-following). Jovian central-meridian (CM) longitudes are given as "CMI", "CMII", and "CMIII"; referring respectively to the three rotation systems—System I (period 9h50m30.0s; applying to the EZ, south edge of the NEB, north edge of the SEB, and the south edge of the NTB), System II (period 9h55m40.6s; applying to the rest of the disk including the impact zone), and System III (period 9h55m29.7s; the periodicity of radio emissions from Jupiter). The colors of the filters used were as follows: Wratten series—12 (deep yellow), 21 (orange), 23A (light red), 25 (red tricolor), 30 (light magenta), 33 (magenta), 38A (blue), 47 (blue tricolor), 57 (green), 58 (green tricolor), 64 (light blue-green), 80A (light blue), and 82A (light bluish); Other—BG28 (blue), NR400 (infrared rejection), OG550 (orange), PO1 (green), RG0 (red), RGB (tricolor exposures through red, green, and blue filters), and VG6 (green). Apparent visual brightnesses are given in the Standard A.L.P.O. Intensity Scale, ranging from 0/10 for black to 10/10 for the brightest possible condition.

Figure 12 (below). Two sectional sketches depicting possible Jovian atmospheric phenomena associated with the S-L9 fragment F (16) impact, predicted to occur on 1994 Jul 18, at 00h33m UT. **Left (a):** Sketch by Carlos E. Hernandez, 1994 Jul 18, 02h15m UT (CMII=019°.0, CMIII=089°.8), 16-in (41-cm) f/6.9 Newtonian, 360X (Wratten 30, 38A, 64, and 82A filters). It shows a large, very bright (8/10), elliptical ring adjacent to the f. limb containing at its center a very dark (1-2/10) condensation with a prominent (3-4/10) "ray-system" extending Sp. the dark core. This appearance was corroborated by two other experienced observers. Although the dark core is most certainly the preexisting E impact site (11.1 hours old) it is possible, although remotely, that the F fragment overlapped the E impact site and therefore did not produce a separate site. **Right (b)**: Sketch by Richard E. Hill, 1994 Jul 18, 04h00m UT (CMII=082°.4, CMIII=153°.3), approximately 3.6 hours after the predicted F impact, using a 14-in (35.6-cm) f/5 Newtonian at 392X (Integrated light). The E impact site is prominent on the CM with a dusky (4/10) "ray-system" Sp. the impact site. What is noted on this drawing, and not on previous ones, is the very dark (1-2/10) patch at the approximate latitude of the South South South Temperate Belt (SSSTB, -56°). Is it possible that this dark patch was produced by the dud F impact or that it was missed by previous observers? The A impact site is noted f. the E impact site and the C impact site appears as a dark spot on the f. limb. Again it must be stressed that the F impact is considered a dud impact.

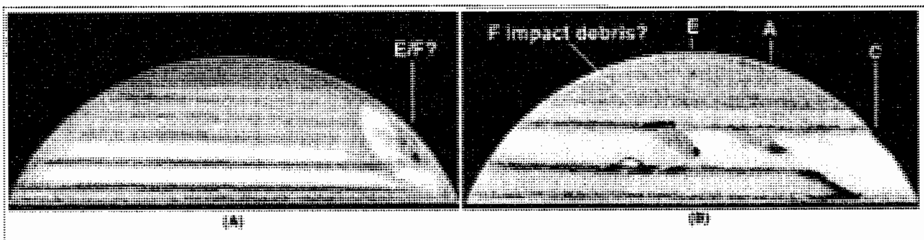


Figure 13 (below). The planet Jupiter was imaged at various wavelengths throughout the impact period (1994 Jul 16-22) and following, especially by noted astro-imagers Donald C. Parker and Isao Miyazaki. Imaging at different wavelengths (e.g., broad-band near-infrared, methane band) allows the study of features at different altitudes within Jupiter's complex atmosphere. These CCD images were obtained by Donald C. Parker on 1994 Jul 23. **Left:** Infrared (740 nm) image, 01h37m UT (CMI=358°.5, CMII=026°.7, CMIII=098°.9), showing the G/D/S/R impact site complex on the p. limb followed by the Q1 impact site, the H impact site (note the prominent N. projection, or extension, from its N. border), and finally the E impact site on the f. limb. At infrared wavelengths we are penetrating deeper into the Jovian atmosphere than in the visual and are therefore observing the deep cores of the above impact sites, possibly at the 1-bar level. Note the poorly delineated Great Red Spot (GRS) f. the CM; this feature lies at a high altitude (8 km) above Jupiter's cloud tops. **Right:** Methane-band image (890 nm; one of several wavelengths absorbed by methane, measured at a concentration of 1,000 ppm by the Galileo probe on 1995 Dec 07), 01h45m UT (CMI=003°.3, CMII=031°.5, CMIII=104°.1), showing the same impact sites as the previous image but now we are witnessing the impact ejecta at great altitudes, approximately 200 km above the Jovian cloud tops, or between the 0.5-1.0 millibar pressure levels.

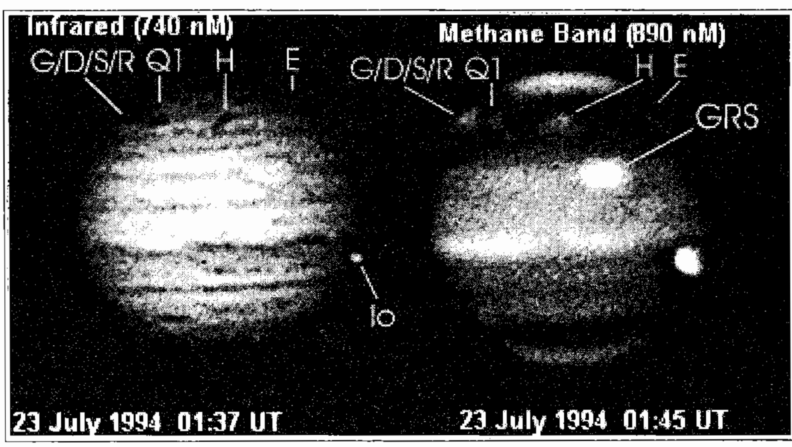
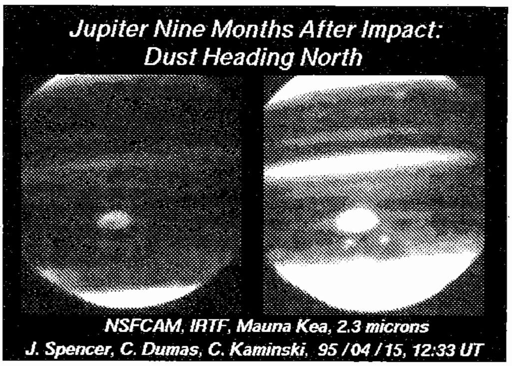


Figure 14 (right). A pair of images obtained on 1995 APR 15, at 12h30m UT (CMI=242°.0, CMII=037°.2, CMIII=181°.2) by John Spencer (Lowell Observatory) and Christophe Dumas (University of Hawaii) in the 2.3-micron methane band with the 3-meter (120-in) Infrared Telescope Facility (IRTF) reflector on Mauna Kea, Hawaii. The S-L9 impact ejecta have apparently spread toward the South Polar Region (SPR) 9 months after the impacts. The impact ejecta exhibit a sharp, undulating northern boundary but some wispy material lies north of the boundary. The bright elliptical feature nearly on the CM is the Great Red Spot (GRS) and the smaller pair of ovals south of the GRS are the long-enduring ovals BC and DE. Images courtesy of John Spencer and Christophe Dumas.



Figures 15-17 continued on pp. 112-118.

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12.) Spencer, John R.; and Mitton, Jacqueline. (1995). *The Great Comet Crash: The Collision of Comet Shoemaker-Levy 9 on Jupiter.* Cambridge, UK: Cambridge University Press. A thorough account of the S-L9 events as recorded by amateur and professional astronomers, written by a noted planetary planetary astronomer and science writer.

S-L9 Figure Gallery

The following full-disk drawings and CCD images of Jupiter by members of the Association of Lunar and Planetary Observers, and other contributing observers, depict the evolution of the Comet Shoemaker-Levy 9 fragment impact sites between 1994 JUL 07-1995 APR 10. (Legend: See p. 109; also: Newt. = Newtonian reflector, Refr. = Refractor, Sch./Cass. = Schmidt-Cassegrain, and Schief. = Schiefspiegler).

Figure 15 (p. 113)

a.) 1994 JUL 07, 01h22m UT, CMI=344°.8, CMII=135°.2, CMIII=203°.2. 6-in (15-cm) Newt. 205×, no filter. Samuel R. Whitby. Pre-impact appearance of Jupiter near the longitude (114° [SII] or 185° [SIII]) of the first S-L9 fragment (A or 21) impact site, calculated for 1994 JUL 16, at 20h11m UT. Especially note the region of the South South Temperate Zone (SSTZ) p. the small, bright oval f. the Central Meridian (CM).

b.) 1994 JUL 16, 23h40m UT, CMI=060°.5, CMII=135°.2, CMIII=205°.7. 16-in (41-cm) Newt., 382×, no filter. Carlos E. Hernandez. The second (confirmatory) observation of the 2.9 hour-old S-L9 fragment A (21) impact site. Note the very dark (1-2/10) core of the A impact site with a prominent (2-3/10) "ray system" Sp. the impact site toward the p. limb above the SSTZ. A very bright (8/10), curved "rift-like" albedo feature is vis. f. the impact site. The long-enduring ovals BC and DE are vis. f. the CM within the dark (3/10) South Temperate Belt (STB).

c.) 1994 JUL 17, 00h00m UT, CMI=072°.7, CMII=147°.2, CMIII=217°.8. 6-in (15-cm) Refr., 200-250×, Wratten 12 (W12, or yellow) Filter. Phillip W. Budine. Confirmatory observation of the newly formed A impact site showing the very dark (1-2/10) core of the impact site toward the p. limb above the SSTZ with a f. pair of small, very bright (8/10) ovals. Long-enduring ovals BC and DE are vis. p. and f. the CM, respectively.

d.) 1994 JUL 17, 10h40m UT, CMI=102°.9, CMII=174°.0, CMIII=244°.7. 16-in (41-cm) Newt., Lynxx PC CCD camera, NR400 (infrared rejection) Filter. Isao Miyazaki. The 13.9 hour-old A impact site is vis. on the p. limb with the 3.5 hour-old S-L9 fragment C (19) impact site following it above the SSTZ (note the very dark core and Sp. ray system similar to the A impact site described above). Long-enduring ovals BC and DE p. the CM within the STB.

e.) 1994 JUL 18, 04h12m UT, CMI=024°.1, CMII=089°.7, CMIII=160°.6. 14-in (36-cm) Sch./Cass., 530×, no filter. Richard W. Schmude, Jr. (A.L.P.O. Remote Planets Coordinator). E impact site (13 hours old) p. CM (note small, dark condensation Sp. impact site), A impact site f. CM (elongated in a Sp.-Nf. direction), and C impact site on f. limb.

f.) 1994 JUL 18, 20h07m UT, CMI=246°.3, CMII=306°.7, CMIII=017°.8. 12-in (30-cm) Refr., 230×, yellow and polarizer filters. John H. Rogers (BAA Jupiter Section Recorder). The newly formed (13.6 hours old) S-L9 fragment G (15) impact site is vis. on the CM. This impression records the typical appearance of the S-L9 impact sites in general (a very dark [1-2/10] core, the actual impact site, with a "crescent-shaped" Sp. albedo feature, the rebounding fragment explosion impact ejecta). A bright oval region is N. of the impact site above the SSTZ. Dr. Rogers described the G impact site as "the darkest feature on the disk" and "exactly like a satellite [Galilean] shadow" . Ganymede is vis. adjacent to the f. limb next to the North Polar Region (NPR).

g.) 1994 JUL 19, 00h56m UT, CMI=062°.4, CMII=121°.4, CMIII=192°.5. 6-in (15-cm) Maksutov-Cassegrain, 150×, no filter. Lawrence Carlino. E impact site toward p. limb, A impact site p. CM (note bright oval p. site above SSTZ), and the C impact site toward f. limb.

h.) 1994 JUL 19, 01h30m UT, CMI=083°.1, CMII=141°.9, CMIII=213°.0. 12.5-in (32-cm) Buchroeder Tri-Schiefspiegler (BTS), 235×, no filter. Richard J. Wessling. E impact site on f. limb (with surrounding bright zone, or ring, probably a contrast effect) and the C impact site toward the f. limb (also surrounded by a bright, elliptical ring and also probably due to a contrast effect), BC and DE within STB f. CM, and shadow of Ganymede on f. limb upon NPR.

i.) 1994 JUL 20, 00h28m UT, CMI=203°.1, CMII=254°.6, CMIII=326°.0. 9-in (23-cm) Refr.,172× and 226×, no filter. John D. Sabia. C impact site on f. limb, K (12) impact site (14 hours-old) f. CM with dark Sp. crescentic impact ejecta vis., and newly formed (2.2 hours-old) L (11) impact site on f. limb (appearing as a dark, circular albedo feature with a dark central core).

j.) 1994 JUL 20, 01h33m UT, CMI=242°.7, CMII=293°.9, CMIII=005°.3. 16-in (41-cm) Newt. Lynxx PC CCD camera, RGB filters. Donald C. Parker. L impact site toward p. limb and G/D impact site complex f. CM (note elongated appearance of very dark core comprising both G and D impact sites).

k.) 1994 JUL 20, 02h04m UT, CMI=261°.6, CMII=312°.6, CMIII=024°.0. 10-in (25-cm) Newt., 254×, no filter. Jose Olivarez. L impact site toward p. limb, G/D impact site complex on CM, and small, bright oval on CM within North Tropical Zone (NTrZ).

l.) 1994 JUL 20, 02h22m UT, CMI=272°.6, CMII=323°.5, CMIII=034°.9. 8-in (20-cm) Newt., 156×-281×, no filter. Cecil Post. L impact site toward p. limb and G/D impact site complex just p. CM.

m.) 1994 JUL 20, 02h23m UT, CMI=273°.2, CMII=324°.1, CMIII=035°.5. 4.25-in (10.8-cm) Schief., 130×, no filter. Gary L. Cameron. L impact site on p. limb, G/D impact site complex p. CM (very dark, elongated albedo feature with a bright oval p. and f. the impact site above the STZ), and 1.3 days-old H (14) impact site on f. limb.

n.) 1994 JUL 20, 11h40m UT, CMI=252°.7, CMII=300°.6, CMIII=012°.2. 16-in (41-cm) Newt., Lynxx PC CCD camera, no filter. Isao Miyazaki. L impact site toward p. limb and G/D impact site complex f. CM.

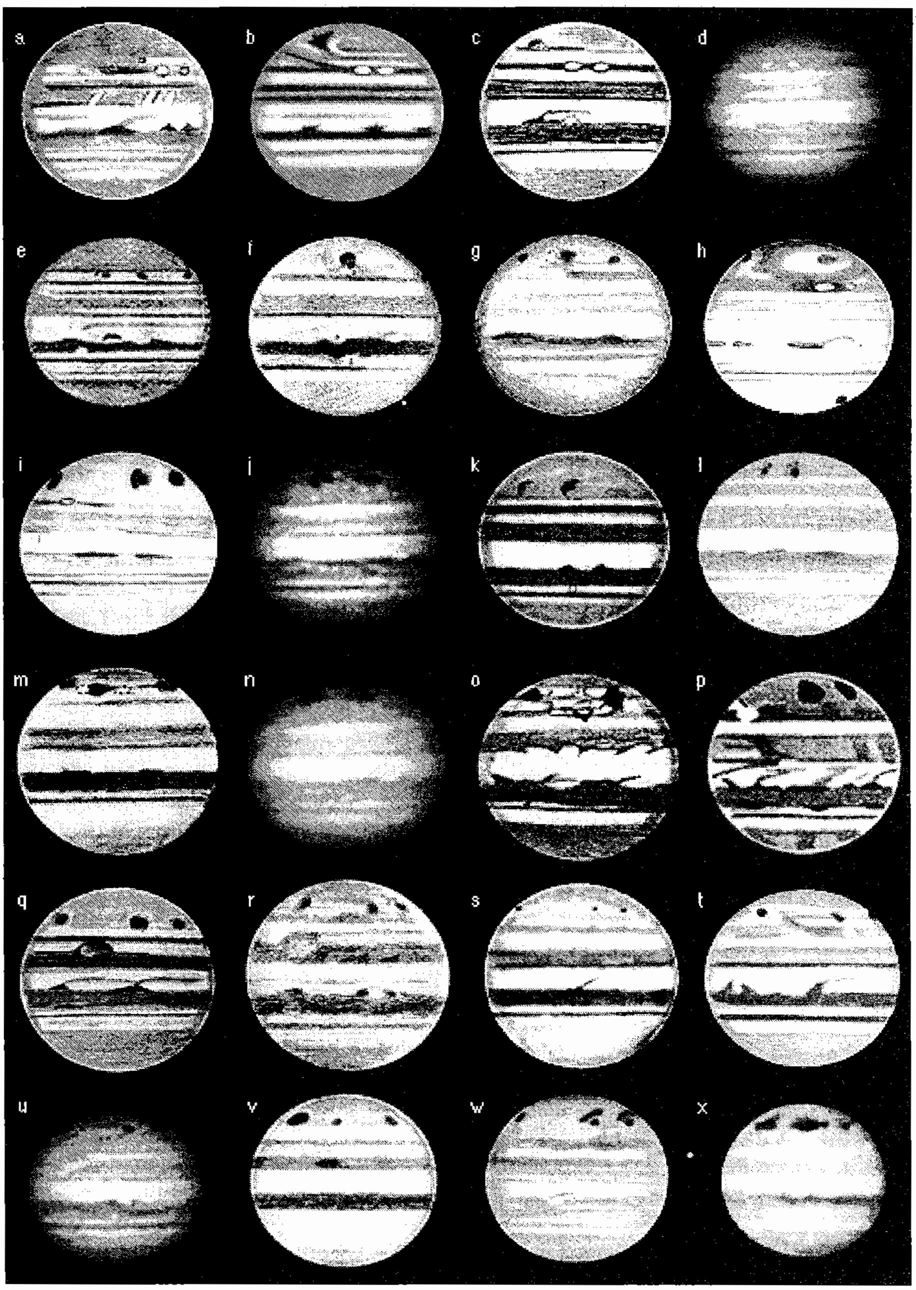

Figure 15. Jupiter drawings and images, 1994 JUL 07-22.

o.) 1994 JUL 20, 19h40m UT, CMI=185°.2, CMII=230°.6, CMIII=302°.7. 8-in (20-cm) Newt., 225×, no filter. D. Niechoy. K impact site toward p. limb, L impact site toward f. limb, and bright oval Np. L impact site within the STB.

p.) 1994 JUL 20, 20h55m UT, CMI=231°.1, CMII=276°.1, CMIII=347°.6. 8-in (20-cm) Newt., 280×, no filter. Martin Lehky. A very bright oval is vis. within the STB toward the p. limb, L impact site on CM, and G/D impact site complex toward f. limb

q.) 1994 JUL 21, 01h00m UT, CMI=020°.4, CMII=064°.1, CMIII=135°.7. 6-in (15-cm) Refr., 200-250×, W12, 25, 38A Filters. Phillip W. Budine. H impact site on p. limb with bright halo surrounding it (probable contrast effect), E impact site following CM (also with bright halo surrounding it), A impact site on f. limb, and the GRS p. the CM.

r.) 1994 JUL 21, 01h05m UT, CMI=023°.4, CMII=067°.1, CMIII=138°.7. 10-in (25-cm) Newt., 189×, no filter. Jean-Francois Viens. H impact site on p. limb, E impact site f. CM, A impact site (vis. as a dark, wispy streak) on the f. limb, and GRS toward p. limb.

s.) 1994 JUL 21, 01h18m UT, CMI=031°.4, CMII=074°.9, CMIII=146°.6. 10-in (25-cm) Newt., 131× and 164×, no filter. Robert L. Robinson. H impact site on p. limb, E impact site f. CM, and A impact site toward f. limb.

t.) 1994 JUL 21, 02h40m UT, CMI=081°.3, CMII=124°.5, CMIII=196°.2. 12-in (30-cm), 173×, no filter. Claus Benninghoven. E impact site toward p. limb (note bright zone (SSTZ) surrounding the impact site as well as bright oval f. site), A impact site depicted as a dusky (4/10) streak f. E impact site (appears to merge with dark bridge connecting SSTB and STB), C impact site toward f. limb, K impact site on f. limb. BC and DE toward f. limb within STB.

u.) 1994 JUL 21, 11h16m UT, CMI=035°.9, CMII=076°.3, CMIII=148°.1. 16-in (41-cm) Newt., Lynxx PC CCD camera, green (P01 + NR400) filter. Isao Miyazaki. H impact site on p. limb (note Np. dark material above STZ), E impact site f. CM (dark projection Nf. impact site above SSTZ), and A impact site noted as dusky (4/10) streak f. E impact site toward f. limb.

v.) 1994 JUL 21, 18h49m UT, CMI=312°.0, CMII=350°.0, CMIII=061°.9. 6.3-in (16-cm) Refr., 143×, polarizer filter. Johan Warell. G/D/S/R impact site complex on p. limb (R component 13.6 hours old and S component 3.6 hours old), Q1 impact site p. CM (22.6 hours old), and H impact site toward f. limb.

w.) 1994 JUL 22, 02h36m UT, CMI=236°.7, CMII=272°.2, CMIII=344°.1. 12.5-in (32-cm) BTS, 235×, no filter. Richard J. Wessling. K impact site on p. limb, L impact site f. CM, and G/D/S/R impact site complex on f. limb.

x.) 1994 JUL 22, 03h56m UT, CMI=285°.4, CMII=320°.5, CMIII=032°.5. 14-in (36-cm) Sch./Cass., Starlight Xpress CCD camera, no filter. John Sanford. L impact site on p. limb, G/D/S/R impact site complex on CM (note R component appears as a dark projection at the f. end of the complex), Q1 impact site toward f. limb, and Io p. the disk adjacent to the SEB.

Figure 16 (p. 115).

a.) 1994 JUL 23, 00h23m UT, CMI=313°.4, CMII=342°.0, CMIII=054°.1. 16-in (41-cm) Newt., Lynxx PC CCD camera, RGB filters. Donald C. Parker. L impact site on p. limb, G/D/S/R impact site complex p. CM (note multi-lobed appearance with dark projection Sp. complex), Q1 impact site f. CM, and H impact site toward f. limb (note dark N. projection above STZ).

b.) 1994 JUL 23, 01h50m UT, CMI=006°.4, CMII=034°.8, CMIII=106°.7. 6-in (15-cm) Newt., 200×, no filter. Matthew Will (A.L.P.O. Lunar and Planetary Training Program Coordinator). G/D/S/R impact site complex on p. limb, H impact site p. CM, and E impact site on f. limb.

c.) 1994 JUL 23, 01h51m UT, CMI=007°.0, CMII=035°.1, CMII=107°.3. 10-in (25-cm) Newt., 178×, no filter. Jose Olivarez. G/D/S/R impact site complex (f. end) on p. limb, Q1 impact site f. G/D/S/R complex, H impact site p. CM (Note Np. projection above STZ and Sp. above SSTZ), E impact site on f. limb, GRS f. CM (note bright N. half), and Io transiting upon NEB toward f. limb.

d.) 1994 JUL 23, 02h10m UT, CMI=018°.6, CMII=046°.6, CMIII=118°.8. 12.5-in (32-cm) Newt., magnification not recorded, no filter. Richard A. Sweetsir. H impact site on p. limb (note dark N. projection above STZ described as "C-shaped") and E impact site on f. limb.

e.) 1994 JUL 23, 02h28m UT, CMI=029°.6, CMII=057°.5, CMIII=129°.7. 16-in (41-cm) Newt., Lynxx PC CCD camera, RGB filters. Donald C. Parker. Q1 impact site on p. limb, H impact site toward p. limb (note Sp. dark, elongated albedo feature above SSTZ, probable H impact debris ejecta), E impact site f. CM (very dark and elongated), A impact site on f. limb (vis. as a dark streak along f. limb), and GRS p. CM (note dark, central core giving the appearance of an "eye").

f.) 1994 JUL 23, 02h45m UT, CMI=039°.9, CMII=067°.8, CMIII=140°.0. 4.25-in (10.8-cm) Schief., 165×, no filter. Gary Cameron. H impact site on p. limb (note note bright oval f. impact site above SSTZ), E impact site f. CM (note bright oval f. impact site above SSTZ), A impact site noted as dusky (4/10) streak on f. limb, and GRS toward p. limb.

g.) 1994 JUL 23, 19h44m UT, CMI=301°.5, CMII=324°.0, CMIII=035°.9. 12-in (30-cm) Refr., 230×, polarizer filter. John H. Rogers. L impact site on p. limb (note dark "V-shaped" appearance), G/D/S/R impact site complex p. CM (note dark, multi-lobed appearance with a bright oval Np. complex and a bright SSTZ f. it), Q1 impact site f. CM, and H impact site on f. limb. All impact sites (complex) appear to be surrounded by a very bright SSTZ.

h.) 1994 JUL 24, 00h35m UT, CMI=118°.4, CMII=139°.3, CMIII=211°.8. 6-in (15-cm) Newt., 205×, no filter. Samuel R. Whitby. E impact site on p. limb, A impact site as dusky streak f. E site, C impact site f. CM (dark and elongated), K/W impact site complex on f. limb, BC and DE f. CM within STB.

i.) 1994 JUL 24, 01h01m UT, CMI=134°.3, CMII=155°.1, CMIII=227°.5. 12.5-in (32-cm) BTS, 235×, no filter. Richard J. Wessling. E impact site on p. limb, A impact site f. E site as broad, , curved, dusky (4/10) streak extending between STZ and SPR, C impact site on CM (dark, elongated with very dark core), K/W impact site complex on f. limb (multi-lobed appearance with Sp. component), BC and DE (also small, bright oval f. DE) within STB on and f., respectively, CM.

j.) 1994 JUL 24, 01h18m UT, CMI=144°.6, CMII=165°.3, CMIII=237°.8. 16-in (41-cm) Newt., Lynxx PC CCD camera, RGB filters. Donald C. Parker. E impact site on f. limb (followed by dusky streaked A impact site), C impact site p. CM (dark and elongated), K/W impact site complex on f. limb (appearance of a "scorpion"), and BC and DE within STB p. and on CM, respectively.

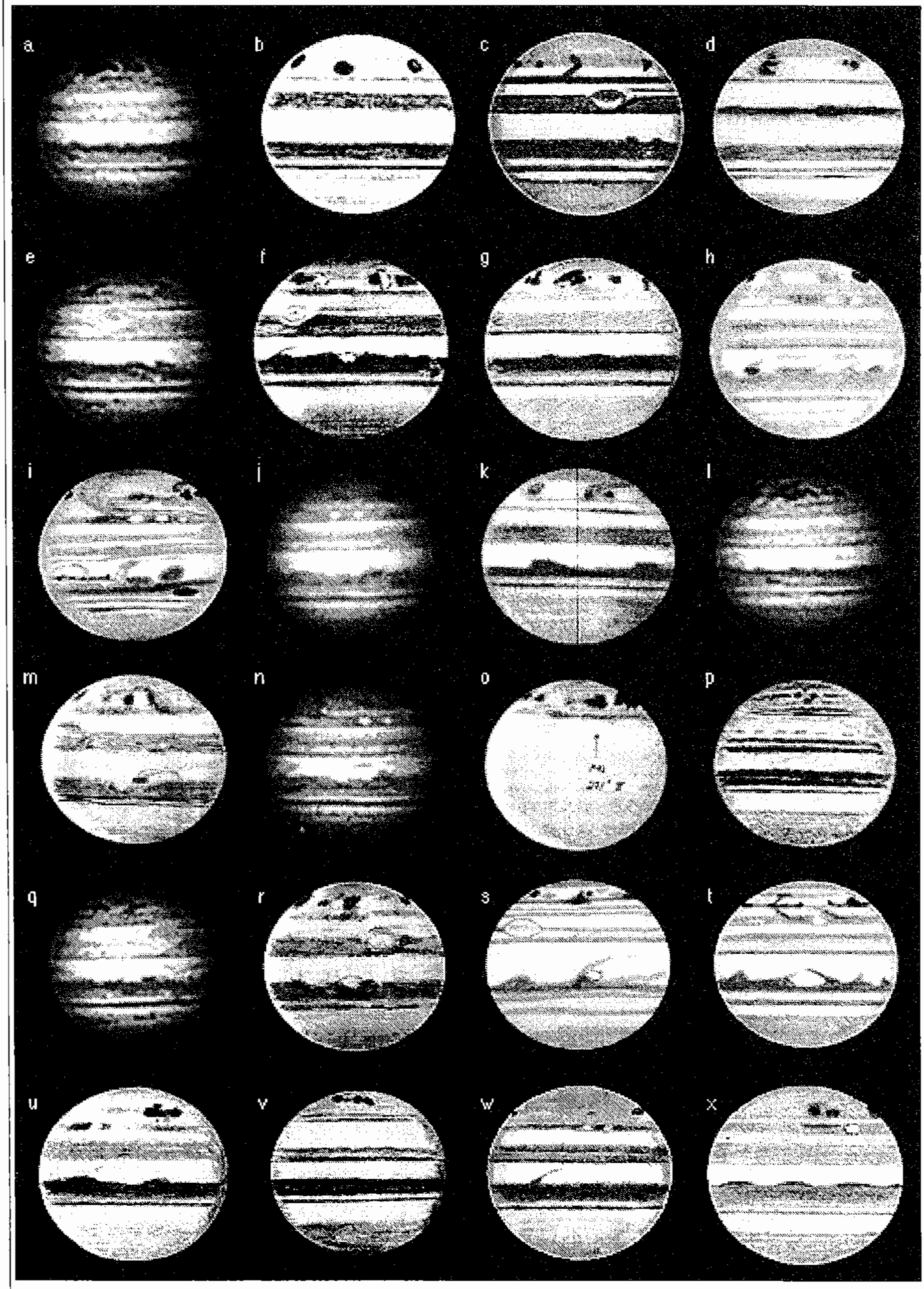

Figure 16. Jupiter drawings and images, 1994 JUL 23-31.

k.) 1994 JUL 24, 02h01m UT, CMI=170°.9, CMII=191°.3, CMIII=263°.8. 6-in (15-cm) Newt., 174X, no filter. Richard Cologne. C impact site on p. limb and K/W impact site complex f. CM (note bi-lobed appearance with dark Sp. component above SSTZ extending nearly to SPR).

l.) 1994 JUL 25, 01h34m UT, CMI=312°.1, CMII=325°.1, CMIII=037°.8. 16-in (41-cm) Newt., Lynxx PC CCD camera, RGB filters. Donald C. Parker. L impact site on p. limb (note "clover-leaf" appearance), G/D/S/R impact site complex p. and on CM, respectively (note very dark [1-2/10] multi-lobed appearance with dark [3/10] Sp. projection above SSTZ), Q1 impact site f. CM, and H impact site on f. limb. All impact sites appear to be surrounded by bright borders (probable contrast effect between very dark impact sites and the SSTZ).

m.) 1994 Jul 26, 00h43m UT, CMI=078°.8, CMII=084°.4, CMIII=157°.4. 10-in (25-cm) Newt., 189X, no filter. Jean-Francois Viens. H impact site on p. limb, E impact site p. CM (appearing very dark [1-2/10] and circular), A impact site f. E site appearing as a dark (3/10), curved streak (p. end appears to connect to Sf. E impact site and bright SSTZ between E and A impact sites).

n.) 1994 Jul 26, 02h21m UT, CMI=138°.6, CMII=143°.6, CMIII=216°.6. 16-in (41-cm) Newt., Lynxx PC CCD camera, RGB filters. Donald C. Parker. E impact site on f. limb, A impact site f. E site (appears dusky [4/10] and separated by a bright [7/10] zone), C impact site f. CM (dark [3/10] and elongated), K/W impact site complex on f. limb, BC and DE f. CM within STB, and Ganymede on p. limb above NPR.

o.) 1994 Jul 27, 01h20m UT, CMI=259°.1, CMII=256°.9, CMIII=330°.2. 10-in (25-cm) Newt., 189X, no filter. Jean-Francois Viens. K/W impact site complex on p. limb, L impact site f. CM (note dark projection extending from p. edge of site above SSTZ), G/D/S/R impact site complex on f. limb.

p.) 1994 Jul 27, 19h52m UT, CMI=216°.9, CMII=208°.8, CMIII=282°.3. 11-in (28-cm) Sch./Cass., 225-311X, Schott OG550 (orange), BG28 (blue), yellow, and VG6 (green) filters. Gerard Teichert. K/W impact site complex on CM appearing as a "cross-shaped" albedo feature consisting of four very dark (1-2/10) nodules.

q.) 1994 Jul 28, 00h44m UT, CMI=034°.9, CMII=025°.3, CMIII=098°.9. 16-in (41-cm) Newt., Lynxx PC CCD camera, RGB filters. Donald C. Parker. G/D/S/R impact site complex on p. limb, Q1 impact site toward p. limb, H impact site on CM (note very dark [1-2/10] Sf. projection above SSTZ and Np. dark [3/10] projection above STZ), E impact site on f. limb, and GRS f. CM.

r.) 1994 Jul 28, 00h45m UT, CMI=035°.5, CMII=025°.9, CMIII=099°.4. 10-in (25-cm) Newt., 189X, no filter. Jean-Francois Viens. G/D/S/R impact site complex on p. limb, Q1 impact site toward p. limb, H impact site on CM (note bi-lobed appearance with dark, broad N. projection above STZ), E impact site on f. limb, and GRS f. CM.

s.) 1994 Jul 28, 02h03m UT, CMI=083°.1, CMII=073°.1, CMIII=146°.5. 8-in (20-cm) Newt., 280X, no filter. Daniel M. Troiani. H impact site on p. limb, E impact site on CM (note very dark [1-2/10] core, or impact site, f. dark [3/10] impact ejecta apparently connecting to STB), C impact site on f. limb, and GRS toward p. limb.

t.) 1994 Jul 29, 01h57m UT, CMI=237°.2, CMII=219°.5, CMIII=293°.3. 8-in (20-cm) Newt., 192X and 236X, no filter. Claus Benninghoven. C impact site on p. limb, K/W impact site complex p. CM (note dark Np. projection above STZ and dark Sp. projection above SSTZ), L impact site on f. limb (note dark, thin projection from Np. edge with dark nodule at p. end), and long-enduring oval FA f. CM within STB.

u.) 1994 Jul 29, 20h36m UT, CMI=199°.2, CMII=175°.7, CMIII=249°.6. 12-in (30-cm) Refr., 230X, no filter. John H. Rogers. C impact site p. CM (becoming very diffuse and difficult to distinguish from SSTB), BC and DE p. CM within STB, and K/W impact site complex f. CM (very large, bi-lobed appearance with Sp. condensation and Np. bright oval above STZ).

v.) 1994 Jul 30, 20h26m UT, CMI=350°.9, CMII=319°.7, CMIII=034°.0. 11-in (28-cm), 225-311X, Schott OG550 (orange), BG28 (blue), yellow, and VG6 (green) filters. Gerard Teichert. G/D/S/R impact site complex on CM consisting of three large, very dark (1-2/10) condensations connected by thin dark (2-3/10) bridges.

w.) 1994 Jul 31, 01h29m UT, CMI=175°.6, CMII=142°.8, CMIII=217°.1. 10-in (25-cm) Newt., 197X, no filter. Robert L. Robinson. E impact site on p. limb, C impact site f. CM (small, nodular and dark), K/W impact site complex on f. limb, and BC and DE f. CM within STB.

x.) 1994 Jul 31, 02h42m UT, CMI=220°.1, CMII=186°.9, CMIII=261°.2. 8-in (20-cm) Newt., 200X, no filter. Cecil C. Post. K/W impact site complex f. CM (very dark [1-2/10] tri-lobed appearance with dark [3/10] Sp. projection above SSTZ), L impact site on f. limb, FA toward f. limb within STB.

Figure 17 (p. 117).

a.) 1994 Aug 01, 00h53m UT, CMI=311°.4, CMII=271°.2, CMIII=345°.7. 12.5-in (32-cm) BTS, 235X, no filter. Richard J. Wessling. K/W impact site complex on p. limb, L impact site p. CM (note very dark impact site and Sp. component, probable impact debris ejecta), and G/D/S/R impact site complex composed of three very dark condensations and dark Sp. projection.

b.) 1994 Aug 02, 01h11m UT, CMI=120°.1, CMII=072°.1, CMIII=147°.0. 10-in (25-cm) Newt., 197X, W21 and 80A Filters. Robert L. Robinson. H impact site on p. limb and E impact site on CM (although drawn darker and larger by other observers at the time).

c.) 1994 Aug 04, 00h10m UT, CMI=038°.4, CMII=335°.5, CMIII=050°.9. 10-in (25-cm) Newt., 189X, no filter. Jean-Francois Viens. L impact site on p. limb, G/D/S/R impact site complex p. CM (very dark [1-2/10]), elongated albedo feature with dark Sp. projection above SSTZ and dark (2-3/10), broad projection from Nf. end above STZ), Q1 impact site f. CM, and H impact site on f. limb.

d.) 1994 Aug 04, 01h11m UT, CMI=075°.6, CMII=012°.4, CMIII=087°.7. 6-in (15-cm) Newt., 205X, no filter. Samuel R. Whitby. G/D/S/R impact site complex on p. limb, Q1 impact site toward p. limb, H impact site f. CM (depicted fainter and smaller than previous drawing), E impact site on f. limb, and GRS toward f. limb.

e.) 1994 Aug 04, 02h30m UT, CMI=123°.7, CMII=060°.1, CMIII=135°.5. 14-in (36-cm) Newt., 392X, no filter. Richard Hill. Q1 impact site on p. limb, H impact site toward p. limb (very dark [1-2/10], bi-lobed appearance), E impact site toward f. limb (dark Sp. dark [2-3/10] projection above SSTZ), GRS toward p. limb.

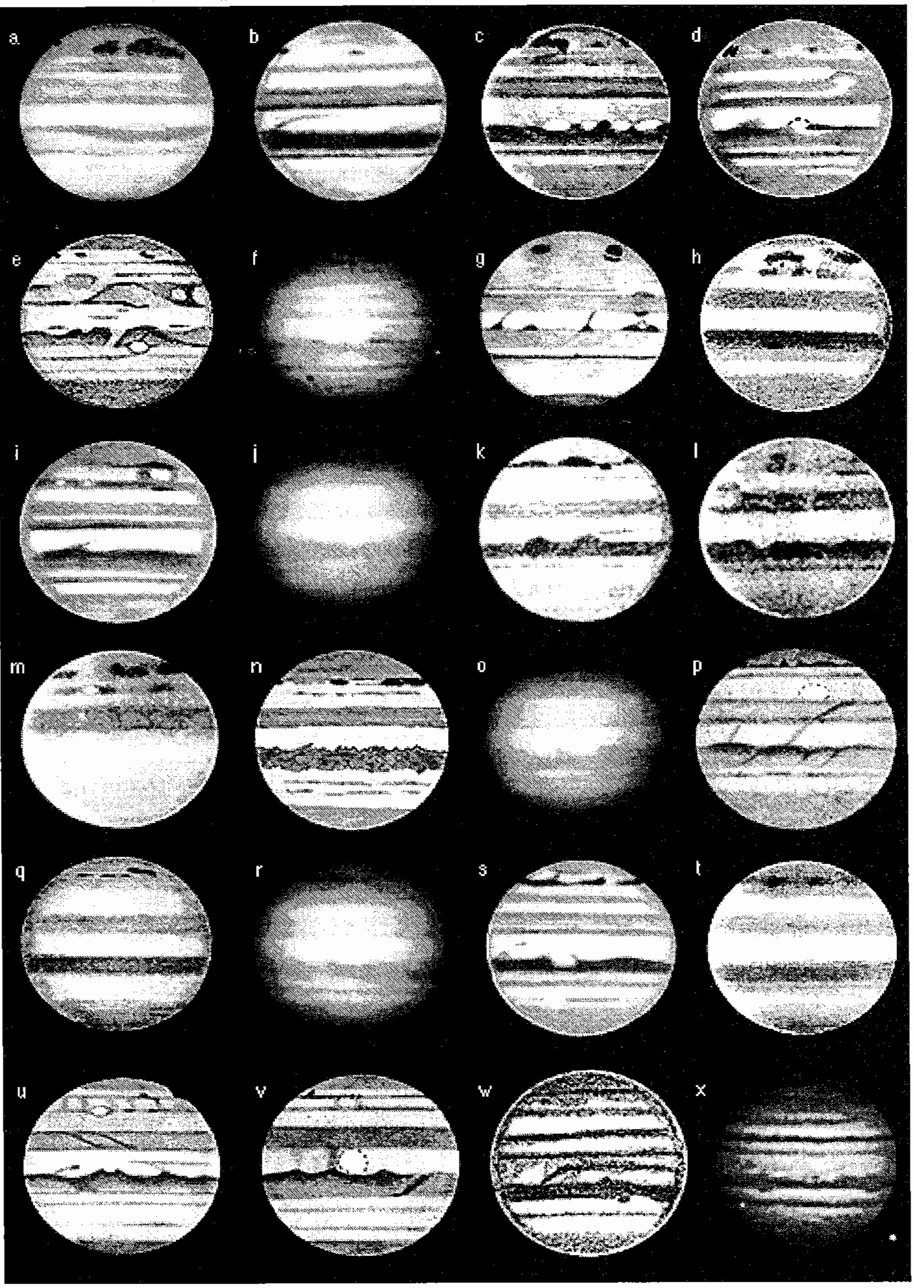

Figure 17. Jupiter drawings and images, 1994 AUG 01-1995 APR 10.

f.) 1994 AUG 04, 10h56m UT, CMI=072°.1, CMII=005°.8, CMIII=081°.3. 16-in (41-cm) Newt., Lynxx PC CCD camera, red (R60 + NR400) filter. Isao Miyazaki. G/D/S/R impact site complex is on p. limb (note Nf. dark projection above STZ), Q1 impact site toward p. limb (very dark [1-2/10] and elongated), H impact site f. CM (with dark, broad S. Projection above SSTZ), shadow of Europa upon North Temperate Zone (NTZ) p. CM, and Io vis. on f. limb above NEB.

g.) 1994 AUG 05, 01h08m UT, CMI=231°.5, CMII=160°.6, CMIII=236°.3. 8-in (20-cm) Refr., 108× and 150×, Filter: W12 and 58. James H. Fox. C impact site toward p. limb (this site was last reported on 1994 AUG 07),and K/W impact site complex on f. limb (dark [2-3/10] thin, curved projection separated from Np. end above STZ).

h.) 1994 AUG 08, 19h43m UT, CMI=304°.3, CMII=204°.7, CMIII=281°.3. 12-in (30-cm) Refr., 230X, Filter: yellow and polarizer. John H. Rogers. K/W impact site complex on and p. CM (very dark [1-2/10], elongated albedo feature with bright area N. of complex above STZ), FA within STB on CM, and L impact site on f. limb.

i.) 1994 AUG 10, 00h40m UT, CMI=283°.0, CMII=174°.2, CMIII=251°.2. 6-in (15-cm) Newt., 155-310X, W21 (orange) Filter. Samuel R. Whitby. The K/W impact site complex has expanded in longitude, primarily to the east (decreasing longitude) in accordance to the predominant zonal current, and now appears as a very dark (1-2/10), elongated albedo feature (with a thickened f. half), a bright region appears to the N. of the complex above the STZ (part of the long-lived SSTBZ present since 1992), and BC and DE appear toward the p. limb within the STB.

j.) 1994 AUG 18, 11h00m UT, CMI=122°.6, CMII=309°.5, CMIII=028°.7. 16-in (41-cm) Newt., Lynxx PC CCD camera, no filter. Isao Miyazaki. An "impact belt" composed of the L impact site on p. limb, a very dark (1-2/10), elongated G/D/S/R impact site complex appears on the CM with a dark (2-3/10) Sp. projection and a thin, dark (2-3/10) projection from its Np. end (apparently connecting to the STB), and the Q1 impact site on the f. limb.

k.) 1994 AUG 23, 19h37m UT, CMI=146°.2, CMII=292°.2, CMIII=012°.9. 12-in (30-cm) Refr., 260X, yellow filter. James Lancashire. Impact belt comprising the L impact site on the p. limb, G/D/S/R impact site complex on the CM (note dark Nf. projection above STZ), and the Q1 impact site on the f. limb.

l.) 1994 AUG 23, 23h55m UT, CMI=303°.5, CMII=088°.1, CMIII=168°.8. 10-in (25-cm) Newt., 189X, no filter. Jean-Francois Viens. E impact site on p. limb (very dark core with dark, broad projection above SSTZ), K/W impact site complex (p. end) on f. limb, and GRS on p. limb.

m.) 1994 AUG 24, 23h55m UT, CMI=101°.2, CMII=238°.2, CMIII=319°.2. 10-in (25-cm) Newt., 189X, no filter. Jean-Francois Viens. K/W impact site complex (f. end) on p. limb, L impact site on CM (multilobed and elongated), G/D/S/R impact site complex on f. limb, and FA within STB toward the p. limb.

n.) 1994 AUG 25, 00h38m UT, CMI=127°.4, CMII=264°.1, CMIII=345°.2. 6-in (15-cm) Newt., 208X, orange filter. Jeffrey Sandel. K/W impact site complex (f. end) on p. limb, L impact site p. CM, and G/D/S/R impact site complex on f. limb.

o.) 1994 AUG 25, 10h54m UT, CMI=142°.8, CMII=276°.3, CMIII=357°.5. 16-in (41-cm) Newt., Lynxx PC CCD camera, no filter. Isao Miyazaki. Impact belt composed of K/W impact site complex, L impact site, G/D/S/R impact site complex, and Q1 impact site vis.

p.) 1994 AUG 27, 03h10m UT, CMI=175°.4, CMII=296°.1, CMIII=017°.7. 14-in (36-cm) Newt., 392X, no filter. Richard Hill. Impact belt comprising the L impact site, G/D/S/R impact site complex, and Q1 impact site (note dark condensations along belt) vis.

q.) 1994 AUG 27, 19h08m UT, CMI=039°.3, CMII=154°.9, CMIII=236°.7. 11-in (28-cm) Sch./Cass., 225X, yellow and green filters. Gerard Teichert. K/W impact site complex on p. limb (main body of complex apparently displaced toward the S. above SSTZ) and dark sections of SSTB noted p. CM.

r.) 1994 AUG 28, 10h34m UT, CMI=243°.7, CMII=354°.4, CMIII=076°.4. 16-in (41-cm) Newt., Lynxx PC CCD camera, NR400 filter. Isao Miyazaki. Impact belt comprising the K/W impact site complex (expanded, dark p. section of belt) and L impact site vis.

s.) 1994 AUG 30, 01h07m UT, CMI=213°.5, CMII=312°.0, CMIII=034°.4. 12-in (30-cm) Refr., 178X, no filter. Claus Benninghoven. Impact belt comprising L impact site, G/D/S/R impact site complex, and Q1 impact site (gap between G/D/S/R complex and Q1 site) noted. Dark Sf. projection noted from L impact site section.

t.) 1994 SEP 04, 00h05m UT, CMI=244°.1. CMII=304°.8, CMIII=028°.5. 10-in (25-cm) Newt., 189X, no filter. Jean-Francois Viens. Dark (2-3/10) impact belt with two very dark (1-2/10) condensations (from L and G/D/S/R impact sites p. and f. CM, respectively) noted.

u.) 1994 SEP 05, 01h26m UT, CMI=091°.2, CMII=143°.8, CMIII=227°.8. 14-in (36-cm) Newt., 392X, Filter: polarizer. Richard Hill. Impact belt less prominent above vis. sector of planet with small, very dark (1-2/10) condensations noted toward f. limb (derived from the f. end of the K/W impact site complex), L impact site (remnant) on f. limb. Series of dark (3/10) projections noted to extend between SSTB and STB above STZ across the vis. disk. FA vis. within STB p. CM.

v.) 1994 SEP 06, 02h37m UT, CMI=292°.1, CMII=336°.7, CMIII=061°.0. 14-in (36-cm) Newt., 392X, no filter. Richard Hill. Impact belt vis. with small, very dark (1-2/10) condensations p. the CM (derived from G/D/S/R impact site complex).

w.) 1995 FEB 08, 11h25m UT, CMI=219°.6, CMII=158°.7, CMIII=285°.1. 6-in (15-cm) Newt., 155X and 205X, W21 and 80A Filters. Samuel R. Whitby. Approximately 7 months after the S-L9 impact period (1994 JUL 16-22) a dark (3/10) single, thin impact belt is vis. at the approximate location of the K/W impact site complex. The South Polar Region (SPR) appears duskier (4/10) than the previous apparition.

x.) 1995 APR 10, 07h43m UT, CMI=357°.0, CMII=192°.0, CMIII=334°.0. 16-in (41-cm) Newt., Lynxx PC CCD camera, RGB filters. Donald C. Parker. Approximately 9 months after the impact period a single dark (3/10) impact belt is vis. S. of the STB between the SSTZ and the SSSTZ . No dark condensations are noted within the impact belt at this time. The SSTZ appears dusky (4/10) and the SPR appears dark (3/10); ground-based observations at infrared wavelengths (2.3 micrometers) displayed the high-altitude impact dust distributed throughout the South Polar Region (SPR), see *Figure 14* (p. 111).

METEORS SECTION NEWS

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

Table 1. Recent A.L.P.O. Meteor Observations; October - December, 1995.

1995 UT Date	Observer and Location	Universal Time	Number and Type* of Meteors Seen	Comments (+N = Limiting Magnitude)
Oct 01	John Gallagher, NJ	04:20-06:34	1 EGE, 1 NPI, 1 NTA, 1 SOR,7 SPO	+7.4
02	John Gallagher, NJ	04:05-06:12	1 KAQ, 1 NTA, 1 ORI, 3 SPO	+7.2
	George Zay, CA	06:14-12:42	6 DAS, 6 NTA, 5 ORI, 3 SOR, 1 SPI, 4 STA, 47 SPO	+5.8
	Mark Davis, SC	08:02-09:02	1 SOR, 11 SPO	+5.8
	Robert Lunsford, CA	08:30-12:30	1 NTA, 3 ORI, 3 SOR, 2 SPI, 34 SPO	+6.3
03	George Zay, CA	07:37-12:00	3 DAS, 3 NTA, 2 ORI,1 SOR, 3 SPI, 2 STA, 27 SPO	+5.8
	Robert Lunsford, CA	08:00-12:30	2 DAS, 2 ORI, 4 SPI, 2 STA, 23 SPO	+6.2
07	Graham Wolf, New Zealand	14:00-17:00	6 STA, 5 SPO	+4.3
12	Graham Wolf, New Zealand	12:00-16:00	9 ORI, 7 STA, 11 SPO	+4.4
14	Graham Wolf, New Zealand	12:00-16:00	9 ORI, 5 STA, 10 SPO	+4.7
15	Graham Wolf, New Zealand	13:00-16:00	12 ORI, 5 STA, 9 SPO	+4.4
16	Graham Wolf, New Zealand	13:00-16:00	14 ORI, 6 STA, 7 SPO	+4.6
17	Graham Wolf, New Zealand	13:00-16:00	13 ORI, 5 STA, 7 SPO	+4.5
18	Mark Davis, SC	02:12-05:12	2 NTA, 4 STA, 18 SPO	+5.8
	Doug Kniffen, MO	03:35-04:30	2 ORI, 15 SPO	+5.7
	George Zay, CA	06:18-12:57	3 EGE, 6 NTA, 15 ORI, 5 SOR, 11 STA, 20 SPO	+5.9
	Richard Taibi, MD	06:46-07:49	2 ORI, 1 STA, 3 SPO	+5.3
	Robert Lunsford, CA	08:00-13:00	3 EGE, 2 NTA, 13 ORI, 4 SOR, 10 STA, 25 SPO	+6.0
	Graham Wolf, New Zealand	13:00-16:00	17 ORI, 7 STA, 8 SPO	+4.5
19	David Holman, CA	03:08-04:36	7 SPO	+6.5
	David Holman, CA	07:19-08:45	10 ORI, 13 SPO	+6.2
	George Zay, CA	06:16-12:50	15 EGE, 4 NTA, 9 ORI, 2 SOR, 9 STA, 27 SPO	+5.8
	Robert Lunsford, CA	08:00-13:00	16 EGE, 5 NTA, 17 ORI, 1 SOR, 5 STA, 21 SPO	+6.1
	David Holman, CA	10:32-11:58	10 ORI, 10 SPO	+6.1
20	John Gallagher, NJ	04:55-08:27	2 EGE, 1 LMI, 1 NTA, 3 ORI, 1 SOR, 8 SPO	+7.5
	Robert Lunsford, CA	08:00-13:00	7 EGE, 1 NTA, 36 ORI, 2 SOR, 11 STA, 35 SPO	+6.2
	David Holman, CA	08:02-13:04	2 EGE, 1 NTA, 49 ORI, 1 STA, 57 SPO	+6.2
21	Robert Togni, AR	04:33-05:39	6 ORI, 2 SPO	+4.3
	David Holman, CA	06:12-12:00	2 EGE, 6 NTA, 53 ORI, 2 STA, 74 SPO	+6.1
	Norman McLeod, FL	07:05-09:26	2 EGE, 1 LMI, 20 ORI, 5 STA, 6 SPO	+7.0
	Robert Lunsford, CA	08:00-13:00	8 EGE, 1 NTA, 53 ORI, 4 SOR, 6 STA, 45 SPO	+6.4
	David Swann, TX	08:30-10:05	5 ORI, 2 STA, 4 SPO	+5.0
	Graham Wolf, New Zealand	13:00-16:00	18 ORI, 7 STA, 12 SPO	+4.3
22	Doug Kniffen, MO	03:40-04:45	7 ORI, 4 SPO	+5.3
	Peter Detterline, PA	04:00-05:00	5 ORI, 2 SPO	+5.4
	Jeffery Sandel, SC	04:30-10:40	3 EGE, 5 LMI,127 ORI, 2 STA, 8 SPO	+5.9
	George Zay, CA	05:00-09:16	4 EGE, 6 NTA, 12 ORI, 10 STA, 18 SPO	+6.0
	Robert Togni, AR	05:01-06:00	1 ORI, 4 SPO	+3.8
	John Gallagher, NJ	05:05-07:51	1 EGE, 2 NTA ,1 OAR, 10 ORI, 4 SPO	+7.3
	Frank Melillo, NY	06:00-08:30	14 ORI, 3 SPO	+4.5
	George Gliba, VT	06:00-09:00	2 AMD 2 NTA, 2 OAR, 82 ORI, 6 STA, 30 SPO	+6.3
	Mark Davis, SC	06:30-09:00	3 EGE, 21 ORI, 4 NTA, 6 STA, 46 SPO	+5.7

Table 1 continued on pp. 120-122 with notes on p. 122.

Table 1—Continued.

1995 UT Date	Observer and Location	Universal Time	Number and Type* of Meteors Seen	Comments (+N = Limiting Magnitude)
Oct 22	Richard Taibi, MD	07:10-09:44	4 EGE, 14 ORI, 2 STA, 6 SPO	+6.0
	Robert Lunsford, CA	08:00-13:00	7 EGE, 3 NTA, 76 ORI, 3 STA, 36 SPO	+6.3
	David Swann, TX	08:20-09:20	2 ORI, 1 STA, 7 SPO	+5.0
	David Holman, CA	08:36-12:30	2 NTA, 18 ORI, 17 SPO	+5.9
	J. Kenneth Eakins, CA	08:45-10:45	13 ORI, 2 SPO	+5.2
	George Zay, CA	10:33-12:51	2 EGE, 58 ORI, 3 SOR, 2 STA, 15 SPO	+5.9
	Graham Wolf, New Zealand	13:00-16:00	31 ORI, 7 STA, 11 SPO	+4.7
23	John Gallagher, NJ	04:40-07:32	4 EGE, 3 NTA, 9 ORI, 2 SOR, 7 SPO	+7.5
	Norman McLeod, FL	06:06-10:29	3 EGE, 1 LMI, 4 NTA, 65 ORI, 12 STA, 17 SPO	+7.2
	Richard Taibi, MD	07:05-09:32	1 EGE, 3 NTA, 12 ORI, 2 STA, 12 SPO	+6.0
	Robert Lunsford, CA	07:47-12:47	31 ORI, 4 STA, 13 SPO	+5.4
	Robert Hays, IL	07:55-09:55	39 ORI, 1 STA, 19 SPO	+6.5
	Peter Detterline, PA	09:00-11:00	20 ORI, 5 SPO	+5.3
	Graham Wolf, New Zealand	14:00-16:00	12 ORI, 3 STA, 8 SPO	+4.4; 10% cloudy
24	Norman McLeod, FL	05:26-09:26	4 EGE, 8 NTA, 60 ORI, 10 SPO	+7.3
	John Gallagher, NJ	06:00-08:15	1 EGE, 1 LMI, 1 NTA, 10 ORI, 1 STA, 3 SPO	+7.5
	Robert Lunsford, CA	07:47-12:47	8 EGE, 3 NTA, 109 ORI, 16 STA, 41 SPO	+6.5
	Peter Detterline, PA	09:00-11:00	8 ORI, STA, 7 SPO	+5.1
	Graham Wolf, New Zealand	13:00-16:00	15 ORI, 6 STA, 11 SPO	+4.5
25	Mark Davis, SC	04:02-05:32	3 ORI, 1 NTA, 17 SPO	+5.6
	Norman McLeod, FL	05:26-10:26	6 LMI, 4 NTA, 58 ORI, 15 STA, 47 SPO	+7.3
	Robert Hays, MO	08:02-10:02	30 ORI, 2 STA, 15 SPO	+6.5
	Peter Detterline, PA	10:00-12:00	12 ORI, 5 STA, 3 SPO	+5.7
	J. Kenneth Eakins, CA	11:00-13:00	3 ORI, 1 LMI, 3 SPO	+5.3
	Graham Wolf, New Zealand	13:00-16:00	14 ORI, 6 STA, 7 SPO	+4.4
26	John Gallagher, NJ	05:20-06:30	2 NTA, 3 ORI, 1 STA, 4 SPO	+7.5; 5% cloudy
	George Zay, CA	05:48-13:01	3 EGE, 7 NTA, 36 ORI, 1 STA, 47 SPO	+5.9
	Robert Lunsford, CA	07:47-12:47	3 EGE, 2 NTA, 43 ORI, 4 STA, 42 SPO	+6.4
	Norman McLeod, FL	08:25-09:28	2 LMI, 12 ORI, 3 STA, 7 SPO	+7.2; 15% cloudy
	Robert Hays, MO	09:02-10:02	12 ORI, 2 STA, 9 SPO	+6.4
27	Norman McLeod, FL	05:26-06:26	1 EGE, 3 LMI, 7 NTA, 41 ORI, 13 SPO	+7.3
28	Norman McLeod, FL	05:35-09:26	1 LMI, 5 NTA, 14 ORI, 11 STA, 13 SPO	+7.3
	George Zay, CA	05:42-12:30	8 NTA, 25 ORI, 11 STA, 33 SPO	+6.0
	Graham Wolf, New Zealand	13:00-16:00	9 ORI, 8 STA, 6 SPO	+4.4; 15% cloudy
29	John Gallagher, NJ	05:10-07:20	2 NTA, 3 ORI, 3 STA, 2 SPO	+7.5
	Norman McLeod, FL	06:26-10:26	3 LMI, 5 NTA, 32 ORI, 26 STA	+7.3
30	John Gallagher, NJ	04:50-07:01	1 DER, 2 NTA, 1 STA, 9 SPO	+7.5
Nov 02	Norman McLeod, FL	05:30-06:55	1 LMI, 1 NTA, 7 STA, 2 SPO	+5.5
04	Norman McLeod, FL	08:26-10:34	2 LMI, 1 NTA, 3 ORI, 5 STA	+6.6
05	John Gallagher, NJ	05:10-07:17	2 STA, 6 SPO	+7.2
07	John Gallagher, NJ	00:35-02:41	1 STA, 2 SPO	+6.2
09	John Gallagher, NJ	06:15-07:20	*None Seen*	+6.2; 5% cloudy
11	John Gallagher, NJ	05:30-06:32	1 DER, 2 SPO	+6.7
13	John Gallagher, NJ	04:40-06:49	2 NTA, 3 SPO	+7.4; 10% cloudy
14	Graham Wolf, New Zealand	13:00-15:30	1 STA, 8 SPO	+4.5
15	Peter Detterline, PA	03:00-04:00	1 LEO, 3 NTA, 1 SPO	+5.4
	Graham Wolf, New Zealand	13:00-15:30	2 LEO, 1 STA, 7 SPO	+4.5
16	John Gallagher, NJ	05:35-07:45	1 AMO, 1 AND 3 LEO, 1 NTA, 4 SPO	+7.5
	Norman McLeod, FL	07:07-09:33	6 LEO, 3 NTA, 2 STA, 9 SPO	+6.2
	Robert Lunsford, CA	09:00-13:30	21 LEO, 3 NTA, 8 STA, 40 SPO	+6.2
	Graham Wolf, New Zealand	13:00-15:30	6 LEO, 3 STA, 8 SPO	+4.4

Table 1 continued on pp. 121-122 with notes on p. 122.

Table 1—Continued.

1995 UT Date	Observer and Location	Universal Time	Number and Type* of Meteors Seen	Comments (+N = Limiting Magnitude)
Nov 17	Mark Davis, SC	04:15-07:15	2 AMO, 6 LEO, 26 SPO	+5.6
	John Gallagher, NJ	05:25-07:42	3 AND, 9 LEO, 2 NTA, 2 STA, 3 SPO	+7.5
	George Zay, CA	05:37-13:18	5 AMO, 39 LEO, 16 NTA, 10 STA, 29 SPO	+5.7
	Norman McLeod, FL	06:20-10:33	2 AMO, 23 LEO, 4 NTA, 9 STA, 10 SPO	+6.2
	Jeffery Sandel, SC	07:00-10:10	2 AMO, 2 DER, 50 LEO, 2 SPO	+5.6
	Robert Lunsford, CA	07:30-13:30	6 AMO, 49 LEO, 7 NTA, 12 STA, 30 SPO	+6.3
	Vincent Giovannone, NY	08:00-08:30	3 LEO	+3.0
	Vincent Giovannone, NY	09:00-09:30	2 LEO	+3.0
	Richard Taibi, MD	09:32-10:42	5 LEO, 2 SPO	+5.0
	David Holman, CA	10:14-11:17	8 LEO, 9 SPO	+6.1
	Graham Wolf, New Zealand	13:00-15:30	1 AMO, 10 LEO, 2 STA, 8 SPO	+4.7
18	David Holman, CA	02:54-05:42	11 SPO	+6.4
	Felix Martinez, FL	03:20-04:20	12 LEO, 8 SPO	-----
	John Gallagher, NJ	04:30-06:16	1 LEO, 2 SPO	+7.2; 35% cloudy
	Mark Davis, SC	05:00-08:42	4 AMO, 27 LEO, 49 SPO	+5.6
	George Zay, CA	05:22-13:18	2 AMO, 50 LEO, 30 NTA, 10 STA, 33 SPO	+5.9
	Tim Printy, FL	05:45-07:50	20 LEO, 5 NTA, 1 STA, 10 SPO	+6.4
	Jeffery Sandel, SC	05:50-09:35	10 DER, 61 LEO, 3 SPO	+5.6
	Robert Lunsford, CA	07:00-13:00	6 AMO, 39 LEO, 6 NTA, 3 STA, 17 SPO	+6.0
	Alan Spier, CT	07:51-08:17	5 LEO, 1 SPO	+5.3
	Alan Spier, CT	08:24-08:47	1 LEO	+4.4
	David Swann, TX	08:55-10:40	3 LEO, 6 SPO	+5.0
	David Holman, CA	09:10-13:05	3 AMO, 29 LEO, 5 NTA, 1 STA, 25 SPO	+6.1
	Norman McLeod, FL	10:05-11:05	1 AMO, 2 NTA, 11 LEO, 1 STA, 1 SPO	+6.0
	Graham Wolf, New Zealand	13:00-15:30	4 AMO, 19 LEO, 2 STA, 9 SPO	+4.3
19	Mark Davis, SC	03:33-04:39	2 NTA, 1 STA, 12 SPO	+5.7
	George Zay, CA	05:28-13:18	1 AMO, 19 LEO, 16 NTA, 8 STA, 34 SPO	+5.9
	Jeffery Sandel, SC	06:00-09:30	2 AMO, 1 DER, 37 LEO, 4 SPO	+6.0
	David Holman, CA	08:00-13:20	3 AMO, 24 LEO, 12 NTA, 3 STA, 73 SPO	+6.3
	Robert Lunsford, CA	08:00-13:30	4 AMO, 30 LEO, 9 NTA, 11 STA, 61 SPO	+6.2
	Norman McLeod, FL	08:15-10:50	1 AMO, 9 LEO, 3 STA, 11 SPO	+7.0
20	George Zay, CA	06:00-13:20	1 AMO, 17 LEO, 15 NTA, 4 STA, 40 SPO	+5.9
	David Holman, CA	06:56-13:15	4 AMO, 17 LEO, 14 NTA, 3 STA, 87 SPO	+6.3
	Richard Taibi, MD	08:20-10:36	4 LEO, 13 SPO	+5.8
	Graham Wolf, New Zealand	13:00-15:30	5 AMO, 5 LEO, 1 STA, 10 SPO	+4.4
21	Robert Lunsford, CA	09:00-13:15	4 AMO, 6 LEO, 6 NTA, 5 STA, 26 SPO	+6.1
	Graham Wolf, New Zealand	13:00-15:30	9 AMO, 3 LEO, 3 STA, 8 SPO	+4.3
22	John Gallagher, NJ	01:55-05:45	2 AMO, 1 LEO, 2 NTA, 2 SPO	+7.4; 20% cloudy
	Mark Davis, SC	03:12-09:12	11 AMO, 5 NTA, 3 STA, 65 SPO	+5.8
	Norman McLeod, FL	04:25-11:45	12 AMO, 10 LEO, 10 NTA, 14 STA, 1 XOR, 39 SPO	+7.3
	Frank Melillo, NY	05:00-08:00	3 AMO, 4 SPO	+4.5
	Robert Lunsford, CA	05:30-13:15	4 AMO, 14 LEO, 19 NTA, 9 STA, 57 SPO	+6.4
	Peter Detterline, PA	06:00-07:00	1 LEO, 1 NTA, 1 SPO	+5.6
	John Gallagher, NJ	06:10-07:55	1 AMO, 1 AND, 1 DER, 1 LEO, 1 STA, 4 SPO	+7.4; 20% cloudy
	George Zay, CA	06:38-13:16	2 AMO, 10 LEO, 16 NTA, 28 SPO	+5.9
	Graham Wolf, New Zealand	13:00-15:30	2 AMO, 1 STA, 8 SPO	+4.7
23	Norman McLeod, FL	04:24-07:26	2 AMO, 7 NTA, 11 STA, 14 SPO	+7.3
	Graham Wolf, New Zealand	13:00-15:30	2 AMO, 1 STA, 5 SPO	+4.3
25	Graham Wolf, New Zealand	09:00-12:00	18 AMO, 2 STA, 15 XOR, 13 SPO	+6.3

Table 1 continued on p. 122 with notes.

Table 1—Continued.

1995 UT Date	Observer and Location	Universal Time	Number and Type* of Meteors Seen	Comments (+*N* = Limiting Magnitude)
Nov 25	Graham Wolf, New Zealand	13:00-15:30	2 AMO, 2 STA, 12 SPO	+6.3
26	John Gallagher, NJ	06:10-07:44	1 LEO, 2 NTA, 2 SPO	+7.3
	Norman McLeod, FL	07:26-10:50	6 LEO, 1 NTA, 5 STA, 1 ZPU, 38 SPO	+7.3
28	Robert Lunsford, CA	06:00-13:30	1 HYD, 1 MON, 1 XOR, 24 SPO	+5.7
29	Robert Lunsford, CA	07:00-13:30	4 HYD, 1 MON, 5 XOR, 19 SPO	+6.0
30	George Zay, CA	07:10-13:23	10 MON, 8 XOR, 38 SPO	+5.8
Dec 01	Norman McLeod, FL	07:14-10:27	1 ZPU, 2 NTA, 4 STA, 49 SPO	+7.3
	George Zay, CA	08:11-13:24	5 MON, 7 XOR, 47 SPO	+5.7
02	Norman McLeod, FL	07:47-10:53	2 STA, 38 SPO	+7.1
03	John Gallagher, NJ	05:35-07:12	1 GEM, 5 SPO	+7.4; 10% cloudy
11	John Gallagher, NJ	04:50-05:32	1 GEM, 1 SPO	+7.1; 10% cloudy
12	John Gallagher, NJ	04:35-06:41	4 GEM, 3 SPO	+7.3
13	Richard Schmude, GA	04:19-04:49	5 GEM	+4.5; 20% cloudy
	John Gallagher, NJ	05:00-07:13	1 COM, 6 GEM, 1 XOR, 5 SPO	+6.9
14	Richard Schmude, GA	02:51-03:21	3 GEM, 1 SPO	+4.0; 30% cloudy
	Robert Lunsford, CA	09:30-13:30	2 COM, 69 GEM, 3 HYD, 1 PUP, 6 SPO	+5.4; 10% cloudy
	David Swann, TX	09:50-10:50	17 GEM, 2 SPO	+4.5; 10% cloudy
15	Robert Lunsford, CA	06:00-10:30	1 COM, 63 GEM, 5 MON, 1 XOR, 9 SPO	+6.1
	George Zay, CA	03:07-10:27	97 GEM, 18 SPO	+5.8
17	Mark Davis, SC	03:29-04:59	1 MON, 10 SPO	+5.7
18	John Gallagher, NJ	05:20-06:06	1 SPO	+7.2; 10% cloudy
23	John Gallagher, NJ	01:35-02:35	*None Seen*	+7.1
	Robert Lunsford, CA	01:45-08:15	3 URS, 18 SPO	+5.9
	George Zay, CA	02:28-07:31	3 URS, 9 SPO	+5.9
	Mark Davis, SC	06:40-09:40	6 URS, 13 SPO	+5.8
27	John Gallagher, NJ	05:55-07:26	3 SPO	+7.5
	Robert Lunsford, CA	10:00-14:00	2 COM, 6 SPO	+5.6
28	Robert Lunsford, CA	09:15-13:15	4 COM, 13 SPO	+5.4
29	John Gallagher, NJ	04:35-06:36	3 SPO	+7.5
	Kevin Kreigh, MO	07:05-08:11	2 COM	+5.7
31	John Gallagher, NJ	05:00-07:31	*None Seen*	+7.0; 20% cloudy

**** Key to Abbreviations***

AMO	Alpha Monocerotids	KAQ	Kappa Aquarids	SOR	Sigma Orionids
AND	Andromedids	LEO	Leonids	SPO,	*Sporadics*
COM	Coma Berneicids	LMI	Leo Minorids	STA	South Taurids
DAS	Delta Aurigids (SEP)	MON	Monocerotids	URS	Ursids
DER	Delta Eridanids	NPI	North Piscids	XOR	Chi Orionids
EGE	Epsilon Geminids	NTA	North Taurids	ZPU	Zeta Puppids
GEM	Geminids	OAR	October Arietids		
HYD	Sigma Hydrids	ORI	Orionids		

SEPTEMBER METEOR ACTIVITY FROM THE ARIES-TRIANGULUM REGION

By Gary W. Kronk and George W. Gliba

ABSTRACT

Two long-time A.L.P.O. members independently detected unexpected meteor activity from the Aries-Triangulum region on 1993 SEP 12. The activity was later noticed in the radio-echo records of a Belgian amateur astronomer. Research into previous photographic, visual, and radio-echo observations reveals a possible annual shower which may have first been noted in 1915. Although no parent body has been found, the orbit of the meteor stream may indicate one of the Aten-class minor planets.

OBSERVATIONS ON 1993 SEP 12

Unexpected meteor activity was independently observed on the night of 1993 SEP 12 and subsequently reported to the International Meteor Organization (IMO). The observations were made by long-time A.L.PO members Gary W. Kronk (Troy, IL) and George W. Gliba (Greenbelt, MD), with Kronk being assisted by Kurt Sleeter (Swansea, IL).

Kronk and Sleeter commenced observing deep-sky objects at 04h00m UT on September 12. Within 5 minutes each observer had detected at least one telescopic meteor through the fields of their telescopes, and they decided to look up whenever possible to see if any meteors were visible to the naked eye. With occasional naked-eye sky observing between 04h00m and 05h15m UT, Kronk and Sleeter saw 11 meteors emanate from the Aries Triangulum region. The brightest meteor was estimated as magnitude +1, while all of the others were between magnitudes +3 and +4.5. There was no reasonable estimate as to the amount of time spent watching for meteors, so no ZHR [zenithal hourly rate; estimated for a radiant at the zenith in a dark sky] estimate could be made.

By 05h15m UT, Kronk and Sleeter began looking exclusively for meteors, and continued to observe until 06h15m UT. They unfortunately were severely hampered by clouds for over one-half hour, but still detected 5 meteors of which 3 were from the Aries-Triangulum region. The magnitudes were all between +3 and +4.

Gliba began observing meteors at 05h18m UT. He was located near Mathias, West Virginia, at a private observing site for members of the Westminster Astronomical Society in Maryland. He had just finished some extensive deep-sky observing and decided to put in some time looking for meteors. During the next two hours, under very clear skies, he observed 35 meteors, of which 11 appear to have radiated from the Aries region. Of these 11, one was magnitude -2, another magnitude +1, and the remainder were between magnitudes +3 and+ 5.

Kronk visually estimated the radiant position as $\alpha = 035°$ $\delta = +30°$, Sleeter plotted five of his observed meteors on a star chart and obtained a radiant of $\alpha = 030°$, $\delta = +30°$, while Gliba estimated that his radiant was near γ Arietis, which indicated a radiant near $\alpha = 028°$, $\delta = +19°$. Kronk and Sleeter had the good fortune of observing a short-trailed meteor just 10° south of Triangulum which approximately confirmed the right ascension of the radiant and indicated a declination farther north than Gliba's +19°; however, Gliba noted that his right ascension was more accurate than his declination because of the meteor distribution he observed. He suggested the radiant was diffuse and noted his radiant could subsequently be off by as much as 5° in any direction. [*Not:e*: The apparent coordinates of meteor-shower radiants, as well as their orbital elements, precess only very gradually. For this reason, epoch dates are not given in this article; the coordinates and elements given will remain reasonably accurate for the foreseeable future.]

Taking the three radiants and applying high weights to the declinations of Kronk and Sleeter, and to the right ascension of Sleeter and Gliba, the resulting average radiant was at $\alpha = 030°$, $\delta = +29°$. This radiant is less than 2° from α Trianguli.

Gliba, Sleeter, and Kronk all reported that the meteors were moving at slow to medium angular speeds. Kronk and Sleeter noted the meteors were much slower than Perseids, and comparable to the speeds seen for the Aquariids and Capricornids.

In an attempt to find other observers of this event, Kronk posted notices to several computer bulletin boards within 48 hours of the observations. He requested positive and negative observations of enhanced activity, with no radiant or approximate location in the sky given. In addition, Kronk also contacted Peter Brown (Coordinator of the North American International Meteor Organization [IMO] Section) and Robert Lunsford (Coordinator of the A.L.P.O. Meteors Section). He gave them the complete details of his observations and asked them to send him any confirmatory reports. Over the course of the next three weeks, a few telephone discussions and numerous e-mail discussions uncovered more information.

Several observers in Europe stated that they saw no unusual visual activity during the period 21h00m to 24h00m UT on 1993 SEP

11. However, between 00h00m and 02h00m UT on SEP 12, Maurice De Meyere (Deurle, Belgium) was operating a forward scatter radio meteor detector and registered enhanced activity that was 17 to 83 percent higher than during the same hours on all other days through SEP 01-15 inclusive.

Among the many United States reports that were received were a few which supplied some interesting details:

Brandon Craig Rhodes (at Windy Gap, a camp in North Carolina) had been looking at the stars with a friend and wrote:

> "I noticed that during the fifteen or twenty total minutes we spent looking up...we saw an unusually high number of meteors for an intershower period when one would expect only a few erratics an hour. We together saw about seven or eight meteors...in that period of time, suggesting an hourly rate of perhaps as high as 20 to 30 meteors .... I commented on the high frequency, but upon arrival home did not find that any shower was strongly active at that time."

Tim Hager (New Milford, Connecticut) spent the entire night observing variable stars and conducting his routine photographic nova patrol program. He wrote:

> "I did notice an unusual number of meteors that night. So many in fact that I went inside to check to see if there were any minor showers active." [He added] "Some seemed to radiate from the Perseus-Cassiopeia area. Now, I know that the Perseids are long over and the radiant has moved somewhere else by now but that's where two or 3 of the brighter ones seemed to radiate from."

Although Hager's estimated radiant is about 30° from that accepted above, his additional description of the three meteors pinpointing this radiant showed they were all moving east to west, either towards or through Cygnus some 50° to 70° away. Only slight alterations to the remembered paths would be needed to move the radiant closer to the Triangulum region.

Paul Martz wrote:

> "I was camping with a friend who's [*sic*] vision is far superior to mine. We were in the southern Uinta mountains, about 200 miles ESE of Salt Lake City, Utah. My friend's limiting magnitude was around 5.0-6.0. He claimed to see much more activity than usual, mostly east to west. This was for observations done from 8:15pm (dusk) to 10pm MST (1:15 - 3:00 GMT [UT])."

Several additional observers reported meteors moving from east to west during observations in the early evening hours. Considering that the radiant did not reach the zenith until 2:31 A.M. (local time), the east-to-west movement at least suggests the radiant producing higher-than-normal activity was in the eastern half of the sky, which would include the Aries-Triangulum region. Note, however, that other minor radiants were active at the time of the above observations, most of which could produce meteors with an east-to-west movement. On the other hand, Kronk and Sleeter noted a total of two Piscids and two sporadics, while Gliba saw six Piscids, one γ Aquariid, and 17 sporadics during 2 hours. These figures indicate that the observed activity levels of these radiants were about typical for the date of the observations, which might lend support to the possibility that any abnormal activity observed in an east-to-west direction would likely be from the same radiant observed by Kronk, Sleeter, and Gliba.

POSSIBLE HISTORICAL OBSERVATIONS

The question now most prevalent was whether this radiant had ever been observed in the past, and a search was conducted through previously published radiant observations which quickly gave potential support of the existence of this radiant.

A search through nearly 10,000 visual radiants revealed several likely candidates. In particular, there are several probable observations in the records of the American Meteor Society (AMS) during the period 1934-1967. These are listed in *Table 1* (below).

Table 1. Candidate Radiants from the Records of the American Meteor Society.

Desig.	UT Date	Position R.A. °	Position Dec. °	Solar Long. °	Observer
1683a	1934 SEP 10.0	034.0	+31.0	166.0	Smith, F.W.
1683b	1934 SEP 11.0	033.0	+27.0	167.6	Smith, F.W.
4051	1940 SEP 08.0	026.0	+19.0	165.2	Khan, M.A.R.
3058	1940 SEP 12.3	036.0	+20.0	169.4	Anderson, P.
4592	1945 SEP 09.7	032.0	+26.0	166.6	Lomaki, K.
3111	1950 SEP 06.2	030.0	+23.0	163.0	Worley, C.E.
3110	1950 SEP 07.2*	027.5	+21.0	164.0	Worley, C.E.
3186	1951 SEP 09.3	026.0	+32.5	165.8	Knowles, J.H.
3192	1951 SEP 10.8	026.0	+27.0	167.3	Knowles, J.H.
3413	1951 SEP 13.3	027.0	+24.0	169.7	Worley, C.E.
3415	1951 SEP 15.3	031.0	+23.5	171.6	Worley, C.E.
3888	1955 SEP 13.3	029.5	+20.0	169.7	Knowles, J.H.
5507	1967 SEP 11.8*	025.0	+29.0	168.3	Menzel, R.

Notes: Desig. = designation; R.A. = right ascension; Dec.= declination; Long. = longitude; * Means that the date was an average of two or more nights of observation.

Another likely group of radiants comes from Cuno Hoffmeister's book *Meteorstrome* (1948), and are given in *Table 2* (p. 125).

Interestingly, there are no traces of this radiant in the records of Alphonso King, Alexander S. Herschel, Eduard Heis, and Robert P. Greg; however, William F. Denning included a radiant called the Beta Triangulids in his 1899 catalog, which he observed during 1872

Table 2. Candidate Radiants from *Meteorstrome* (Hoffmeister, 1948).

Desig.	UT Date	Position R.A.	Position Dec.	Solar Long.
		°	°	°
747	1915 SEP 12.9	035	+21	169.
1075	1921 SEP 09.0	034	+17	165.8
1240	1923 SEP 12.7	025	+25	168.9
5086	1929 SEP 09.6	033	+34	166.4
2273	1934 SEP 10.0	023	+29	166.6
2716	1936 SEP 10.5	037	+29	167.6
4141	1937 SEP 07.0	032	+27	164.0

Notes: As in *Table 1*; all observations were by Hoffmeister, except Desig. 5086, by Richter.

Table 3. Hypothetical Orbital Elements of the Aries-Triangulum Meteors.

Type of Orbit	Argument of Perihelion	Argument of Node	Incli-nation	Perihelion Distance	Eccen-tricity	Period
	°	°	°	AU		years
Parabola	304.2	169.5	127.5	0.221	1.000	---
Ellipse #1	321.5	169.5	117.4	0.143	0.929	2.83
Ellipse #2	337.4	169.5	93.7	0.078	0.922	1.00
Ellipse #3	343.5	169.5	42.5	0.082	0.882	0.586

Table 4. Elements of Meteor Streams found by Z. Sekanina (1969)

Name of Orbit	Argument of Perihelion	Argument of Node	Incli-nation	Perihelion Distance	Eccen-tricity	Period
	°	°	°	AU		years
α Triang.	345.9	165.7	38.7	0.087	0.870	0.55
α Arietids	324.6	165.8	117.4	0.143	0.929	2.81

AUG 24-SEP 14, at a radiant of α = 034°, δ = +35°. Also, Denning's supplement to that catalog was published in 1912 with a radiant detected during 1885 SEP 03-17, from α = 029°, δ = +36°, together with a radiant detected during 1902 SEP 03-07, from α = 030°, δ = +37°.

For the most part, Denning's radiants were higher in declination than those of the AMS and Hoffmeister, and were certainly of a greater duration. Also, Denning's 1902 radiant was the only radiant to average more than one meteor per night, which indicates the overall weakness of these data. Therefore it appears likely that the earliest recorded radiant from the Aries-Triangulum region would be that of Hoffmeister's in 1915.

Arguments might still be made by some meteor-stream researchers that the weight of the pre-1993 data is too low to consider as confirming, but there are key observations within the visual data that are indisputable. First, on 1934 SEP 10, the radiant was observed by Smith in the United States and also by Hoffmeister in Germany. Second, in both 1940 and 1951, the radiant was detected independently by two AMS observers.

There is reason to put a high confidence in the AMS data. First, the observers of the radiant in 1934, 1940, and 1951 were among the most prolific and experienced observers in the organization's history. Second, in the days of Charles P. Olivier, the AMS criterion for radiant determination was the intersection of four or more meteors within a circle of no more than 2°.5, which is more stringent than what some groups accept today.

When all of the apparent visual confirmations are considered, the average radiant derived from the 1993 observations appeared little changed and Kronk computed a series of hypothetical orbits. Although the meteors obviously were not moving at speeds indicative of a parabolic orbit, he decided to start from there and then determine three elliptical orbits, whose elements are given in *Table 3* (left center)

No comets were found with orbits anywhere within the range defined by the parabola and Ellipse #1. It is curious that comet Machholz (1988 XV) moved in an orbit nearly identical to Ellipse #3; but the ellipse would also be indicative of an Aten-class minor planet, while the comet's orbit was a parabola. Although comet Machholz' orbit was defined by less than a month's worth of precise positions, all attempts by Kronk to generate a short-period orbit failed drastically to represent the available positions as well as did the parabola.

It was obvious that visual observations would do little to isolate the orbit. A search through other sources was needed. The next search was among nearly 7000 photographic meteors. Searches by radiant and orbit were made for the period of mid-August to the end of September, but absolutely no matches were made. This is consistent with the 1993 evidence that the stream meteors are primarily faint.

Next, the results of the various radio-echo surveys conducted during the 1950s, 1960s, and 1970s were checked, and two probable candidates were found. Zdenek Sekanina's 1969 survey revealed streams which he called the α Triangulids and the α Arietids. The α Triangulids were based on 13 radio-echo meteors, which had an average radiant of α = 030°.4, δ = +29°.5. The α Arietids were based on six radio-echo meteor orbits which came from an average radiant of α = 032°.6, δ = +21°.8. The resulting orbits are described in *Table 4* (left column).

Since these streams were detected after the 1969 survey, Kronk decided to consult the raw data obtained by Sekanina, which totaled nearly 40,000 orbits, and find all meteors detected during the period of 1962-1965, as well as in 1969. He hoped that if any members were found for the period of 1962 to 1965 their orbits could be combined with those detected in 1969 to more precisely determine the orbit. Unfortunately, where the solar longitude of the radiant's appearance in 1993 was

169°.5, Sekanina's surveys never were conducted while the radiant was above the horizon after solar longitude 168°.1, more than a day earlier than the potentially observed maximum in 1993. However, as the visual radiants indicated a visibility of several days, it was assumed the radio-echo data would confirm this. A radiant ephemeris was computed for the period preceding a solar longitude of 169.5°, and the search was conducted for meteors seen during the first half of September, with a right ascension between 020- 040°, and a declination between +10°-+40°.

The initial search detected 47 meteors. Among those were perhaps five potential streams. Both the α Triangulids and the α Arietids were detected among this group, as well as three potential minor radiants which produced four meteors or less. The α Arietids appeared only in 1969, so that the above orbit could not be improved upon. The α Triangulids produced meteors in 1962, 1963, and 1969; the equipment did not operate between August 23 and September 21 during 1965, and no meteors were detected in 1964. This subsequently increased the overall number of radio meteors; however, it was then noted that a strong core of 9 meteors was apparent. The orbit of this core is described in *Table 5* (below).

The average radiant for solar longitude 165°.8° was $\alpha = 027°.5$, $\delta = +28°.8$ which was less than 1° from the extrapolated radiant of Ellipse #3. Subsequently, if the probable radiant motion was added to this radiant the predicted position for a solar longitude of 169°.5 would be about $\alpha = 030°.8$, $\delta = +30°.3$.

Despite the evidence presented above, much remains to be learned about this radiant. The only solid facts that appear indisputable from the above discussion is that the radiant probably produces annual activity and its perihelion distance is well within the orbit of Mercury. The next opportunity for observation would be on or about 1997 SEP 12 (UT). Future observations will be needed to firmly define the characteristics of both the radiant and the stream.

Table 5. Elements of Radio-Echo Meteor Orbit.

Argument of Perihelion	Argument of Node	Inclination	Perihelion Distance	Eccentricity	Period
°	°	°	AU		years
344.1	165.8	36.1	0.097	0.857	0.560

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OBSERVATIONS OF URANUS, NEPTUNE AND PLUTO IN 1994

By: Richard W. Schmude, Jr., A.L.P.O. Remote Planets Coordinator, Gordon College, Barnesville, Georgia

ABSTRACT

Seven observers submitted over 500 observations of the Remote Planets in 1994. A total of 102 photoelectric magnitude measurements of Uranus and Neptune were made, yielding selected normalized magnitudes of B(1,0) = -6.56±0.04; V(1,0) = -7.17±0.03; R(1,0) = -7.00±0.02 and I(1,0) = -5.78±0.02 for Uranus; and B(1,0) = -6.49±0.03; V(1,0) = -6.93±0.02; R(1,0) = -6.61±0.01 and I(1,0) = -5.56±0.06 for Neptune. Over 400 visual magnitude estimates of Uranus and Neptune were also made, giving selected normalized values of Vvis(1,0) = -7.1±0.2 for Uranus and Vvis(1,0) = -6.8±0.1 for Neptune. Photographs of Pluto suggest that it may be possible to monitor the position of Charon using an 8-in telescope.

INTRODUCTION

The 1994 dates of opposition were July 17 for Uranus, July 14 for Neptune, and May 17 for Pluto. [1] At opposition, Uranus and Neptune, respectively, had declinations of -22° and -21°, while their angular diameters were 3.8 arc-sec and 2.3 arc-sec. Pluto's declination was -5° on opposition day. Photometric, photographic and visual results of all three Remote Planets are summarized here. People who submitted results or who assisted in the gathering of results pertaining to the remote planets are listed in *Table 1* (below).

PHOTOELECTRIC PHOTOMETRY

A preliminary summary of photometric results for both Uranus and Neptune was given at the A.L.P.O. meeting at the Roper Mountain Science Center in Greenville, South Carolina on June 18, 1994. [2] A complete report of 1994 data is presented here.

As in previous years, an SSP-3 solid-state photometer was used with Johnson B (blue), V (visual), R (red) and I (infrared) filters for all photoelectric photometry; a description of this instrument is given elsewhere. [3,4] Most of the measurements were made by the author while at Texas A&M University. The comparison stars used for photometric work were φ Sgr and 50 Sgr. The positions and magnitudes of these stars are listed in *Table 2* (p. 128). [5,6]

Table 3 (p. 129) lists all photometric measurements made in 1994 of Uranus and *Table 4* (p. 130) lists all measurements of Neptune in 1994. As in previous reports [7,8] the date (in Universal Time) is listed in the first column followed by the filter, measured magnitude, normalizes magnitude (i.e., corrected to a distance of 1 astronomical unit from both the Earth and the Sun), comparison star and the difference in air mass between the comparison star and planet at the time of measurement. In the last column, a negative sign means that the air mass of the planet was less than the air mass of the comparison star, meaning that the planet had a higher altitude than the comparison star at the time of measurement. All of the measured magnitudes were corrected for atmospheric extinction. On some dates, extinction coefficients were measured and applied to the measurements. On nights when no coefficients were measured, extinction coefficients (in magnitudes/air mass) of 0.40, 0.26, 0.19 and 0.16 for the B, V, R and I filters, respectively, were used; these coefficients are average values measured at Texas A&M University Observatory. [9]

The average normalized magnitudes for Uranus and Neptune are summarized in *Table 5* (p. 130). The B, V and R magnitudes for both planets are similar to values in the previous five years (1989-1993). [3, 7, 8, 10, 11] The infrared magnitudes for both planets, however, show some fluctuation, which may be due to the larger uncertainties for the I measurements. The V(1,0) magnitude of Neptune remained slightly lower (fainter) than the literature value. [12] It is interesting to note that the great dark spot on Neptune disappeared sometime during the early to mid-1990s [13] which may correspond to the slight increase in brightness of that planet in 1993-94.

Table 1. Individuals who submitted (or assisted with) observations of the Remote Planets in 1994.

Individual	Type of Observation*	Location (USA)
Danny Bruton	PP	College Station, TX
Rik Hill	PP	Tucson, AZ
Gus Johnson	VP	Swanton, MD
Frank Melillo	PP, P	Holtsville, NY
Gary Nowak	VP	Essex Junction, VT
Richard Schmude, Jr.	PP, VP, V, P	College Station, TX
Ted Stryk	V, P	Bristol, VA

*Type of Observation: PP = photoelectric photometry, P = photography, VP = visual photometry, V = visual (drawings or color estimates).

Table 2. Summary of comparison stars used for photoelectric and visual photometry of Uranus and Neptune in 1994.

Star Name	Coordinates (2000.0) R.A.	Dec.	Magnitude B	V	R	I	Spectral Type
φ Sgr	19h16m	-25°15'	+5.38	+4.82	+4.36	+4.01	F5
SAO 187992	19h21m	-22°24'	6.5	5.5	---	---	---
50 Sgr	19h26m	-21°47'	6.81	5.59	4.65	4.04	K3
SAO 188112	19h26m	-22°27'	8.0	7.0	---	---	K0
SAO 188123	19h27m	-21°20'	8.6	7.4	---	---	K2
SAO 188219	19h31m	-21°19'	6.6	6.0	---	---	A2
SAO 188234	19h31m	-21°02'	8.5	7.9	---	---	K5
SAO 188252	19h32m	-21°31'	8.1	7.1	---	---	A3
SAO 188317	19h36m	-20°47'	----	6.7	---	---	G0
56 Sgr	19h46m	-19°46"	6.1	5.0	---	---	K1
SAO 188580	19h48m	-20°57'	7.4	6.8	---	---	G0

VISUAL PHOTOMETRY

A total of 394 visual magnitude estimates were made of Uranus in 1994; the author made almost all of these estimates with 10×70 binoculars using a technique similar to that used by the AAVSO. The comparison stars used in the visual study are also listed in *Table 2*. Several sets of comparison stars were used in the hope of averaging out color differences between the planet and comparison stars. A normalized magnitude of Vvis(1,0) = -7.10 ±0.2 was determined for 1994; this value is slightly (0.1-0.2 magnitudes) dimmer than estimates in previous years.

Gus Johnson made 6 visual magnitude estimates of Neptune using a 2.4-in (6-cm) telescope while the author made an additional 15 magnitude estimates using mainly 10×70 binoculars. An average normalized determined magnitude of Vvis(1,0) = -6.8±0.1 for Neptune was determined in 1994. This value is similar to previous visual estimates. [8,10]

DISC APPEARANCE: DRAWINGS AND PHOTOGRAPHS

Several observers remarked on the appearance of Uranus and Neptune in 1994. Uranus was usually described as having a bluish-green color while Neptune was described as having a dark bluish color. Ted Stryk noticed a faint dark belt on Neptune near the North Pole on 1994 OCT 19, at 00h30m UT with a 12.5-in (31-cm) Newtonian telescope at 300×. Interestingly, just nine days prior to his observation, a bright band was present at uranocentric latitude about 30°N,which is near the feature he observed. [13] The author observed Uranus on 1994 AUG 04, 1994 at 05h30m UT and noticed that the center of the disc was slightly darker than the surrounding areas.

Frank Melillo and the author photographed the Remote Planets in 1994. Figure 1 (p. 130) shows two photographs of Pluto made by Frank Melillo using an 8-in (20-cm) telescope. In the photograph on 1994 JUN 03, Pluto has a more circular shape than the surrounding stars; at this time Charon (Pluto's moon) was at greatest southern elongation. In the second photograph, taken a day after the first one, Pluto has the same elongated shape as the nearby stars. The change in shape may be due to the changing position of Charon.

The author photographed both Uranus and Neptune in 1994. The best results for Uranus were obtained with ISO-1000 speed Kodak Ektar color print film, using a 6-second exposure at f/106 with the 14-in (36-cm) telescope at Texas A&M University Observatory. As in 1993, the bluish color of Uranus was evident in the photographs.

CONCLUSIONS

Normalized magnitudes of -6.56±0.04, -7.17±0.03, -7.00±0.02, and -5.78±0.02 were selected for Uranus in the B, V, R and I filters, respectively, and the corresponding values for Neptune were: -6.49±0.03; -6.93±0.02, -6.61 ±0.01, and -5.56±0.06 for 1994. The magnitudes of both Uranus and Neptune were estimated visually with resulting normalized values of: Vvis(1,0) = -7.1±0.2 and Vvis(1,0) = -6.8±0.2. Uranus and Neptune had an appearance similar to previous years. Photographs of Pluto suggest the possibility of detecting Charon with an 8-inch telescope.

ACKNOWLEDGMENTS

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(References continued on p. 129)

Table 3. Photoelectric photometry measurements of Uranus in 1994.

Filter and Date (UT)	Magnitude Obser. +	Magnitude Normalized -	Comp. Star	Δ Air Mass
B-Filter				
APR 02.439	6.51	6.45	50 Sgr	0.461
02.453	6.55	6.41	50 Sgr	0.135
07.422	6.38	6.57	50 Sgr	0.734
07.464	6.38	6.57	50 Sgr	-0.019
17.385	6.40	6.53	50 Sgr	-0.102
17.415	6.40	6.53	50 Sgr	-0.016
AUG 04.242	6.17	6.65	φ Sgr	-0.342
04.276	6.13	6.70	φ Sgr	-0.209
07.172	6.26	6.57	50 Sgr	-0.062
07.201	6.27	6.56	50 Sgr	-0.002
07.242	6.28	6.55	50 Sgr	0.030
07.276	6.28	6.55	50 Sgr	0.057
07.309	6.33	6.51	50 Sgr	0.097
SEP 06.107	6.24	6.63	50 Sgr	0.004
06.159	6.32	6.55	50 Sgr	0.041
V-Filter				
APR 02.441	5.84	7.12	50 Sgr	0.449
02.455	5.88	7.08	50 Sgr	0.139
07.424	5.78	7.17	50 Sgr	0.709
07.466	5.78	7.17	50 Sgr	-0.019
17.387	5.78	7.15	50 Sgr	-0.097
17.417	5.78	7.15	50 Sgr	-0.015
AUG 04.244	5.63	7.20	φ Sgr	-0.353
04.278	5.58	7.25	φ Sgr	-0.213
07.173	5.69	7.14	50 Sgr	-0.057
07.202	5.68	7.15	50 Sgr	-0.001
07.243	5.70	7.13	50 Sgr	0.032
07.278	5.68	7.15	50 Sgr	0.060
07.311	5.70	7.13	50 Sgr	0.100
SEP 06.109	5.63	7.24	50 Sgr	-0.004
06.161	5.69	7.18	50 Sgr	0.042
19.111	5.64	7.24	50 Sgr	-------
R-Filter				
APR 02.457	6.00	6.96	50 Sgr	0.133
07.426	5.94	7.01	50 Sgr	0.662
07.467	5.94	7.01	50 Sgr	-0.015
17.389	5.94	6.99	50 Sgr	-0.106
17.418	5.92	7.01	50 Sgr	-0.009
AUG 04.246	5.88	6.95	φ Sgr	-0.366
07.175	5.83	7.00	50 Sgr	-0.053
07.205	5.82	7.01	50 Sgr	-0.001
07.245	5.83	7.01	50 Sgr	0.036
07.280	5.85	6.99	50 Sgr	0.065
07.313	5.84	6.99	50 Sgr	0.105
SEP 06.111	5.81	7.05	50 Sgr	-0.012
06.164	5.85	7.01	50 Sgr	0.045
I-Filter				
APR 02.459	7.19	5.77	50 Sgr	0.128
07.427	7.14	5.81	50 Sgr	0.645
07.469	7.14	5.81	50 Sgr	-0.018
17.391	7.09	5.84	50 Sgr	-0.100
17.420	7.11	5.82	50 Sgr	-0.009
AUG 04.248	7.13	5.70	φ Sgr	-0.379
07.177	7.06	5.77	50 Sgr	-0.050
07.206	7.05	5.78	50 Sgr	0.001
07.247	7.04	5.80	50 Sgr	0.037
07.282	7.06	5.77	50 Sgr	0.068
07.315	7.09	5.72	50 Sgr	0.105
SEP 06.113	7.06	5.81	50 Sgr	-0.018
06.166	7.10	5.77	50 Sgr	0.050

------- = Δ air mass not recorded.

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Table 4. Photoelectric photometry measurements of Neptune in 1994.

Filter and Date (UT)	Magnitude Obser.	Magnitude Normalized	Comp. Star	Δ Air Mass	Filter and Date (UT)	Magnitude Obser.	Magnitude Normalized	Comp. Star	Δ Air Mass
B-Filter	+	-			**R-Filter**	+	-		
Apr 07.434	8.30	6.50	50 Sgr	0.242	Apr 07.439	8.20	6.61	50 Sgr	0.200
07.454	8.30	6.51	50 Sgr	-0.039	07.458	8.19	6.61	50 Sgr	-0.042
17.375	8.36	6.43	50 Sgr	-0.126	17.380	8.22	6.57	50 Sgr	-0.164
Aug 04.251	8.13	6.60	φ Sgr	-0.324	Aug 04.256	8.12	6.61	φ Sgr	-0.342
06.310	8.29	6.44	50 Sgr	0.035	06.314	8.13	6.60	50 Sgr	0.045
07.158	8.24	6.49	50 Sgr	-0.068	07.163	8.09	6.64	50 Sgr	-0.066
07.191	8.25	6.48	50 Sgr	-0.028	07.195	8.11	6.62	50 Sgr	-0.027
07.228	8.27	6.46	50 Sgr	-0.015	07.233	8.11	6.62	50 Sgr	-0.009
07.265	8.25	6.48	50 Sgr	0.001	07.270	8.13	6.60	50 Sgr	0.008
07.300	8.29	6.44	50 Sgr	0.020	07.304	8.12	6.61	50 Sgr	0.028
Sep 06.118	8.24	6.51	50 Sgr	-0.040	Sep 06.130	8.14	6.62	50 Sgr	-0.047
V-Filter					**I-Filter**				
Apr 07.437	7.85	6.96	50 Sgr	0.216	Apr 07.441	9.22	5.59	50 Sgr	0.187
07.456	7.86	6.94	50 Sgr	-0.038	07.461	9.25	5.55	50 Sgr	-0.048
17.377	7.90	6.89	50 Sgr	-0.134	17.382	9.36	5.43	50 Sgr	-0.157
Aug 04.253	7.75	6.98	φ Sgr	-0.332	Aug 04.258	8.99	5.74	φ Sgr	-0.352
06.312	7.84	6.89	50 Sgr	0.043	06.317	9.14	5.64	50 Sgr	0.055
07.160	7.81	6.92	50 Sgr	-0.065	07.165	9.13	5.60	50 Sgr	-0.064
07.193	7.81	6.92	50 Sgr	-0.028	07.198	9.15	5.58	50 Sgr	-0.027
07.231	7.80	6.93	50 Sgr	-0.012	07.267	9.13	5.60	50 Sgr	-0.003
07.267	7.82	6.91	50 Sgr	0.002	07.273	9.22	5.51	50 Sgr	0.012
07.301	7.80	6.93	50 Sgr	0.016	07.306	9.32	5.41	50 Sgr	0.020
Sep 06.135	7.77	6.98	50 Sgr	-0.035	Sep 06.133	9.25	5.50	50 Sgr	-0.047
19.090	7.79	6.97	50 Sgr	-------					

------- = Δ air mass not recorded.

Table 5. Average B, V, R and I magnitudes for Uranus and Neptune in 1994.

Filter	Normalized Magnitude* Uranus	Normalized Magnitude* Neptune	Number of Measurements Uranus	Number of Measurements Neptune
B	-6.56±0.04	-6.49+0.03	15	11
V	-7.17±0.03	-6.93±0.02	16	12
R	-7.00±0.02	-6.61±0.01	13	11
I	-5.78±0.02	-5.56±0.06	13	11
(B-V)	+0.51±0.05	+0.44±0.04	---	---
(V-R)	-0.17±0.04	-0.32±0.02	---	---
(R-I)	-1.22±0.03	-1.05±0.06	---	---

* Uncertainties calculated in the same way as in [10].

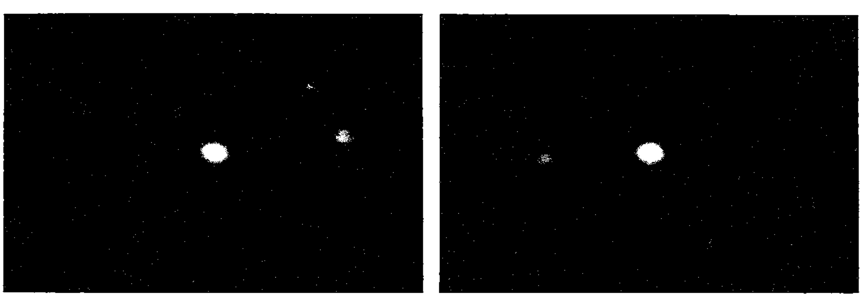


Figure 1. Two photographs of Pluto taken by Frank Melillo with a 20-cm (8-in) Schmidt-Cassegrain reflector at f/10 (prime focus) with hypered TP-2415 Film. The left view was taken on 1994 Jun 03, 04h30m-04h50m UT; the right on 1994 Jun 04, 04h30m-04h50m UT. In both cases, the seeing was rated "very good" and the transparency as "excellent." Pluto is at the center, north at the top, and west to the right in both views, which have been enhanced and highly magnified.

THE APPARITION OF COMET AARSETH-BREWINGTON (1989a1 = 1989 XXII)

By: Don Machholz, A.L.P.O. Comets Coordinator

ABSTRACT

This report examines the 1989 Apparition of Comet Aarseth-Brewington. This comet was observed for nearly three months in late 1989-early 1990. The comet displayed a fine tail, was visible briefly with the naked eye, and was seen from both hemispheres.

DISCOVERY

On the evening of November 16, 1989, Knut Aarseth of Volda, Norway, was sweeping for comets with his 5.5-in (14-cm) "Comet Catcher" reflector. Sweeping nearly due west and at an altitude of 30°, he picked up a faint fuzzy object in the constellation Corona Borealis. The object appeared diffuse with some condensation, and at magnitude +9.0. He reported it as a new comet. [1]

Six hours and fifteen minutes later, on the other side of the Atlantic Ocean, Howard Brewington was searching for comets from a remote site 20 miles from his home in Newberry, South Carolina. He had both 16-in (40-cm) and an 8-in (20-cm) reflectors on an altazimuth Dobsonian mount. He was using the 8-in reflector, at f/4.3 with a 2°.4 field at 27× with a light pollution filter. At an altitude of 19° in the west-northwest he picked up a comet-like object. Unknown to him, this was the same object seen by Aarseth only hours before. Brewington reported the object to the Smithsonian Astrophysical Observatory.

Thus, the newly found comet was named Comet Aarseth-Brewington (1989a1). [2] For each man this was his first named comet. Aarseth had spent 177 hours before finding this comet, while Brewington had searched for 230.5 hours over 14 months.

Finally, on NOV 18.75, Mauro Zanotta of Italy also picked up the comet, although it was too late by then for his name to be added to it.

At discovery, the comet was moving south-southeast at the rate of 0°.8/day and was estimated to be 1'.5 in diameter.

The A.L.P.O. observers who contributed observations of this comet are listed in *Table 1* (below).

ORBIT

An early orbit was published on November 22, followed by a more accurate one that was published eight days later by the Central Bureau for Astronomical Telegrams and appeared on IAU Circular 4916 and MPC 15520. Its Equinox-1950 elements were:

Time of perihelion:	1989 DEC 27.886
Distance of Perihelion:	0.30060 AU
Argument of Perihelion:	205°.272
Ascending Node:	345°.208
Inclination:	088°.378
Eccentricity:	1.000

VISIBILITY OF COMET AARSETH-BREWINGTON

With an orbit almost perpendicular to the Earth's orbit, and a perihelion distance over three times closer to the Sun than is the Earth, the comet moved rapidly southward, and spent most of the next two months within 30° of the Sun, its elongation dropping to a minimum of 18° on 1989 DEC 28.

After being found in the evening sky at an elongation of 49° and a declination of +28°, the comet moved south and into the morning sky, and remained more than 30° north of the Sun, during the first week of December. It never came closer to the Earth than 0.93 AU, [1 AU is the mean distance of the Earth from the Sun; 149,597,870 km] on 1989 DEC 27. Crossing the celestial equator on DEC 15, it traveled to -40° by the end of the year, and went as far south as -45°.6 on 1990 JAN 08 before moving slowly northward again.

Table 1. Participating Observers, Comet Aarseth-Brewington (1989a_1).

Observer	Observing Site	Instrument(s)
Camilleri, Paul	Victoria, Australia	20X80 binoculars, 20-cm reflector
Garradd, Gordon	Tamworth, NSW, Australia	10X50 binoculars, 20-cm reflector
Jahn, Jost	Bodenteich, Germany	20-cm reflector, 5-cm refractor
Kronk, Gary	Troy, IL, USA	33-cm reflector, 20X80 binoculars
Modic, Robert	Richmond Hgts, OH, USA	20-cm reflector, 10X50 binoculars
Pearce, Andrew	Scarborough. W. Australia	20X80 binoculars
Pryal, Jim	Kirkland, WA, USA	20-cm SC.
Robinson, Paul	Norman, OK, USA	10X50 binoculars
Seargent, David	The Entrance, NSW, Australia	15X80 binoculars
Viens, Jean-F.	Charlesbourg, Quebec, Canada	11-cm reflector, 10X50 binoculars

MAGNITUDE

Comet Aarseth-Brewington, despite being visible for only a couple of months, and remaining close to the sun for much of that time, provided over 100 A.L.P.O. magnitude estimates. These were corrected for aperture and sent to A.L.P.O. comet observer and author Gary Kronk. He noted the consistency of the A.L.P.O. observations and furnished the following figures and comments.

The apparent visual magnitude estimates, spanning the time period of 1989 NOV.18-1990 JAN 31, are plotted in *Figure 1* (p. 133). They show the comet brightening from magnitude +8.7 shortly after discovery to +2.4 near perihelion, then dimming to magnitude +9.2 by the end of January, 1990.

Next, correcting for the comet's varying distance from the Sun and Earth, we calculate the absolute magnitude. This is the brightness of the comet at a standard distance of 1.0 AU from both the Earth and the Sun, which is the mean distance of the Earth from the Sun. Since a comet is almost never at such a distance, we use the following formula to calculate its absolute magnitude:

$m = Ho + 5 \log D + 2.5N \log R$, where

- m = apparent magnitude
- Ho = Absolute magnitude;
- D = Comet-Earth distance in AU;
- R = Comet-Sun distance in AU;
- N = A constant representing the rate of brightness change as the comet-sun distance changes. A high number indicates a high rate of change; the average for all comets is 3.3.

The absolute magnitudes computed from the observed magnitudes are plotted in *Figure 2* (p. 133). Kronk calculates the mean absolute magnitude to be +7.67, with an "N" value of 3.6. The latter is about average for a comet.

THE COMA AND TAIL: SIZE AND APPEARANCE

The angular size of the coma, or head of the comet, was estimated by observers and can vary depending upon sky conditions and the observers' eyes and instrument. Given its distance from the Earth, the actual size of the coma can be found from the apparent size. The coma-size estimates were fairly consistent for this comet; starting at about 100,000 km (62,000 mi) at discovery, shrinking to about two-thirds this size at perihelion (1989 DEC 27), then increasing again to nearly 200,000 km (124,000 mi) by the end of January, 1990.

Most observers were reporting a tail by the second week of December. Indeed, many reported two tails, one a dust tail and the other a gas tail. Quite often the tail length reached 2°, which translated to an actual length of 10 million km (6.2 million mi). This comet had one of the longest actual tail lengths that has been reported to the A.L.P.O. Comets Section.

The comet was diffuse when discovered. Its degree of condensation increased as the comet reached perihelion, and it retained the condensed appearance during the remaining observations. The degree of condensation, measured on a scale ranging from 0 (no condensation) to 10 (star-like) is plotted in *Figure 3* (p. 133). Selected observers' drawings are shown in *Figure 4* and *5* (p. 134).

OBSERVERS' COMMENTS

The following are a selection of the observer's comments during late 1989 and early 1990, listed in chronological order:

NOV 22: Jost Jahn suggested an anti-tail or jet directed toward the sun (PA 194°; or south-southwest). On the same night he reported the nuclear magnitude to be about +11.

DEC 05: Paul Robinson described the tail as being "diffuse and fanned with a central ray."

DEC 07: Jahn reported a "Long tail as emission of a point source."

DEC 09: To Robert Modic the tail appeared 2-3 times wider in 10×50 binoculars than it did in a 20-cm reflector.

DEC 12: Jean-Francois Viens reported a distinct green hue to the comet. Likewise, Gordon Garrard mentioned a "strong greenish color" on DEC 29.

Mr. Viens also reported a one-day brightening, which would have occurred between DEC 12.44-13.44, and lasted one day. He suggested that the tail also brightened and lengthened during that time. Lack of other reports on those two days make this report hard to confirm.

DEC 31: Paul Camilleri reported that the comet looked "like Halley in Feb. 1986." Also, on JAN 16 he commented that it looked "like a small Comet West (1975n)- a sight you only read about."

JAN 01: Camilleri reported that the tail appeared 7°.0 long through his 20×80 binoculars, and 2°.4 long through a 20-cm reflector. The 7° tail translates to a real length of 18.2 million km (11.3 million mi)!

JAN 03: Andrew Pearce described the tail as parabolic-shaped.

JAN 23: David Seargent reported that the comet had "virtually no coma, tail just appeared as a faint nebulous streak."

Footnotes:

[1] Central Bureau for Astronomical Telegrams. *International Astronomical Union Circular No. 4907*, issued November 17, 1989 by Daniel W.E. Green.

[2] *Ibid.*

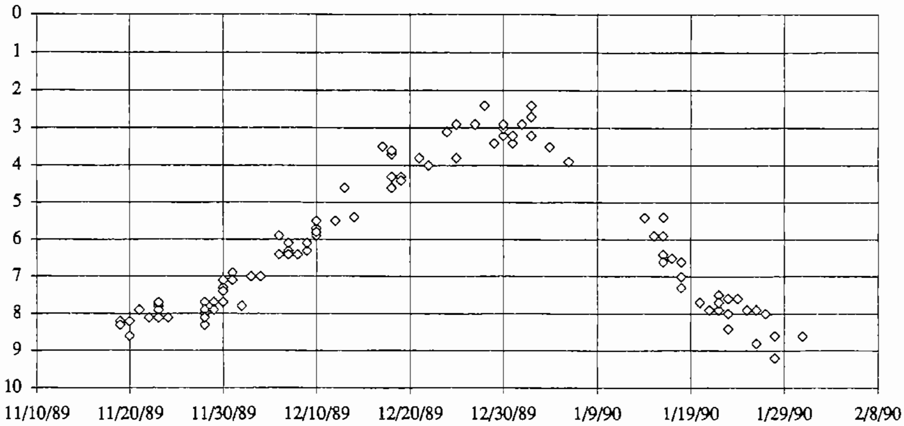


Figure 1. Comet Aarseth-Brewington (1989a_1): Visual magnitudes corrected for aperture.

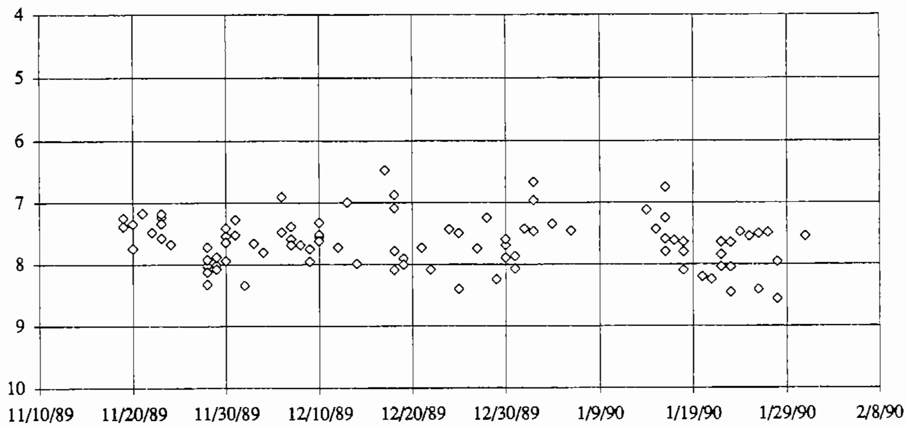


Figure 2. Comet Aarseth-Brewington (1989a_1): Absolute magnitudes.

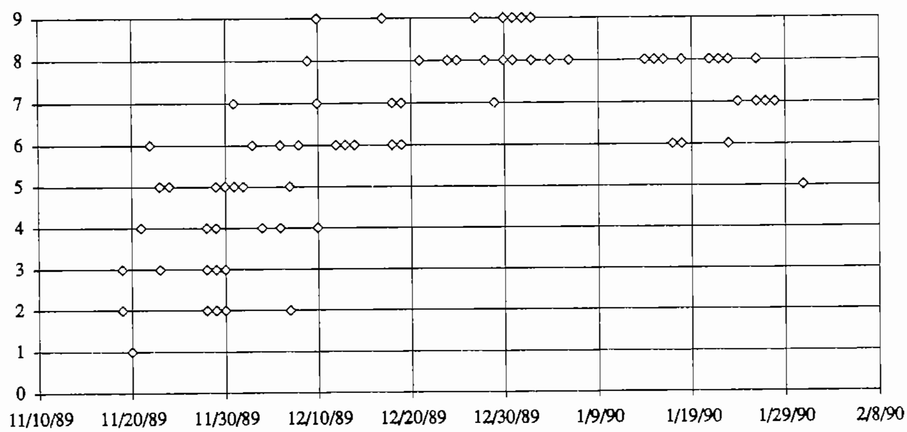


Figure 3. Comet Aarseth-Brewington (1989a_1): Degree of condensation.

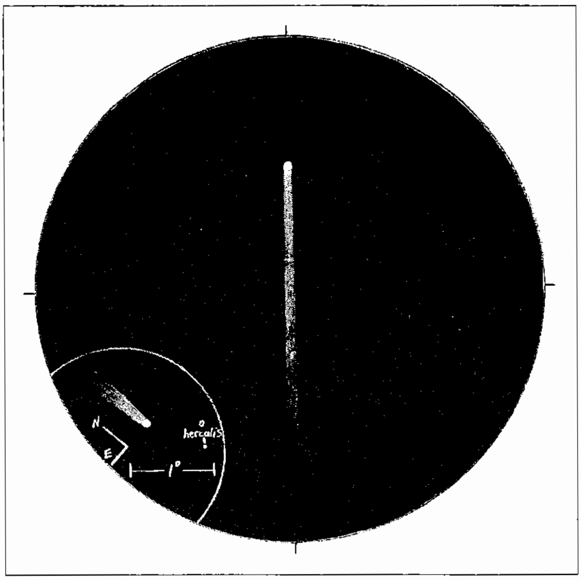
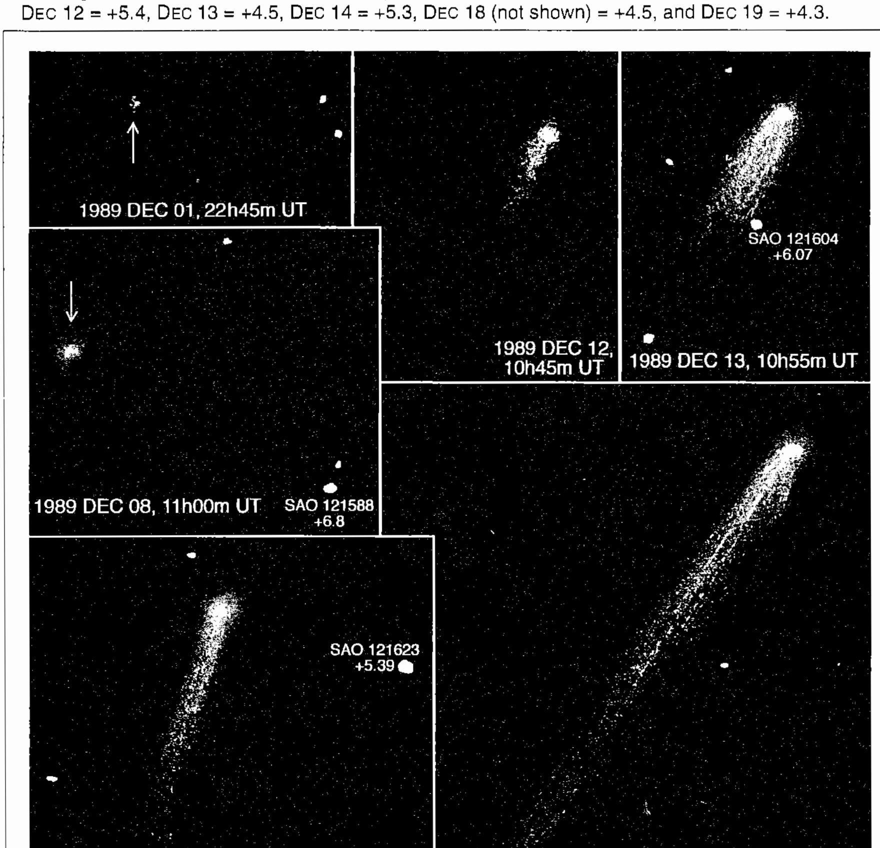


Figure 4 (to the left). Drawings of Comet Aarseth-Brewington by Robert Modic, converted from negative to positive. The larger sketch has celestial south at the top and east to the right, made on 1989 DEC 09, 10h40m-11h05m UT with an 8-in (20-cm) f/5 Newtonian, 35X, 1°.4 field; Seeing 7-8 (on the A.L.P.O. scale, ranging from 0 = worst to 10 = perfect), limiting magnitude +4.0. The inset sketch in the lower left was done at the same time with 10X50 binoculars, oriented as indicated. Mr. Modic noted that the comet's elevation was 5-10°; with the telescope the coma was 1' in diameter, round and strongly condensed, and the tail extended 3/4° but was very narrow; with the binoculars he estimated the tail as 1° long and 2-3 times as wide as through the telescope; the tail position angle 000° (north) ±10°.

Figure 5 (below). Composite of six drawings of Comet Aarseth-Brewington by Jean-Francois Viens with a 4.5-in (11-cm) Newtonian reflector at 40X. His drawings have been reoriented with celestial south at the top, and east to the right; they also have been converted from negative to positive drawings. He estimated the total cometary magnitude as follows: DEC 01 = +7.9, DEC 08 = +6.3, DEC 12 = +5.4, DEC 13 = +4.5, DEC 14 = +5.3, DEC 18 (not shown) = +4.5, and DEC 19 = +4.3.



FAST-MOVING LUNAR PHENOMENA

By: Alexey V. Arkhipov, Institute of Radio Astronomy, Kharkov

ABSTRACT

From time to time reports have appeared in the literature describing fast-moving objects (FMOs) moving across or near the lunar surface. Typically, these take the form of either light or dark spots, with apparent velocities of 0°.001-0°.1/sec and a duration under one minute. We have evaluated the hypothesis that such phenomena are of terrestrial origin and only appear projected against the Moon by chance. Statistical analysis, however, reveals a significant excess of sightings in the Mare Imbrium area relative to the Mare Nectaris-Foecunditatis area. These unexpected results, as well as the trajectory angle of some of these objects, imply that FMOs may be of lunar origin. Clearly, further systematic patrols are warranted.

INTRODUCTION

This article addresses the phenomenon of sporadic, fast-moving objects (FMOs) which reportedly appear and disappear across and near the lunar disk. Observations of birds, insects, terrestrial meteors, and so forth that occasionally pass across the line of sight have naturally been excluded from this analysis. FMOs have been reported by a number of prominent observers, including Schroeter (1791), Schafarik (1885), Haas (1947), and Firsoff (1960). They have also been listed in the NASA *Lunar Transient Phenomena Catalog* (Cameron, 1978).

Schafarik (1885) emphasized the difference between terrestrial meteors and the star-like FMOs in the following report:

> "In class I, I should place an object of so peculiar a character that I do not know what to make of it. 1874, April 24, at about 3-1/2 h.p.m., I observed the moon (illuminated nearly 3/4 in bright sunshine, with power 66, field 34', of a fine 4-in. achromatic by Dancer, when I was surprised by the apparition, on the disc of the moon, of a dazzling white star, which traveled slowly from E.S.E. to W.N.N., and after leaving the bright disc, shone on the deep blue sky like Sirius or Vega in daylight and fine air. The star was quite sharp and without a perceptible diameter...It was absolutely sharp, and its flight so slow (about 5 s.) that even a trace of indistinctness would have been perceptible."

Haas (1947) argued that fast-moving lunar objects exhibited properties statistically different from those of terrestrial meteors, particularly with respect to their short path lengths and small angular dimensions. In the 1940s, he thought that meteors could actually be observed in the lunar atmosphere, although it is now clear that such an atmosphere is far too rarefied for this to occur. It is primarily for that reason that most modern observers *a priori* favor a terrestrial explanation for FMOs. This postulate can be usefully tested, however.

FMO CATEGORIES

Although the author has collected reports of moving phenomena on the Moon for many years, including observations recorded in the literature as well as direct correspondence with individual observers, to date only 114 cases have been compiled. Reports of FMOs are indeed rare and comprise only about 5 percent of current reported Lunar Transient Phenomena (LTP). From an analysis of the available LTP reports, Arkhipov (1994a) recognized three types of moving objects:

(a) Permanent lunar spots exhibiting very slow movement due to libration and periodic illumination effects.

(b) Cloud-like objects, lasting several minutes to three hours, with angular velocities of 0°.0000001-0°.001/sec., and possibly the result of charged dust particles rising in electrical fields on the lunar surface.

(c) Fast-moving objects, lasting < 1 min. and moving between 0°.001-1°/sec.

Only the latter category constitutes a sample large enough to warrant statistical evaluation. Accordingly, only FMOs whose duration and location on the lunar surface have been reported were selected for the analysis (see *Table 1*, p. 136). In *Table 1*: Xi = cos (latitude[i]) × sin (longitude[i]); Yi = sin (latitude[i]); the rectangular coordinates of the starting (i = 1) or the terminal (i = 2) points of the FMO trajectories; n = the number of objects or clusters of objects; t = duration of the event; * = personal communication with the observer (from the author's files).

FMO DISTRIBUTION ON THE MOON

Since only 66 usable data points were available from our list, a contour-smoothing technique had to be utilized to demonstrate FMO distribution patterns across the lunar surface. The number (k) of points inside a circle with a circle of 0.3 lunar radii was calculated. This procedure was applied by scan-

Table 1. Characteristics of Lunar Fast-Moving Objects.

Date	XI	Y1	X2	Y2	n	t	References
1789 Oct 15	-0.296	+0.500	---	---	2	~4.0s	Schroeter, 1791
1941 Jul 10	---	---	-0.749	-0.208	1	~1 s	Corliss, 1979
1941 Jul 10	-0.546	-0.309	-0.586	-0.309	1	1 s	Haas, 1947
1942 Aug 24	+0.474	+0.723	+0.474	+0.740	1	~0.3 s	" "
1943 Feb 20	-0.123	+0.238	-0.218	+0.144	1	~0.8 s	" "
1943 Feb 20	-0.088	+0.767	-0.088	+0.787	1	0.5 s	" "
1944 May 05	+0.546	-0.748	-0.536	-0.738	1	1.5 s	" "
1944 Jun 27	-0.210	-0.525	-0.210	-0.475	1	~1.0 s	" "
1944 Aug 11	+0.269	+0.574	+0.292	+0.574	1	~1.8 s	" "
1946 Jun 10	-0.335	+0.284	-0.335	+0.746	1	1.0 s	" "
1946 Jul 22	+0.280	+0.557	+0.280	+0.590	1	~1.0 s	" "
1946 Jul 22	-0.101	+0.259	-0.101	+0.259	1	3.0 s	" "
1952 Aug 05	+0.000	+0.000	---	---	1	~1.5 s	Arkhipov, 1994b
1954 Oct --	+0.342	+0.940	-0.342	-0.940	1	~12 s	" "
1955 May 24	+0.137	-0.985	---	---	1	~2.0 s	Firsoff, 1960
1959 Mar 24	-0.664	+0.342	---	---	2	~1.5 s	Arkhipov, 1994b
1968 Jul 30	---	---	-1.000	0.000	1	~15 s	Hobana, 1976
1991 Nov 19	+0.719	+0.515	-0.148	+0.891	1	10 s	Arkhipov, 1994b
1991 Dec 15	-0.352	-0.927	---	---	1	1.0 s	Arsykhin, 1992*
1991 Dec 15	-0.051	-0.225	+0.099	-0.309	1	<1.0 s	Arkhipov, 1994b
1991 Dec 15	-0.048	+0.276	+0.265	+0.276	1	<1.0 s	" "
1991 Dec 15	+0.014	+0.559	+0.265	+0.276	1	<1.0 s	" "
1992 Jan 18	+0.174	+0.026	+0.342	+0.017	1	2.0 s	" "
1992 Mar 15	+0.017	-0.017	-0.051	-0.242	1	2.5 s	" "
1992 Apr 12	-0.077	+0.477	-0.075	+0.515	1	2.0 s	" "
1992 May 11	-0.604	+0.342	---	---	1	10 s	Lindhard, 1992
1992 Jul 10	+0.840	-0.242	---	---	1	~0.1 s	Arkhipov, 1994b
1992 Jul 14	-0.096	+0.788	+0.683	+0.259	1	~5.0 s	Kuleshov, 1994*
1992 Jul 16	-0.730	-0.454	---	---	1	~7 s	Arkhipov, 1994b
1992 Nov 07	-0.370	+0.156	-0.368	+0.191	1	~1.0 s	" "
1992 Dec 07	-0.361	-0.777	+0.485	-0.766	1	1.5 s	" "
1993 Mar 04	-0.367	+0.755	-0.417	+0.643	1	2.0 s	Arsykhin, 1994*
1993 Aug 27	+0.509	+0.276	+0.629	+0.208	1	0.8 s	" "
1993 Nov 20	+0.840	-0.530	+0.879	-0.423	1	3.0 s	" "
1994 Feb 14	0.000	-0.242	-0.202	-0.682	1	8.0 s	" "
1994 Mar 22	-0.469	-0.035	-0.530	+0.035	1	1.0 s	" "
1994 Mar 24	-0.145	-0.829	-0.145	-0.829	1	40-50 s	Likhachev, 1995*

ning the entire lunar disk with this circle. For every position of the circle center, the ratio (f) of k and its average value were calculated. The resulting map of the f parameter is shown in *Figure 1* (p.137).

The only statistically significant feature on the map is the excess of points in the Mare Imbrium region (A) relative to the Mare Nectaris - Mare Foecunditatis region (B). Indeed, 19 data points fall inside the f = 1.5 contour of Region A. The area within this contour constitutes 0.131 of the entire visible lunar disk. The probability that ≥19 points would fall within this contour by chance on the basis of the binomial distribution is found as follows:

$$(1) \qquad W_A = \sum_{i=M}^{N} \{[N!p^i(1-p)^{N-1}]/[i!(N-1)!]\},$$

where M = 19 and N = 66. This gives a probability of 0.0006. With respect to Region B, only one data point falls within the f < 0.5 radius, yielding a probability of ≤1 point inside this area, comprising 0.148 of the visible surface, of W_B = 0.0003. Obviously these calculated probabilities are sufficiently low to contradict the expected uniform distribution of FMO events should they be of terrestrial origin.

The apparent correlation of FMO events with certain lunar regions for what are presumably random events is certainly unusual, however, possible selection effects must also be considered.

First, it is possible that the probability of observing lunar meteors is affected by the albedo of the lunar background. The ratio of the visual albedo of the brightest crater Aristarchus to the darkest Grimaldi, is only 3 or a magnitude difference of 1.19 (Fessenkov, 1962). The cumulative number of meteors brighter than magnitude *m* is proportional to $10^{0.3\Delta m}$ for -10<m<+10 (Astapovich, 1958). Consequently, the background effect cannot account for the differences in meteor visualization by a factor of $10^{0.3 \times 1.19}$ or 2.28 times. The average value of the f-parameter is M/Np = 2.20 in Region A (where f≥ 1.5), but only 0.1 for Region B (f≤0.5). Clearly the lunar background differences cannot account for a 22-fold difference.

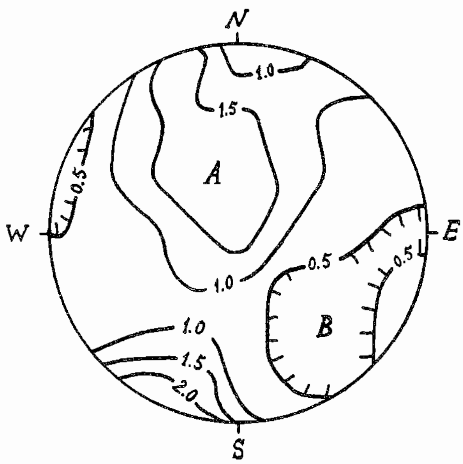


Figure 1. Contour map of the relative density (f) of the start and end points of FMO trajectories across the lunar disk, where 1.0 is the mean of f. The selenographic orientation is also indicated.

Second, some regions of the Moon might be observed more frequently due to favorable solar illumination and the restricted field of view of the telescope. However, lighting conditions should be identical for the lunar Northern and Southern Hemispheres, yet there is asymmetry with respect to the distribution of points; 39 in the north and 25 in the south. The probability of such a difference being due to chance is 0.052 ($M = 39$; $N = 64$; $p = 0.5$), implying at a 95-percent confidence level that the north-south asymmetry is real. In addition, most observers whose data were analyzed here, used small telescopes with low magnification, and thereby examined almost the entire lunar disk. Conceivably, the search for LTP in the Plato region could draw an observer's attention towards Mare Imbrium, resulting in an unintentional bias toward observing that area. However, Aristarchus, the "Mecca" of all LTP hunters (Cameron, 1977), is outside region A, suggesting such bias is in fact unimportant in this context. Collectively, the above indicate that biased selection effects do not explain the reported asymmetry in FMO distribution patterns.

Finally, some FMOs exhibit curved, non-meteoric trajectories. Let me cite one such original report. On 1955 AUG 15, using a small refractor, Yaremenko (1983) stated: "A luminous body similar to a 3rd mag star flew at about 0.2 lunar radii above the disk, parallel to its edge [limb]. The body flew about a third of the circumference (it continued for 4-5 seconds) and [apparently] landed on the lunar surface with a steep trajectory." His drawing is reproduced in *Figure 2* (to the right). Similar examples of paths are shown in *Figures 3 - 5* (p. 138). Although curved trajectories are very rare events, they must be taken into account.

CONCLUSIONS

Reports about lunar FMOs clearly warrant serious attention. It can be argued that at least some FMOs occupy circumlunar locations, but clearly more data are needed before this can be verified. The author would greatly appreciate receiving reports about any moving phenomena in the vicinity of, or over, the lunar disk. Please contact: Alexey V. Arkhipov, Institute of Radio Astronomy, 4, Krasnoznamennaya St., Kharkov 310002, Ukraine.

ACKNOWLEDGEMENTS

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(References continued on p. 138)

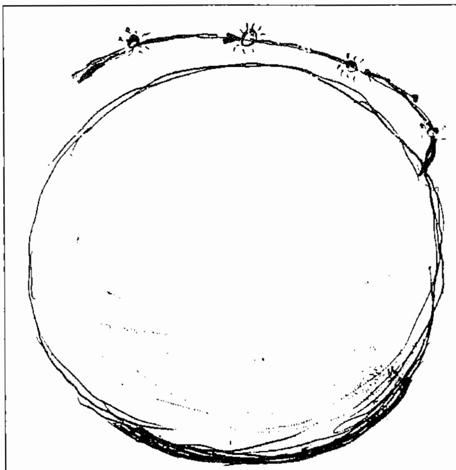

Figure 2. The circular trajectory of a starlike object near the lunar limb observed by V.V. Yaremenko, in mid-August, 1955 at about 17h00m UT, from Novocherkask, USSR, with a home-made refractor (aperture and magnification not given). Original drawing by the observer.

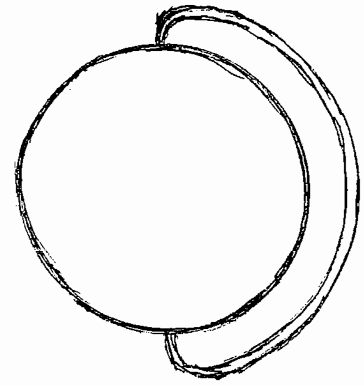

Figure 3. Trajectory of white line circling the Full Moon for 5-6 s before merging with the lunar surface. This phenomenon was observed in October or November, 1954-55 with the naked eye by V.I. Timkov from Ordjonikidze, USSR. Drawing by observer.

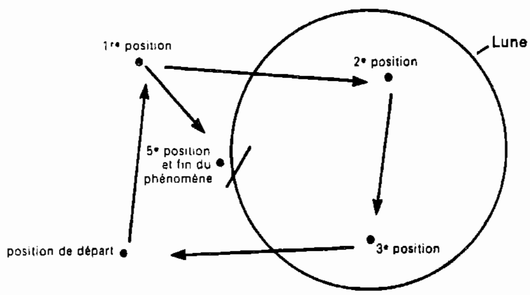

Figure 4. The curious trajectory of a starlike object near the crescent Moon, observed on 1968 JUL 30 by M. Beres from Tusnad-Bai, Rumania (Hobana and Weverbergh, 1976). The object appeared to disappear behind the Moon. (No telescope or other details given.)

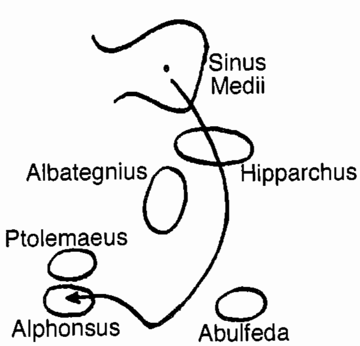

Figure 5. The twisted trajectory of a dark object observed by E.V. Arsykhin on 1992 MAR 15, 16h45m UT and lasting about 2.5 s. Observed with a 65-mm Newtonian from Moscow, Russia.

(References continued from p. 137.)

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Book Reviews

Edited by Jose Olivarez

Mars.

Edited by Hugh H. Kieffer, Bruce M. Jakosky, Conway W. Snyder and Mildred S. Matthews.

The University of Arizona Press, 1230 N. Park Avenue, Suite 102, Tucson, Arizona 85719-4140. 1992. 1,498 pages, 435 illustrations, 18 color plates, and six maps shipped with the book (not bound into it). Price $75.00 cloth (ISBN 0-8165-1257-4).

Reviewed by Jeffrey D. Beish

It has been nearly 20 years since the United States launched the Viking 1 and Viking 2 spacecraft to Mars that conducted the first successful exploration of the planet's surface. Viking-l reached Mars in June 1976 and on 20 July sent Lander-l to the surface in a region called Chryse Planitia. Viking-2 arrived that same month and dispatched Lander-2 to the Utopia region. Although Viking Orbiter/ Lander-2 ceased operating in 1980; Orbiter/ Lander-l sent data to Earth for six years—until November 1982!

None of the several books published about Mars since then have covered the entire results of the Viking Space missions. Indeed, not since 1882, when Camille Flammarion published *The Planet Mars*, has there been a more thorough book written about the Red Planet Mars until now. Over a century later, the book *Mars* has been written by 144 authors, with nearly 40 chapters of essential information for the professional and amateur Mars student. Covering every aspect of the Red Planet—such as Earth-based telescopic observations, its evolution, geology, or its satellites—*Mars* gives researchers everything they would want to know about the Red Planet, including six topographic and geologic maps produced by the U.S. Geological Survey.

Prior to publishing *Mars*, the Fourth International Conference on Mars was held in Tucson, Arizona in January 1989 to gather together the world's leading Mars scientists to discuss their findings. Except for the first chapter, which has been added, the book contains the entire results of papers and subsequent follow-up research presented at that meeting.

The first chapter describes classical telescopic observations of Mars, giving the Association of Lunar and Planetary Observers (A.L.P.O.) credit for keeping amateur astronomers involved in the study of the planet. Walter H. Haas, the founder of the A.L.P.O., is cited for his great contributions to our knowledge of the Solar System. Also, Charles F. ("Chick") Capen receives honorabl mention as one of the few professional astronomers who gave much of his time to help amateur astronomers find a place in history. This chapter was written by Leonard J. Martin (Lowell Observatory), Philip B. James (University of Toledo), Audouin Dollfus (Observatoire de Paris), Kyosuke Iwasaki (Kwasan Observatory), and Jeffrey D. Beish (then A.L.P.O. Mars Recorder).

Other chapters thoroughly describe the studies of the planet conducted at leading universities, other research institutions, and major observatories. A complete account of *Mars* would occupy this entire Journal; so let me just say that no other single publication contains even a small percentage of the information in this book.

Mars brings us nearer to completing the story of the Red Planet that Camille Flammarion started. His summary of knowledge of the Red Planet and subsequent studies by modern professional and amateur planetary scientists are often credited with giving us the courage for space missions to the Moon and planets.

I recommend this book highly as an advanced research tool, giving a complete history and reference library of the study of Mars by the leading experts. It is a must for observatory libraries and amateur astronomers.

THE A.L.P.O. PAGES

THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS

Founded by Walter Haas in 1947, the A.L.P.O. now has about 650 members. Our dues include a subscription to the quarterly Journal, *The Strolling Astronomer*, and are $16.00 for one year ($26.00 for two years) for the United States, Canada, and Mexico; and $20.00 for one year ($33.00 for two years) for other countries. One-year Sustaining Memberships are $25.00; Sponsorships are $50.00. There is a 20-percent surcharge on all memberships obtained through subscription agencies or which require an invoice.

A bimonthly newsletter, *Through the Telescope*, is available for an additional $6.00 annual charge.

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

All payments should be in U.S. funds, **drawn on a U.S. bank with a bank routing number**, and payable to "A.L.P.O." All cash or check dues payments should be sent directly to: **A.L.P.O. Membership Secretary, P.O. Box 171302, Memphis, TN 38187-1302.** VISA or MasterCard may be used by telephoning the Chabot Observatory and Science Center, 510-530-3480 (ask for "Extension 30" and leave a message) between the hours of 10 AM-noon and 1-4 PM Pacific Time, M-F, or by mail to: Chabot Observatory and Science Center, Starry Nights Gift Shop, 4917 Mountain Boulevard, Oakland, CA 94619 U.S.A; you may also FAX to 1-510-482-0425.

When writing our staff, please provide stamped, self-addressed envelopes. Note that the A.L.P.O. maintains a World-Wide Web homepage at: **http://www.lpl.arizona.edu./alpo/**

SOME THOUGHTS ABOUT OUR 1997 CONVENTION

By: Harry D. Jamieson, A.L.P.O. Executive Director

The 48th Convention of the Association of Lunar and Planetary Observers will take place on June 25-29, 1997, at the Holiday Inn de Las Cruces in Las Cruces, New Mexico. While no definite plans for fields trips have yet been made, options include the Very Large Array, Trinity atomic bomb blast site, White Sands National Monument, the White Sands Missile Range, Cloudcroft, and the Apache Point Observatory. Those planning to attend this convention are welcome to share their thoughts with me about these or other possible excursions.

The A.L.P.O. will be marking its 50th anniversary in 1997, and our convention this summer should be a celebration of that event. Although we will have some "normal" scientific-paper sessions, I encourage our members to submit papers having to do with the past, present, or future of the A.L.P.O. itself. I also encourage our older members to come and reminisce about the past, and any member is welcome to share his thoughts or dreams about the A.L.P.O. with us. Likewise, I extend a special invitation to our younger members to present papers. The A.L.P.O. will be in your hands someday! Suggestions for field trips, workshops, or other activities having to do with our anniversary are also very welcome.

The deadline for paper abstracts will be May 15, 1997. Naturally, we are planning to publish the *Proceedings* for this special meeting, and speakers should give camera-ready copies of their papers to Editor John Westfall at the time of the meeting.

This should be a very special convention, and with everyone's help and input it will be.

(More details about the Convention registration and the hotel will be sent in a special mailing.)

A.L.P.O. ANNOUNCEMENTS

A.L.P.O. Publications Team.—Most of our readers may not know that several persons beside the Editor are now helping produce our *Journal*, by means of reviewing manuscripts and in planning the future of this and other A.L.P.O. publications. Those who have helped with recent issues are Julius L. Benton, Jr. (also a Venus, Saturn, and Lunar Coordinator), Klaus R. Brasch (a Mars Recorder for several years), and Richard E. Hill (Assistant Solar Coordinator). A new member with astronomical publications experience, Andrew Oakes, has provided valuable advice. In addition, those who have helped the present Editor for several years are Walter H. Haas (our Founder, who edited our Journal for its first 38 years!), and Michael Mattei (our Instruments Coordinator), who compiles our annual indices. We are very grateful to these gentlemen, who have significantly improved our publication and speeded its production.

New Acting Assistant Jupiter Coordinator.—A new Acting Assistant Jupiter Coordinator has been appointed: Carl W. Keller, P.O. Box 54, Canastota, NY 13032-0054. Mr. Keller will be in charge of radio observations of the Giant Planet. A long-time member of the Society of Amateur Radio Astronomers, Mr. Keller will provide liaison with that organization. He notes that "The Jupiter Section will begin observations of the Jovian decametric radio burst during the 1997 Apparition. ... An adequate outdoor antenna and a sensitive shortwave receiver are required for these types of observations. A working knowledge of electronics is desirable, but not essential. An amateur capable of building an optical telescope can also develop and commission a radio telescope. This coming apparition is the most favorable in several years for the Jovian noise bursts." Mr. Keller invites those interested in this program to contact him.

New Acting Assistant Minor Planets Coordinator.—The latest member of the A.L.P.O. staff is in a newly-created position: Acting Assistant Minor Planets Coordinator, Lawrence S. Garrett, 206 River Road, Fairfax, VT 05454. Mr. Garrett is organizing a Minor Planets observing program; details can be found on the A.L.P.O. webpage.

Director Changes E-Mail Address.—Harry D. Jamieson, the A.L.P.O. Executive Director, Membership Secretary, and Lunar Coordinator, has changed his E-mail address, effective immediately, to: hjam@worldnet.att.net .

Coordinator Benton Changes E-Mail Address.—Our second E-mail address change is that of Julius L. Benton, Jr., who serves on the A.L.P.O. Board of Directors and as a Venus, Saturn, and Lunar Coordinator. His new E-mail address is: jlbentonjr@msn.com .

New Meteors Guide Available.—Mark Davis, our Acting Associate Meteors Coordinator, has announced the availability of the second edition of *Meteor Showers and Their Observation: A North American Meteor Network Guide*, a significant revision of the first edition. Those interested in receiving a copy of this ca. 50-page publication, via E-mail only, should send a request to him at: MeteorObs@charleston.net .

How High the Moon's Features?—The measurement of the heights of the Moon's features is a neglected field, even though the heights of thousands of peaks and the depths of thousands of craters remain to be determined. An A.L.P.O. lunar enthusiast, William F. Davis, III, has prepared a 34-page paper, *Determination of Lunar Elevations by the Shadow Method: Analysis and Improvements*, detailing the shadow-measurement method of lunar height determination, along with a discussion of its accuracy. In order to obtain a copy, write to Mr. Davis at 20 Beverly Garden Dr., Metairie, LA 70001, enclosing $4.50 and a self-addressed mailing label.

Changes to A.L.P.O. Guidelines for Authors.—The A.L.P.O. Board of Directors has approved an addition to the *Guidelines for Authors*, published in our last previous issue: Photocopier ("xerox") copies of grey-scale drawings, photographs, or images are no longer acceptable. This is because such copies are actually black-and-white, with no intermediate grays, so that their brightness and contrast cannot be adjusted for publication. On the other hand, such copies of black-and-white originals (e.g., line drawings) are still acceptable. For grey-scale originals, we advise either making photographic copies, or scanning them and sending the Editor a diskette with the illustration in the form of a graphics file in a standard format (JPEG, GIF, TIFF, or PICT). You can also send the original drawing, 35-mm slide, or film negative, or photographic print to the Editor, along with a stamped self-addressed return envelope; he will scan your originals and then return them to you.

THE UNIVERSE BEYOND THE A.L.P.O.

This section provides news about non-A.L.P.O. organizations, meetings, and individuals concerned with Solar-System topics and thus which should be of interest to our readers.

Riverside Telescope Makers Conference.—The 29th Annual Riverside Telescope Makers Conference will be held on May 23-26, 1997. This year's conference theme is "Making, Using, and Choosing Telescopes." The keynote speaker will be Rick Fienberg, President/Publisher of *Sky & Telescope* magazine. Other events include a swap meet on Saturday, commercial exhibitors, paper sessions, and of course the star party. The conference site will be the Y.M.C.A. Camp Oakes, eight miles east of Big Bear City in the San Bernardino Mountains in southern California. Per-person costs prior to May 1st range from $10.00 daily use fee to $69.00 for eight meals and dorms/camping, with several options in between; prices go up after May 1st. For registration materials, write to: Riverside Telescope Makers Conference, 9045 Haven Ave., Suite 109, Rancho Cucamonga, CA 91730. If you wish to be a speaker, send an abstract and AV requirements, before May 1, to: Alan Guthmiller, 3186 Juanita Dr., Las Vegas, NV 89102 (Tel. 702-873-5790).

33rd International Astronomical Youth Camp.—IAYC'97 will be held July 28-August 17 at the "Jugendgasthause Mortelgrund" near Sayda, Germany. Youth camp participants will work in one of eight groups—Ancient Astronomy, Celestial Mechanics, Cosmology, Molecular Astronomy, Practical Astronomy, Spectroscopy, and Variable Stars. This program is open to all persons between 16 and 24 years of age who can communicate in English; the total charge is DM 790. For information, use the IAYC website (http://www.ster.kuleuven.ac.be/~bart/iayc), or write for an information booklet/application to: IWAe.V., c/o Gwendolyn Meeus, Parkstraat 91, 3000 Leuven, Belgium (e-mail: gwendolyn@ster.kuleuven.ac.be).

Division for Planetary Sciences.—The DPS is meeting earlier than usual in 1997; July 28-August 1, in Cambridge, Massachusetts. One of the two major planetary science meetings, the DPS will meet on the campus of the Massachusetts Institute of Technology. In addition to campus housing, the Cambridge Center Marriott nearby will house attendees at special rates. Up-to-date information on the meeting can be found on the DPS website: http://www.aas.org/~dps . You can also obtain information from: LeBessa Simmons, Publications and Program Services Department, Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston, TX 77058-1113; Tel. 281-486-2158; FAX 281-486-2160; E-mail: simmons@lpi.jsc.nasa.gov .

Mount Wilson Summer Program for Undergraduates.—This is a unique opportunity to learn how to observe with some of the major instruments at Mt. Wilson Observatory, including the 24-in f/30 Snow Horizontal Solar Telescope, a 7-in refractor, a 24-in reflector, and the historic 60-in reflector. This course is intended for junior- or senior-level students in physics or astronomy. The program will be held August 13-26, 1997, and staff members and students will live on the mountain for that period; the tuition fee is $1375. For more information and application materials, contact: Prof. Joseph L. Snider, Dept. of Physics, Oberlin College, 110 North Professor Street, Oberlin, OH 44074 (Tel.: 216-775-8335; E-mail: joseph.l.snider.@oberlin.edu).

Educational Opportunity.—The Southeastern Association for Research in Astronomy (SARA) will grant a research internship in astronomy, with a $2750 stipend plus lodging, for summer, 1997. This 8-10 week appointment will include observing with the 0.9-meter SARA telescope at Kitt Peak. Application forms are due by March 17, and can be obtained from the SARA website, http://pss.fit.eud/SARA_REU/.html , or from Dr. Terry D. Oswalt, SARA REU Program Director, Department of Physics and Space Sciences, Florida Institute of Technology, Melbourne, FL 32901-6988 (Tel.: 407-768-8000, Ext. 8098; FAX: 407-984-9461; E-mail: oswalt@tycho.pss.fit.edu .

French Ephemerides.—The historic Bureau des Longitudes has added polynomial-coefficient tables for the satellites of Mars, Jupiter, Saturn, and Uranus to its *Connaissance des Temps 1997*. This 190-page ephemeris is available for 250 francs (plus 20 francs shipping) from: Les Editions de Physique, 7, Avenue du Hoggar, Z.I. de Courtabœuf, F91944 LES ULIS Cedex A, France. Available directly from the Bureau (Bureau des Longitudes, URA 707 du CNRS, 77, Avenue Denfert-Rochereau, 75014, Paris, France) are separate publications (prices not given) for the satellites of Jupiter and Saturn, graphing their positions and tabulating the "normal" and mutual satellite phenomena for 1997.

Assorted Meetings.—Lack of space prevents us from giving details, but here are several upcoming meetings in 1997, along with their places, dates, and how to obtain more information:

Problems of Celestial Mechanics; St. Petersburg, Russia, June 3-6; A.S. Baranov, FAX +1-812-272-79-68: E-mail: AML@ita.spb.su .

Workshop on Remote Sensing of Planetary Ices: Earth and Other Solid Bodies; Flagstaff, AZ, June 11-13; Dr. Wendy M. Calvin; E-mail: wcalvin@flagmail.wr.usgs.gov ; Website: http://wwwflag.wr.usgs.gov/USGSFlag/Space/RSIce/rsice.html .

Workshop on Observations of the Saturn System from the 1995-6 Ring Place Crossings; Wellesley College, Wellesley, MA, June 25-26; Dick French; E-mail: rfrench@ahab.wellesley.edu ; Website: http://ringside..arc.nasa.gov///www/rpx/wellesley/workshop.html .

North American Sundial Society; Chicago, IL, September 11-14; Sara Schechner Genuth, National Museum of American History, Room 1040, MRC 605, Smithsonian Institution, Washington, DC 20560; FAX 202-786-2851; E-mail: sgenuth@aip.org .

Io During the Galileo Era; Lowell Observatory, Flagstaff, AZ, September 22-24; John Spencer; E-mail: spencer@lowell.edu .

Francis G. Graham, *Assistant Coordinator-Eclipses;* P.O. Box 209, East Pittsburgh, PA 15112. Internet: fgraham@kenteliv.kent.edu

Lunar Section: Julius L. Benton, Jr. , *Coordinator, Selected Areas Program;* Associates in Astronomy, 305 Surrey Road, Savannah, GA 31410. Internet: jlbentonjr@msn.com

David O. Darling , *Coordinator, Lunar Transient Phenomena;* 416 W. Wilson St., Sun Prairie, WI 53590-2114

William M. Dembowski, *Acting Coordinator, General Lunar Programs;* 219 Old Bedford Pike, Windber, PA 15963. Internet: dembow@mail.third-wave.com

Francis G. Graham, *Coordinator, Eclipses and Photometry;*P.O. Box 209, East Pittsburgh, PA 15112. Internet: fgraham@kenteliv.kent.edu

Harry D. Jamieson, *Coordinator, Lunar Dome Survey;* Harry D. Jamieson, P.O.Box 171302, Memphis, TN 38187-1302. Internet: hjam@worldnet.att.net

Guido E. Santacana, *Acting Assistant Dome Coordinator;* Nuevo Laredo #1678, Venus Gardens, Rio Piedras, PR 00926

Mercury Section : Dr. Oscar Cole-Arnal, *Acting Coordinator;*Waterloo Lutheran Seminary, Waterloo, Ontario N2L 3C5, CANADA. Internet: ocole@mach1.wlu.ca

Venus Section: Julius L. Benton, Jr. , *Coordinator;* Associates in Astronomy, 305 Surrey Road, Savannah, GA 31410. Internet: jlbentonjr@msn.com

Mars Section: Daniel M. Troiani , *Coordinator; all observations; U.S. correspondence;* 629 Verona Court, Schaumburg, IL 60193

Carlos E. Hernandez, *Coordinator; all other correspondence,* 9430 SW 29nd Terrace, Miami, FL 33165

Donald C. Parker, *Assistant Coordinator; CCD imaging, "Mars Project";* 12911 Lerida Street, Coral Gables, FL 33156

Daniel Joyce, *Acting Assistant Coordinator;* 6203 N. Keeler Ave., Chicago, IL 60648-5109

Minor Planets Section: Frederick Pilcher, *Coordinator;* Illinois College, Jacksonville, IL 62650

Lawrence S. Garrett, *Acting Assistant Minor Planets Coordinator,* 206 River Road, Fairfax, VT 05454

Jupiter Section: Wynn K. Wacker, *Acting Coordinator;* 7601 Carrington Dr. #D, Madison, WI 53719

Phillip W. Budine, *Assistant Coordinator, Transit Timings;* R.D. 3, Box 145C, Walton, NY 13856

Carlos E. Hernandez, *Assistant Coordinator*; 9430 SW 29nd Terrace, Miami, FL 33165

John E. Westfall , *Assistant Coordinator, Galilean Satellites;* P.O. Box 16131, San Francisco, CA 94116. Internet: 73737.1102@compuserve.com ; FAX 415-731-8242

Sanjay Limaye, *Acting Assistant Coordinator; Scientific Advisor;* Atmospheric Oceanic & Space Sciences Bldg. 1017, 1225 W. Washington Ave., University of Wisconsin, Madison, WI 53806. Internet: LIMAYE@MACC.WISC.EDU

Carl W. Keller, *Acting Assistant Coordinator, Radio Observations.* P.O. Box 54, Canastota, NY 13032-0054

Saturn Section: Julius L. Benton, Jr., *Coordinator;* Associates in Astronomy, 305 Surrey Road, Savannah, GA 31410. Internet: jlbentonjr@msn.com

Remote Planets Section: Richard W. Schmude, Jr.,*Coordinator;* Gordon College, Division of Natural Sciences and Nursing, 419 College Drive, Barnesville, GA 30204. Internet: Schmude@Falcon.gdn.peachnet.edu

Comets Section: Don E. Machholz, *Coordinator;* P.O. Box 1716, Colfax, CA 95713

James V. Scotti; *Assistant Coordinator;* Lunar and Planetary Lab., University of Arizona, Tucson, AZ 85721

Meteors Section: Robert D. Lunsford; *Coordinator;* 161 Vance Street, Chula Vista, CA 91910. Internet: LUNRO.IMO.USA@PRODIGY.COM

Mark A. Davis, *Acting Assistant Coordinator;* 7304 Doar Road, Awendaw, SC 29429

Instrument Section: Michael Mattei , *Coordinator;* 11 Coughlin, Littleton, MA 01460

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Bob Manske, *Acting Associate Coordinator;* 404 Prospect Road, Waunakee, WI 53597

Mercury/Venus Transit Section: John E. Westfall , *Coordinator;* P.O. Box 16131, San Francisco, CA 94116. Internet: 73737.1102@compuserve.com ; FAX 415-731-8242

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A.L.P.O. monographs are publications that we believe will appeal to our members, but which are too lengthy for our *Journal.* Order them from our Editor (P.O. Box 16131, San Francisco, CA 94116 U.S.A.) for the prices indicated, which include postage; make checks to "A.L.P.O."

Monograph Number 1. *Proceedings of the 43rd Convention of the Association of Lunar and Planetary Observers. Las Cruces, New Mexico, August 4-7, 1993.* 77 pages. Price: $12.00 for the United States, Canada, and Mexico; $16.00 elsewhere.

Monograph Number 2. *Proceedings of the 44th Convention of the Association of Lunar and Planetary Observers. Greenville, South Carolina, June 15-18, 1994.* 52 pages. Price: $7.50 for the United States, Canada, and Mexico; $11.00 elsewhere.

Monograph Number 3. *H.P. Wilkins 300-inch Moon Map.* 3rd Edition (1951), reduced to 50 inches diameter; 25 sections, 4 special charts; also 14 selected areas at 219 inches to the lunar diameter. Price: $28.00 for the United States, Canada, and Mexico; $40.00 elsewhere.

Monograph Number 4. *Proceedings of the 45th Convention of the Association of Lunar and Planetary Observers. Wichita, Kansas, August 1-5, 1995.* 127 pages. Price: $17.00 for the United States, Canada, and Mexico; $26.00 elsewhere.

Monograph Number 5. ***Astronomical and Physical Observations of the Axis of Rotation and the Topography of the Planet Mars. First Memoir, 1877-1878.*** By Giovanni Virginio Schiaparelli, translated by William Sheehan. 59 pages. Price: $10.00 for the United States, Canada, and Mexico; $15.00 elsewhere.

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The A.L.P.O. Solar System Ephemeris: 1997. $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 Galilean satellites, minor planets, meteors, and comets. Make payment to "A.L.P.O."

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 171302 Memphis, TN 38187-1302 U.S.A:

A.L.P.O. Membership Directory. $5.00 in North America; $6.00 elsewhere. Continuously updated list of members on 3.5-in MS-DOS diskette; whether DBASE or ASCII format. Make payment to "A.L.P.O." Also available as an e-mail downloaded file, given the requester's e-mail address. *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. *8* (1954); 7-8. *11* (1957); 11-12. *21* (1968-69); 3-4 and 7-8.
23 (1971-72); 3-4, 7-8, 9-10, and 11-12. *25* (1974-76); 1-2, 3-4, 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].
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33 (1989); 4-6, 7-9, and 10-12 [each $2.50]. *34* (1990); 2 and 4 [each $2.50].
37 (1993); 1, 2, 3, and 4 [each $2.50]. *38* (1994-96); 1, 2, 3, and 4 [each $2.50]. *39* (1996); 1 and 2 ($2.50).

Current Issue [*39,* 3]—$3.00.

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Order the following directly from the appropriate Section Coordinator; use the address in the staff listing unless another address is given below.

Lunar and Planetary Training Program (Robertson): *The Novice Observers Handbook,* $10.00. An introductory text to the Training Program. Includes directions for recording lunar and planetary observations, useful exercises for determining observational parameters, and observing forms. To order, send a check or money order made out to "Timothy J. Robertson."

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.)*

Lunar (Graham): (1) Forms with explanations (in English or German); send a SASE. **(2)** *Lunar Photometry Handbook,* $5.00 Ppd. paperbound, $15.00 Ppd. hardbound. **(3)** Orders are now being accepted for a *Lunar Eclipse Handbook,* $3.00 paperbound plus $1.00 shipping and handling. **(4)** *Solar and Lunar Eclipse Observations 1943-1993*; $25.00 postpaid.

Lunar (Jamieson): A "Lunar Observer's Tool Kit," consisting of a 3-1/2-in. MS/DOS diskette containing an observation-planning program and a lunar dome data base with built-in instructions. Price $25.00.

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 SASEs; 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, P.O. Box 572, West Burlington, IA 52655): *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.)*

Comets (Machholz): Send SASEs to the Recorder for monthly installments of *Comet Comments*, a one-page newsletter reviewing recent comet discoveries and recoveries, and providing ephemerides for bright comets.

Meteors (Astronomical League Sales, P.O. Box 572, West Burlington, IA 52655): (1) The pamphlet, *The A.L.PO. Guide to Watching Meteors* is available for $4.00 (price includes postage). **(2)** *The Meteors Section Newsletter* is published quarterly (March, June, September, and December) is available free of charge if you send 32¢ in postage per issue to Coordinator Robert D. Lunsford, 161 Vance Street, Chula Vista, CA 91910

Minor Planets (Derald D. Nye, 10385 East Observatory Drive, Corona de Tucson, AZ 85641-2309): Subscribe to: *The Minor Planet Bulletin*; quarterly, $9.00 per year for the United States, Mexico and Canada; or $13.00 for other countries (air mail only).

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