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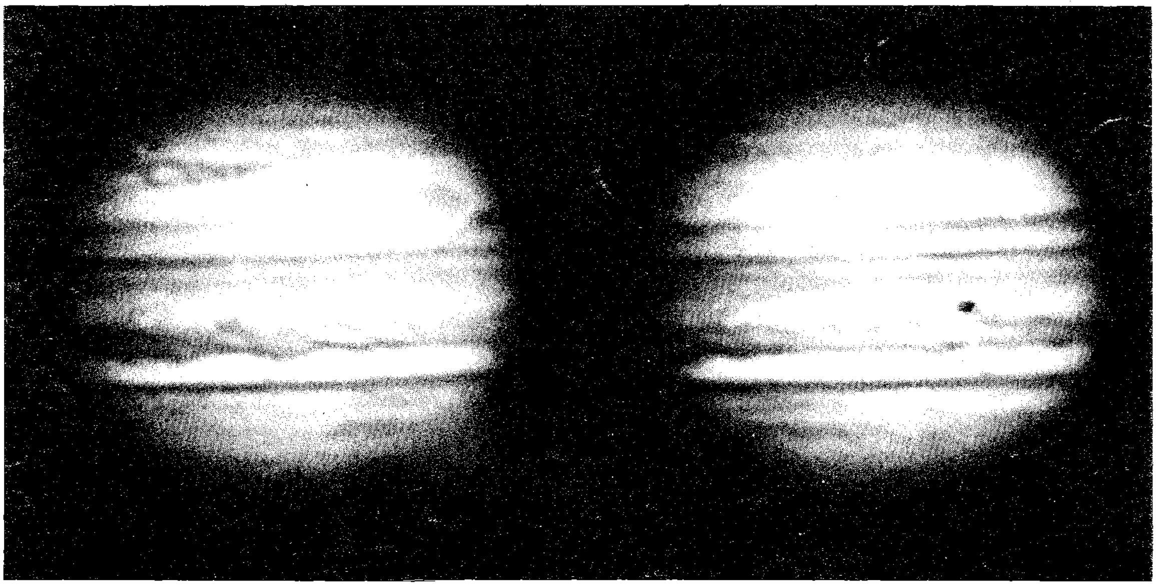

Two images of Jupiter, taken by Donald C. Parker on 1991 Dec. 10 with a Lynxx CCD camera and a 41-cm (16-in) Newtonian reflector. Black-and-white reproductions of color three-image composites. Left view taken at 09h 32m UT [CM(I) = 227°, CM(II) = 347°]; right view at 10h 55m UT [(CM(I) = 278°, CM(II) = 038°]. South at top, celestial west at left. The Great Red Spot is near the right limb in the left image and left of and above center on the left image. The right image also shows the shadow of the satellite Io to the lower right of center. For the identification of other features, see the map of Jupiter on p. 12; for information about CCD imaging see the article by Donald Parker and Richard Berry on pp. 1-8.

THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS
c/o Dr. John E. Westfall, Director/Editor
Membership Secretary, Harry D. Jamieson
P.O. Box 143
Heber Springs, AR 72543 U.S.A.

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In This Issue

PLANETARY IMAGING WITH A SMALL CCD CAMERA

By: Donald Parker and Richard Berry†

†Address: Route 1 Box 58A, Cedar Grove, WI 53013.

ABSTRACT

CCD images rival the human eye, capturing diffraction-limited planetary detail with short exposure times. The authors present their first six months' experience with a Lynxx PC CCD camera and outline the potential that CCD imaging offers amateur planetary observers.

CCD (charge-coupled device) cameras recently developed for amateur astronomy appear well suited for planetary imaging. These cameras offer sufficient resolution to capture diffraction-limited detail over planetary disks, relative freedom from seeing [atmospheric turbulence] problems because of short exposure times, and linear recording of brightness. They produce digital images that can be enhanced with currently available image-processing software. Although CCD cameras are still expensive, the prospect of planetary images that show more detail than the human eye can discern through the same telescope should be very appealing to those who study the planets.

THE PHOTOGRAPHIC STANDARD OF EXCELLENCE

Over the past two decades, improvements in film and processing materials have permitted amateur astronomers to produce professional-quality images of the planets. Modern films convert several percent of the incident photons into exposed grains of silver, representing a factor of three improvement in efficiency in the last decade. Color films permit efficient recording of planetary colors, while fine-grain black-and-white emulsions record plentiful surface detail. Finally, photographic emulsions are self-contained, require no electrical power, and are ready for use at a moment's notice.

However, even at its best, photography rarely if ever is a match for the human eye/brain combination in detecting planetary detail. One reason for this failure is that the eye "grabs" fine detail during moments of good seeing, when the Earth's atmosphere is steady. Films, however, usually require exposures of several seconds, during which some image blurring occurs. A detector that could capture an image in a fraction of a second would have a significant advantage over photography.

In photography, the relationship between exposure [cumulative amount of light] and image density is non-linear. In addition, photographic emulsions lose some of their sensitivity when exposures exceed a few seconds, an effect known as *reciprocity failure*. The combination of non-linear response and reciprocity failure makes measuring brightness from photographs difficult, and the loss of speed in reciprocity failure places serious limitations on planetary color-filter imaging. A linear detector free of reciprocity failure would certainly outshine photography in these applications.

These problems are most obvious with color photography. Even with today's excellent tripack [three layers, each sensitive to a different wavelength range] color films, each emulsion layer responds differently to produce color errors that depend on the length of the exposure. For this reason, conventional color emulsions do not record the exact colors of planetary features. Although color information can be obtained from film through calibrated tricolor separation, this technique requires sophisticated darkroom processing. Color images that could be readily manipulated, for example on a computer screen, could compete seriously with color photography.

Photography reproduces image information over a limited tonal range. In planetary imaging, shadow details often contain information of great interest to the astronomer, and this situation is the one where film is at its worst. Although techniques such as compensating development [Parker and Capen, 1980], hypering film in hydrogen or forming gas [Reynolds and Parker, 1988], composite printing, or unsharp masking, can improve the tonal separation in planetary images, a detector that would permit precise control of the tonal scale would almost certainly be superior to photography.

CCD IMAGING FILLS THE BILL

CCD cameras largely overcome atmospheric seeing because unfiltered exposures are short— typically one-tenth the same exposure required by photography. Because the observer can inspect each image as soon as it is taken, he or she can continue to take frames until a good image is secured. Even when CCDs are used for filter imaging, the exposure times are still short enough to overcome the worst effects of seeing.

CCDs are highly linear so that the brightness of a given pixel in a planetary image corresponds precisely to the intensity of light that fell upon that pixel at the moment of exposure. Because CCD images are digital, this linear photometric information is instantly available. CCDs are therefore well suited for measuring the colors of objects, and tricolor filter images can be combined to produce true-color [or false-color!] images.

Today's CCD cameras permit virtually

filling the detector with a planetary image. At this scale, a 12-inch (30-cm) telescope can allow image sampling on the order of 0.25 arc-seconds per pixel [image element], yielding an effective resolution of 0.5 arc-seconds. With these conditions, the 165X192-pixel format of amateur CCD cameras is perfect for high-resolution work.

Finally, CCDs give high photometric precision as well as high angular resolution. Cameras made for the amateur market use 12 binary bits to record the brightness of each pixel, thus measuring light over a *dynamic range* of 4096 to 1, with a precision of about 1 part per 1000 at the upper end of the image scale. This accuracy means that the resulting images can be unsharp-masked [accentuating small-scale detail], stretched, sharpened, and otherwise manipulated in order to make the information contained in the image more visible.

In brief, CCD imaging is strong in precisely those areas where photography is weakest. CCDs are capable of short planetary exposures. They are both linear and free of reciprocity failure, and they have an enormous dynamic range so that they are capable of photometric and scientific-grade color imaging. Furthermore, because they are digital, CCD images can be computer-processed in order to reveal all the information that they contain.

Using a CCD: Our Experience

The authors have collaborated to explore the value of the CCD camera as a practical tool for planetary imaging. Parker concentrated on obtaining images at the telescope, while Berry emphasized creating software to process planetary images. Both authors have used CCD cameras: Parker began in February, 1991, with a 16-inch (41-cm) Newtonian telescope, while Berry began in October, 1990, with an 8-inch (20-cm) Schmidt-Cassegrain. Since that time, they have exposed several thousand CCD frames and have obtained images that equal or exceed the quality of photographic images or even of visual observations made with the same telescopes. Our experience suggests that CCD cameras can be extremely powerful in the hands of amateur planetary observers.

The cameras that we have used are a SpectraSource Lynxx PC (Berry) and a Lynxx PC Plus (Parker). Both devices employ 0.1-inch (2.5-mm) square Texas Instruments TC-211 CCD chips with 192 columns and 165 rows of pixels. To reduce noise, each unit is cooled to -30°C by a Peltier thermoelectric cooler. The signal is sampled to 12 bits, or 4096 grey levels.

The CCD camera is connected to a PC or PC-compatible computer via a card inserted into one of the computer's expansion slots. [A version for the Macintosh II series of computers is also available.] Image acquisition and focussing are done with an inexpensive NTSC [US-standard] video monitor driven by signals generated on the card. Menu functions and final image presentation appear on the computer's VGA monitor. This equipment arrangement is shown in *Figure 1* below.

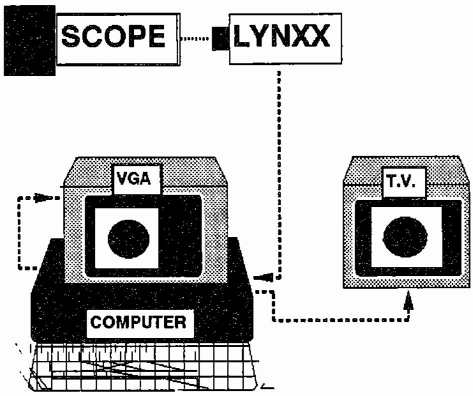

Figure 1. Typical equipment arrangement for CCD imaging with a PC-compatible computer.

The size of a planetary image at the focal plane of most amateur telescopes is quite small—usually less than one millimeter. This is too small for any collector, be it film or CCD chip, properly to record planetary details. Because the size of a given planet's image depends only upon the optical system's focal length, one can enlarge the image formed on the detector by increasing the effective focal length (EFL) of the telescope. This is most efficiently done with a technique called eyepiece projection. By selecting the proper ocular and projection distance, the astrophotographer can achieve the proper balance between image scale and exposure time. The principles of projection photography are straightforward and are discussed in detail elsewhere [Dobbins *et al.*, 1988], but here we wish to stress that these principles apply equally to CCD imaging.

We have done most of our imaging with an effective focal length selected so that the image of Jupiter nearly fills the CCD detector. It is a fortuitous coincidence that the stellar diffraction disk produced by 8- to 16-inch (20-41 cm) telescopes satisfies the Nyquist sampling theorem [which predicts the minimum pixel size to prevent loss of detail] for the pixel size of the TC-211 chip at effective focal ratios (EFRs) of f/20 to f/40 [Berry, 1991d], the same range of focal ratios that gives frame-filling images of the brighter planets.

Our methods of capturing images are quite similar to each other. After bringing the planet into the field of view, focusing, and determining the correct exposure time (tips for carrying out these operations are given below), we take many image frames in rapid succession, typically ten frames per minute. If an image appears fuzzy or disturbed by seeing, we simply shoot another frame. When a good frame appears on the monitor, we save it on the computer's hard disk.

An unexpected advantage of CCD imaging is the automatic logging of the date and exact time when each image was captured. These data can be seen by simply entering the directory command to view the contents of the subdirectory that contains the images. Before each observing session the computer's clock can be set to the Universal Time and Date, either manually from WWV signals or by synchronizing the computer with the National Time Service via a modem. Storing many images in rapid succession in a short period of time can be time-consuming if each image's name and filepath must be entered by hand. Recent improvements in the Lynxx software allow storage and automatic numbering of images with only two keystrokes.

At some time during or immediately after each imaging run we obtain up to fifteen flat-field images. Flat-fielding is absolutely essential if one is to produce useful planetary images. This process is discussed later.

In the course of an evening, we may save several dozen to several hundred images. These "raw images" are usually lacking in contrast and fine detail and must therefore be manipulated so that the wealth of data they contain will be readily visible. This manipulation is called *image processing*; and, like the darkroom phase of conventional photography, is a critical stage in the production of high-quality images.

USING A CCD: IMAGE PROCESSING

Today, most of the CCD cameras on the market provide basic image-processing capability in their data-acquisition software. Although these routines are "user friendly" and provide the basic utilities needed for saving images, they are not versatile enough for planetary work. Fortunately, there is now at least one inexpensive commercial software package available that has been optimized for astronomical image manipulation [Berry, 1991a].

This program, called *AstroIP* or *AIP*, performs all the basic operations needed for improving planetary images. These images can be: loaded into memory; enhanced in contrast and brightness using both linear and non-linear stretches [routines that create a greater dynamic range in the image]; filtered with a standard set of matrix convolution routines that sharpen detail and enhance the visibility of small features; masked with the digital equivalent of photographic unsharp mask techniques; examined analytically for individual pixel values or the statistical properties of the entire images; and saved to disk in a variety of file formats.

Image processing may also be carried out on a batch basis. After a good night, when we have taken over 100 images, we use a program called *BatchPIX* [Berry, 1991b] to carry out a standard suite of image-processing procedures. *BatchPIX* automatically applies a flat-field, centers the planet in the frame, performs an unsharp mask to enhance broad detail, performs a sharpening routine to enhance small-scale detail, scales the image to make use of the full display range of the computer monitor, and saves the resulting image as a file on the computer's hard disk. *BatchPIX* can process up to 255 images at a rate of about three images per minute.

USING A CCD: TIME-SEQUENCE IMAGING

The CCD makes recording and replaying a time sequence of images quite easy. The time span may be minutes, days, or months, depending on what is to be shown. For example, sequences may show Jupiter's rotation over a few hours, or the evolution of cloud features on Mars, Saturn, or Jupiter over days, weeks, or months. [Over long time periods, the images will need to be consistently scaled to compensate for the changing apparent size of the planet. Ed.] We use *BatchPIX* to process the images in a sequence. After a sequence of frames has been processed, the program displays the "movie" at several frames per second.

Our best sequence to date shows Jupiter's rotation over a 45-minute span. There are 16 frames in the series; and, during the sequence, Io and its shadow move across the disk. Another series of four images is shown in *Figure 2* (p. 4); low-contrast clouds rotating with Saturn. The 1991-1992 Apparition of Jupiter is presenting an excellent opportunity for Northern-Hemisphere observers to record Jupiter for one full rotation; and the coming apparition of Mars could yield "movies" showing different central meridians over three weeks of observation. This form of imaging would be ideal for following the progress of Martian dust clouds over a period of days.

Time-sequence imaging is an excellent teaching tool. For example, one can readily detect the differences in the planet's rotation between System I and System II. Sequences taken over longer time periods may prove useful in detecting countercurrents in Jupiter's atmosphere, motions of the Red Spot, and progressions of atmospheric disturbances.

Some form of sequential imaging should be done routinely for Mars, Jupiter, and Saturn. These planets rotate rapidly enough to allow us to detect the motion of surface or atmospheric features after only a few minutes. Images taken 20 to 30 minutes apart are useful because they allow the observer to determine whether a given feature is real or an artifact.

To get the most pleasing results from serial imaging, take care that each image has the same orientation. Doing so is fairly simple with Jupiter and Saturn; but if Mars is imaged over a period of weeks, one should rotate the image to compensate for changes in the position angle of the planet's axis. Changes will also occur in Mars' apparent diameter, phase, and subearth point, but these can produce a pleasing "space travel" effect as well as provide a teaching aid.

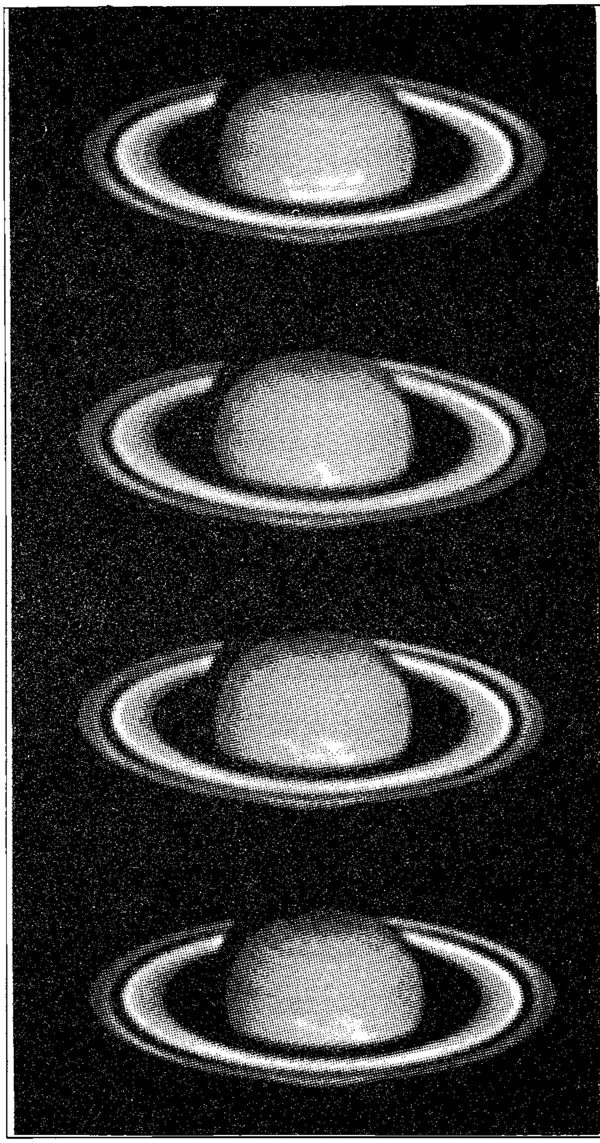

Figure 2. Sequence of four CCD images of Saturn taken over a 55-minute period on 1991 SEP 29 UT, showing the rotation of Equatorial Zone (EZ) bright spots. 1.30-second exposures at f/27 with a 41-cm (16-in) Newtonian, and a SpectraSource Lynxx cooled CCD camera, flatfield corrected with Imagepro software. Seeing 6-8 on the A.L.P.O. scale of 0 (worst) to 10 (perfect); Transparency (limiting magnitude) +4.0. Taken in integrated light (no filter); north at the top, and west is to the left, in all views.

From top to bottom:

00h26m UT. Note the two bright spots in the EZ west (left) of the CM (central Meridian) and streaks running eastward from the spots. NEB (North Equatorial Belt) very faint and diffuse; the NNTB (North North Temperate Belt) is prominent. CM(I) = 012°, CM(II) = 123°.

01h02m UT. Note that the two bright spots in the EZ have now crossed the CM. There is a diffuse light streak west of the CM as well as dark spots in the NEB. CM(I) = 033°, CM(II) = 144°.

01h18m UT. The bright spots and streaks in the EZ continue to rotate with the planet. CM(I) = 042°, CM(II) = 153°.

01h21m UT. The bright spots and streaks in the EZ are prominent and continue to rotate with the planet. Note the light north polar spot. CM(I) = 044°, CM(II) = 154°.

USING A CCD: COLOR FILTERS

Color filters, used visually or photographically, are indispensable tools for planetary astronomers. They improve contrast, reduce irradiation and atmospheric dispersion, and may even combat image distortion due to poor seeing.

Another most important function of filters is to provide information about planetary atmospheres. For example, when Venus is photographed through an ultraviolet filter, dark bands and other features can be detected, as is shown in the CCD image in *Figure 3* (p. 5). If Mars is viewed or photographed through a dark-blue filter, clouds, polar hoods, limb hazes, and other atmospheric phenomena become conspicuous. One of the key programs of the A.L.P.O. Mars Section is the long-term study of Martian meteorology based on visual and photographic dark-blue-light observations [Beish and Parker, 1990].

Color-filter photography of the planets has always been difficult, owing to light absorption by the filters and the resulting increase in exposure times. Parker has been doing filter photography of Mars and Jupiter for many years with Kodak Technical Pan 2415 Film and its precursors. He has found that even the lightest filters require nearly doubling exposures; while dark-blue and ultraviolet filters demand inordinately long exposures of 20 to 30 seconds. We have developed techniques for obtaining dark-blue-light information from color slides [Parker *et al.*, 1986], but considerable darkroom work is necessary. Clearly, a more efficient method is needed, and we hope that CCD's will provide that method.

While the amounts of light lost through filters are no less with CCD cameras than with conventional film, the smaller images required

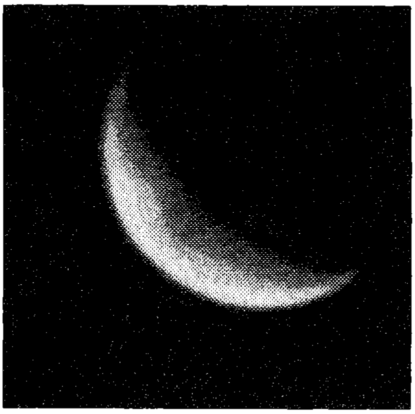

Figure 3. CCD image of Venus in ultraviolet light, using UG-1 and infrared-absorbing filters to show dark markings. Acquired on 1991 Oct 07, 10h02m UT by Donald C. Parker with a 41-cm (16-in) Newtonian at an effective f/27. 20-sec. exposure on a SpectraSource Lynxx cooled CCD camera. Transparency +3.5 (limiting magnitude), Seeing 6 (0-10 scale). North at top. Apparent diameter of Venus 33.5 arc-seconds. Phase coefficient = 0.342.

with CCDs mean lower EFLs and therefore lower EFRs, with much shorter exposure times. Since May, 1991, Parker has taken numerous red (Wratten 25), green (W58), and dark-blue (W47) images of Saturn. An infrared rejection filter was also used, causing an additional 10-percent loss of light. At f/27, exposure times were 8 seconds with the W25 filter, 11 seconds with the W58, and 30 seconds with the W47. While these exposures were long, especially for the dark-blue, filter imaging was virtually impossible with conventional photography; where, for example, the W47 dark-blue filter would have demanded a 2- to 3-minute exposure! Because the surface brightness of Mars is seven times that of Saturn, dark-blue-light images require only 10-second exposures at f/47. The Mars Recorders find this an exciting prospect, for it means that good atmospheric data should be obtainable for the aphelic (but meteorologically active) Mars apparitions of the 1990s.

Using a CCD: Tricolor Imaging

Visual and photographic color-filter observations are the most accurate methods for determining the true colors of planetary features. However, visual color perceptions vary tremendously among individuals; and, as mentioned previously, color films are unreliable indicators of true colors. Visual intensity estimation of planetary features through various filters is a time-honored method for quantifying colors. This is carried one step further by taking black-and-white photographs of a planet through different filters and then comparing the intensities of areas of interest. Also, greater accuracy can be realized if the photographs are measured with a densitometer.

To actually see accurate color rendition, however, a technique called tricolor separation should be used. Here, the subject is photographed three times onto separate black-and-white film frames through red, green, and blue filters. Each negative is then printed through a filter of the same color onto a single sheet of color positive print paper. If the film-filter combinations have been properly calibrated, the resulting color-composite print will portray the true colors of the object. This method can produce spectacular color photographs; but it requires meticulous attention to detail, precise registration, and a grasp of sensitometry if the results are to be quantitatively accurate. Excellent discussions of this technique can be found in Wallis and Provin (1988) and in Malin (1990).

Producing planetary images with tricolor separation on any regular basis is simply too complex, expensive, and time-consuming for most amateurs. Now, however, tricolor imaging can be done quickly and accurately with a CCD camera and red, green, and blue filters. We have composited tricolor images using a program called *ColorPIX* [Berry, 1991c]. This program allows the user to load three images that were taken in different colors, shift them with respect to each other, adjust the color balance of the composite image, and save the image as a 24-bit TIFF-format file for export to desktop publishing software. For examples of such pictures, see Berry (1992). [*TIFF* stands for "Tagged Image File Format," a widely-used file format for exchanging gray-scale and color images between programs. Ed.]

Although commercially available software, such as Adobe Photoshop for the Macintosh and Aldus PhotoStyler for the PC, can also make color composites, these programs were not designed for color compositing; and obtaining proper image registration is difficult.

We have used the standard tricolor Kodak Wratten filters, W25, W58, and W47, with success. [Note that these three filters represent the additive primary colors and thus their images can be combined to create true-color composites. Ed.] These have proven to be quite satisfactory for those Solar-System objects that have continuous spectra. For comets, however, these filters may have too little spectral overlap to permit imaging some emission bands, such as the 516nm Swan Band or the sodium D lines at 589.0 and 589.6nm. For comets and for deep-sky emission nebulae, the broad-band red (W23A) and green (W57A) filters could be used with the W47.

Because Mars, Jupiter, and Saturn rotate rapidly, tricolor images must be taken quickly. As a rule of thumb, Mars tricolor images should be taken over an interval no longer than 5 minutes; while for Jupiter and Saturn the interval should not exceed 2 minutes.

How to Obtain Good CCD Images

As with any technique, taking CCD images requires finesse on the part of the observer. We have overcome most of the problems that we have encountered, but not without some frustration. To help others who may follow the same path, here are some tips on making CCD images.

Use a high-power finder and reflex viewer. The small size of the CCD detector produces a high apparent magnification and, unfortunately, a field of view of the order of 1 arc-minute in diameter. This often presents difficulties in finding and centering the image. This chore can be eased if a small auxiliary telescope is employed. If eyepiece projection is used, a Parker Seeing Monitor [Parker, 1980] can provide accurate centering.

Put good right-ascension and declination drives on your telescope. Because it is difficult to get your target into the frame, you don't want to lose it again. Both drives should be smooth and have fine controls, and the right-ascension drive have minimal periodic error. [Excellent polar alignment is also necessary.]

Image with an effective focal ratio between f/20 and f/40. To capture all the information present in an image, the image should be matched to the detector so that there are two samples (pixels) per resolution element [Schroeder, 1987]. If you take the central region of the Airy disk as the resolution element, then the TC-211 chip requires a focal ratio between f/20 and f/40 [Berry, 1991e]. Use eyepiece projection to attain this focal ratio.

Expose your images fully. The big advantage of the CCD camera is that exposure times are drastically reduced; not because of the chip's inherent speed (it is in fact rather slow), but because of the relatively low focal ratios that can be employed. For CCDs, the *unfiltered* exposure time in seconds, E, may be calculated from the relation [Berry, 1991d]:

$$E = (P/P_{max}) \times (F^2)/(S \times B),$$

where **P** is the pixel value of the most significant part of the image and $\mathbf{P_{max}}$ is the maximum pixel value for the camera (4095 for the Lynxx). **F** is the effective focal ratio, **S** is the camera's speed (80 for the Lynxx camera), and **B** is the relative surface brightness of the object. [Approximate **B**-values for the Moon and bright planets are given in several references about astrophotography, such as Covington (1985). Ed.] You should normally expose so that **P** is about 80 percent of the value of $\mathbf{P_{max}}$, or about 3280. Thus, for imaging Jupiter (**B** = 30) with a telescope using eyepiece projection at f/27:

$$E = (3280/4095) \times (27 \times 27)/(80 \times 30).$$

In this example, the exposure would be 0.24 seconds. To show that this is a reasonable value, *Figure 4* (below) shows a CCD image of Jupiter taken at f/27 with a 0.28-second exposure. With filters, of course, the exposures will be longer.

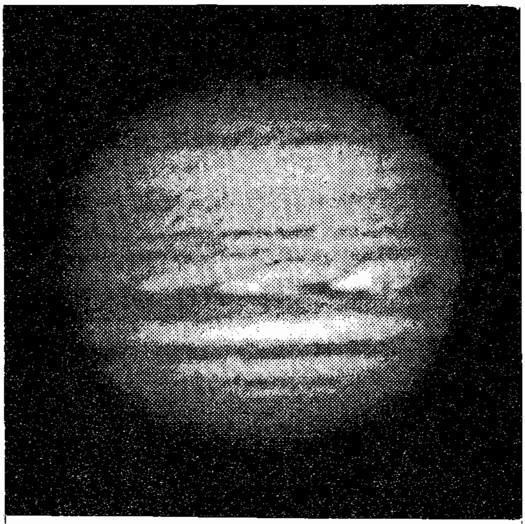

Figure 4. CCD image of Jupiter in integrated light by Donald C. Parker on 1991 Oct 07, 11h00m42s UT. 41-cm Newtonian at effective f/27. 0.28-sec. exposure on SpectraSource Lynxx cooled CCD camera. Transparency +4 (limiting magnitude), seeing 6-7 (0-10 scale). Taken in morning twilight. Apparent diameter 32.2 arc-seconds. Central Meridians: CM(I) = 260°.3; CM(II) = 148°.1. North at top, celestial west at right.

Mark the focus position of your focuser. Focusing a CCD camera is a challenge. If the eyepiece that you are using for eyepiece projection is more than a few millimeters from the focal plane, the image may not even be visible on the focusing monitor. When you first use a particular projection arrangement, focus on a bright object like the Moon and then measure or mark the position of focus. Then, the next time that you use the same projection system, the focus will be close enough to get an image on the first try.

Use an electric focuser. Hands-off focusing from a distance is a big help because touching the focusing knob shakes the telescope. In addition, with planetary projection photography it is usually necessary to focus frequently, and there is less reluctance to focus often if an electric focuser is used.

Use an infrared-blocking filter for color imaging. Most blue, violet, and ultraviolet filters pass large amounts of infrared light [Kodak, 1985], to which most CCD chips are sensitive. To plug this "red leak," Parker uses an NR-400 infrared-blocking filter from the Corion Corporation [Corion, 1991]. Light transmission with the NR-400 is nearly 90 percent in the visual wavelengths; but because it blocks the infrared, using it means a significant increase in exposure times. When Parker tried to take a violet-light image of Mars to search for orographic clouds without an infrared-blocking filter, he obtained a fine infrared image with considerable surface detail but no clouds!

Flat-field your images. Flat-fielding is one of several techniques peculiar to electronic imaging. A flat-field is similar to a control in scientific experiments and is nothing more than an image of an evenly-lighted blank area, such as cloud, twilight sky, or an illuminated target in the observatory. Parker employs a light box that fits over the end of the telescope. Light from a 100-watt tungsten lamp passes through diffusion screens to the telescope. This device weighs very little, and can be placed on the telescope while it remains pointed toward the object being imaged when the flat-field frames are obtained.

A proper flat-field image should be an average of at least 10 individual flat-field exposures. (*BatchPIX* includes a frame-averaging utility.) By averaging so many frames, thermal and amplifier noise in the flat-field frame will not appreciably increase the noise in the final image. Proper flat-fields should be obtained for each change in filter, ocular, or focus. By dividing the astronomical image by the flat field, bad pixels, dust spots, and other imperfections are removed.

Shoot dark-current frames for long exposures. When exposure times exceed 30 seconds, it is advisable to capture a thermal (or "dark current") data frame and subtract it from the desired images. Dark current produces background noise that results from heat in the CCD camera generating electrons. Cooling the CCD reduces dark current. Exposing a frame with the camera's shutter closed, and at the same exposure time and temperature as the normal image frames, will produce an image that contains noise only. Because each pixel in the array generates dark-current electrons at its own rate, the noise will have approximately the same pattern as that on the astronomical images, and subtracting the dark-current frame will clean up the image considerably.

Avoid image rotation. For tricolor or any other work that will involve compositing images, prevent camera rotation. Although it is possible to rotate images in software, this may cause loss of detail. Make sure that the camera is not rotated during flat-fielding or imaging.

One final note: Don't confuse the two categories of CCD imaging—video and still. Although CCDs are now used in most video cameras and camcorders, the chip's output is treated as an analog signal, unlike the digital signal of the CCD still camera. While video imaging has proven to be an excellent adjunct to visual planetary observation [Troiani and Joyce, 1990], it is the CCD still camera that permits a wide range of image manipulations and which is the type discussed here. The video camera is able to store the brightness of a pixel with a precision of only 1 part in 20 or 1 part in 30 at best. The CCD still camera is very different; the image is digitized and stored with an accuracy of 1 part in 4096. What differentiates digital CCD cameras from analog CCD cameras and camcorders is the high photometric precision of the former.

PRINTING, SHARING, AND ARCHIVING CCD IMAGES

Preliminary work by the authors on Jupiter, Saturn, the Moon, and Venus has produced images that contain details that were at the very limit of visual observation. Sharing these data with others usually requires producing some form of "hardcopy" or printed output. There are three basic methods of producing hard copy: by photography, by laser printing, and by continuous-tone printer.

Simply photographing the computer screen and making slides or prints yields quick copies. However, photography cannot reproduce the full tonal range of a normal computer monitor unless care is taken to shorten the tonal scale by "squeezing" it or by processing the displayed image so that no significant detail is too bright or too dark to show properly on the photograph. Black-and-white slides and prints cost roughly 30 cents per image.

Printing images with a laser printer is initially more expensive than simple photography. The current selection of CCD software reproduces the CCD tonal range on the printer by drawing black dots that are inversely proportional to the brightness of each pixel. If the dots are as large as 32 to the inch, however, the image has a coarse pattern that is distracting when it is viewed at close range. Only by holding a laser-printed page at arm's length can this pattern be minimized.

Another approach to laser printing can be used if an image can be imported into desktop-publishing software, such as Quark XPress or Ventura Publisher, and printed as a halftone. Halftone images are composed of dots that are small enough that they are not distracting at ordinary viewing distances. Most 300 dpi [dots per inch] laser printers produce 53 halftone dots per inch, which is fine enough to be acceptable to most people. Whether it is used for large-dot or small-dot printing, a laster printer represents an investment of $1000 or more and an operating cost of roughly 6 cents per page.

It is also possible to print a CCD image on phototypesetting equipment, such as the Linotronic 300 or Imagesetter, that can produce halftones with 150 or more halftone dots per inch. These halftones look much like photographic prints. At present, however, typesetter output costs as much as $10 per page. Several images can be printed on each page.

A nearly-ideal solution is to buy a continuous-tone or gray-scale printer. These devices produce a full range of gray tones in a small format (typically 4 inches wide); but they require special paper, at a cost of about $1 per print. Sony retails such a printer for approximately $1500.

Persons new to CCD imaging sometimes complain that CCD images "don't look natural." This is probably because most people are familiar with the characteristically limited tonal range of photography or are disturbed by dot or halftone patterns. Furthermore, because image processing can remove Jupiter's limb darkening or show the polar caps of Mars without gross overexposure, the images may actually be "unnatural." However, the data present in an original CCD image is a more faithful record of nature than a photographic negative or slide, and the user has complete control over how a CCD image is displayed.

It is just as important to archive original CCD observations as it is to store original photographic negatives and slides. Original images, flat frames, and processed images should be archived so that, when the original record is needed, it can be retrieved. Images may be stored on 1.44-megabyte high-density floppy disks which, at today's prices, cost only about 6 cents per image.

CCD Imaging Today

CCD cameras are a relatively new technology and as such are still rather expensive. The price of a good-quality CCD camera is over $1300 and is likely to remain so for several more years. Operating a CCD camera also requires a computer. The minimum MS-DOS computer that we consider effective for CCD imaging is an 80286-based PC-AT with 2 megabytes of RAM, a 40-megabyte hard disk drive, and a VGA monitor. This costs about $2000 currently. An 80386/80387 computer with 4 megabytes of RAM and a 130-megabyte hard drive would be able to store more images and would work at a faster speed, but of course the initial cost would be higher.

The cost of the CCD imaging system is balanced by its ability to rival or even exceed the human eye in the detection of lunar and planetary detail. Our experience strongly suggests that a CCD camera on a 41-cm (16-in) telescope allows the observer to detect smaller features and lower-contrast detail than by visual observation with the same instrument. Furthermore, the CCD makes possible planetary observations in the deep violet and the near infrared, and greatly enhances color-filter observations in the visible wavelengths.

Image processing permits the observer to accentuate low-contrast detail and to sharpen soft-edged features. In just a few minutes, one can replicate hours of demanding darkroom work and batch-process an evening's hundreds of planetary images on a routine basis.

To validate observations of very subtle planetary detail, it is possible to make computer movies that show low-contrast features rotating with the planet. Although some features may not be readily apparent on a single frame, their frame-to-frame persistence argues for their reality. Furthermore, color-filter images can be combined to produce true-color images, enhanced true-color images, or false-color images. Used appropriately, these techniques show planetary features more clearly.

These are exciting times for today's Solar-System astronomers. New technologies have opened marvelous vistas to them and have provided them with new challenges. If they respond with honesty and intelligence, the sky's the limit!

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THE DENSITY OF MARTIAN CRATERS AS A FUNCTION OF ELEVATION AND ITS APPLICATION TO THE IDENTIFICATION OF ANCIENT SEA BEDS

By: Tyson York Winarski

ABSTRACT

This study uses a global mapping of the density of Martian impact craters as a function of the surface elevation in order to trace the outlines of ancient seas on that planet.

INTRODUCTION

The distribution of impact craters, which occur almost everywhere on the Martian surface, is significant because the proportion of areas that are covered by craters gives an indication of the the relative ages of different parts of the surface. The density of impact craters also records the effects of processes that have modified the surface. Even a cursory visual assessment of the density of impact craters shows that it varies considerably from the heavily cratered Southern Hemisphere to sparsely cratered regions such as the lowlands of the Northern Hemisphere and the remnant polar caps.

With the Mariner 9 and Viking 1 and 2 missions, the search for Martian water has focused considerably upon interesting Martian surface features such as channels and stream beds. However, additional proof of past hydrological activity lies in the variation of the density of impact craters with elevation. This study is the first effort to quantify the distribution of impact craters as a function of the elevation of the local surface of Mars. [Martian elevations are relative to an arbitrary datum, there being no *present* sea level to refer to. Their values are only approximate and are based on earthbased radar and spacecraft atmospheric absorption measurements. Ed.]

MEASURING CRATER DENSITY

Crater density is here defined as the nondimensional ratio of the total area of all impact craters larger than 4 km in diameter to the total area being analyzed. The diameter of each impact crater in km, **D**, was carefully measured with calipers using the map by Batson *et al.* The primary form of crater density analysis was the calculation of the incremental crater density, ρ, as a function of elevation, using the following formula:

$$\rho_{i.5} = (\pi/4) \sum D^2/A_{i,i+1}\,, \qquad [1]$$

where the subscript **i.5** indicates the density at an elevation of i + 0.5 km and $A_{i,i+1}$ is the area between two successive contour lines at elevations **i** and **i+1** km, the summation limits. Thus the density at elevation 2.5 km applies to the elevation range from 2.0 to 3.0 km.

An incremental analysis was chosen over a cumulative one because the former method better displays differences in crater density between different elevations. Because unit-km increases in elevation were used, the crater density determined by equation [1] is termed arithmetic incremental, as opposed to geometric incremental.

For regions containing major volcanoes, and for both remnant polar caps, when crater density did not vary with elevation, a generalized form of equation [1] was used:

$$\rho_j = (\pi/4) \sum D^2/A_j\,, \qquad [2]$$

where **j** refers to a particular region.

ANALYSIS OF CRATER DENSITIES IN THE NORTHERN HEMISPHERE

The influence that elevation has on mean incremental crater density in the Northern Hemisphere of Mars is seen in *Figure 5* (p. 10). There is a change in the slope of the crater-density function at the -0.5 km elevation level. This change in slope is interpreted as indicating the presence of a vast ancient sea with its shore coinciding with the present -0.5 km contour line. The outline of this ancient sea in the Northern Hemisphere is shown in *Figure 6* (p. 11).

This ancient sea had a maximum depth of approximately 2.5 km. The depth of this sea offered some protection for its bed against cratering from small meteoroids. It also eroded or buried, by sedimentation, large impact craters which might have been formed before or during the sea's existence.

Above -0.5 km elevation, *Figure 5* shows that crater density is a continuous function of elevation. This is the result of a process called *gradation*; the steady reduction of surface relief by the erosion and transport of material from high to low areas.

ANALYSIS OF CRATER DENSITIES IN THE SOUTHERN HEMISPHERE

The influence that elevation has on mean incremental crater density in the Southern Hemisphere of Mars is also shown in *Figure 5*. At an elevation of -1.5 km there is a change in the slope of the crater density function for the Southern Hemisphere. This change indi-

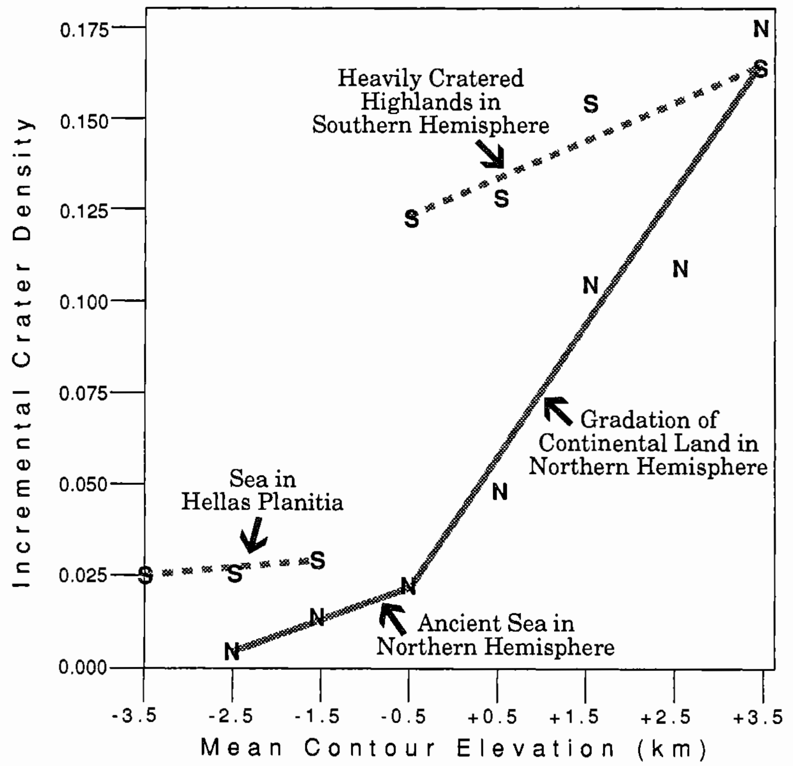

Figure 5. Incremental density of Martian impact craters with diameters 4 km or larger (vertical axis) as a function of the mean surface elevation [horizontal axis], where **N** refers to the Northern Hemisphere and **S** to the Southern Hemisphere.

cates that Hellas Planitia once held an ancient sea which was cut off from the vast ancient sea of the Northern Hemisphere that is shown on *Figure 6*.

Several valleys drain into Hellas Planitia, consisting of Dao, Harmakhis, Reull, and Axius. The watershed area that these define provides more evidence that Hellas Planitia was an inland sea. Through hydrological gradation, craters in the basin of Hellas Planitia were infilled and buried. The maximum depth of this inland sea was 2.5 km, estimated from the difference between its deepest point of -4.0 km and its shoreline at -1.5 km.

Another exception to the densely cratered highlands in the Southern Hemisphere is Valles Marineris. Liquid water from Valles Marineris flowed from the Southern Hemisphere into the Northern Hemisphere and the vast ancient sea that it held. Liquid water from Juventae Chasma and Echus Chasma in the Southern Hemisphere flowed to the Northern Hemisphere through Maja Vallis and Kasei Vallis, respectively. Similarly, liquid water flowed from the Southern Hemisphere to the Northern Hemisphere through Al-Qahira Vallis and Ma'adim Vallis.

The effect of this extensive drainage to the north was greater gradation of the surface of the Northern Hemisphere, as can be seen by the steeper slope of the Northern-Hemisphere line in *Figure 5*. The crater density of the Northern Hemisphere above -0.5 km in elevation increases linearly with elevation. In contrast, the crater density in the Southern Hemisphere above -1.5 km elevation jumps with a distinct discontinuity.

Origin and Extinction of the Ancient Seas

The water that once carved massive channels on the surface of Mars and which smoothed the primordial craters in the lowlands may have come from the melting of glaciers and subsurface permafrost. These glaciers and permafrost could have been melted by solar heat trapped in the Martian atmosphere by the "greenhouse gas," carbon dioxide. Mars on the average receives 44 per cent of the intensity of solar radiation that the Earth does, so that the need for a greenhouse gas such as carbon dioxide in providing extra warmth and density to the Martian atmosphere appears to be plausible. Even today, the thin Martian atmosphere contains 95.32 percent carbon dioxide [Carr, p. 189].

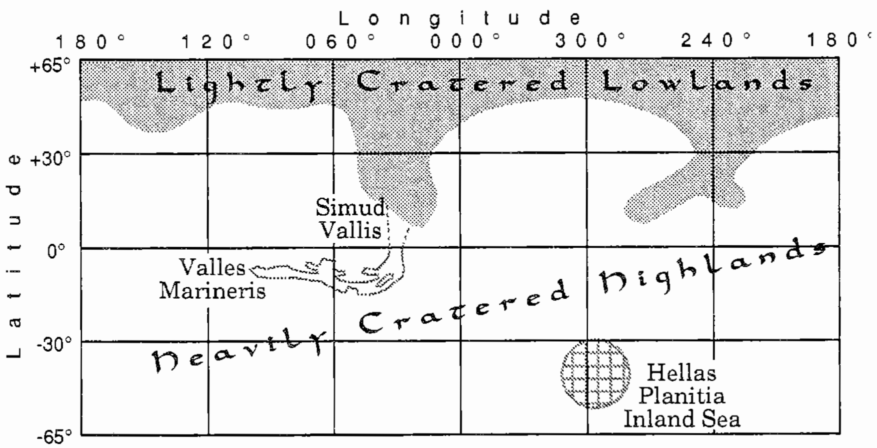

Figure 6. Cylindrical-projection map of Mars showing the differentiation between the heavily cratered highlands of the Southern Hemisphere (white) and the lightly cratered lowlands of the Northern Hemisphere (dark); the latter are inferred to represent the extent of an ancient Sea, which included the areas northwards of latitude +65°. Hellas Planitia (crosshatch) represents another ancient sea.

The source of this carbon dioxide could have been Martian volcanoes. To determine whether there is a relationship between volcanic and hydrologic activity on Mars, the regional crater density for major Martian volcanoes was calculated. This regional crater density, 0.009, is of the same order of magnitude as the mean crater density shown in *Figure 5* for elevations of -1.5 km or less. This indicates that the ancient seas and the major volcanoes existed at about the same time in the history of Mars. The similarity in crater density between the lowlands and the volcanic regions supports the hypothesis that the existence of liquid water on the surface of Mars was made possible by the volcanic emission of carbon dioxide.

A crater density of 0.0011 was measured for the remnant ice cap at the north pole of Mars. The South Polar Cap is similarly lightly cratered with a density of 0.0008. These densities, lower than any in *Figure 5*, indicate that the remnant Martian polar caps are two of the youngest surfaces on the planet.

Regardless of the actual origins of the ancient seas, they have since disappeared. Measurements by the Viking orbiter spacecraft of oxygen ions moving away from the planet, coupled with Mariner 9 observations of hydrogen escaping from the planet's upper atmosphere, give evidence that Mars has been losing the basic ingredients for water for billions of years (Ezell and Ezell, p. 376). Thus, the water which resulted in a widespread smoothing of the lowlands has mostly escaped into outer space, leaving Mars a desert-like planet. Only a small fraction of the total water outgassed over geologic times is represented by that currently in the atmosphere or at the poles [Carr, p. 189].

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The above article is a condensed version of the paper, "Martian Hydrological and Geological Activity," which was submitted to the Southern Arizona Regional Science and Engineering Fair, where it placed first overall in the earth-science category. The condensed version here was entered in the 50th Annual Westinghouse Science Talent Search, where Mr. Winarski achieved Semifinalist status.

JUPITER UPDATE

By: José Olivarez and Phillip W. Budine, A.L.P.O. Jupiter Recorders, and Isao Miyazaki

I. NOVEMBER-DECEMBER, 1991

(Prepared January 10, 1992)

LONGITUDES OF MAJOR FEATURES (AS OF 1991 NOV 30)

•The Great Red Spot's (GRS) center was at System II longitude 029°.

•The System II longitudes of the long-enduring STB (South Temperate Belt) White Oval Spots were: **BC** = 205°, **DE** = 231°, and **FA** = 322°.

•The System I longitudes of the NEBs-EZn (North Equatorial Belt Southern Component - Equatorial Zone Northern Component) dark projections ("Olivarez Blue Features") were (the numbers in parentheses represent the years the features were first recorded):

OL-1 (83) = 061°	**OL-23 (89)** = 096°
OL-1 (89) = 186°	**OL-4 (86)** = 244°
OL-5 (88) = 321°	**OL-8 (90)** = 000°

•The longitudes of other transit features that were being followed were:

STB Feature, Dark (Center) No. 1 = 338° (System II)

NEBs-EZn Features (System II):

White (Center) No. 1 = 070°
Dark (Center) No. 2 = 077°
Dark (Center) No. 3 = 147°

[System I rotates 877°.90 per day and applies to the EZ, south edge of the NEB, north edge of the SEB (South Equatorial Belt), and the southern edge of the NTB (North Temperate Belt); System II rotates 870°.27 per day and applies to the remainder of the disk. Ed.]

REMARKS ON JOVIAN FEATURES AND GENERAL ACTIVITY (AS OF 1991 DEC 07)

•A map of the general appearance of the planet for 1991 DEC 04-07, prepared by Isao Miyazaki appears in *Figure 7* (right).

•The North Tropical Zone (NTrZ) was the brightest zone on the planet.

•The activity in the SEB had subsided, and the belt had divided into a southern and a northern component. The SEB Z (South Equatorial Belt Zone) was dusky and featureless.

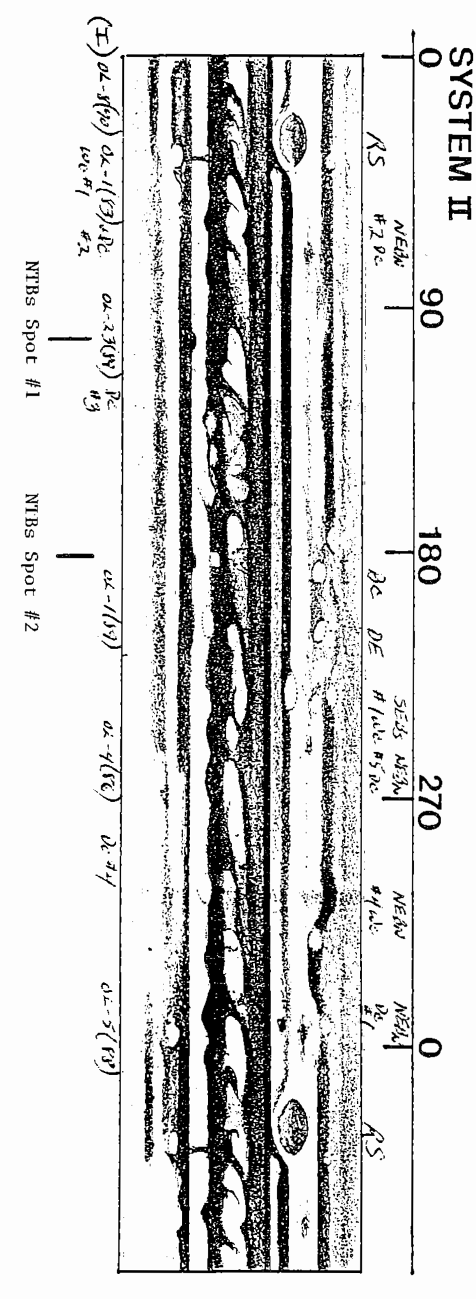

Figure 7. Sketch map of Jupiter prepared for 1991 DEC 04-07 by Isao Miyazaki, using a 41-cm (16-in) reflector. Marginal identifications by Phillip W. Budine. South is to the right; rotate this page 90° counterclockwise to see the normal inverted view.

•According to Miyazaki, a white spot which formed a bay on the SEBs was outstanding and appears to have persisted since 1987. As of 1991 DEC 04, its System II longitude was 232°.1, and its latitude was 20°.8 south.

•The SEBs was uneven in intensity, becoming darker from System II longitude 232° towards the Great Red Spot.

•The Great Red Spot was faint, with its northern half more so. The latitude of the GRS during November was 23° south. The System II longitude of the GRS decreased during the period near solar conjunction in 1991.

•After being difficult to see for some time, White Oval Spot **FA** was clearly visible. However, **BC** and **DE** were again difficult to see because of the missing STB.

•The SSTB (South South Temperate Belt) exhibited a 25°-long very dark segment preceding **FA**.

•The southern half of the EZ was strongly shaded, although the shading appeared to have lost much of its orange color.

•Overall, the NTB continued to be dark.

CONTRIBUTING OBSERVERS

This report is based largely on contributions by Isao Miyazaki and Phillip Budine. Other observers who contributed to this report were Benninghoven, MacDougal, Olivarez, and Whitby.

II. JANUARY, 1992

(Prepared January 22, 1992)

The visibility of the NTBs Dark Spots described in the letter by Isao Miyazaki below may require large apertures, very good seeing, or high-resolution photography for their detection. However, you may be able to see them as *lumps* on the south edge of the NTB.

(text continued on p. 14)

12 January 1992

Dear Jose,

In this apparition three small dark spots (or projections) are visible on the NTeBs. I found that they are moving rapidly with the NTBs jetstream at -9° – -10° per day in System II which corresponds to a rotation period of 9h 49m. They resemble a dark spot which was observed by E.J. Reese and B.A. Smith in 1964/65 (*Icarus 5*, 248-257 [1966]).

My first observation of them was on 18 Nov 1991 (JBW013-92), and they were still discernible last night. Longitudes and latitudes are as follows:

	longitude λ_1	longitude λ_2	zenographic latitude	Photo. no.
NTBs dark spot No. 1				
1 Dec 1991 21:26 UT	326°.5	151°.3	23°.9	JBW021-92
6 Dec 1991 19:32	315°.7	103°.0	23°.5	028-92
NTBs dark spot No. 2				
18 Nov 1991 21:15 UT	77°.5	1°.2	24°.3	JBW013-92
4 Dec 1991 21:16.5	39°.1	201°.1	24°.1	022-92
6 Dec 1991 21:29	41°.8	188°.6	23°.2	033-92
NTBs dark spot No. 3				
18 Nov 1991 21:15 UT	98°.0	21°.7	24°.5	JBW013-92
4 Dec 1991 21:16.5	60°.2	222°.2	24°.0	022-92
6 Dec 1991 21:29	62°.1	208°.9	23°.1	033-92

Please track them!

Sincerely yours,

Isao Miyazaki

III. December, 1991 Synopsis
(Prepared February 5, 1992)

This synopsis is based on observations by Budine, Miyazaki, Whitby, and Parker as of December 31, 1991.

•As of 1991 DEC 31, the center of the **Great Red Spot** was at System II longitude 031°.

•The System II longitudes of the long-enduring STB Ovals as of 1991 DEC 31 were: **BC** = 160°, **DE** = 203°, and **FA** = 311°.

•The System I longitudes of the NEBs-EZn dark projections ("Olivarez Blue Features") as of 1991 DEC 31 were :

OL-1 (83) = 060°	**OL-23 (89)** = 095°
OL-1 (89) = 185°	**OL-4 (86)** = 243°
OL-5 (88) = 320°	**OL-8 (90)** = 010°

A **plume** extending from OL-1 (83) (WcNo. 1) was centered at System I longitude 069°.

•**Other central-meridian transit features** being followed by the A.L.P.O. Jupiter Section had the following longitudes as of 1991 DEC 31:

SSTB/SSTeZ (all System II):

White Oval Center No. 1 = 350°
White Oval Center No. 2 = 035°
White Oval Center No. 3 = 245°
White Oval Center No. 4 = 280°
White Oval Center No. 5 = 305°

NTBs Dark Spots No. 1-No. 3 (see p. 13) are rotating with a period of 09h 49m! The **NTBs Dark Spot No. 4** is rotating at 09h 48m 49s!

•On 1991 DEC 10, Donald C. Parker obtained two high-resolution colored CCD images of Jupiter, which are reproduced in black and white on the front cover of this issue.

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If our readers approve, these "Jupiter Updates" will become a semi-regular feature of this magazine. Their purpose is to inform Jupiter observers of recent developments while they are still observable, and do not replace the less-frequent apparition reports.Please send your current Jupiter observations to Recorder Olivarez (address on inside back cover) so that they can be included in upcoming reports. Ed.

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A Challenging Occultation of Mercury by the Moon, 1992 Jun 01

Our Eclipses Recorder, Mr. Francis G. Graham (address on inside back cover), has called our attention to an unusual occultation of Mercury by the Moon, which will occur at about 05h UT, 1992 JUN 01. This event is unusual in that the planet will be only about 58 arc-minutes from the center of the Sun. Thus, accurate timing of this event can demonstrate Einstein's Theory of General Relativity, which predicts that light from the planet, near superior conjunction, should be displaced about 0.48 arc-seconds from its "normal" position due to gravitational deflection by the Sun. However, the Moon will be between us and the Sun so its position is not subject to this effect. The shift of Mercury's position with respect to the Moon should affect the time of the occultation by the order of a second or more; time the event to at least 0.1-second precision.

On the other hand, this will be a very challenging event to observe because Mercury is so near the Sun. At the time, Mercury's magnitude will be approximately -2.25, with a fully-illuminated disk only 5.1 arc-seconds in diameter. The Moon itself will be totally invisible. In order to find Mercury, it is likely that a coronagraph will be necessary, which is a highly-baffled telescope designed to study the Sun's corona. With a coronagraph, Mercury has been seen and even photographed when only 28 arc-minutes from the Sun's center (G. Ratier, "Observation de Mercure au Voisinage de la Phase Nulle," *Icarus*, Vol. 10 [1972], pp. 318-320). **Even with a coronagraph, use special care to avoid exposing your eyes, or any other detection equipment, to full sunlight.**

The occultation will be visible low in the sky, and then only from the northern portions of Europe, Asia, and North America, as diagramed on p. D-8 of the *A.L.P.O. Solar System Ephemeris: 1992.* (See also Mr. Graham's article, "Moon to Occult Mercury in a Demonstration of relativity," in *Selenology*, Vol. 10, No. 3 [Dec., 1991], pp. 23-24.) Some *approximate* data on this occultation for selected stations are given in *Table 1*, below.

Table 1. Approximate Times and Altitudes: Lunar Occultation of Mercury,1992 JUN 01.

Location	Ingress UT	Ingress Alt.	Egress UT	Egress Alt.
	h	°	h	°
Paris, France	03.9	+0.2	04.6	+5.2
Berlin, Germany	04.0	+8.2	04.5	+12.8
London, England	04.0	+0.8	04.7	+6.1
Edinburgh, Scotland	04.1	+2.7	04.8	+8.1
Oslo, Norway	04.1	+11.2	04.9	+16.7
Stockholm, Sweden	04.1	+14.3	04.8	+19.4
St. Petersburg, Russia	04.2	+21.0	04.7	+25.2
Hammerfest, Norway	04.4	+21.2	05.2	+25.6
Reykjavik, Iceland	04.4	+3.4	05.2	+7.5
Longyearbyen, Spitzbergen	04.6	+21.2	05.6	+24.2
Fairbanks, Alaska	05.7	+9.8	06.6	+5.5
Anchorage, Alaska	05.8	+7.7	06.7	+3.1

A New Volunteer Program to Help Train Novice and Intermediate Observers

By: Harry D. Jamieson, A.L.P.O. Membership Secretary

The A.L.P.O. has long had a need to provide training for the many new members who join our organization each year. In the mid-1960's Clark R. Chapman founded our original Lunar and Planetary Training Program, which was then and is still intended to provide instruction in such basic skills as preparing drawings. More advanced training has typically been provided by individual Recorders who have taken their most promising observers "under their wings." One advantage of the latter system has been that the "students" have usually received their tutoring from our most knowledgeable observers. However, there has often been the disadvantage that the Recorders could not cope with large numbers of students in addition to their other duties. Thus, many promising observers have fallen through the cracks, and the A.L.P.O. has suffered for this failure. In a recent survey of our lapsed members, the most frequent reason given for their not renewing was that they felt that our training programs were inadequate. The second reason given was that they felt that the papers published in our *Journal* were too dry and technical. Clearly, better training would help these members to cope with the latter problem.

Although we have a number of observers who have given up on lunar and planetary astronomy due to a lack of advanced training, I think that we also have a number of seasoned observers who would be willing—if shown a need—to volunteer to tutor a few novice observers at a time. The new program described here seeks to bring together these two populations within our organization.

We need volunteers knowledgeable in all aspects of Solar-System astronomy. This includes persons experienced in telescope making, astronomical computing, photography, and electronic imaging. We also need volunteers who can advise novices about topics such as telescope and eyepiece selection. All volunteers will be allowed to decide for themselves which topics they wish to tutor in, as well as how many students they will be able to tutor at a time. The subject matter can be whatever the tutor and student agree upon. Each student will be expected to provide his or her tutor with a self-addressed stamped envelope each time he or she writes, and each student may have as many tutors in as many topics as he or she desires. Persons wishing to volunteer as tutors should write to me concerning which subjects they are interested in teaching. These persons will then be listed regularly in our Membership Directory as tutors and will also be announced in our *Journal*; along with their topic areas so that students can contact the right teachers.

By passing on your knowledge to the next generation of observers, you will be leaving a lasting legacy for the future.

IR-Blocking Paint for Telescope and Observatory

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

A common enemy of high-quality telescopic observing is heat currents inside the telescope tube; and heat radiating from the walls and floors of our observatory, which spoils the stable air above the telescope. Tube currents can be reduced by replacing a tube other than aluminum or wood with an aluminum one and by painting both the inside and outside black. This may sound like bad advice—black absorbs heat and is harder to clean than other colors. However, if we want to use our telescope soon after opening up our observatory, then a black tube radiates heat out into space faster than, for example, a white one. This follows the rules of blackbody radiation—something we should have learned about in science class. This approach works very well for us in South Florida, where the temperature often exceeds 110°F inside our telescope houses!

Another way to reduce daytime equipment heating is to paint our observatories with paint that blocks infrared (IR) radiation. This paint also reduces heating of the observatory's roof, walls, and floor. Some suitable paints are ordinary white house paint, titanium dioxide, and special paints used in painting gravel or shingle house roofs.

A relatively low-cost paint is available that is the equivalent of R19 insulation (about 6 inches of foam). The Air Force states that workers' skin temperatures fell by 20°F after warehouses were coated with this paint. Tests by various school districts, apartment owners, individuals, and NASA have given equivalent or better results. An Engineering Division Commander reports a 64°F reduction in surface temperature and a 23°F reduction in attic temperature after coating a building's asphalt-shingle roof. We are indebted to Ed Lucas, a colleague at the U.S. Naval Observatory, for informing us about this paint. Also, we will, of course, test this coating on our wooden observatory and will report the results in the near future. Copies of the several test results, average costs, and the address of the manufacturer of this "Flexible Ceramic Coating Insulate" are available upon request.

METEORS SECTION NEWS

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

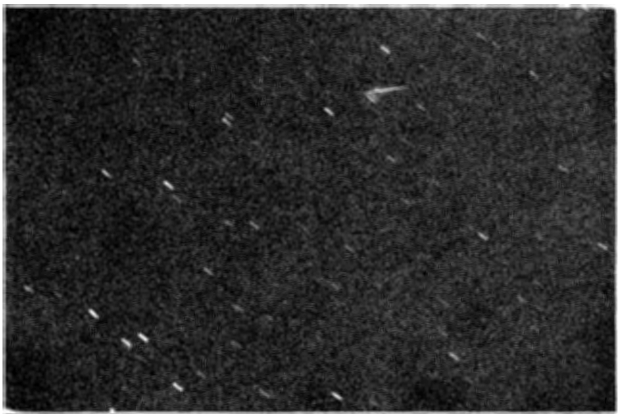

Figure 8. Orionid meteor passing in front of the Beehive star cluster (M45). Photographed by Robert H. Hays, Jr., in Illinois, on 1991 DEC 15, 06h43m-06h45m UT, with the meteor occurring at 06h45m. Kodak Tri-X Film, 35mm f/2.8 lens.

Despite strong interference from moonlight, many Orionid meteors were seen in Fall, 1991. Activity was noted from October 6th through November 6th. The published limits for this shower are October 5th through November 3rd, agreeing well with A.L.P.O. observers.

The *International Meteor Organization: List of Visual Radiants* did forecast a possible radiant in Aquila for the period November 5th through 15th, 1991, due to the intersection of the orbit of the Earth and the orbit of Comet Hartley 2. Two observers reported positive sightings of this radiant. On the evening of the 8th local time, John King of Honolulu, Hawaii, reported spotting a "swarm" from the predicted radiant. Mr. King stated:

> "..at 0650 UT on November 9th during the meteor watch at Ewa Beach a swarm of meteors was seen. These meteors were at the limit of visibility and were running parallel from west to east in a band 1.5 to 2 degrees wide centered about 2 degrees north of Altair (Alpha Aquilae) and were 2 to 3 degrees in length. These were 12-15 in number and lasted about 30 seconds."

Subsequently, on November 15th, John Gallagher of Spotswood, New Jersey, reported only one meteor from this radiant.

Instead of dying down as some astronomers have predicted, the Geminids produced one of their strongest displays in December, 1991. Unfortunately, the East Coast of the United States was clouded out on the morning of maximum (November 14th-15th local time), so that many deserving observers missed a great display of celestial fireworks. *Figure 8* above shows one bright Geminid photographed from the Midwest United States, however. Correspondence with overseas observers indicates that the maximum occurred near 06h UT on 1991 DEC 15, with a zenithal hourly rate approaching 150.

Finally, send me your stamped self-addressed envelope to obtain the *Meteors Section Newsletter*, which debuted in February, 1992, with the 1991 Yearly Review. My address is on the inside back cover.

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

1991 UT Date	Observer and Location	Universal Time	Number and Type of Meteors Seen*	Comments* (+N = Limiting Magnitude)
AUG 11	Daniel Louderback, WA	10:30-11:45	7 PER	*Not given*
12	" " "	08:45-10:45	21 PER	*Not given*
SEP 02	John Gallagher, NJ	04:20-05:20	1 SPC, 1 SPO	+6.0
04	" " "	04:20-05:20	1 EPR, 1 SPO	+5.4
06	" " "	05:30-08:15	3 EPR, 1 ABP, 5 :LYN. 6 SPO	+5.9; 20% cloudy
07	" " "	04:20-08:20	3 PRD, 5 EPR, 1 ABP, 1 LYN, 13 SPO	+6.0
10	" " "	04:25-05:42	1 PRD, 1 EPR, 3 SPO	+4.9
13	" " "	05:00-07:50	1 PRD, 2 EPR, 2 NPI, 1 KAQ, 1 QAD, 6 SPO	+6.0
SEP 17	John Gallagher, NJ	04:30-06:30	1 ABP	+5.3
21	" " "	04:50-06:52	1 SPC, 1 KAQ, 2 QAD, 4 SPO	+5.4

----- Table 1 continued on pp. 17-19 with notes on p. 19 -----

Table 1—*Continued.*

1991 UT Date	Observer and Location	Universal Time	Number and Type of Meteors Seen*	Comments* (+N = Limiting Magnitude)
SEP 23	John Gallagher, NJ	07:45-08:50	1 SPO	+6.1; 45% cloudy
27	" " "	03:40-06:55	2 NPI, 1 QAD, 1 AND, 5 SPO	+5.4
28	" " "	04:15-06:22	1 SPC, 1 KAQ, 1 AND, 4 SPO	+5.4
29	" " "	04:30-07:09	7 SPO	+5.4
30	" " "	03:30-05:40	1 SPC, 1 KAQ, 7 SPO	+5.5
OCT 01	" " "	03:30-05:00	1 SPO	+5.5; 25% cloudy
02	" " "	00:55-03:32	2 QAD, 1 GIA, 1 NTA, 7 SPO	+5.5; 15% cloudy
04	" " "	03:35-06:40	1 NTA, 1 QAD, 2 SPO	+4.9
	George Gliba, MD	06:30-08:30	5 SOR, 1 NTA, 1 STA, 1 DAU	+5.3
05	Mark Davis, VA	06:00-07:30	*None seen*	90% cloudy
	Phyllis Eide, HI	09:30-11:35	4 SPO	+5.0; 10% cloudy
	Michael Morrow, HI	09:30-11:45	1 STA, 5 SPO	+5.0; 20% cloudy
06	Phyllis Eide, HI	09:30-11:30	1 ORI, 1 STA, 4 SPO	+5.2; 20% cloudy
	Michael Morrow, HI	09:30-11:30	1 ORI, 1 SPO	+5.2; 20% cloudy
	John King, HI	09:40-11:32	5 SPO	+6.0; 20% cloudy
07	John Gallagher, NJ	03:55-07:13	4 STA, 2 ORI, 2 EGM, 1 DAU, 1 QAD, 3 AND, 11 SPO	+5.9
	Mark Davis, VA	05:30-09:30	*None seen*	80% cloudy
07-08	John Gallagher, NJ	23:35-01:55	1 PEG, 1 QAD	+6.1; 30% cloudy
08	" " "	04:15-06:57	2 NTA, 2 ORI, 1 GIA, 2 AND, 4 SPO	+6,1
	Michael Morrow, HI	10:00-11:15	1 SPO	+5.0; 20% cloudy
09	John Gallagher, NJ	03:10-07:31	1 NTA, 3 EGM, 1 DAU, 1 GIA,1 AND, 9 SPO	+6.2
	Mark Davis, VA	07:30-09:30	1 SOR, 2 ORI, 10 SPO	+5.9
11	John Gallagher, NJ	05:10-07:19	3 NPI, 1 EGM, 2 DAU, 1 QAD, 5 SPO	+6.1
13	Mark Davis, VA	07:30-09:00	1 ORI, 7 SPO	+5.7; 35% cloudy
15	Robert Lunsford, CA	10:17-11:17	7 ORI, 1 EGM, 2 STA, 1 SOR, 20 SPO	+6.7
	" " "	11:17-12:47	2 ORI, 2 EGM, 2 STA, 1 NTA, 15 SPO	+6.6
16	" " "	08:47-09:47	2 ORI, 1 SOR, 12 SPO	+6.7
	" " "	09:47-10:47	5 ORI, 15 SPO	+6.7
	" " "	10:47-11:47	2 ORI, 1 SOR, 1 NTA, 1 STA, 12 SPO	+6.7
	" " "	11:47-12:47	4 ORI, 2 EGM, 1 NTA, 1 STA, 4 SPO	+6.6
19	Bev Bennett, NC	02:00-03:00	*None seen*	+2.9
	Deborah Carroll, NC	02:00-03:00	*None seen*	+2.9
	Rex Carroll, NC	02:00-03:00	1 SPO	+2.9
	Barbara Hands, NC	02:00-03:00	*None seen*	+2.9
	Dennis Hands, NC	02:00-03:00	*None seen*	+2.9
	Mary Krieg, NC	02:00-03:00	*None seen*	+2.9
	Don Talbert, NC	02:00-03:00	2 SPO	+2.9
	John Gallagher, NJ	06:20-08:48	1 SPC, 1 NPI, 8 ORI, 1 EGM, 1 QAD, 3 SPO	+6.3
	Mark Davis, VA	07:20-09:20	1 SOR, 3 ORI, 1 EGM, 9 SPO	+5.8
	Daniel Rhone, NJ	08:30-09:57	8 ORI, 1 SPO	+5.0
	Phyllis Eide, HI	12:20-14:25	11 ORI, 20 SPO	+5.8
	John King, HI	12:22-14:25	11 ORI, 3 EGM, 15 SPO	+5.8
	Michael Morrow, HI	12:25-14:25	2 ORI, 1 EGM, 12 SPO	+5.8
20	J.-F. Viens, Quebec, Can.	07:30-08:00	4 ORI, 2 STA	+5.0
	Michael Morrow, HI	13:10-15:00	5 ORI, 2 EGM, 7 SPO	+5.5; 10% cloudy
	Phyllis Eide, HI	13:12-15:00	3 ORI, 1 EGM, 1 STA, 18 SPO	+5.5; 10% cloudy
	John King, HI	13:12-15:01	3 ORI, 3 EGM, 8 SPO	+5.8
21	John Gallagher, NJ	08:00-10:35	4 ORI, 5 EGM, 5 SPO	+5.9
	Robert Bacon, NJ	08:30-10:00	4 ORI, 1 SPO	+3.9
	Daniel Rhone, NJ	08:30-10:00	2 ORI, 1 SPO	+4.5
	John King, HI	13:20-15:26	7 ORI, 2 EGM, 3 SPO	+5.3
	Phyllis Eide, HI	13:25-15:25	5 ORI, 6 SPO	+5.0
	Michael Morrow, HI	13:25-15:30	5 ORI, 1 EGM, 4 SPO	+4.5
OCT 22	John Gallagher, NJ	07:25-10:25	2 LMI, 6 ORI, 2 EGM, 6 SPO	+6.0

---------------------------------- *Table 1 continued on pp. 18-19 with notes on p. 19* ----------------------------------

Table 1—*Continued.*

1991 UT Date	Observer and Location	Universal Time	Number and Type of Meteors Seen*	Comments* (+N = Limiting Magnitude)
Oct 22	Robert Bacon, NJ	08:15-10:15	5 ORI, 2 SPO	+3.9
	Daniel Rhone, NJ	08:15-10:15	7 ORI, 4 SPO	+3.9
23	John Gallagher, NJ	09:21-10:40	3 ORI	+6.1
28	" " "	06:05-07:06	1 STA	+5.8
29	" " "	00:30-02:11	1 SPU, 8 SPO	+6.2
	" " "	04:45-07:23	1 NTA, 1 STA, 2 EGM, 1 DAU, 1 SPU, 4 SPO	+6.2
30	" " "	04:05-06:47	1 LMI, 5 NTA, 1 STA, 1 ORI, 1 SPU, 8 SPO	+6.3
	Robert Lunsford, CA	11:00-12:00	4 SPO	+5.2
	" " "	12:00-13:00	1 STA, 3 SPO	+5.2
31	John Gallagher, NJ	06:10-07:59	1 NTA, 2 STA, 1 ORI, 2 SPO	+6.3; 20% cloudy
Nov 03	Phyllis Eide, HI	08:00-10:30	4 NTA, 2 STA, 12 SPO	+5.0
	John King, HI	08:00-10:30	3 NTA, 5 STA, 5 SPO	+5.5
	Michael Morrow, HI	08:00-10:30	4 NTA, 3 STA, 7 SPO	+4.8; 15% cloudy
	John Gallagher, NJ	08:50-10:30	2 STA, 1 ORI, 1 EGM, 6 SPO	+5.8; 35% cloudy
	John King, HI	11:50-13:40	1 NTA, 4 STA, 4 SPO	+6.0; 20% cloudy
04	" " "	09:20-11:40	9 STA, 5 NTA, 1 CEP, 7 SPO	+6.0; 30% cloudy
	Robert Lunsford, CA	09:48-13:18	5 STA, 2 ORI, 3 NTA, 17 SPO	+5.7
	Michael Morrow, HI	10:00-11:39	1 STA, 5 SPO	+4.9; 30% cloudy
05	John King, HI	08:50-12:00	9 STA, 1 NTA, 15 SPO	+6.0; 25% cloudy
	Michael Morrow, HI	10:40-12:10	1 STA, 1 NTA, 4 SPO	+5.0; 20% cloudy
06	John Gallagher, NJ	01:35-03:46	3 BIE, 1 CEP, 1 LMI, 8 SPO	+6.4
	" " "	06:05-07:44	3 NTA, 1 STA, 2 ORI, 4 SPO	+6.4
07	" " "	00:55-02:30	2 NTA, 1 PEG, 2 SPO	+6.4, 20% cloudy
08	" " "	01:45-03:23	2 NTA, 3 SPO	+6.2; 25% cloudy
09	Phyllis Eide, HI	04:30-09:00	2 NTA, 2 STA, 8 SPO	+4.8
	Michael Morrow, HI	04:30-10:30	2 NTA, 2 STA, 1 PEG, 1 CEP, 12 SPO	+4.5; 10% cloudy
	John King, HI	06:16-10:30	4 STA, 2 CEP, 15 AQU, 1 SPO	+4.5
10	Robert Hays, IL	03:50-04:50	4 NTA, 4 STA, 7 SPO	+6.0
	Michael Morrow, HI	04:30-08:30	*None seen*	90% cloudy
	Robert Hays, IL	04:50-05:50	3 NTA, 7 STA, 3 SPO	+6.0
11	Michael Morrow, HI	04:30-07:30	*None seen*	90% cloudy
14	John Gallagher, NJ	06:35-10:22	4 NTA, 9 SPO	+6.4
	Mark Davis, VA	08:30-09:30	7 SPO	+5.5
14-15	John Gallagher, NJ	23:20-02:32	1 NTA, 1 AQU, 3 SPO	+6.3
15	Robert Lunsford, CA	03:30-04:30	*None seen*	+4.7
17	John Gallagher, NJ	06:10-10:15	2 STA, 6 LEO, 1 MON (N), 1 ZPU, 9 SPO	+6.5
	George Gliba, MD	08:12-09:12	3 LEO, 5 SPO	+5.4
	Mark Davis, VA	08:30-09:45	2 LEO, 7 SPO	+5.6
	Daniel Rhone, NJ	08:45-10:15	4 LEO, 1 SPO	+5.0; 15% cloudy
	Robert Lunsford, CA	10:17-11:47	14 LEO, 2 STA, 2 NTA, 5 SPO	+6.7
	" " "	12:17-13:17	8 LEO, 1 NTA, 6 SPO	+6.5
18	Michael Morrow, HI	04:00-11:45	1 STA, 1 LEO, 3 SPO	+4.3; 50% cloudy
	Phyllis Eide, HI	05:00-08:45	1 STA, 2 SPO	+4.0; 55% cloudy
	John Gallagher, NJ	07:35-10:25	2 STA, 7 LEO, 2 MON (N); 8 SPO	+6.5
	George Gliba, MD	08:02-09:02	4 LEO, 1 MON (N), 5 SPO	+5.5
	Mark Davis, VA	08:23-09:01	1 LEO, 3 SPO	+5.6; 90% cloudy
	Robert Bacon, NJ	08:45-10:45	5 LEO	+4.9; 15% cloudy
	Daniel Rhone, NJ	08:45-10:45	14 LEO, 3 SPO	+4.9; 15% cloudy
26	John Gallagher, NJ	05:15-07:48	1 STA, 2 MON (D), 1 SPO	+6.0
27	" " "	06:00-08:33	2 MON (D), 2 SPO	+5.7
30	" " "	08:35-10:13	2 SPO	+5.9; 35% cloudy
Dec 02	Michael Morrow, HI	07:00-08:30	1 SPO	+4.8; 20% cloudy
	Phyllis Eide, HI	07:25-08:30	1 SPO	+5.0; 15% cloudy-

Table 1 continued on p. 19 with notes

Table 1—*Continued.*

1991 UT Date	Observer and Location	Universal Time	Number and Type of Meteors Seen*	Comments* (+N = Limiting Magnitude)
DEC 05	John Gallagher, NJ	05:50-06:33	1 MON (D), 2 GEM, 1 HYD, 1 ARI, 2 SPO	+6.4
	Phyllis Eide, HI	08:00-11:30	4 GEM, 17 SPO	+6.0
	Michael Morrow, HI	09:40-11:30	5 SPO	+5.2; 20% cloudy
06	John King, HI	09:17-11:34	12 GEM, 1 MON (D), 1 NTA, 6 SPO	+5.5
07	John Gallagher, NJ	05:00-08:40	1 MON (D), 1 GEM, 1 ORN, 2 ORS, 4 SPO	+6.1; 55% cloudy
	John King, HI	09:00-11:00	8 GEM, 3 ORN, 1 ORS, 1 HYD, 6 SPO	+6.0; 55% cloudy
08	Michael Morrow, HI	08:00-11:30	1 GEM, 18 SPO	+5.7; 15% cloudy
09	" " "	09:50-11:20	1 GEM, 6 SPO	+5.0; 20% cloudy
11	Robert Hays, IL	03:50-04:50	6 GEM, 1 ORN, 1 ORS	+6.0; 10% cloudy
	John Gallagher, NJ	05:30-09:19	2 MON (D), 8 GEM, 2 ORS, 3 HYD, 2 COM, 8 SPO	+6.4
	George Gliba, MD	05:50-06:50	3 GEM, 2 MON (D), 2 ORS, 1 HYD, 1 ARI, 2 SPO	+5.3
12	John Gallagher, NJ	07:30-08:33	1 GEM, 1 COM	+6.4, 30% cloudy
13	Robert Lunsford, CA	06:17-07:17	21 GEM, 1 ORS, 1 HYD, 12 SPO	+6.3; GEM ZHR = 32
	" " "	07:17-08:00	10 GEM, 2 HYD, 5 SPO	+6.4; GEM ZHR = 28
	" " "	08:00-09:00	32 GEM, 1 ORS, 1 HYD, 6 SPO	+6.5; GEM ZHR = 34
	" " "	09:00-10:00	34 GEM, 3 DLE, 1 HYD, 1 ORS, 16 SPO	+6.5; GEM ZHR = 35
	" " "	10:00-11:00	42 GEM, 1 ORS, 3 COM, 1 DLE, 1 HYD, 1 VEL, 6 SPO	+6.5; GEM ZHR = 43
	" " "	11:00-12:00	38 GEM, 1 HYD, 1 COM, 8 SPO	+6.5; GEM ZHR = 40
	" " "	12:00-13:17	17 GEM, 1 COM, 10 SPO	+6.4; GEM ZHR = 34
14	Wanda Simmons, FL	04:30-05:30	43 GEM, 7 SPO	+5.7; 10% cloudy GEM ZHR = 118
	Karl Simmons, FL	04:32-05:32	44 GEM, 4 SPO	+5.7; 10% cloudy GEM ZHR = 121
	Wanda Simmons, FL	05:30-06:34	31 GEM, 13 SPO	+5.3; 20% cloudy GEM ZHR = 123
	Karl Simmons, FL	05:38-06:31	27 GEM, 1 ORN, 1 ORS, 9 SPO	+5.3; 20% cloudy GEM ZHR = 130
	Robert Lunsford, CA	06:00-07:00	56 GEM, 4 SPO	+6.3; GEM ZHR = 82
	" " "	07:00-08:00	102 GEM, 2 HYD, 2 DLE, 1 MON (D)	+6.4; GEM ZHR=121
	Michael Morrow, HI	07:40-08:20	2 GEM	+4.3; 65% cloudy
	Robert Lunsford, CA	08:00-09:00	89 GEM, 1 MON (D), 1 COM, 1 HYD	+6.6; GEM ZHR = 82
	" " "	09:00-10:00	123 GEM, 1 COM, 1 MON (D), 1 ORS, 1 DLE, 3 HYD, 9 SPO	+6.6; GEM ZHR=113
	" " "	10:00-11:00	68 GEM, 1 ORS, 1 COM, 1 HYD, 6 SPO	+6.6; GEM ZHR = 67
	" " "	11:10-12:00	57 GEM, 1 COM, 3 HYD, 5 SPO	+6.5; GEM ZHR = 57
15	John Gallagher, NJ	05:50-10:52	27 GEM, 2 HYD, 6 COM, 16 SPO	+5.8
	George Gliba, MD	06:24-07:24	41 GEM, 3 HYD, 2 MON (D), 1 DLE, 1 ORS, 7 SPO	+6.5
	" " "	07:24-08:24	29 GEM, 2 HYD, 1 COM, 6 SPO	+6.5
	" " "	08:24-09:24	20 GEM, 2 ORS, 1 HYD, 1 DLE, 1 MON (D), 4 SPO	+6.5
	" " "	09:24-10:24	12 GEM, 4 HYD, 2 COM, 1 DLE, 10 SPO	+6.5
18	John Gallagher, NJ	06:00-09:08	1 GEM, 1 HYD, 1 VEL, 7 SPO	+6.2
20	" " "	06:45-08:48	1 URS, 3 SPO	+6.0
22	" " "	05:50-10:19	1 URS, 4 SPO	+6.0; 55% cloudy
31	" " "	07:15-09:53	11 SPO	+6.0

Key To Abbreviations: **ABP** = Alpha-Beta Perseids, **AND** = Andromedids (Annual), **AQU** = Aquilids (from P/Hartley 2), **ARI** = Delta Arietids, **BIE** = Bielids (Andromedids), **CEP** = Cepheids, **COM** = Coma Berenicids, **DAU** = Delta Aurigids, **DLE** = December Leonids, **EGM** = Epsilon Geminids, **EPR** = Epsilon Perseids, **GEM** = Geminids, **GIA** = Giacobinids (October Draconids), **HYD** = Sigma Hydrids, **KAQ** = Kappa Aquarids, **LEO** = Leonids, **LMI** = Leo Minorids, **LYN** = Lyncids, **MON (D)** = December Monocerotids, **MON (N)** = November Monocerotids, **NPI** = Northern Piscids, **NTA** = Northern Taurids, **ORI** = Orionids, **ORN** = North Chi Orionids, **ORS** = South Chi Orionids, **PEG** = Pegasids, **PRD** = Pi Eridanids, **QAD** = October Quadrantids, **SOR** = Sigma Orionids, **SPC** = Southern Piscids, **SPO** = Sporadic, **SPU** = Sigma Puppids, **STA** = Southern Taurids, **URS** = Ursids, **VEL** = Puppids/Velids, **ZPU** = Zeta Puppids.

THE 1991 APPARITION OF URANUS

By: Richard W. Schmude, Jr., A.L.P.O. Remote Planets Recorder

ABSTRACT

Three individuals, all using SSP-3 solid-state photometers, measured the magnitude of Uranus during 1991. This photometer and some general photometric concepts are discussed. In all cases, the observers used filters closely matching the Johnson U, B, V, R and I system. The adopted magnitudes of Uranus in 1991, reduced to 1 AU distance from the Earth and the Sun, are: U(1,0) = -6.40, B(1,0) = -6.62±.02, V(1,0) = -7.20±.02, R(1,0) = -7.01±.02, and I(1,0) = -6.22±.05. Visual photometry and disk studies of Uranus were also carried out.

INTRODUCTION

Uranus reached opposition on 1991 JUL 04, having a declination of 23°S and an angular diameter of 3.8 arc-seconds [**1**, **2**]. This southerly declination meant that the planet reached a maximum altitude of 37° at latitude 30°N, 27° at 40°N, and only 17° at latitude 50°N. Five persons contributed visual observations and photometric measurements of Uranus in 1991, and are listed in *Table 1* (below), with their locations, instruments, and types of observation. In this report we will describe the type of photoelectric photometer used, followed by the photometry results and then by visual observations.

Table 1. Participating Observers, 1991 Apparition of Uranus.

Observer and Location	Type of Observation*	Type of Telescope†
David L. Graham, England‡	V, C	15-cm Ref
Aryan W. Hastings, IN, USA	V	91-cm Cas
Frank J. Melillo, NY, USA	PP, V, C	20-cm S-C
Richard W. Schmude, Jr., NM, USA	PP, VP, V, C	25-cm New 8X40 Bin
John E. Westfall, CA, USA	PP	36-cm S-C

*C = color, PP = photoelectric photometry, V = visual, VP = visual photometry.
†Bin = binoculars, Cas = Cassegrain, New = Newtonian, Ref = refractor, S-C = Schmidt-Cassegrain.
‡1988 observations sent to the Recorder in 1991.

THE SSP-3 SOLID-STATE PHOTOMETER

The SSP-3 solid-state photometer has a built-in S1087-01 photodiode which serves as its detector. The photodiode has a quantum efficiency of 75 percent at wavelengths between 400-1100 nm [the visual and near-infrared range], which means that three-quarters of the incident photons influence the output, which is proportional to the number of photons and is displayed using four decimal digits. [**3**] Because the quantum efficiency is relatively high over the 400-1100 nm range, the SSP-3 photometer can yield precise measurements of Uranus with the Johnson B, V, R and I filters [blue, visual, red, and near infrared] with telescopes of 15-cm aperture or greater. The main advantage of the SSP-3 photometer over many photomultiplier-tube instruments is that it is sensitive in the red and infrared. Two disadvantages of the SSP-3, however, are that it is not very sensitive in the ultraviolet [U] and that it cannot be used to measure Pluto with instruments under about 40-cm (16-in) aperture. The SSP-5 photoelectric photometer, though, is sensitive enough to yield precise measurements of Pluto with 15-40-cm (6-16-in) telescopes. [**4**] [If you can find Pluto in the first place! Ed.] Both the SSP-3 and SSP-5 are manufactured by Optec Instruments, Inc.

PHOTOMETRIC CONVENTIONS

The magnitudes of the planets are often reported in terms of the values they would have if 1.0 astronomical unit (AU; 149.6 million km or 93.0 million mi) from both the Earth and Sun. The symbols for this form of magnitude are U(1,0), B(1,0), V(1,0), R(1,0), and I(1,0) for the Johnson ultraviolet, blue, visual, red, and infrared filters, respectively. If one wishes to convert any of these to mean opposition magnitudes, a factor of 12.71 must be added, which is based on a mean opposition Uranus-Sun distance of 19.191 AU, and a mean Uranus-Earth distance of 18.191 AU. [**5**]

The V(1,0) magnitude of Uranus is computed from equation (1):

$$V(1,0) = V_{meas} - 5\log(r\Delta) - 2.5\log k - (m\alpha)\,, \quad (1)$$

where V_{meas} is the measured magnitude, **r** is the Uranus-Sun distance, Δ is the Uranus-Earth distance [both distances in AU], **k** is the fraction of Uranus' disk which is illuminated as seen from the Earth; **m** is the solar phase-angle coefficient, which is estimated to be 0.0028 magnitudes/degree; and α is the phase angle in degrees, or angle between the Earth and the Sun as seen from Uranus. [**6**] The third term, **2.5 log k**, never exceeds 0.001 magnitudes for Uranus and is ignored here. The fourth term, (**m**α), is less than 0.01 magnitudes for Uranus when using the V filter because the phase angle, α, never exceeds 3°. There is no guarantee, however, that this is the case for the other filters. Indeed, one goal of

Table 2. Comparison Stars Used for the Photometry of Uranus in 1991. (2000.0 Coordinates)

Star Name	R. A.	Dec.	U	B	V	R	I	Observers Using Star
ν1 Sgr	18h 54.2m	-22°45'	7.51	6.23	4.83	3.82	3.13	Melillo, Schmude*, Westfall
ν2 Sgr	18h 55.1m	-22°40'	7.80	6.30	4.98	4.04	3.38	Schumde
o Sgr	19h 04.7m	-21°44'	5.63	4.77	3.77	3.05	2.52	Schmude†
SAO 187468‡	18h 56.0m	-23°10'	--	5.93	5.91	--	--	---

*Used as check star. †Used only for the **U** measurement.
‡Measurements made by Schmude. This star was used only for visual photometry.

the A.L.P.O. Remote Planets Section is to evaluate m for the Johnson B, R, and I filters. In this report, the (mα) term was neglected for all five filters for the sake of consistency.

RESULTS OF PHOTOELECTRIC PHOTOMETRY

The names, positions, and multicolor magnitudes [7] of the calibration stars used in the 1991 measurements are summarized in *Table 2* (above), along with the names of the observers who used those stars. Because the comparison stars were close to Uranus, no differential-extinction corrections were made. Note that Schmude used ν1 Sgr as a check star for several of his measurements. He measured that star's magnitudes as V = +4.82 and B = +6.23, which were both within 0.01 magnitude of the values in *Table 2*. The author thinks that measurements of a check star serve as a valuable control on the magnitude measurements

A total of 1 U-filter, 17 B-filter, 53 V-filter, 4 R-filter, and 7 I-filter photoelectric measurements of Uranus were made by Melillo, Schmude, and Westfall in 1991, and are summarized in *Table 3* (p. 22). All the magnitudes in *Table 3* are based on the star magnitudes given in *Table 2*. Small inconsistencies often occurred when persons used different star catalogs, even when the same calibration star was used, so it was necessary to standardize on one set of comparison-star magnitudes.

The mean magnitudes of Uranus for 1991 are given in *Table 4* (p. 22), along with the literature values [1] and those reported in Harris [6]. The 1991 values are all close to the values in references [1] and [6], suggesting that no drastic brightness changes occurred on Uranus between their dates and 1991.

Appleby and Irvine [8] reported a value of V(1,0) = -7.14±.01 for Uranus, based on measurements made at Boyden Observatory during 1964. When the changing effects of Uranus' polar flattening are considered, the 1964 value is 0.04 magnitudes dimmer than the 1991 result. Although no definite conclusions can be drawn at this time, future studies may shed new insights into any seasonal or irregular changes in Uranus' magnitude.

VISUAL PHOTOMETRY

The writer also made visual magnitude estimates for Uranus with 8×40 binoculars, using ν2 Sgr and SAO 187468 as comparison stars. He measured the magnitude of SAO 187468 as B = +5.93 and V = +5.91 with a SSP-3 photometer during June, 1991–the same time that the visual magnitude estimates were made. Other recent visual magnitude estimates for Uranus are reported in Hollis [9] and Schmude [10]. Here, 25 magnitude estimates were made in June, 1991, giving V_{vis} = -7.19, where the symbol "V_{vis}" is used instead of "V" because the sensitivity of the human eye differs from that of the Johnson V filter. For individual observations, the standard deviation was ±0.13 magnitude, but other uncertainties may well have increased this to perhaps ±0.2 magnitude, implying an uncertainty of the mean of about ±0.04 magnitude.

This Recorder hopes to see other A.L.P.O. members visually estimate the magnitude using either small telescopes or binoculars. The purpose of this project is to evaluate the reliability of this method and thus the scientific value of more than a century of visual magnitude work upon Uranus.

TELESCOPIC STUDIES OF URANUS

Three persons submitted visual observations of Uranus made during 1991. Melillo studied the planet in July and August, 1991, and felt that it had a blue-green color. He reported no sharp albedo irregularities, but twice he suspected that the disk center was brighter than the limbs. The writer studied Uranus on 1991 JUN 19 at 301× and thought that it appeared brighter near the disk center.

Hastings reported seeing 17 bright points near Uranus but was unable to identify satellites due to there being no diagrams available with predicted satellite positions.

Graham also submitted observations of Uranus; these were made in 1988. He reported that the planet's color was greenish and that it lacked distinct albedo irregularities. He suspected a brightening toward the disk center on two dates, which is similar to what the writer observed in 1991 and 1987 [11].

CONCLUSION

During the 1991 Apparition of Uranus, three individuals from different portions of the United States used SSP-3 solid-state photometers for a total of 82 multicolor measurements of the brightness of the planet. The mean reduced magnitudes that resulted are given in *Table 4* (p. 22). These values are close to measurements made in previous apparitions. [1,6] Uranus was described as having a green color in 1991, with possible limb darkening.

Table 3. Summary of Photometric Measurements Made of Uranus During the 1991 Apparition.

Note: "Me." = measured magnitude; "Nor." = magnitude normalized to 1 AU from Earth and Sun.

1991 UT Date	Filter	Magnitude Me.	Magnitude Nor.	Star
JUNE		+	-	
05.421	V	5.60	7.19	v2 Sgr
06.338	V	5.59	7.19	v2 Sgr
06.378	B	6.16	6.62	v2 Sgr
09.326	V	5.58	7.20	v2 Sgr
09.359	B	6.15	6.63	v2 Sgr
13.318	V	5.60	7.19	v2 Sgr
13.342	B	6.18	6.61	v2 Sgr
15.336	V	5.57	7.21	v2 Sgr
15.347	V	5.58	7.20	v2 Sgr
17.284	V	5.58	7.20	v2 Sgr
17.310	B	6.17	6.61	v2 Sgr
17.323	V	5.58	7.20	v2 Sgr
17.334	B	6.09	6.69	v2 Sgr
18.231	V	5.58	7.20	v2 Sgr
18.241	B	6.17	6.61	v2 Sgr
18.248	V	5.60	7.18	v2 Sgr
18.258	B	6.16	6.62	v2 Sgr
18.264	V	5.60	7.18	v2 Sgr
18.276	B	6.20	6.58	v2 Sgr
18.285	V	5.61	7.17	v2 Sgr
18.290	B	6.16	6.62	v2 Sgr
18.297	V	5.61	7.17	v2 Sgr
19.241	V	5.58	7.20	v2 Sgr
21.234	V	5.61	7.17	v2 Sgr
21.256	V	5.58	7.20	v2 Sgr
22.227	V	5.62	7.16	v2 Sgr
22.251	V	5.58	7.20	v2 Sgr
22.267	V	5.59	7.19	v2 Sgr
22.282	V	5.59	7.19	v2 Sgr

1991 UT Date	Filter	Magnitude Me.	Magnitude Nor.	Star
JUNE		+	-	
22.304	B	6.17	6.61	v2 Sgr
24.231	V	5.57	7.21	v2 Sgr
24.247	V	5.60	7.18	v2 Sgr
24.255	B	6.19	6.59	v2 Sgr
27.244	V	5.60	7.18	v2 Sgr
JULY				
05.234	V	5.58	7.19	v2 Sgr
05.246	V	5.56	7.22	v2 Sgr
05.255	V	5.59	7.19	v2 Sgr
05.285	V	5.58	7.18	v2 Sgr
05.330	V	5.58	7.20	v2 Sgr
05.338	V	5.57	7.21	v2 Sgr
05.345	V	5.58	7.20	v2 Sgr
05.352	V	5.60	7.18	v2 Sgr
05.363	V	5.60	7.18	v2 Sgr
05.372	V	5.59	7.18	v2 Sgr
11.184	V	5.55	7.23	v2 Sgr
16.132	V	5.50	7.28	v1 Sgr
16.146	I	6.50	6.28	v1 Sgr
17.132	V	5.55	7.23	v1 Sgr
17.146	I	6.56	6.22	v1 Sgr
19.255	V	5.61	7.17	v2 Sgr
31.232	V	5.58	7.21	v2 Sgr
31.240	B	6.18	6.61	v2 Sgr
AUGUST				
06.132	V	5.55	7.26	v1 Sgr
06.146	I	6.56	6.24	v1 Sgr
06.158	V	5.58	7.22	v2 Sgr
06.167	B	6.22	6.58	v2 Sgr

1991 UT Date	Filter	Magnitude Me.	Magnitude Nor.	Star
AUGUST		+	-	
08.161	V	5.58	7.22	v2 Sgr
11.132	V	5.61	7.19	v1 Sgr
11.146	I	6.44	6.36	v1 Sgr
17.144	R	5.80	7.01	v1 Sgr
20.135	I	6.80	6.02	v2 Sgr
20.147	R	5.81	7.01	v2 Sgr
22.118	V	5.63	7.19	v2 Sgr
22.126	B	6.24	6.58	v2 Sgr
22.145	R	5.79	7.03	v2 Sgr
27.113	R	5.84	6.99	v2 Sgr
27.127	I	6.74	6.09	v2 Sgr
27.139	V	5.61	7.22	v2 Sgr
SEPTEMBER				
04.104	V	5.59	7.25	v1 Sgr
04.104	I	6.54	6.30	v1 Sgr
08.17	V	5.61	7.24	v1 Sgr
08.17	B	6.11	6.74	v1 Sgr
15.095	V	5.66	7.20	v2 Sgr
15.110	V	5.63	7.23	v2 Sgr
15.122	V	5.68	7.18	v2 Sgr
15.131	V	5.65	7.21	v2 Sgr
21.20	V	5.65	7.22	v1 Sgr
21.20	B	6.27	6.60	v1 Sgr
22.15	V	5.65	7.22	v1 Sgr
22.15	B	6.26	6.61	v1 Sgr
OCTOBER				
06.114	V	5.72	7.18	v2 Sgr
06.138	U	6.50	6.40	v2 Sgr & o Sgr

Table 4. Mean Magnitudes for Uranus During the 1991 Apparition.

Type of Magnitude	1991 Observations: Mean Value	1991 Observations: No. Meas.	Literature: Ref. [1]	Literature: Ref. [6]
U(1,0)	-6.40	1	-6.35	-6.35
B(1,0)	-6.62±.02	17	-6.63	-6.63
V(1,0)	-7.20±.02	53	-7.19	-7.19
R(1,0)	-7.01±.02	4	---	-7.04
I(1,0)	-6.22±.05	7	---	-6.24
B-V	+0.58	-	+0.56	+0.56
U-B	+0.22	-	+0.28	+0.28
V-R	-0.19	-	---	-0.15
R-I	-0.79	-	---	-0.80

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GETTING STARTED: MOONLIGHTING

By; John E. Westfall, A.L.P.O. Executive Director

INTRODUCTION

In planning and reporting our observations, we often need to be able to predict or to describe the Moon's lighting conditions. This may simply consist of knowing the Moon's *phase* or *age*. This general information is useful to describe the amount of glare from the Moon that may interfere with the observation of other objects. On the other hand, if we are observing features on the Moon itself, we need more detailed lighting information, perhaps even specific to the particular part of the Moon that we are studying.

PHASE AND AGE

The reason the Moon's phase must be described is that it changes over the course of each *lunation*, a period which averages 29.53 days in length (but which can vary from this value by about ±1 percent). During this period the Moon, as seen from the Earth, grows from a black (or earthlit) disk to an almost-completely sunlit circle, and then shrinks to invisibility again, only to begin a new cycle. The most commonly used way to describe phase is the sequence:

New Moon [NM]
(Waxing Crescent)
First Quarter [FQ]
(Waxing Gibbous)
Full Moon [FM]
(Waning Gibbous)
Third {or Last} Quarter [LQ]
(Waning Crescent)

This verbal system has drawbacks. Even in theory, only the four terms not in parentheses represent precise events. (For example, "New Moon" occurs at the moment when the Moon has the same celestial longitude as the Sun; fairly near to that time when it appears closest to the Sun.) These terms are often used loosely; some people refer to the quarter phases as "Half Moon," because then the Moon is approximately half-illuminated from our viewpoint.

Not everyone realizes that the periods between the four well-defined phases (i.e., New Moon-First Quarter, First-Quarter-Full Moon, Full Moon-Third Quarter, Third Quarter-New Moon) are usually not even of equal length. This happens because the Moon's orbit is not circular, and the lengths of each of the four periods above can vary by ±11 percent.

The first improvement in precision of terminology is the Moon's *age*. This is simply the amount of time that has elapsed from the last New Moon. We are usually satisfied to express age to 0.1-day precision, but enthusiastic spotters of "Young Moons" (less than one day old) use hours and even minutes

Naturally, we can also simply express the Moon's phase in terms of the proportion of the apparent lunar disk that is sunlit, called the *phase coefficient* or simply *proportion illuminated*. This value can be given as a percentage or a decimal fraction, and the suffices "waxing" or "waning" can be added to differentiate between the first and last halves of the lunation, respectively.

ELONGATION AND PHASE ANGLE

Expressing the Moon's phase in terms of its age is definitely more precise than a verbal description, but it is still rendered inaccurate by the Moon's variations in apparent velocity during each lunation. To do better, we need to use *angles*. One such angle is the apparent distance of the Moon from the Sun in the sky, usually with "East" added before Full Phase and followed by "West" after Full. This angular distance is the *elongation*, or "solar elongation," often abbreviated "Elong."

The elongation is approximately 0° at New Moon and 180° at Full (if exactly at those angles, then at the mid-times of a central solar or lunar eclipse!). However, the elongation is not exactly 90°E at First Quarter or 90°W at Third Quarter, because the Sun is "only" some 400 times farther away than the Moon, not infinitely far. The resulting effect of the Sun's finite distance on the elongation:phase relationship can be up to 0°.15.

Thus, our final upwards step in precisely describing the apparent phase of the Moon in terms of an angle is to use the *Earth's* elongation from the Sun as seen from the *Moon*. This quantity is called the *phase angle*. When it is necessary to indicate the difference, the phase angle is taken to be negative before Full Moon and positive thereafter.

As with all the quantities previously described, tabulated values of the phase angle are usually *geocentric*; for the center of the Earth, rather than *topocentric*, which would be for a particular location on the Earth's surface.

BRIGHTNESS AND MAGNITUDE

We may be interested in the intensity of moonlight, for example in reducing the limiting magnitude for stars or deep-sky objects. This intensity can be expressed either in terms of the Moon's *relative brightness* compared with Full Moon, or as *stellar magnitude*. The chief effect here is phase, but the Moon's brightness is also affected by its distance from the Earth and, to a lesser extent, by the Earth's distance from the Sun. There are no simple theoretical formulae to calculate these quantities, which rest on empirical measurements of the Moon's actual brightness under varying

Table 1. Relation Among Lunar Phase Measurements.

Assumptions: Phases are *geocentric* (seen from the center or the Earth; or with the Moon overhead).
The Moon's angular velocity in its orbit is constant.
The Moon and Sun are at their average distances.
The Moon's latitude (distance north or south of the ecliptic) is zero.
The effect of the Sun's finite distance (relative to the Moon's) is ignored.

Visual stellar magnitudes are interpolated (and extrapolated!) from Rougier's measurements as cited in: V.G. Fessenkov (1962), "Photometry of the Moon." p. 103 in: Zdenek Kopal, ed. *Physics and Astronomy of the Moon.* New York: Academic Press.

Age	Phase Coeff.	Solar Elong.	Phase Angle	Rel. Bright.	Vis. Stellar Magnitude
d	%	°	°		
0.0 NM	0	0	±180	.000	-----
1.0	1	12 E	-168	.001	-5.7
2.0	4	24 E	-156	.003	-6.6
3.0	10	37 E	-143	.007	-7.4
4.0	17	49 E	-131	.014	-8.1
5.0	26	61 E	-119	.026	-8.8
6.0	35	73 E	-107	.043	-9.3
7.0	46	85 E	-095	.069	-9.8
7.4 FQ	50	90 E	-090	.082	-10.0
8.0	57	98 E	-082	.109	-10.3
9.0	67	110 E	-070	.158	-10.7
10.0	76	122 E	-058	.223	-11.1
11.0	85	134 E	-046	.310	-11.5
12.0	91	146 E	-034	.421	-11.8
13.0	96	158 E	-022	.570	-12.1
14.0	99	171 E	-009	.794	-12.5
14.8 FM	100	180	000	1.000	-12.7

Age	Phase Coeff.	Solar Elong.	Phase Angle	Rel. Bright.	Vis. Stellar Magnitude
d	%	°	°		
15.0	100	177 W	+003	.929	-12.7
16.0	98	165 W	+015	.667	-12.3
17.0	95	153 W	+027	.483	-12.0
18.0	89	141 W	+039	.356	-11.6
19.0	81	128 W	+052	.256	-11.3
20.0	72	116 W	+064	.185	-10.9
21.0	62	104 W	+076	.131	-10.5
22.0	52	92 W	+088	.090	-10.1
22.1 LQ	50	90 W	+090	.083	-10.0
23.0	41	80 W	+100	.059	-9.7
24.0	30	67 W	+113	.035	-9.1
25.0	21	55 W	+125	.020	-8.5
26.0	13	43 W	+137	.011	-7.8
27.0	7	31 W	+149	.005	-7.0
28.0	3	19 W	+161	.002	-6.2
29.0	0	6 W	+174	.000	-----
29.5 NM	0	0	±180	.000	-----

conditions. The Moon's brightness or magnitude is thus rarely tabulated.

HOW THEY'RE RELATED

All the quantities described so far are related to each other. If we assume that the Moon's angular velocity is constant throughout a lunation, the relationships are fairly straightforward, and are as listed in *Table 1* (above). It is useful to know where to find these values for a particular date. The annual *Astronomical Almanac* tabulates age and phase coefficient, while the annual *A.L.P.O. Solar System Ephemeris* gives the phase angle. Some ephemeris computer programs, such as *Voyager*, allow one to find solar elongation and phase coefficient for any place and time.

SOLAR LATITUDE AND COLONGITUDE

The quantities discussed above describe the lighting conditions for the Moon as a whole. They can only imperfectly describe the lighting conditions relative to the features of the Moon's surface. The reason for this lack is that the whole-Moon quantities are based on our view from the Earth, and the Moon "wobbles" up to about 8° east-west and 7° north-south in relation to the Earth. These wobbles are called the Moon's librations.

Thus, in order to accurately describe the direction of solar lighting on the Moon's surface itself, it is necessary to describe the Sun's position in terms of two lunar coordinates. The first is the north or south lunar latitude where the Sun is overhead; the full name for this is the *selenocentric solar latitude* (**b'**). Because the Moon's axis is tilted only 1°.6 in relation to its orbit around the Sun, the "seasonal" effects of changing solar latitude are significant only near the lunar poles. Also, this quantity changes very slowly; so, to 0°.1 accuracy one need not interpolate for time of day.

The second coordinate is, of course, the Sun's lunar longitude. Rather than giving the lunar longitude where the Sun is overhead, the convention is to give the lunar longitude, on the equator, where the Sun is rising. That longitude, called *solar selenocentric colongitude*, is measured 0°-360° westwards (in the IAU sense; toward Oceanus Procellarum) from the Moon's central meridian. Symbolized **C**, the colongitude is *approximately* 270° at New Moon, increases to 360° (i.e., 0°) near First Quarter, is close to 90° for Full Phase, and about 180° at Last Quarter.

Thus, to a good approximation, colongitude gives the position of the Moon's *terminator*, which is the line of sunrise or sunset. To convert colongitude into terminator longitude, use the following formulae, where east and west are in the IAU sense:

Phase	Sunrise Longitude	Sunset Longitude
LQ-FQ	E. Long. = 360° - C	W. Long. = C - 180°
FQ-LQ	W. Long. = C	E. Long. = 180° - C

For most lunar observations, it is desirable to include the current colongitude as part of the records. Both annual ephemerides, the *Astronomical Almanac* and the *A.L.P.O. Solar System Ephemeris*, give colongitude for 0h UT for every day of the year. All you need do is to interpolate the value for your actual time of observation. This can be done in either of two ways, as is shown here for the example of 1992 FEB 07, 06h 16m UT. For reference, the *A.L.P.O. Solar System Ephemeris: 1992* gives the colongitude at 0h UT on 1992 FEB 07 as 310°.48, and as 322°.66 for 0h UT on FEB 08.

1. Assume that colongitude advances uniformly at a rate of 0°.508 per hour; multiply this by the elapsed hours and add to the 0h UT value:

C at 0h UT FEB 07........	310°.48
+6.27h × 0°.508/h...........	3°.19
C at 6h 16m UT............	313°.67

2. Convert the UT to fraction of a day and interpolate between the 0h UT values of the observation day and the next day.

Change in 24 hours = 322°.66
-310°.48
12°.18

Fraction of a day = 6.27h/24h
= 0.261d

C at 0h UT FEB 07......... ..	310°.48
+12°.18/d × 0.261d...........	3°.18
C at 6h 16m UT................	313°.66

Although the second method appears more complicated, the writer has found it to be actually the simpler if a calculator with memory is used. It is also more accurate than the first method because the rate of colongitude change actually varies from day to day. Note that the two methods give answers that differ by 0°.01. In reality, this difference is usually not significant because the light source we are concerned with, the Sun, has an angular diameter of about 0°.5, blurring the terminator to that extent. Thus, we customarily round colongitude (as well as phase angle and elongation) to the nearest 0°.1.

APPENDIX: SOLAR ALTITUDE AND AZIMUTH

In terms of lunar lighting, most observers need be concerned only with the calculation of colongitude. If one is studying a particular feature under low lighting, it may be of interest to know the Sun's altitude above the lunar horizon at that particular place. It is necessary to know this quantity if one is conducting lunar photometry or is determining the relative altitudes of lunar features by measuring the lengths of their shadows. Indeed, in the latter case, one also needs to calculate the Sun's azimuth in order to calculate the coordinates of the shadow tip.

In order to calculate the Sun's local altitude and azimuth we need to know the selenocentric solar latitude, **b'**, and the colongitude, **C**. In addition, we must know the lunar latitude, **b**, and longitude, **L**, of the feature in question. These values are all expressed in degrees, with the convention that north and IAU east are positive; and south and IAU west negative. They should be obtained from a catalog of lunar formations or from a large-scale lunar map Then, letting **A** represent the solar altitude:

let: $\Delta L = C - 90° + L$

then: $\sin A = \sin b \sin b' + \cos b \cos b' \cos \Delta L$

As an example, suppose that we observe a lunar dome in Mare Fecunditatis at latitude 3°.4N, longitude 48°.6E at 06h 16m UT, 1992 FEB 07. As before, C = 313°.7. From the *A.L.P.O. Solar System Ephemeris* we also find the solar latitude, **b'** = +1°.0.

First: $\Delta L = 313°.7 - 90° + 48°.6$
$= 272°.3$

Second: $\sin A = (\sin +3°.4)(\sin +1°.0) +$
$(\cos +3°.4)(\cos +1°.0)(\cos 272°.3)$

$\sin A = (+0.0593)(+0.0175) +$
$(+0.9982)(+0.9998)(+0.0401)$

$\sin A = +0.0010 + 0.0400$

$\sin A = +0.0410$

$A = +2°.3$

The Sun's local azimuth, **Az**, is found from the same quantities by the formulae below. The convention for measuring azimuth is that north is 0°; east, 90°; south,180°; and west has an azimuth of 270°.

$\sin Az = -\sin \Delta L \cos b'/\cos A$

$\cos Az = (\sin b' - \sin b \sin A)/(\cos b \cos A)$

We give formulae for both the sine and cosine of the azimuth in order to resolve any ambiguity as to in which quadrant Az falls. Actually, the cosine formula suffices as long as we remember that the azimuth will lie between 0° and 180° in the lunar morning, and between 180° and 360° in the lunar afternoon.

Continuing with our example:

$\sin Az = -(\sin 272°.3)(\cos +1°.0)/(\cos +2°.3)$

$\sin Az = -(-0.9992)(+0.9998)/(+0.9992)$

$\sin Az = +0.9998$

$Az = +89°.1 \text{ or } +90°.9$

$$\cos Az = \frac{(+0.0175) - (+0.0593)(+0.0410)}{(+0.9982)(+0.9992)}$$

$\cos Az = (+0.0175 - 0.0024)/(+0.9974)$

$\cos Az = +0.0151/+0.9974$

$\cos Az = +0.0151$

$Az = +89°.1 \text{ or } -89.°1$

Comparing the two results, it is clear that the solar azimuth must be equal to 89°.1. This is what we would expect for morning lighting.

OUR READERS SPEAK: TELESCOPE SELECTION

Readers of our *Journal* have often suggested that we carry a letters column. Mr. Harry Jamieson's article on telescope choice in our last issue ("Getting Started: Telescope Selection," December, 1991, pp.181-183) has provided the impetus, generating the five letters that appear below. (They have been slightly edited for style; but not for content, for which the writers, and not the A.L.P.O., are responsible.)

I found Harry Jamieson's article on telescopes ["Getting Started: Telescope Selection." *J.A.L.P.O.*, Vol. 35, No. 4, Dec., 1991, pp. 181-183] very interesting, as well as the Editor's comments in response. Since the article was directed to the "serious lunar and planetary observer" [p. 181], I feel that two of the criteria that Mr. Jamieson used to judge the instruments should not be considered.

As the telescope is going to be used by an active observer, it will soon become totally familiar to the observer, no matter how many quirks or peculiarities it has. There may be some telescopes that take considerable use to master, but even the most complicated is not that hard to use. Therefore, I don't feel that ease of use is important in choosing a telescope for the serious observer.

Likewise, in a frequently used telescope, ease of maintenance should not be a factor. With modern telescopes, problems with the mount, drive, or controller would be equally likely with any type of telescope, leaving the optical system as the only difference. Even refractors and Schmidt-Cassegrains require cleaning and "tweaking," and Schmidt-Cassegrains occasionally have to be collimated. The collimation of Newtonian and classical Cassegrain telescopes is within the abilities of anyone. It really isn't some arcane art. A good set of collimating tools makes it easy, and some simple modifications to the mirror cell and secondary holder make the telescope hold collimation much better.

Other types of telescope were not mentioned, but certainly the Tri-Schiefspiegler in the 10-12 inch aperture range can produce superb, color-free images, and would be much cheaper and more portable than a 10-12 inch refractor. Even buying the optical components of the Tri-Schiefspiegler and having the tube assembly and mount built for you would be cheaper than buying, mounting and housing a comparable refractor.

Another possibility would be a large Newtonian on a Dobsonian-type mount with an equatorial platform. This would give you portability and aperture. An aperture of 16-20 inches with an f/6 focal ratio could take advantage of sub-arcsecond seeing and be capable of superb images. A 16-inch Newtonian coupled with a CCD camera is used by Don Parker to make some of the finest planetary images ever produced *sans* spacecraft. (Don's 'scope is mounted on a massive equatorial mount.) This final choice, either permanently mounted or as a Dobsonian with a platform, would top my wish list.

Bob Grant
December 28, 1991

I should like to comment on the article by Harry Jamieson. In general I agree with his comments, but would like to clarify some areas I think are important.

The typical central obstruction of an 8-inch Schmidt-Cassegrain (S-C; also "SCT") from either major manufacturer is *35 percent* of the diameter. I know of no S-C with a 25-percent obstruction. For the Meade 10-inch, the ratio is 43 percent. Mr. Jamieson omits the Maksutov-Cassegrain type, which usually has a somewhat smaller central obstruction than the S-C. My 3.5-inch Questar has a 30-percent central obstruction. Both Questar and Carl Zeiss Jena manufacture 7-inch aperture Maksutov-Cassegrains, and Jena states that their 7-inch Maksutov-Cassegrain equals the performance of their Semi-Apochromatic 6-inch f/15 Observatory Coudé refractor.

Refractors are more portable than Mr. Jamieson states. Several models can be carried in one hand even when mounted. Long-focus traditional refractors can be optically folded if one builds a larger instrument oneself. My 3-inch f/15 Brandon refractor (*circa* 1954) weights 17 pounds; while my 4.25-inch Bausch and Lomb refractor, on a Unitron altazimuth mounting, weighs less than 40 pounds.

Reflective surfaces always scatter more light than do refractive surfaces, because metal coatings scatter more light by their very nature. For this reason, no successful reflecting coronagraph has ever been built for the study of the solar corona—all such instruments use refractive elements.

Regarding Barlow lenses—they should be used *if* the observer needs them even for high-power work; for example, if one has severe astigmatism. The Barlow preserves the original eye relief of a given ocular and may reduce the effects of aberration in certain eyepiece types. However, for *maximum* image fidelity, a short-focus eyepiece is preferable to a longer focus one because it usually has fewer air/glass surfaces. I prefer a top-quality 4-8 mm ocular over the equivalent combination of a Barlow and a longer-focus eyepiece.

Straight-through observing is preferable to using a prism or mirror diagonal, as it involves fewer optical surfaces. However, *if* the neck becomes constrained for positions high overhead, the carotid arteries may be constricted, reducing blood flow and oxygen to the brain. This may lead to fatigue and a loss of some image sensitivity—far greater than the loss due to the diagonal.

Long-focus instruments of *any type* are preferable to shorter-focus ones, even if apertures and optical quality are equal. This is because a long-focus instrument has a large depth of focus when compared with a short-focus one. The minute focus changes caused by atmospheric turbulence have far less effect on an image in long-focus systems than in short ones. An f/15 telescope has a depth-of-focus range of 0.020 inch compared to only 0.0022 inch in an f/5. The longer-focus system tolerates these "excursions" in seeing much better with less need to refocus. I once had a superb 6-inch f/5, ±1/20 wave Newtonian with a small diagonal. The image was almost always changing focus at 180X, requiring constant refocusing, while a 6-inch f/15 refractor alongside had very steady images with an only occasional need to refocus. This fact has long gone unrecognized in instrument performance, but was pointed out by the late optical expert Robert E. Cox almost 30 years ago.

Nothing is said about eyepieces. Many highly touted eyepieces today give *less* performance on the Moon and planets than eyepieces 30-50 years old. A modern wide-angle eyepiece, often available in shorter focal lengths, may have 7 or 8 elements, some quite thick, and 8 or 10 air/glass surfaces. They frequently transmit 10 to 20 percent less light than an equivalent focal length eyepiece with 3 or 4 elements and 4 air/glass surfaces. These modern wide-angle eyepieces also have numerous internal reflections and ghost images visible when used on bright objects, some so badly that the scattered light washes out the "earthshine" on the non-illuminated portion of the Moon!

For best results and maximum contrast, an eyepiece of *top* quality using no more than 3 or 4 elements and a *maximum* of 4 air/glass surfaces gives superior performance. Such eyepieces necessarily will have a smaller field of view.

I use *top quality* Abbé orthoscopics or "solid" eyepieces like my 10-mm modified Coddington (made at the Frankford Arsenal in World War II) or my 9-mm Zeiss Monocentric from the 1930s. All these oculars produce extremely dark fields and maximum light transmission and contrast. Some observers are currently fabricating specialized solid oculars from Hastings Triplet lenses or Steinheil Triplet lenses offered by Edmund Scientific, Barrington, New Jersey, or Rolyn Optics in Covina, California. They have fields of just 25°-30°, but outperform any modern wide-angle eyepiece for lunar and planetary observing.

Multicoatings (m.c.) on eyepieces are a mixed blessing. Some 2-layer m.c. currently used on eyepieces scatter 5-6 percent of the light from each m.c. surface between 4000-5000Å in the visual spectrum, which drops to about 0.5 percent between 5000-7000Å; but since blue light is scattered more than yellow or red, the damage is already done. Note that the "average" scatter from bare uncoated glass is 3-4 percent. My standard MgF2-coated 6-mm Jena Abbé orthoscopic has a much dimmer reflection than a 5-mm Nikon fully-m.c. Abbé orthoscopic when both are tested on a nearby mercury vapor floodlight. An eyepiece has to have *every* air/glass surface m.c. for best results, but most have such coating on only one or two external surfaces at best.

It does not make much sense to demand excellent quality optical systems and then equip them with unsuitable eyepieces that reduce their performance potential. Also, the wrong eyepieces will have more of an effect on image quality than an "inferior" eyepiece used with a Barlow lens. An optical system is no stronger than its weakest link! It is ironic that may who would never use a Barlow instead use "modern" wide-angle eyepieces that have a built-in (dedicated) Barlow lens!

Rodger W. Gordon
December 30, 1991

I found Mr. Jamieson's article ("Getting Started: Telescope Selection") quite useful as a guide for selecting a planetary telescope. However, I feel that he failed to emphasize aperture as the single most important factor in telescope performance, assuming high-quality optics.

For example, an 8-inch SCT would be a better choice as a planetary 'scope than a 3-inch refractor.

From personal experience, I have found that an obstructed light-path telescope will be about equal in performance to a refractor whose aperture is equal to the obstructed telescope's aperture minus the diameter of the obstruction. Hence an 8-inch f/10 SCT will perform about as well as a 5-inch refractor, while the typical 6-inch f/8 Newtonian will do slightly worse.

While it is true that refractors deliver the best image per inch of aperture, it is also true that most Newtonians and SCTs deliver more aperture per dollar spent. In many cases, a large obstructed aperture will deliver a better planetary image than a smaller unobstructed one.

Karl Fabian
January 5, 1992

The recent article by Harry Jamieson on telescope selection for lunar and planetary observation was on balance quite good and fairly represented the general consensus of opinion regarding the performance of the three major types of telescopes. However, there are several areas where further explanation to the beginner might be apropos.

First, Mr. Jamieson failed to consider the Maksutov-Cassegrain form of catadioptric telescope (MCT). While the primary instrument of this design that is currently manufactured carries a rather high price tag (about $800-900 per inch of aperture), the instrument offers superb optical performance and compares favorably with high-quality refractors, as stated in the A.L.P.O.'s own *Saturn Handbook* (pp. 6-7). There have been excellent drawings of Saturn published in *The Strolling Astronomer* which were made by an observer using a 3.5-inch MCT. It would seem to me, therefore, that for an observer with the money to buy a first-rate fully-equipped 4-inch apochromatic refractor, but a desire for the ultimate in portability, the 3.5-inch MCT would be a good tradeoff. (Note that it comes with eyepieces and a clock drive.)

Second, the comment that the observer should choose "a relatively-long focal ratio, at least f/7" (p. 181) so as to avoid the necessity for using a Barlow lens, is really too general a statement and may not be applicable in many cases. For example, a 4-inch f/7 refractor has a focal length of only a little over 700mm, and would require a 4-mm eyepiece to achieve a magnification of 175X. If you have ever tried to use a 4-mm eyepiece, you will probably agree with me that it is far better to use a 7-mm eyepiece and a high-quality 1.8X Barlow in such a case than to squint and strain through a tiny opening with minimal eye relief, not to mention an exit pupil of less than 0.6mm. With the 7-mm eyepiece, the eye relief is much better and the exit pupil is 1mm, which is the exit-pupil diameter considered by many to give maximum planetary detail. [The last point is incorrect, as Mr. Bock acknowledges in a later letter; the exit pupil would be 0.6mm with the Barlow/7-mm eyepiece combination, as it is a function of only the telescope aperture and the magnification. Ed.] And, to be a little subjective, the observer and his eye will be more relaxed if not squinting, and may see as much through the Barlow as through the 4-mm eyepiece under strain. Naturally, if the focal length of the telescope will provide high magnification with reasonable eyepiece focal lengths (I prefer not less than 6mm), so much the better; but, if not, the observer shouldn't shun the Barlow out of hand.

Third, Mr. Jamieson has fallen into the trap which so often ensnares those who attempt to do some type of objective analysis of performance; he has used the terms "worst," "best," and "medium" without telling us quantitatively what these mean. In *Astronomy* or *Sky & Telescope* such vague terminology might be expected (probably more so with the former than the latter), but in the *J.A.L.P.O.* I think we can do better. Why not choose three objects (the Moon, Saturn or Jupiter, and a close binary pair, for example) and observe each with different instruments at roughly the same magnification, under excellent seeing conditions? It would be difficult to have equal sizes of instrument, but two classes of size might be sufficient. For example, "Class 1" could include a 4-inch SCT, a 3.5-inch MCT, a 4-inch refractor, and a 6-inch Newtonian. "Class 2" might contain an 8-inch SCT, a 6-inch refractor, and an 8- or 10-inch Newtonian. Rank the images for each object on a scale of 1 to 10, using the descriptions of seeing conditions 1 to 10 (suitably modified for this application) as a guide. The results would indicate not only which telescope was "better" or "worse," but by how much and on which objects. This might be more meaningful to someone trying to choose an instrument; answering, for example: (1) How much a factor of 1.5 improvement on planets will cost in dollars; or (2) How much image quality is being sacrificed for portability.

Finally, both the Editor and Mr. Jamieson mention the newer apochromatic refractor designs, but the disadvantages (other than cost) are not discussed. Three-element all-glass apochromats take a long time to stabilize their temperature, a factor that will reduce observing time for those who have only limited hours to observe (especially on weekdays!), unless the instrument is housed in a permanent observatory. Also, fluorite elements are somewhat fragile thermally and mechanically, and are easily damaged by moisture, so considerable caution is needed to protect the instrument. A crown-flint doublet, on the other hand, is the nearest thing there is to indestructible in a telescope (assuming that the flint is on the inside, of course), and modern lens-figuring formulae and glass can produce instruments of relatively fast focal ratios (5-in f/10, 6-in f/12, and so forth) with well-controlled chromatic aberration; not eliminated, mind you, but certainly not intrusive. Also, such lenses are noticeably less expensive than apochromats.

Actually, I thought "Telescope Selection" quite a good article, Harry, and I hope that you get a lot of feedback on it from the readers. Such ideas and dialogue will benefit us all.

Paul H. Bock, Jr.
January 6, 1992

Here are some comments and observations in response to Harry Jamieson's stimulating article, "Getting Started: Telescope Selection," and the accompanying editorial remarks. I am glad to see the A.L.P.O. finally getting into this subject matter and hope that an "Equipment Review" section is not far behind.

During my now (shudder) 35 year-long career in amateur astronomy, I have had the opportunity of using almost every type of telescope available for all kinds of observational and photographic purposes; including lunar, solar, planetary and deep-sky. I have used literally the best and the worst, commercial and amateur-made, under superb and mediocre skies, and so forth. The main lesson from all this is really very simple; there are good and bad instruments, no matter what the reputation of the manufacturer, and when you look through one of excellent optical quality, it shows!

Having stated the obvious, however, let me address some specific points. The first is the classic controversy, reflectors versus refractors. There is no doubt that the optical quality of apochromatic refractors (APOs) available today is simply superb. The high-contrast, color-free images produced by these instruments are outstanding. This permits not only the use of higher than "traditional" levels of magnification, but also renders exceptionally crisp visual and photographic images. The cost per aperture is a major limiting factor, however, and 7- to 8-inch telescopes are likely to be the biggest most of us will ever see in this category. The litmus test, moreover, is still this: would I choose a significantly larger instrument of excellent quality over a smaller APO for lunar and planetary work? Every time! All things being equal, one "law" about telescopes remains constant: bigger is usually also better.

What about the traditional "achromatic" refractor? I used 3-, 4-, 5- and 6-inch instruments of this type for many years; visually and for black-and-white photography of the Moon and planets. Their contrast is good in general, but residual color can be quite a nuisance. Suitable filtration solves that problem nicely, however, and also reveals more elusive planetary detail. A light-yellow filter, for example, removes all residual blue color completely and enhances the contrast of many features on Mercury, Mars, Jupiter, and Saturn. Color photography can also be done through a minus-violet filter. Again, though, the cost per aperture is a limiting factor, and not too many of us can afford or house a really large f/15 refractor.

Returning to the "reflector versus refractor" question, I can state categorically that I have enjoyed some of the finest lunar and planetary views with classical Newtonians. A well-made 8- to 12-inch, f/6-f/7 reflector is an ideal, inexpensive photo-visual instrument, with completely achromatic, high-contrast images. Moreover, on a cost-per-aperture basis, the Newtonian remains without equal. Just witness the work of our distinguished colleague, Don Parker. It's "world class" and its's all done with a traditional f/6 reflector. Short-focus Dobsonians tend not to perform well with the Moon and planets, unless their optics are really tops and allow high magnification. Most do not.

What about the very-popular Schmidt-Cassegrain (SCT) and the perennial controversy over contrast and image deterioration introduced by its comparatively large central obstruction? Bogus, I say, in practice if not in theory. Let me address this point from a prime-user's perspective. I have done most of my visual and photographic work in recent years, both Solar-System and deep-sky, with SCTs. The reason for this is again very simple. SCTs are the ultimate "compromise" telescopes: compact, sturdy, portable, affordable and very good optically. They are rarely outstanding in any category; just very good all around.

Some qualifiers are in order. I have personally used and/or owned SCTs 5, 8, 10, 11, 12 and 14 inches in aperture. Some were classic instruments now no longer manufactured by Celestron. The early C-10 and C-12, for example, were long-focus f/12-f/13 telescopes optimized for lunar and planetary work. The diameter of their central obstructions, though, was still 30-40 percent of the aperture, well above "acceptable" levels. My present C-14 is of similar design. All these instruments performed very well indeed. Under excellent seeing and transparency, I have clearly resolved the disks of Jupiter's largest moons with the C-14, and have taken many resolution-limited [*diffraction*-limited? Ed.] photographs of Mars, Saturn and Jupiter. Though not "easy" by any means, the central star in M-57, and the Horsehead Nebula, have also been glimpsed with this telescope.

Why the controversy, then, over SCTs, and their reputation among many observers for low-contrast or "soft" optics? Again, a very simple reason. Some SCTs produced during the "heady" pre-Halley days were indeed of marginal optical quality. A rush by both Celestron and Meade to mass-produce telescopes at that time apparently led to a decline in quality control, and some lemons were sold. That trend appears to have reversed, however, and optical quality is again a prime selling feature. An interesting footnote in this regard, is that even such highly critical authors as Wallis and Provin feature numerous outstanding photographs taken with SCTs in their fine book, *A Manual for Advanced Celestial Photography* (Cambridge University Press, 1980).

At least two additional aspects warrant consideration: eyepieces and clean, properly collimated, optics. These factors are often overlooked or minimized in relation to telescope performance. Dusty or tarnished optics will always yield lower-contrast images, and improper collimation is even more detrimental. In that regard, too, I concur fully with the Editor's point; to never use diagonals for lunar and planetary work—always look straight through. Also, no matter how good the primary objective of your instrument may be, it must be matched by the eyepieces used, both for visual and photographic purposes. Until relatively recently, many commercial eyepieces were of considerably poorer quality than warranted, particularly with respect to contrast and eye-relief. That has changed dramatically during the past few years, thanks to multicoated lenses and new optical designs. I traded away all my old Kellners and short-focus Orthoscopics, and now use only the best eyepieces possible for Solar-System and deep-sky work alike.

Finally, it is well worth remembering that, no matter what your preference regarding telescopes, the best "quality" instrument is the one you take out and actually use! The more you do that, the more practiced you become and the more likely you are to catch those rare nights of outstanding seeing when your telescope performs beyond all expectations. That, in the end, is what it's all about.

Klaus R. Brasch
January 23, 1992

COMET CORNER

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

COMET ACTIVITY FOR 1991

The year 1991 saw 34 designated comets, which were more than for an average year. Among these were the following:

•Three new comet finds were by amateurs, and one of these was photographic.

•Sixteen new comets were found by professionals. Eleven of these discoveries were part of two different surveys taking place in both hemispheres; the Shoemaker-Levy team of Palomar Mountain found seven comets, while Robert McNaught of Australia found four.

•Fifteen returning comets were recovered. Four of these were initially thought to be discoveries of new comets. In one of those cases, the comet acquired the discover's name. Of the remaining recoveries, T. Seki of Japan recovered five, while Jim Scotti at Kitt Peak recovered four.

•Meanwhile, Comet Halley outburst early in 1991, and Periodic Comet Chernykh suffered a split nucleus.

COMET FINDS FOR THE SECOND HALF OF 1991

The following comets were discovered or recovered during the second half of 1991.

Periodic Comet Wirtanen (1991s).—T. Seki of Japan recovered this comet on 1991 JUL 08 at magnitude +17. It reached its closest point to the Sun at a distance of 1.0 AU [AU = Astronomical Unit; the Earth's mean distance from the Sun, about 149.6 million km] on 1991 SEP 21, brightening to magnitude +10.

Periodic Comet Hartley 2 (1991t).—T. Kryachko of the then USSR found what was first thought to be a new comet at magnitude +11 on 1991 JUL 09. It turned out that this was Periodic Comet Hartley 2, returning six days earlier than predicted, and thus five degrees off course. Over the succeeding six months, this comet brightened to magnitude +8.5, putting on a good show until the end of 1991.

Periodic Comet Arend (1991u).—T. Seki recovered this comet on 1991 AUG 01 when it was at magnitude +17. The comet did not get much brighter.

Comet McNaught-Russell (1991v).— Robert McNaught and Kenneth Russell of Australia discovered this 17th-magnitude object in early August, 1991, as part of the Earth-Crossing Object project. This comet will slowly approach to within 3.3 AU from the Sun in April, 1992, but it will not get much brighter.

Comet McNaught-Russell (1991w).— The same team found this comet on 1991 SEP 03 when it was at magnitude +18. Its orbit brings it to a very distant perihelion, 7.1 AU, so it is not getting brighter.

Periodic Comet Spacewatch (1991x).—T. Gehrels of Kitt Peak, using the 91-cm (36-in) Spacewatch telescope, discovered a very faint 21st-magnitude comet on 1991 SEP 08. This comet, which apparently is very small, has a short orbital period of 5.32 years and a perihelion distance of 1.58 AU.

Periodic Comet McNaught-Hughes (1991y).—Robert McNaught discovered this comet on a plate taken by S. Hughes. Its orbital period is 6.7 years and the comet got no brighter than magnitude +15.

Periodic Comet Shoemaker-Levy 5 (1991z).—Carol and Eugene Shoemaker and David Levy discovered this comet on plates that were exposed on 1991 OCT 02 with the 46-cm (18-in) Schmidt telescope on Palomar Mountain. The comet's orbital period is 8.6 years. It did not brighten more than to magnitude +16 as it approached perihelion at 1.98 AU in early December, 1991.

Comet Shoemaker-Levy (1991a1).—The same team found this comet four days later than the previous one. It will be closest to the Sun at 0.8 AU in July, 1992, when it should be visible in binoculars.

Periodic Comet Shoemaker-Levy 6 (1991b1).—In early November the same team found this comet. Early reports indicated that it was as bright as magnitude +11, but it faded rapidly. The orbital period is 7.5 years.

Periodic Comet Tsuchinshan 1 (1991c1).—T. Seki recovered this comet on 1991 NOV 08 when it was at magnitude +17 and fading.

Comet Shoemaker-Levy (1991d1).—This comet was discovered on 1991 NOV 08 when it was at magnitude +16 and already fading.

Periodic Comet Tsuchinshan 2 (1991e1).—Jim Scotti and D. Rabinowitz recovered this comet from Kitt Peak on 1991 DEC 03. It was then faint, at magnitude +21, and did not get much brighter.

Periodic Comet Kowal 2 (1991f1).—M. Ishikawa of Japan discovered this comet photographically at magnitude +14. It transpired that this was a previously-known returning comet, arriving 54 days earlier than predicted. The comet remained faint.

Comet Zanotta-Brewington (1991g1).— Mauro Zanotta of Italy discovered this comet on 1991 DEC 23. Howard Brewington picked it up 9 hours later. Zanotta found the comet with a homemade 15-cm (6-in) reflector at

25X. He had independently found Comets 1989a and 1990i also, but too late to receive credit. Brewington used his homemade 41-cm (16-in) reflector at 55X to find this 9th-magnitude object. He had searched for 228 hours since his previous find earlier in the year.

When found, the comet was in the western evening sky in the northern portion of the constellation Delphinus. It reached perihelion on 1992 FEB 01 at 0.64 AU. The comet failed to brighten much following discovery, but Southern-Hemisphere observers may try to view it through March of this year.

Comet Mueller (1991h1).—Jean Mueller discovered this comet on 1991 DEC 13 as part of the Palomar Sky Survey II. It was then at magnitude +17 in the morning sky. The orbit will carry the comet to within 0.20 AU of the Sun on 1992 MAR 21. As the comet is small, with an absolute magnitude of +13 [i.e., its magnitude if 1 AU from both the Earth and the Sun], it appears unlikely that it will be able to survive perihelion passage. However, if it does, it will be visible to Northern-Hemisphere observers in early April, 1992.

PRESENT COMET ACTIVITY

During the Spring and Summer of 1992, the following comets will be visible in our skies. Please send observations of them to this Recorder (address on inside back cover).

Periodic Comet Schwassmann-Wachmann 1.—This comet will occasionally outburst by several magnitudes. For example, in both early August and early December, 1991, it attained magnitude +12. This comet follows a near-circular 15-year orbit more than 5 AU from the Sun. Please report all positive *and negative* observations to this Recorder. [*Table 1*, right column]

Comet Helin-Lawrence (1991L).—Found nearly a year ago, this comet is dimming as it recedes from the Sun. [*Table 2*, right column]

Comet Shoemaker-Levy (1991d).—This comet has brightened by more than four magnitudes in the year since its discovery. The team of Carolyn and Eugene Shoemaker and David Levy found it as part of the Earth-Crossing Comet/Asteroid Discovery Program at Palomar Mountain. [*Table 3*, p. 32]

Comet Shoemaker-Levy (1991a1).—The same team discovered this comet on 1991 OCT 06. It will be closest to the Sun on 1992 JUL 24 at 0.84 AU. This comet will be circumpolar from the northern temperate latitudes during June and July, 1992. It should brighten to near magnitude +6. [*Table 4* and *Figure 9*, p. 32]

Comet Zanotta-Brewington (1991g1).—Found in late December, 1991 (see above), this comet is in the southern sky and is pulling away from both the Earth and the Sun. It may be slightly fainter than indicated below. [*Table 5*, p. 32]

Comet Mueller (1991h1).—This comet, also found in late December, 1991, is expected to pass within 0.2 AU of the Sun in late March (see above). Most comet experts believe that the comet will disintegrate by then. If it survives, look for it in the morning northern sky in the positions indicated in *Table 6* (p. 32).

EPHEMERIDES

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

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

1992 UT Date (0h UT)	2000.0 Coörd. R.A. h m	Decl. ° '	Elongation from Sun °		Total Mag.
MAR 04	03 22.2	+27 11	072	E	+17.7
09	03 25.0	+27 13	067	E	+17.7
14	03 28.0	+27 16	063	E	+17.7
19	03 31.1	+27 20	059	E	+17.7
24	03 34.5	+27 25	055	E	+17.7
29	03 38.0	+27 30	050	E	+17.8
APR 03	03 41.6	+27 36	046	E	+17.8
08	03 45.4	+27 42	042	E	+17.8
13	03 49.3	+27 49	038	E	+17.8
18	03 53.3	+27 56	035	E	+17.9
23	03 57.4	+28 03	031	E	+17.9
28	04 01.7	+28 11	027	E	+17.9
MAY 03	04 05.9	+28 19	023	E	+17.9
(Too close to the Sun for observation.)					
JUL 07	05 03.6	+29 54	028	M	+17.9
12	05 07.8	+30 00	032	M	+17.9
17	05 11.9	+30 06	036	M	+17.9
22	05 16.0	+30 12	040	M	+17.9
27	05 19.9	+30 18	044	M	+17.9
Aug 01	05 23.6	+30 23	047	M	+17.8
06	05 27.2	+30 28	051	M	+17.8
11	05 30.7	+30 33	055	M	+17.8
16	05 34.0	+30 38	059	M	+17.8
21	05 37.1	+30 43	064	M	+17.8
26	05 40.0	+30 48	068	M	+17.7
31	05 42.7	+30 52	072	M	+17.7

Table 2. Ephemeris of Comet Helin-Lawrence (1991L).

1992 UT Date (0h UT)	2000.0 Coörd. R.A. h m	Decl. ° '	Elongation from Sun °		Total Mag.
MAR 04	01 11.7	-33 44	041	E	+10.3
09	01 16.5	-30 36	038	E	+10.5
14	01 21.1	-27 43	035	E	+10.6
19	01 25.4	-25 02	033	E	+10.8
24	01 30.0	-22 33	030	E	+10.9
29	01 33.6	-20 14	028	E	+11.1
APR 03	01 37.4	-18 05	026	E	+11.2
08	01 41.1	-16 04	025	E	+11.3
13	01 44.7	-14 10	024	E	+11.5
18	01 48.1	-12 24	023	E	+11.6

(Too close to the Sun for observation.)

Table 3. Ephemeris of Comet Shoemaker-Levy (1991d).

1992 UT Date (0h UT)	2000.0 Coörd. R.A. h m	Decl. ° '	Elongation from Sun °		Total Mag.
MAR 04	19 53.6	+41 33	064	M	+11.3
09	20 04.2	+41 40	064	M	+11.4
14	20 14.0	+41 48	064	M	+11.4
19	20 23.2	+41 57	064	M	+11.5
24	20 31.6	+42 06	064	M	+11.5
29	20 39.3	+42 17	065	M	+11.6
APR 03	20 46.3	+42 29	065	M	+11.6
08	20 52.6	+42 41	066	M	+11.7
13	20 58.2	+42 54	067	M	+11.7
18	21 03.1	+43 07	068	M	+11.8
23	21 07.4	+43 20	070	M	+11.8
28	21 10.9	+43 33	072	M	+11.9
MAY 03	21 13.7	+43 45	074	M	+11.9
08	21 15.7	+43 56	076	M	+11.9
13	21 17.1	+44 06	078	M	+12.0

Table 4. Ephemeris of Comet Shoemaker-Levy (1991a_1).

1992 UT Date (0h UT)	2000.0 Coörd. R.A. h m	Decl. ° '	Elongation from Sun °		Total Mag.
APR 13	00 41.2	+35 35	028	M	+12.5
18	00 44.8	+36 40	029	M	+12.3
23	00 48.6	+37 53	030	M	+12.1
28	00 52.6	+39 13	032	M	+11.8
MAY 03	00 56.8	+40 43	034	M	+11.6
08	01 01.3	+42 22	036	M	+11.3
13	01 06.1	+44 14	038	M	+11.0
18	01 11.4	+46 19	041	M	+10.7
23	01 17.3	+48 41	043	M	+10.3
28	01 24.2	+51 22	045	M	+10.0
JUN 02	01 32.5	+54 28	047	M	+9.7
07	01 43.3	+58 04	050	M	+9.3
12	01 58.5	+62 14	052	M	+8.9
17	02 22.6	+67 05	054	M	+8.4
22	03 07.0	+72 28	055	M	+8.0
27	04 45.6	+77 27	055	M	+7.6
JUL 02	07 50.6	+77 55	055	E	+7.2
07	10 06.1	+70 50	055	E	+6.9
12	11 04.7	+59 49	054	E	+6.7
17	11 32.7	+47 34	052	E	+6.6
22	11 47.9	+35 38	051	E	+6.6
27	11 56.9	+24 58	049	E	+6.8
AUG 01	12 02.5	+15 53	047	E	+7.0
06	12 06.1	+08 21	045	E	+7.3
11	12 08.4	+02 06	043	E	+7.7
16	12 10.1	-03 07	040	E	+8.0
21	12 11.4	-07 33	038	E	+8.4
26	12 12.4	-11 22	035	E	+8.7
31	12 13.4	-14 43	033	E	+9.1

Table 5 Ephemeris of Comet Zanotta-Brewington (1991g_1).

1992 UT Date (0h UT)	2000.0 Coörd. R.A. h m	Decl. ° '	Elongation from Sun °		Total Mag.
MAR 24	04 02.8	-65 56	079	E	+10.7
29	04 43.4	-67 24	083	E	+11.0
APR 03	05 27.7	-68 12	088	E	+11.3
08	06 13.6	-68 17	092	E	+11.6
13	06 58.4	-67 42	096	E	+11.9
18	07 39.7	-66 30	099	E	+12.2

Table 6. Ephemeris of Comet Mueller (1991h_1).

1992 UT Date (0h UT)	2000.0 Coörd. R.A. h m	Decl. ° '	Elongation from Sun °		Total Mag.
MAR 24	23 36.4	-05 24	012	M	+6.7
29	23 18.6	+04 53	018	M	+8.6
APR 03	23 12.8	+15 03	026	M	+10.0
08	23 12.3	+24 27	033	M	+11.1
13	23 14.8	+33 02	039	M	+12.0
18	23 19.0	+40 49	044	M	+12.7

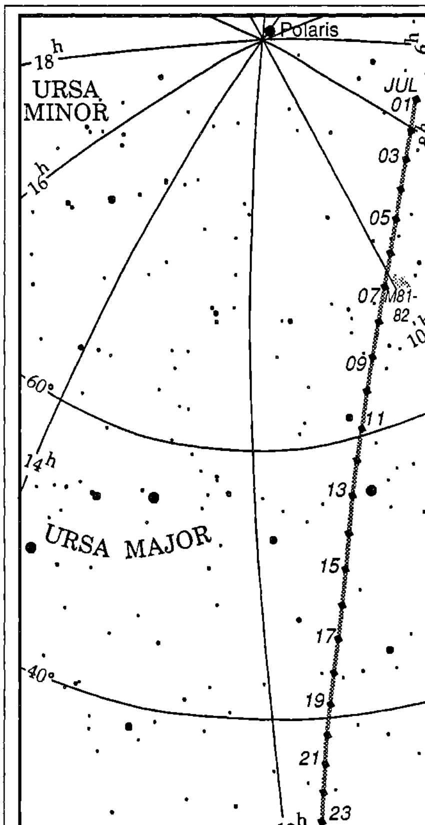

Figure 9. The path of Comet Shoemaker-Levy 1991a1 through the constellations of Ursa Minor and Ursa Major at 1-day intervals for 1992 JUL 01-23. Limiting magnitude +6.

COMING SOLAR-SYSTEM EVENTS: MARCH-MAY, 1992

WHAT TO LOOK FOR

The purpose of this column is to alert our readers about upcoming events in the Solar System; giving the visibility conditions for major and minor planets, the Moon, comets, and meteors. You can find more detailed information in the 1992 edition of the *A.L.P.O. Solar System Ephemeris*. (See p. 48 to find out how to obtain this publication.) Celestial directions are abbreviated. All dates and times are in Universal Time (UT). For the time zones in the United States, UT is found by adding 10 hours to HST (Hawaii Standard Time), 9 hours to AST (Alaska Standard Time), 8 hours to PST, 7 hours to MST, 6 hours to CST, and 5 hours to EST. Note that this addition may put you into the next UT day!

PLANETS: ESPECIALLY JUPITER

There are now few planets to view in the evening, although Mars and Saturn are becoming visible longer in the mornings.

Jupiter remains in Leo and is visible nearly all night because it was at opposition very recently; 1992 FEB 29. On that date, the Giant Planet's disk measured 45 by 42 arc-seconds. At magnitude -2.45, it was the brightest object in the night sky, except for the Moon and Venus. Although we are now pulling away from the Giant Planet, and its disk gradually shrinks to 36 by 34 arc-seconds on June 1st, its visual magnitude then will still be -1.9, brighter even than Sirius. At declination 9° to 11° N, it remains well-placed for the Northern Hemisphere, although it is moving S every year now.

Besides their normal pageant of eclipses, transits, occultations, and shadow transits, the **Galilean Satellites** of Jupiter experience the last *mutual events* of the 1990-1992 series. The following six events are scheduled:

- MAR 22, 08:08-09:32. Europa eclipses Ganymede (annular; 36% light loss).
- MAR 22, 15:17-15:22. Europa eclipses Ganymede (graze; 0% light loss).
- MAR 29, 09:26-10:43. Europa occults Ganymede (annular; 23% light loss).
- MAR 29, 16:37-16:53. Europa occults Ganymede (graze; 0% light loss).
- APR 05, 02:14-03:08. Europa eclipses Ganymede (partial; 23% light loss).
- APR 12, 05:02-05:49. Europa occults Ganymede (partial; 22% light loss).

Mars is now pulling slowly away from the Sun in the morning sky and is visible as a reddish star as it moves from Capricornus to Aquarius to Pisces. It will brighten slightly from visual magnitude +1.2 on March 1st, when 32° west of the Sun to +0.9 on June 1st, at 51° from the Sun. Its disk diameter grows only from 4.3 to 5.3 arc-seconds during the same period, rather small to see many details. A phase defect (on the W or preceding limb) should become gradually more evident, however, with the fraction illuminated dropping from 97 percent on March 1st to 91 percent on June 1st. On the positive side for Northern-Hemisphere observers, the Red Planet is moving northward 26° during these three months, ending at declination 7° N on June 1st.

Saturn, in Capricornus, is now a reasonable object to observe before dawn; it moves from only 28° W of the Sun on March 1st to 112°W on June 1st. Although its visual magnitude stays in the range +0.6 to +0.8, its disk size grows from 15 by 14 to 17 by 16 arc-seconds. The tilt of the Ring System with respect to us is slowly diminishing from 17°N to 15° N, making its minor axis a fairly constant 10 arc-seconds, while its major axis expands from 35 to 40 arc-seconds. Although still above our Southern Hemisphere, Saturn does move N by 2° during this three-month interval, ending at declination 16°S.

Saturn's "variable" moon, **Iapetus**, is also of interest about now because its orbit, significantly tilted with respect to Saturn's Ring Plane and the orbits of the other satellites, makes it appear to pass near the planet from our viewpoint. The first occasion is the 11th-magnitude satellite's superior conjunction on 1992 MAR 29, 22.9h, when it will pass 7.9 arc-seconds N of the Ball's N limb. An even closer passage occurs at the inferior conjunction on 1992 MAY 08, 00.2h, with Iapetus passing just 3.5 arc-seconds S of Saturn's S limb.

The remote planets **Uranus** and **Neptune** are both in Sagittarius, about 25-30° west of Saturn, and are thus that much farther from the Sun in the morning sky. By June 1st, their respective magnitudes are +5.6 and +7.8, and their disk diameters 3.8 and 2.3 arc-seconds.

Even if 14th-magnitude **Pluto** is not an easy object, this is the best season to attempt finding it. It reaches opposition with the Sun on 1992 MAY 12, at declination 3°.4 S near the Serpens-Libra border.

Unlike most of the rest of the Solar System, **Venus** is becoming less easily visible as it draws toward the Sun, approaching from 27°W on March 1st to only 3°W on June 1st; it is in superior conjunction on 1992 JUN 13. At such times, the planet's disk shrinks (down from 11.4 to 9.6 arc-seconds), while its phase changes from Gibbous to Full (growing from 90 to 100 percent illuminated).

If we define a "visibility period" for **Mercury** as the time interval when the planet is farther than 15° from the Sun, such a period occurs in the evening sky between 1992 MAR 02-17 At Greatest Eastern Elongation on 1992 MAR 09, it is just 18° from the Sun, but it is almost directly above the Sun from the northern mid-latitudes just after sunset. Its date of *dichotomy* (theoretical half-phase) is 1992 MAR 08, 22h, although the date when an inner planet appears half-illuminated often differs from that predicted. The next viewing opportunity is during 1992 APR 05-MAY 18, with a Greatest Western Elongation (morning) of 27° on 1992 APR 23 and theoretical dichotomy on 1992 APR 26, 20h.

PLANETARY CONJUNCTIONS

Only two close planetary conjunctions will take place this Spring, and only one is observable, but then the two planets will be close enough together that they can be compared in a medium-power telescope field.

- MAR 06, 13h. **Mars** (Mag. +1.2) passes 26' N of **Saturn** (Mag. +0.8). Both are 33° W of the Sun.

The unobservable planetary conjunction is that between Mercury and Venus on May 28th, when both are only 4° W of the Sun.

MINOR PLANETS

Six of the brightest of the **minor planets** reach opposition in our period. Their 10-day ephemerides are given in the 1992 edition of the *A.L.P.O. Solar System Ephemeris*, and their opposition data are given below:

	Opposition Data		
Minor Planet	1992 Date	Stellar Magnitude	Declination& Constellation
4 Vesta	MAR 13	+6.0	15°N Leo
12 Victoria	APR 13	+10.0	17°S Vir
15 Eunomia	APR 17	+9.8	29°S Hya
11 Parthenope	MAY 01	+9.7	07°S Vir
9 Metis	MAY 27	+9.6	21°S Sco
532 Herculina	MAY 31	+9.1	04°S Oph

Besides the objects above, the remaining three of the "Big Four" minor planets, **1 Ceres, 2 Pallas**, and **3 Juno** will be brighter than Mag. +10 during at least part of the current period, along with **8 Flora**, **14 Irene**, and **20 Massalia**.

THE MOON

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

New Moon	First Quarter	Full Moon	Last Quarter
MAR 04.6	MAR 12.1	MAR 18.8	MAR 26.1
APR 03.2	APR 10.4	APR 17.2	APR 24.7
MAY 02.7	MAY 09.6	MAY 16.7	MAY 24.7

The three lunations listed above constitute Numbers 856-858 in Brown's series.

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

South	West	North	East
MAR 06	MAR 10	MAR 19	MAR 23
APR 03	APR 05	APR 15	APR 19
APR 30	MAY 02	MAY 13	MAY 16
MAY 27	MAY 29	JUN 09	JUN 12

Lunar E and W directions here follow the usage of the International Astronomical Union, with Mare Crisium near the *east* limb. Favorable libration-lighting conditions for viewing the NE limb occur on MAR 19-21, APR 18-20, and MAY 17-18. Likewise, the SW limb will be well-presented on MAR 30-APR 01, APR 28-30, and MAY 27-30. Worthwhile dates for viewing the lunar N polar area are MAR 17-22, APR 13-18, and MAY 10-15.

PLANETARY AND LUNAR OCCULTATIONS

Three major, and eighteen minor, planets will occult stars in 1992 MAR-MAY, as shown in *Table 1* (p. 35) which lists the date, occulting object, visual magnitude of planet followed by that of the star, and *possible* zone of visibility for each occultation. Note that naked-eye stars will be occulted in the APR 30 and MAY 06 events.

The Moon passes in front of no bright planets during the period covered here, but note that there is a very difficult occultation of Mercury by the Moon, less than 1° from the Sun, on 1992 JUN 01, described in a separate article on p. 14.

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

PARTIAL LUNAR ECLIPSE: 1992 JUN 15

Although outside the time period covered in this article, here is advance notice of the partial lunar eclipse of 1992 JUN 15. The entire event will be visible from the E United States and Canada, most of Mexico, and Central and South America. Also, the earlier portions of the event will be seen from central, western, and southern Europe; Africa, and the Levant. The later phases of the eclipse will be visible from the remainder of N America, Hawaii, New Zealand, and E Australia.

At mid-eclipse, the N 68.7 percent of the Moon will be covered by the Earth's umbral shadow. The predicted times of the eclipse *contacts* are:

First Penumbral Contact	**02h**	**09.1m**
First Umbral Contact	**03**	**26.6**
Mid-Eclipse	**04**	**57.0**
Fourth Umbral Contact	**06**	**27.2**
Fourth Penumbral Contact	**07**	**44.9**

In a partial lunar eclipse, there are no Second or Third Umbral Contacts, the partial umbral phase falling between the First and Fourth Umbral Contacts. The penumbral phases fall between the First Penumbral Contact

Table 1. Occultations of Stars by Planets, 1992 MAR-MAY.
(For further information, consult the A.L.P.O. Solar System Ephemeris: 1992 or Sky & Telescope, January, 1992, p. 76.)

1992 UT Date	Occulting Object	Visual Mag. Occulter	Star	Predicted Visibility Zone
MAR 09.95	**31 Euphrosyne**	+13.2	+9.1	E Africa
10.17	**VENUS**	-3.9	+8.7	Africa
12.71	**38 Leda**	+13.4	+7.8	E Africa
13.54	**47 Aglaja**	+13.1	+9.1	N Australia
17.27	**34 Circe**	+13.2	+8.8	Florida, Bahamas, NW Africa
20.16	**175 Andromache**	+13.8	+9.5	SW Europe
26.49	**409 Aspasia**	+11.2	+8.7	Indonesia, NE Australia, S I. New Zealand
APR 09.95	**144 Vibilia**	+13.0	+8.7	N India, Middle East
12.46	**154 Bertha**	+11.9	+8.8	Florida, S Mexico, SE Australia
13.38	**184 Dejopeja**	+12.6	+7.0	Caribbean, Mexico
14.41	**276 Adelheid**	+13.3	+8.9	W Pacific, New Zealand
18.16	**44 Nysa**	+10.7	+9.0	SW U.S.A., N Caribbean
30.78	**MARS**	+1.0	+5.5	SW Pacific, E Australia, New Zealand
MAY 05.31	**410 Chloris**	+11.5	+9.4	S South America
05.48	**804 Hispania**	+12.4	+8.8	Australia, N I. New Zealand
06.10	**429 Lotis**	+14.0	+4.8	S Brazil, Peru, Mexico?
08.93	**1093 Freda**	+12.8	+8.0	Africa
15.48	**914 Palisana**	+12.2	+7.0	Antarctica, SW Canada
21.26	**PLUTO**	+13.7	+13.5	North America, South America?, Hawaii?
23.14	**84 Klio**	+12.7	+8.7	S South America
26.99	**233 Asterope**	+12.2	+9.3	Africa
30.10	**175 Andromache**	+12.5	+7.7	S Africa, Argentina, Chile

and the First Umbral Contact, as well as between the Fourth Umbral Contact and the Fourth Penumbral Contact.We plan more extensive coverage of this event in the next issue of this Journal.

COMETS

The column by Don E. Machholz, "Comet Corner," on pp. 30-32, and the *A.L.P.O. Solar System Ephemeris: 1992* list eleven known comets that will be visible during at least part of this period. Of these, **Comets Shoemaker-Levy (1991d), Helin-Lawrence (1991L), Chernykh (1991o), and Shoemaker-Levy (1991a1)** should be readily visible in amateur instruments under dark skies.

METEOR SHOWERS

(Contributed by Robert D. Lunsford, A.L.P.O. Meteors Recorder)

The beginning of our period is past the peak of the **Delta Leonids**, on February 28, but some shower activity can be expected as late as March 19th.

The **Lyrids** peak on the morning of April 21st, with interference from a bright waning gibbous Moon (age 18 days), and with a duration of only 2 days. Under these conditions, expect to see no more than 5 meteors per hour at best.

The **Eta Aquarids** will peak under much more favorable circumstances during the first week of May. [The *A.L.P.O. Solar System Ephemeris* forecast is for maximum on MAY 03.2 UT, with a duration of 3 days. Ed.] The peak rate that one may see depends upon one's latitude. Observers in the N United States and Europe may see between 10 and 15 per hour. Observers in more temperate latitudes can expect 30 per hour. From the Southern Hemisphere, the Eta Aquarids are the richest annual stream, producing a meteor per minute near the peak. These meteors are very swift and have the highest percentage of trains of the annual major showers. The best time to look for them is during the last two dark hours before dawn.

Looking forward to June, two of the strongest daylight showers reach their maximum strength near June 7th. Although these showers, the **Arietids** and **Zeta Perseids,** reach their highest altitude in the sky at about 10 AM local time, stream members may be seen radiating from low in the NE just before the onset of morning twilight. The combined zenithal hourly rate for these two showers would be nearly 100 per hour were they visible when their radiants are on the meridian.

Another strong daylight shower, the **Beta Taurids**, peaks on June 29th. These meteors consist of debris from Comet Encke and may have produced the Tunguska event [a major impact or "air burst" in Siberia] earlier this century. Again, if any of these stream members are visible, they will be seen radiating from the NE horizon just before the start of morning twilight.

Book Review

Edited by José Olivarez

The Sky: A User's Guide.
By David H. Levy. Cambridge University Press, 40 West 20th Street, New York, NY 10011. 1991. 282 pages, index. Price $24.95 cloth (ISBN 0-521-39112-1).

Reviewed by Craig MacDougal.

The subtitle of this book, "A User's Guide," may bring to mind the user's guide that comes with most computer software. Depending upon one's experience with computer software, this can have a positive or a negative connotation. However, regardless of your past experience with "User's Guides," you have no need to fear this one. The writing is clear and the style is downright friendly.

The Sky is laid out in six parts, which are subdivided into a total of 24 chapters. Part 1 is called "Getting started," and begins with simple observing projects that require only your eyes. It ends with a good section on choosing a telescope and an exhortation on recording your observations. The author uses some personal examples of his own records, but states, "For our first purpose, any sort of record that you understand is probably sufficient."

Part 2 is titled "Moon, Sun and planets." It presents fairly detailed instructions on how to observe these bodies. The author starts with the Moon, the easiest of these objects to observe, and moves on in order of difficulty. Similarly, for each body you are presented with some relatively easy features to observe, followed by some more advanced projects.

Part 3 is "Minor bodies," which deals with asteroids and comets. Part 4 is titled "Deep sky." It starts with double stars, then moves on to variables, and then on to the "fuzzier things" that are out there, followed by the techniques of astrophotography. Part 5 is "Special events," which splendidly covers eclipses and occultations. Part 6 is titled "A miscellany." The first section in it is "Passing the torch." Here, the author gives some much-needed (and rarely found) advice on how to teach young children the wonders of astronomy. In Part 6 is also "The poet's sky," which is something you won't find anywhere else, and a fine section on "Resources."

The entire book is arranged in the order easy-to-hard, which makes it the type of book that you can meet on your own terms. There are plenty of clear charts and wonderful examples of sketches and photographs that can be made by anyone, if they have a little practice and use diligence. Mr. Levy liberally illustrates all of this practical advice with accounts of his personal experiences. This makes *The Sky* appear less like a book, and more like having a friendly astronomer in your living room, giving you tips and advice gleaned from experience.

The overall tone of this "beginner's book" is a little different from other introductory books that I have seen. Whereas most books of this genre appear to be aimed at the 16-to-20 age group, *The Sky* appears to be written with the slightly older adult in mind. It looks to be perfect for the person who is out of college, has settled into a career, and now is ready to make the time to pursue that interest in astronomy that has been lurking in the back of his or her mind since childhood. For these people we need only to put a copy of David Levy's *The Sky* in their hands!

Readers may have noticed that this Journal has published few book reviews in recent issues. The chief reason for this is not any lack of books, but a lack or reviewers Note that each reviewer retains the book that he or she reviews, and there are books for every interest. Thus, we invite potential book reviewers to become actual reviewers by contacting Mr. Olivarez at the address given on the inside back cover.

New Book Received

Notes by José Olivarez

Variability of Active Galactic Nuclei.
By H. Richard Miller and Paul J. Wiita, editors. Cambridge University Press, 40 West 20th Street, New York, NY 10011. 1991. 387 pages Price $49.50 cloth (ISBN 0-521-41295-1).

Active Galactic Nuclei (AGNs) continue to receive a great deal of attention from both observational astronomers and theorists. The pace of discovery is so fast that conferences and workshops remain the chief means by which the latest data and models are first discussed. This book collects the results presented at Georgia State University in May, 1990, on the topic of variability in active galactic nuclei. The contents, consisting of 60 technical papers, are a valuable summary on the variability observed in a wide variety of AGNs, and of the substantial constraints now imposed on models for the "central engine" of the AGNs and on the production of the variability.

Product Review: The Moon on Videodisc

Reviewed by John E. Westfall, A.L.P.O. Executive Director

There are many products of interest to A.L.P.O. members besides books,including other informational media, equipment, and accessories. This new occasional column will give A.L.P.O. staff and members' evaluations of astronomy products. If you have experience with a new product, or even an older product if it is still on the market, and are prepared to evaluate it in an unbiased manner (or at least as unbiased as we get), please get in touch with the Editor.

NATIONAL AIR AND SPACE MUSEUM. ARCHIVAL VIDEODISC 6. LUNAR MISSIONS IMAGERY.

National Air and Space Museum, Information Management Division, 1989. Distributed by the Smithsonian Institution Press, Department 900, Blue Ridge Summit, PA 17294-0900. 1989. Two-sided, 12-inch CAV videodisc; about 76,000 frames. (ISBN 0-87474-939-5.) [Also available from Starship Industries, 605 Utterback Store Road, Great Falls, VA 22066 for $59.95.]

Videodiscs

Videodiscs, or "laser discs," are a medium for storing video images. They come in several sizes; 5-inch (5 minutes of video), 8-inch (30 minutes), and 12-inch (60 minutes per side). Although more expensive than videotape, they offer higher quality, with a horizontal resolution typically about 425 lines. (The vertical resolution is, of course, the 525 lines of the American standard NTSC video.) This makes it possible, for example, clearly to read written text on the screen. Videodiscs are apparently also more durable and "archival" than are videotapes.

Videodiscs also come in two formats, CLV (constant linear velocity) and CAV (constant angular velocity). The CAV allows only 30 minutes of continuous video per side of a 12-inch disc, but has one tremendous advantage—individual frames can be addressed by random access. Thus each side of a CAV disc can be thought of as a set of up to 54,000 slides, any of which can be accessed in a few seconds. Also, this format can be scanned in slow motion, run in reverse, or accessed by computer to allow multimedia productions.

It is clear that the CAV format is useful for more than watching old movies; it permits imagery archives. Unfortunately, the cost of *making* videodiscs is prohibitive for most of us; but the cost of videodisc players is dropping, and several models are now in the $300-400 range. Add a conventional video monitor, preferably of good quality, and you are ready to go. Also, if you wish to produce "hard copy," there are several video printers in the $1000-1500 range that can produce colored prints at an cost of about $1 each, with a picture area of about 3 by 4 inches. The illustrations in this report are from the videodisc being reviewed and were printed by a Sony video printer, for example. Note that the standard video signal output by videodisc players can be input into a computer video digitizer and then subsequently edited and enhanced.

Solar-System Videodiscs

There are CAV-format videodiscs currently on the market that contain imagery from almost all the United States space missions that produced imagery. This includes the Voyager Missions to Jupiter, Saturn, and Uranus; the Mariner and Viking Missions to Mars; and the Mariner Missions to Venus and Mercury. Undoubtedly the Voyager-Neptune Encounter; the Galileo Venus, Earth, and Moon flybys; and the Magellan Venus images will follow. We hope to review these other astronomical videodiscs in future issues. [Also, as a professional geographer, this reviewer has to note that available videodiscs contain weather satellite images, Landsat satellite imagery of the entire United States and of a number of foreign areas; along with Mercury, Gemini, Apollo, Skylab, and Space Shuttle Earth photography. Great for astrobleme hunting!]

The Disc of the Moon

What follows is a summary of the contents of the two sides of this videodisc, indicating frames by side (A or B) and the range of frame numbers, which also gives (by subtraction) the number of frames. Included are some historical notes on the missions themselves for our younger (i.e., pre-middle-aged) readers. It is a sad comment on our space program that the *most recent* photographs on this disc were taken 20 years ago!

Ranger (A00011-01893). These were taken in 1964-65 by the three successful Ranger Missions: Ranger-VII, Mare Nubium; Ranger-VIII, Mare Tranquilitatis; and Ranger-IX, Alphonsus. Each Ranger returned video images of the Moon at a gradually increasing scale before they impacted. A sample Ranger-IX frame of Alphonsus is shown in *Figure 10* (p. 38).

Surveyor (A01894-02961). The Surveyor and Ranger Missions were the only unmanned missions, and the only ones to return non-photographic (electronic) imagery. The four successful Surveyors that returned images "soft-landed" on the Moon in 1966-68, and were Surveyor-III, near Montes Riphaeus; Surveyor-V, Mare Tranquilitatis; Surveyor-

Figure 10. Ranger-IX photograph of the lunar crater Alphonsus (right of center), which is about 118 km in diameter. North approximately at top. (Videodisc frame A01713.)

VI, Sinus Medii; and Surveyor-VII, Tycho. Surveyor-I also landed, near Flamsteed in Oceanus Procellarum, and returned images; but these are unaccountably not on the videodisc. Note that the images on the disc are only a fraction of the 87,674 that were taken by the five successful spacecraft, including the 11,240 taken by Surveyor-I. The Surveyor cameras delivered images only after landing; most show the vicinity of the spacecraft, but some show the Earth and even an eclipse of the Moon (an eclipse of the Sun from Surveyor's viewpoint!). A sample Surveyor-VII view is shown in *Figure 11*, below.

Figure 11. Surveyor-VII image of part of the outer wall of the crater Tycho under low lighting. The view is highly tilted, with "up" to the upper right. Note the data block on the right, which appears on some of the Surveyor frames. (Videodisc frame A02710.)

Orbiter (A2967-06094). The five Lunar Orbiter Missions took place in 1966-67 and photographed the Moon from orbit on photographic film that was processed in the spacecraft, and then scanned and transmitted to Earth. Although providing highly detailed views of most of the Moon, the method by which the photographs were scanned and assembled into strips meant that they are inadequate for precise elevation and position measurements.

Orbiters-I, -II, and -III primarily photographed candidate areas for Apollo landings near the lunar equator. After this task was done, Orbiters-IV and -V were placed in near-polar orbits in order to conduct global mapping of most of the remainder of the Moon.

Figure 12, below, is a highly-publicized ("The picture of the century") oblique view of the crater Copernicus by Lunar Orbiter-II. Note that the actual picture occupies only part of the frame. Given the importance of the systematic global coverage of the Orbiter Series, it is unfortunate that their videodisc versions apparently were made by photographing prints mounted on a wall! Thus the videodisc Lunar Orbiter photographs are most suitable for browsing, or for locating frames of interest. For serious research, however, it is necessary to consult the actual prints, microfilm copies, or perhaps the half-tone versions in lunar atlases (that unfortunately are now out of print).

Figure 12. Lunar Orbiter-II oblique photograph of the central floor and peaks or the crater Copernicus (top) as seen from the South. The double crater Fauth is in the left foreground. Lunar Orbiter-II High-Resolution frame 162, part 2 of 3. (Videodisc frame A03799.)

Apollo 70mm (A06100-29099). The nine manned Apollo lunar Missions (i.e, Apollo-8, and 10 through 17) carried astronauts who took thousands of photographs of the Earth and Moon from orbit, and (for Apollo-11 and 12, and 14 through 17) from the Moon's surface. They mainly used hand-held Hasselblad cameras with 70mm film, both color and black-and-white. The quality of these photographs varies, but most are very good, as the example in *Figure 13* (p. 39) shows. With all Apollo photography, it is important to know that only the last three missions traveled significantly north or south of the lunar equator, that Apollo-13 did not enter lunar orbit, and that all the missions included distant whole-disc views of the Moon showing the lunar Eastern Hemisphere.

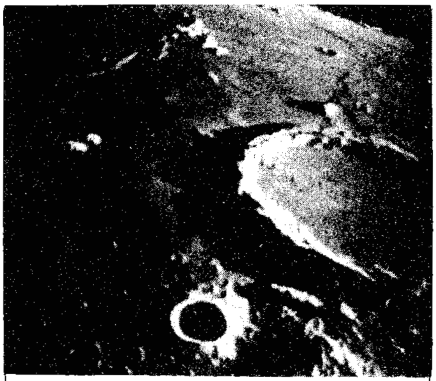

Figure 13. Looking north over the 83-km crater Archimedes, with 13-km Bancroft (Archimedes A) in the foreground and the Montes Spitzbergensis in the background. Apollo-15 photograph AS 15-91-12402. (Videodisc frame A13996.)

Apollo Metric (A22439-29241). Apollo Missions 15, 16, and 17 carried a mapping camera with a 76-mm f/4.5 lens which took vertical-format views with resolutions of about 20 meters. Coverage was in the form of continuous strips, permitting stereoscopic viewing. Apollo 15 metric coverage extended westward (IAU sense) from about 179°E to 67°W longitude, reaching latitudes as high as 26°N and S. Apollo 16 photographed westward from 165°W to 48°W, with extreme latitude limits of 12°N and S. The final Apollo Mission's coverage was from longitude 151°W westward to 44°W within the latitude limits of 23°N and S. A representative Apollo Metric photograph is shown in *Figure 14* (below). This video print can be compared with the reproduction of an actual photographic print of an adjoining frame on the front cover of our June, 1991 issue.

Figure 14. Apollo-17 Metric Camera photograph 1829, showing the area between the ruined 28-km crater Wallace (lower right edge) and the Montes Apenninus (upper left). The area shown is roughly 200 km on a side. South at top. (Videodisc frame A28336)

Apollo Panoramic (B00010-46588). This form of photography comprises the largest number of frames because each of the highly-elongated photographs had to be divided between ten videodisc frames. This form of coverage was confined to the last three Apollo Missions and had about the same longitude coverage as did the Metric Camera photography described above. One difference between the two forms is that the Panoramic Camera had a 610-mm f/3.5 lens with a ground resolution of 2-3 meters directly below the spacecraft. Also, each photograph was a strip extending from the N to the S horizon as seen from the spacecraft. Thus, the only way to see an entire panoramic photograph at once is to make video prints of the pertinent videodisc frames and then to assemble them. When the writer tried this, it turned out that there were small gaps between the adjoining videodisc frames. A sample Apollo Panoramic Camera videodisc frame appears in *Figure 15* (below).

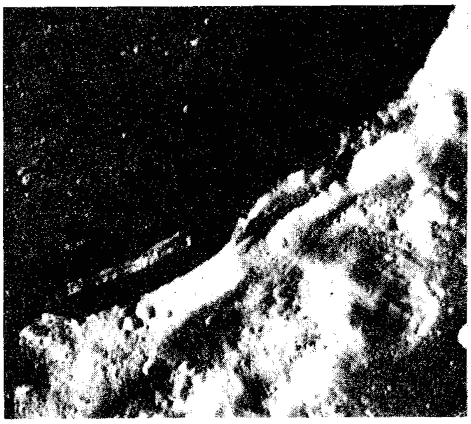

Figure 15. Looking north over the southeast rim of the crater Archimedes. Apollo 15 Panoramic Camera photograph AS 15-9390. (Videodisc frame B05504.)

CONCLUSION

This lunar imagery videodisc is admittedly not a flashy professional product; it is a research tool. Much of its contents consists of images of photographic prints, where transparencies would have had better tones and resolution. The absence of Surveyor-I images is a loss. The gaps between videodisc frames in the Apollo Panoramic Camera photographs is, at best, an annoyance. Certainly, there is no substitute for the original photographs—but how many of our readers have access to them?

On the positive side, a printed index is provided and, better yet, sections of the disc contain map indices of the photographs. Thus, after a little searching, one can always find a particular area of interest. Although not always of the best quality, these videodisc images can be useful, as *Figures 10-15* will attest. Finally, where else can you obtain 76,000 views of the moon for 60 dollars?

INDEX TO VOLUME 35 OF *THE JOURNAL OF THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS* *(THE STROLLING ASTRONOMER)*

By: Michael Mattei

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SUBJECT INDEX

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WHITHER THE WESTERN AMATEUR ASTRONOMERS?

By: John E. Westfall, A.L.P.O. Executive Director

The Western Amateur Astronomers (WAA) is a federation of amateur astronomy clubs in the western United States. Founded in 1949, it holds annual conventions and makes several awards, which are functions similar to those performed for the remainder of the country by the Astronomical League (AL), which was founded in 1946.

Frankly, the WAA is not doing well; their 1991 convention was canceled, and their most recent Board Meeting, at Fresno, California on February 15, 1992, was attended by only 13 delegates. It is quite possible that the WAA Board, at their meeting on July 18 at COSMOCON '92 in San Jose, California, will decide to dissolve the organization. It may simply cease to exist; or may become, or merge with, a new Western Region of the Astronomical League.

The Astronomical League will also meet in San Jose. Their Council meeting will be on July 14, and their Region X (Western) organizational meeting will be held on July 13.

Why is the A.L.P.O. concerned? Our organization is affiliated with, and sits on the Boards of, both the WAA and the AL. Our first convention was held with that of the WAA in 1956, and our second with the AL in 1957. We have convened with each group many times since then.

We will meet with both groups in San Jose in July, and the writer intends to represent the A.L.P.O. at the three business meetings listed above. When we help to decide what is to become of the Western Amateur Astronomers, *it is essential that he know the feelings of the A.L.P.O. membership. If you have recommendations about the future of the WAA, please inform the writer about them. If you plan to attend COSMOCON '92, also attend the A.L.P.O. Business Meeting on July 16th, where we can discuss what we think should be done at the WAA Board Meeting on July 18th.*

Observation and Comments: Lunar Drawing by Andrew Johnson

A new A.L.P.O. member, but a veteran English amateur astronomer, Andrew Johnson has recently sent in a set of his lunar drawings. These are in the style of Harold Hill, as exemplified in Mr. Hill's recent book, *A Portfolio of Lunar Drawings* (Cambridge University Press, 1991). The tedious stipple drawing technique allows fine control of shading and also reproduces well.

A sample drawing by Mr. Johnson appears in Figure 16 (below). The area shown straddles the lunar equator on the western shore of Oceanus Procellarum. From top (south) to bottom, the large craters are Lohrmann, Hevelius, and Cavalerius. Note the distance scale and thorough documentation provided by the observer. For information about the solar lighting conditions ("⊙"), see "Getting Started: Moonlighting" on pages 23-25 of this issue.

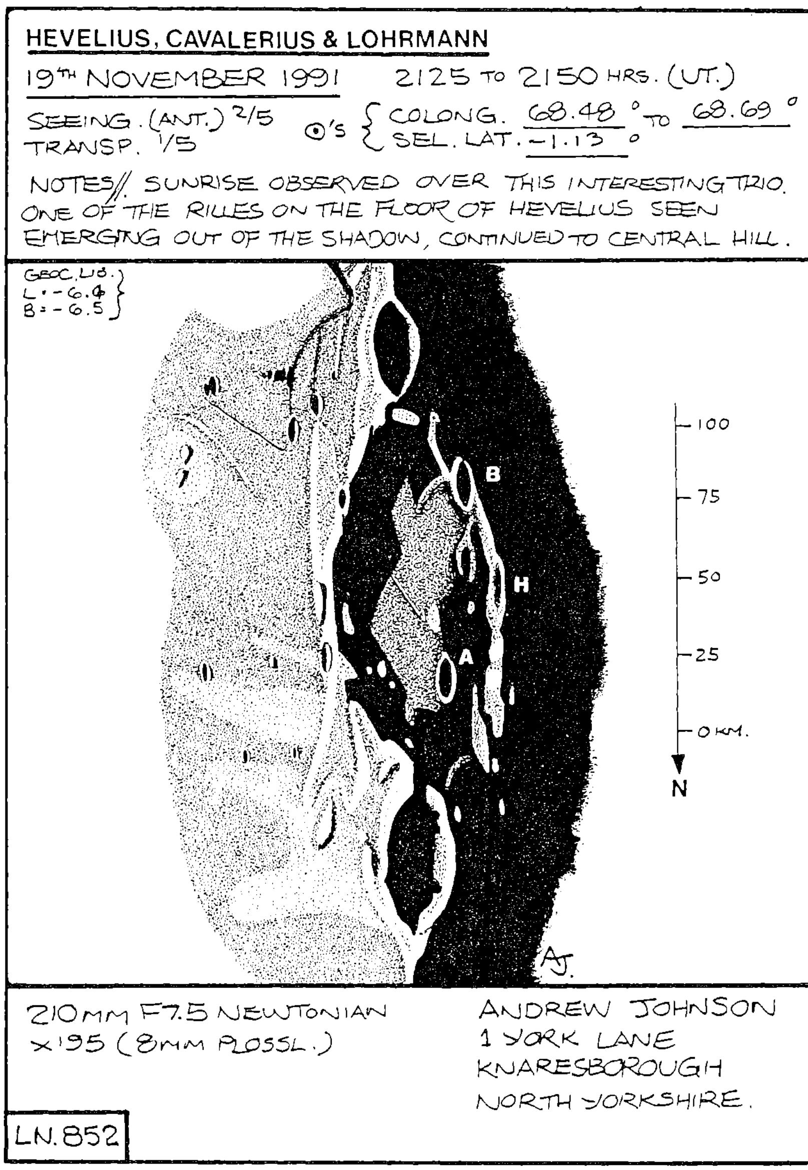


Figure 16. Lunar drawing of the craters Lohrmann (Top), Hevelius (middle), and Cavalerius (bottom) by Andrew Johnson. For further information see his annotations with the drawing and the text above it.

ANNOUNCEMENTS

ASSOCIATION BUSINESS

Staff Change: Lunar Dome Survey Recorder.—The previous Recorder of our Lunar Dome Survey, Jim Phillips, M.D., has resigned his position due to the press of family business. We express our gratitude for the years of service he has given the A.L.P.O. in coordinating this observing project. Our Membership Secretary, Harry D. Jamieson, has consented to replace Dr. Phillips as Acting Recorder of the Lunar Dome Survey. Mr. Jamieson's address is given on the front cover, and we invite those interested in observing these low-relief lunar features to contact him.

COSMOCON '92.—Our 42nd Meeting will be held with COSMOCON '92 on July 13-18, 1992, at San Jose State University in San Jose, California, U.S.A. This national amateur astronomy convention will include the Astronomical League (AL) and the Western Amateur Astronomers (WAA), with participation by the Planetary Society. The organizing group for the conference is the Astronomical Association of Northern California.

A Teachers' Workshop, "Reach for the Stars," will be held on July 13-14, and participants can earn a unit of credit through San Jose State University. The amateur astronomy portion of the conference starts with a Reception Buffet on the evening of July 14, followed by a special lecture cosponsored by the Planetary Society. On July 15 there will be amateur papers, a special lecture, evening viewing at the campus observatory, and a Lick Observatory tour with viewing through the 36-inch Alvan Clark refractor and a look at the 120-inch reflector. A.L.P.O. activities will be on Thursday, July 16, including a paper session, workshop, and Board/Members meeting. On the evening of the 16th there will be more evening viewing on campus as well as a tour of Chabot Observatory in Oakland, including its 20-inch Brashear refractor. On Friday, July 17, talks will continue, with a NASA-Ames tour, which will include the Kuiper Airborne Observatory if it is "in port." The Joint Awards Banquet is on the evening of the 17th. The final convention day will be Saturday, July 18th, with talks, two special lectures, and brunch, ending with the Star-B-Que at Fremont Peak Observatory that evening, with viewing through the 30-inch Challenger Telescope.

*A.L.P.O. members are invited to deliver papers on Thursday, July 16th. If you wish to do so, send a typewritten two-paragraph abstract by **May 15, 1992**, to: Cosmocon '92 Convention Committee, Chabot Observatory, 4917 Mountain Blvd., Oakland, CA 94619.* Please indicate your audio-visual needs. The normal length of papers is 20 minutes, with an additional 5 minutes for questions, but this can be changed for exceptional cases. Poster papers by individuals are also welcome. Naturally, you can also bring your "raw" observations (e.g., drawings and photographs) for the general A.L.P.O. Exhibit.

Those privileged (or forced) to attend business meetings should note the following:

- Astronomical League Region X (Western) organization, July 13th.
- Astronomical League Council, July 14th.
- A.L.P.O. Board/Members, July 16th.
- Western Amateur Astronomers, July 18th

For a registration packet and further information, write:

COSMOCON 92
Krebs Convention Management Services
Pioneer Square, Suite 200
555 De Haro Street
San Francisco, CA 94107-2348

Travel arrangements for COSMOCON '92 are being handled by Uniglobe Express Travel Agency, telephone number 1-800-283-4101 (8 AM - 5 PM Pacific Time). They can provide discounts on air travel to the San Francisco-San Jose Bay Area via United Airlines, rental automobiles through Alamo Rent-A-Car, and off-campus lodging at Best Western Inns. Note that you have the option of meals and lodging on campus.

OTHER DESERVING ORGANIZATIONS AND EVENTS

UNIVERSE'92.—This is the 104th Annual Meeting of the Astronomical Society of the Pacific, and is cosponsored by the A.L.P.O. The conference will be held June 20-25, 1992, at the University of Wisconsin in Madison. The tentative schedule begins with a national astronomy exposition and fair, with talks, seminars, and exhibits on June 20-21 (Saturday-Sunday); these two days will probably be those of most interest to our readers. On Monday, June 22 there are tours of Yerkes Observatory and other places. A scientific symposium on "Massive Stars: Their Lives in the Interstellar Medium" will be held on June 23-25 (Tuesday-Thursday). It will coincide with a workshop on teaching astronomy in grades 3-12 on June 23-24, with panels and papers on astronomy education on June 25, and with a program on the history of astronomy on the afternoon of Wednesday, June 24.

Because the A.L.P.O. is one of this meeting's sponsors, we hope to supply some exhibits, literature about us for distribution, and several papers on amateur Solar-System observing. Any A.L.P.O. member who expects to attend this major conference should contact the A.L.P.O. Director fairly soon so that we can begin making plans.

To obtain a registration packet, write to: Meeting Registration Packets, A.S.P., 390 Ashton Avenue, San Francisco, CA 94112.

Meeting of European (and International) Planetary and Comet Observers.—MEPCO'92 is scheduled to meet in Violau, Germany on September 18-21, 1992. For ten years, the *Arbeitskreis Planetenbeobachter* have held a planetary-comets conference for German-speaking amateurs. This year, they will hold their first **English-language** conference, in the beautiful setting of Violau, Bavaria. The entire conference will be held in the same building as the Violau Observatory; with discussions, workshops, papers, and posters. This will be a rare opportunity to meet and talk with active planetary amateurs from many countries. Some workshop topics will be international observing campaigns, including the upcoming Mars apparition, and the use of CCD detectors. Included will be a guided tour of the European Southern Observatory headquarters near Munich. The registration fee is DM 200 (about $US 120) and includes Proceedings, accommodation, and full catering. To obtain a registration form, write *before April 30* to: Wolfgang Meyer, Martinstr. 1, D-(W) 1000, Berlin 41, Germany.

While you are in Bavaria, a visit to the **Deutsches Museum** would be in order. They have announced the opening of their new Astronomy Gallery in May, 1992. This 1000-square meter gallery will contain 85 demonstrations, which will include a solar radio receiver, blink comparator, spark chamber, and much else. A special section will emphasize Classical Astronomy, containing historical instruments. The museum houses a planetarium and an observatory with 30-cm (12-in) and 40-cm (16-in) refractors. The formal opening conference will be held on May 6, 1992, 9 AM - 4 PM. Details can be obtained by writing: Deutsches Museum, D-8000 München 26, Postfach 260102, Germany.

Astronomy Day: May 9, 1992.—This year's Astronomy Day will be on May 9th, marking the 20th successive annual occasion. The A.L.P.O. is proud to continue as a cosponsor of this event, whose goal is to bring astronomy to the public via publications, lectures, star parties, planetarium shows, and any other means that work. A.L.P.O. members at public star parties should note that Jupiter and the first-quarter Moon will be well-displayed in the evening sky on May 9th. For serious activity-planning, you should obtain the 120-page handbook for Astronomy Day, which includes organizational ideas for special events, the dates of Astronomy Day for the rest of the century, and rules and entry forms for the Astronomy Day Award. Obtain it by sending a check payable to the Astronomical League for $7.00 ($8.00 for first-class postage; outside the United States add $1.00 for surface mail or $3.00 for air mail) to: Gary Tomlinson, Astronomy Day Coordinator, Public Museum of Grand Rapids, 54 Jefferson S.E., Grand Rapids, MI 49503 (telephone 616-456-3987).

24th Annual Riverside Telescope Makers Conference.—The RTMC is probably the largest amateur gathering in the United States, and is held at a dark-sky, 7300-foot elevation, site: Camp Oakes, in the San Bernardino Mountains some 50 miles northeast of Riverside, California. The 1992 conference will be held on May 22-25 (Friday-Monday), and includes speakers, commercial exhibitors, telescope awards, a swap meet, and *lots* of observing after dark.

You may camp, or stay in dormitories, and have meals at Camp Oakes, or may wish to stay in nearby Big Bear City. There is a discount for registering before May 1. To find out more, telephone 714-948-2205 and leave a message, or write to Cliff Holmes, 8642 Wells Avenue, Riverside, CA 92503.

1992 IAPPP Big Bear Symposium.—The 1992 meeting of the International Amateur Professional Photoelectric Photometry group is designed to mesh with RTMC, being held just prior to it at the Ramada Inn in San Bernardino (down in the lowlands). The Symposium begins with informal discussions Wednesday evening, May 20, and paper sessions on Thursday, the 21st. An observatory tour is planned for Friday, May 22. For more information and a registration form, contact: Robert A. Jones, Running Springs Observatory, P.O. Box 2203, Running Springs, CA 92382 (evening telephone 714-867-4521).

Fourteenth Texas Star Party.—The TSP'92 falls on April 25th-May 2nd; and, as always, will be held at Prude Ranch, in the Davis Mountains of West Texas. Activities will consist of guest speakers (including Carolyn and Eugene Shoemaker), paper sessions, seminars, and dark-sky observing. You can choose from a variety of on-site accommodations. Prior to April 15th, registration is $23.00 per person, plus $7.00 per additional family member (the price jumps to $75.00 per person after April 15th). To register, to receive more information, or both, write to: Bobby R. Braley, Jr., TSP Registrar, P.O. Box 386, Wylie, TX 75098 (telephone 214-442-6391).

International Workshop on Variable Phenomena in Jovian Planetary Systems.— This workshop will deal with variable phenomena of the interiors, atmospheres, magnetospheres, rings, and satellites of the Jovian Planets. It will be held at the Governor Calvert House at the Historic Inns of Annapolis, Maryland, July 13-16, 1992. *It is significant that several professionals who have used amateur data on Jupiter and Saturn have explicitly invited A.L.P.O. observers of the Jovian Planets to come in order to report their observations and to plan future observing programs.* Those intending to give a paper should obtain an abstract form from: Dr. Nick Schneider, LASP, Campus Box 392, University of Colorado, Boulder, CO 80302-0392. The deadline for abstract submission is May 15, 1992. We realize that this workshop is in direct time conflict with the A.L.P.O. convention on the opposite coast of the United States. We hope that one or more of our advanced observers who might not be able to attend our West Coast meeting may be able to come to Annapolis and represent us and our work.

For information on this workshop, contact: Dr. Theodor Kostiuk, Jupiter Workshop, NASA Goddard Space Flight Center, Code 693.1, Greenbelt, MD 20771 (telephone 301-286-8481). For general logistical information, call Meta Hutchinson-Frost at 301-220-0685.

Solar Astronomy Convention.—Looking ahead, we note that the Second Solar Astronomy Convention is scheduled for April 5-7, 1993, in La Paz, Baja California Sur, Mexico. (This was the site of the 1991 A.L.P.O. convention.) The conference will be in both Spanish and English, and some of the topics will be: results from the July 11, 1991, solar eclipse; developments in solar astronomy; preparations for the annular solar eclipse of May 10, 1994; plans for the 1993 and 1999 Transits of Mercury and the 2004 and 2012 Transits of Venus; and meso-american archeoastronomy. You can obtain more information from: Congreso de Astronomía Solar, apartado postal 44-A (CP 23050), Ciudad de La Paz, Baja California Sur, Mexico (telephone (91-682) 2-97-32).

Division for Planetary Sciences.—The 24th annual conference of the Division for Planetary Sciences of the American Astronomical Society will be held at the Ludwig-Maximilians-University in Munich, Germany, on October 12-16, 1992. This is one of the two most important annual professional Solar-System meetings, and is preceded by the Fourth International Conference on Laboratory Research for Planetary Atmospheres on October 10-11. To be placed on the mailing list for information, write to: Ms. LeBecca Simmons, Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston, TX 77058 (telephone 713-486-2158).

The Planetary Society.—With over 100,000 members, the Planetary Society is the largest space-interest organization in the world, and has frequently cosponsored conferences with amateur organizations, including the A.L.P.O., such as the UNIVERSE '92 conference. One benefit of membership is the bimonthly magazine, *The Planetary Report.* One can join by sending $25.00 to: The Planetary Society, 65 North Catalina Avenue, Pasadena, CA 91106.

The Planetary Society sponsors several scholarships, including the Mars Institute Student Contest, their College Fellowship Awards, and the New Millennium Committee Scholarship Awards for High School Students. Information on all these can be obtained by writing the Planetary Society.

PUBLICATIONS

Observatory Techniques.—This new quarterly deals with visual, photographic, and electronic observing and with the equipment needed to make the observations. Computer techniques, such as in image processing, also receive attention. For more information, see the advertisement below.

The Cosmic Exchange.—Keeping up with observing trends can be expensive. One solution is secondhand equipment and supplies. This monthly publication consists of classified advertising for astronomy. The latest issue had 14 pages covering: Accessories," "Antique and Classics," "Binoculars," "Cameras/Photographic," "Catadioptric/Maksutov," "Computers/Software," "Eyepieces," "Magazines/Books/Charts," "Reflectors," "Refractors," "Scientific Instruments," "Swap or Trade," "Telescope Parts/Optics," and "Wanted." A subscription is $16.00 per year for those in the United States ($22 for Canada and Mexico; $36 elsewhere), and should be mailed to: The Cosmic Exchange, PO Box 688-C, Liberty Lake WA 99019-0688, U.S.A.

Ephemerides of Minor Planets for 1992.—This annual ephemeris is prepared by the Institute of Theoretical Astronomy, St. Petersburg (Pulkovo Observatory), Russia. The 498-page 1992 volume contains orbital elements and opposition ephemerides of more than 4600 minor planets. Separate ephemerides are given for minor planets that approach the Earth. Also, where known, this publication gives data on rotation periods and variations of brightness. For the first time, in 1992, the J2000.0 equinox is used. In order to obtain this unique source of information, contact: White Nights Trading Co., 520 NE 83rd St., Seattle, WA 98113, U.S.A. (Telephone 206-525-8399, FAX 206-523-0851.) The cost is $38 for the United States, $43 for Canada, $51 for Europe, and $58 for Japan and Australia. The price includes shipping and handling. Payment should be in US$ and made to "White Nights Trading Co."

PUBLICATIONS OF THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS

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

◆◆

Order from: Mark A. Davis, 130 Greenway Drive N.W., Christiansburg, VA 24073, U.S.A:

The A.L.P.O. Solar System Ephemeris: 1992. $6.00 in the United States, Canada, and Mexico; $8.50 elsewhere (airmail included). Over 120 pages of tables, graphs, and maps describing the positions and appearances of the Sun, Moon, each major planet, the major planetary satellites, Minor Planets, meteors, and comets. Make payment to "A.L.P.O."

◆◆

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

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

◆◆

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

① ***A.L.P.O. Section Directory--1991/92.*** *Free*; just send a stamped, self-addressed envelope. An 8-page description of each Observing Section's personnel, projects, and publications.

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

◆◆

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

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

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

Current Issue [*36*, 1]—$3.00.

KEEPING YOUR MEMBERSHIP CURRENT—

A.L.P.O. memberships include a subscription to the *Strolling Astronomer (J.A.L.P.O.),* the top line of your mailing label gives the volume and issue number for which your membership will expire (e.g., "36.1" means Vol. 36, No. 1). We include a *First Renewal Notice* in that issue, and a ***Final Notice*** in the next one.

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

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

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

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

The Association of Lunar and Planetary Observers

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

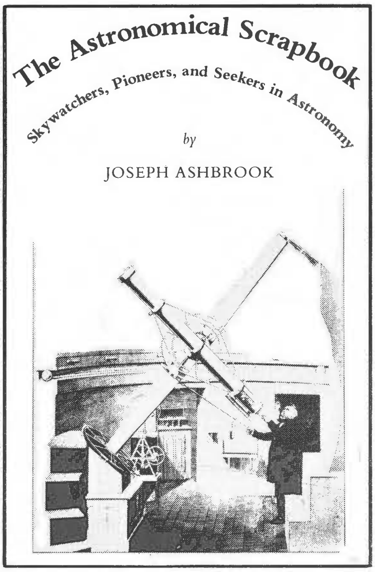
There is a 20-percent surcharge on all memberships obtained through subscription agencies or which require an invoice.

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

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

The Astronomical Scrapbook

Joseph Ashbrook



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