Proceedings of The 49th Convention of the Association of Lunar and Planetary Observers

Atlanta, Georgia

July 9 – 11, 1998

Compiled and Edited by Ken Poshedly

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Association of Lunar and Planetary Observers, 49th Convention, Atlanta, Georgia, July 9-11, 1998

Proceedings Contents

Association of Lunar & Planetary Observers

ALPO `98 Agenda
July 9 - 11, 1998
Atlanta, Georgia

Thursday, July 9

Morning Session -- Chaired by Harry D. Jamieson, executive director, ALPO

9 - 9:05 a.m.	Call to Order and Welcoming remarks from Mr. Jamieson
9:05 – 910 a.m.	Welcoming remarks from Ken Poshedly, chairman, ALPO `98

9:10 - 9:35 a.m.

A Remote Place for a Rare Event
by Derald D. Nye, member, ALPO

Rarer than solar eclipses, rarer than Mercury transits, rarer than Venus transits, but not as rare as a Jupiter transit. The journey of four amateur astronomers (three Americans and a Swiss) to the only land mass where the event could be seen in its entirety in dark sky to view the simultaneous occultation of Jupiter and Venus by the Moon on 1998 April 23 is presented in video and slides.

9:35 - 10:10 a.m.

Plato's Hook
by Bill O'Connell, member, ALPO
(presented by Harry Jamieson)

Half a century ago, observing with the world's third largest refractor, the great English amateur H.P. Wilkins recorded a puzzling feature on the floor of the lunar crater Plato. Instead of the long spires of shadow usually seen, he drew a sharply curved shadow cast from one of the peaks on the crater's rim.

A modern CCD image of the feature "Plato's Hook" confirms its reality. It may be a fleeting shadow effect caused by a lava flow front on the lava-filled floor of the crater. Lunar Orbiter and Clementine satellite images were used to try to verify this hypothesis, but more research is required.

10:10 -10:35 a.m.

Making the Best Lunar Observation
by Matthew L. Will, coordinator, Lunar and Planetary Training Program

This paper concerns the steps an amateur astronomer should take in performing a general lunar observation. This includes a certain amount of preparation before the observer goes to the telescope and the basics steps in visually recording a lunar observation.

10:35 – 10:55 a.m. Break.

10:55 - 11:10 a.m.

The State of the ALPO Message
by Harry D. Jamieson, executive director

Remarks about the current status of several ongoing ALPO projects and plans for the future.

11:10 - 11:20 a.m.
The 1997-1998 Annual Report of the ALPO Solar Section
by Richard Hill, coordinator, Solar Section

11:20 - 11:30 a.m.
The 1997-1998 Annual Report on the ALPO Website
by Richard Hill, coordinator, ALPO website

11:30 a.m. - 12 Noon *ALPO Business Meeting*

12 Noon - 1:30 p.m.
Lunch in the Fernbank Museum Dining Room (lower level; ticket required)

Afternoon Session -- Chaired by Harry D. Jamieson, executive director, ALPO

1:30 – 1:55 p.m.

Changes in the ALPO Jupiter Section
by David J. Lehman,
acting assistant coordinator, Jupiter Section, Internet Communications
(presented by John McAnnally,
acting assistant coordinator, Jupiter Section, Transit Timings)

The Jupiter Section of the ALPO has undergone a facelift with new staff and a number of new features. This paper outlines the staff changes and introduces the new features. New features include: newly revised Jupiter observation forms; establishment of an e-mail network; a newsletter for the Jupiter Section; submittal of transit timings and drawings over the Internet; a list of where observers are to submit observations; availability of a "Jupiter Observer's Start-Up Kit"; and ongoing work on unpublished apparition reports.

1:55 – 2:20 p.m.

Addendum to the Jupiter Section Report,
by John McAnnally,
acting assistant coordinator, Jupiter Section, Transit Timings)

Current developments and actual planet observations.

2:20 – 2:40 p.m.

A Presentation of Some Jupiter Images Taken from Japan
by Donald C. Parker, associate director, ALPO

2:40 – 3:10 p.m.

Observations of the Remote Planets: 1989-1998
by Richard W. Schmude, Jr., Ph.D.,
coordinator, Remote Planets Section

This paper will deal with the measurements and observations of the remote planets (Uranus, Neptune and Pluto) that ALPO members have made between 1989 and 1998. Emphasis will be placed on observations/measurements made in the last two years.

3:10 – 3:20 p.m.

The ALPO Historical Section: A Request for Documents
by Gary Cameron, provisional cordinator for the ALPO Historical Section

This short presentation describes the intended work of the ALPO Historical Section and requests documents, newsletters, correspondence, etc., from ALPO members which would prove of historical value.

3:20 – 3:50 p.m.

Enthusiasm in the Amateur Astronomy Community: Is It Contagious?

by Phillip Sacco, president, Atlanta Astronomy Club

A look at how one local club increased its membership four-fold AND the corresponding level of activity among its membership at monthly program meetings, observing sessions, and its amateur telescope-making group.

4 p.m.

Field trip to the Bradley Observatory at Agnes Scott College, hosted by Christopher G. DePree, Department of Physics and Astronomy, Agnes Scott College

7:30 p.m.

Field trip to the Fernbank Science Center, Planetarium and Observatory. Planetarium program begins promptly at 8 p.m. Observatory open 8 to 10:30 p.m. (weather permitting)

Friday, July 10

Morning Session - Chaired by Harry D. Jamieson, executive director, ALPO

9 - 9:30 a.m.

Amateur Observations of the Moon: The ALPO Selected Areas Program

by Julius L. Benton,

coordinator, ALPO Lunar Selected Areas Program

Worthwhile studies of the Moon can still be pursued by amateur astronomers, but programs must be carefully organized and executed. One such program is the ALPO Lunar Selected Areas Program (SAP) where observers monitor "selected" features on the Moon that have historically been suspected of displaying "seasonal" or long-term variations.

This paper summarizes how participants in the SAP log albedo data for as many of the selected lunar features as possible throughout a lunation and for successive lunations, employing systematic and objective methods of observation. With regard to instrumentation, lunar observers benefit more by using a telescope of high optical and mechanical quality than simply aperture alone.

So that erroneous results are minimized, observers are encouraged to learn how to recognize scattered or reflected light, irradiation, as well as aberrations caused by the eye, the instrument, and the atmosphere. The text points out that the likelihood of achieving confirmed observations of anomalous lunar events is improved when visual, CCD, video, and photographic techniques are employed in a simultaneous observing program.

9:30 - 10 a.m.

Spectrographic Study of Comet Hale-Bopp's Tail

by Tom Buchanan, member, Atlanta Astronomy Club

This article describes spectra taken of the tail of Comet Hale-Bopp with a slitless spectrograph. Images were taken on eight different dates between 09 March 1997 and 05 May 1997. The slitless spectrograph providing spectral reference marks is described.

Observation data and representative spectrograms are presented. The spectra show seven identifiable forked tails of CO+ and an unforked sodium tail. The orientations and relative angles of these tails were measured, tabulated, and shown graphically. The angle between limbs of the CO+ ion tail is about 14', although this angle was measured to be 23' on 05 May. The sodium tail generally lies close to the western limb of the CO' ion tail, but maintains a near-constant angle of 16' with the eastern limb.

10 - 10:30 a.m.

Saturn: Programs and Recent Observations

by Julius L. Benton, Jr., coordinator, Saturn Section

The planet Saturn, together with its majestic ring system, exhibits numerous features that invite well-organized observational attention. In a telescope of moderate aperture, a series of bright zones and darker belts can be seen running across the globe roughly parallel to the equator, as on Jupiter, and the rings are subdivided into three main components, the outer two separated by Cassini's Division.

Although Saturn requires about twice the magnification needed for viewing Jupiter, the planet is far from being a dull and unchanging world. A list of results gleaned from over 50 years of ALPO studies of Saturn are cited, and a summary is given of current observing programs, including an appeal for simultaneous observations. Since the 1995-96 edgewise presentation of the rings, increasingly favorable views of the southern hemisphere of Saturn's globe and the south face of the rings have been possible. Some of the more interesting observations of Saturn during the last two apparitions are described.

10:30 – 10:55 a.m. Break

10:55- 11:25 a.m.

An Error Study of Jupiter Central Meridian Transits by Taking Transits of the Galilean Satellites and Their Shadows, 1939-1998

by Walter Haas, ALPO founder and director emeritus

One method of studying the random and systematic errors in central meridian transits of surface features on Jupiter is to observe similar transits of the four Galilean satellites and their shadows, since positions of these bodies are known to a high order of accuracy. This paper examines the differences between observation and compilation for 207 such transits recorded in the timespan 1939-1998 with different telescopes ranging in aperture from 14 to 46 cm. Average values and standard deviations of the timing errors are determined. Possible correlations of these errors with such parameters as aperture, seeing, magnification, and the phase angle of Jupiter are investigated.

11:25 – 12 Noon

Useful Observations With a Small Telescope

by Craig MacDougal, member, ALPO

In the past decade, technology has advanced at such a rate that one does not have to be independently wealthy to be able to own a large telescope. Today many amateurs are using CCD's (charge-coupled devices) and employing image processing techniques that were only the realm of the professional just a few years ago. However, this does NOT mean that the interested observer with a 6 inch telescope is relegated to looking at the Moon, saying "wow," and then going back inside. There are still many ways to explore the solar system with a small telescope that is both personally rewarding and useful to the scientific community.

12 Noon - 1:30 p.m.

Lunch in the Fernbank Museum Dining Room (lower level; ticket required)

Afternoon Session -- Chaired by Harry D. Jamieson, executive director, ALPO

1:30 – 2 p.m.

A Most Unusual Graze: The Transit of Mercury on 1999 Nov 15
by John E. Westfall,
coordinator, Mercury/Venus Transit Section

The upcoming transit of Mercury will be visible from most of North and South America, the Pacific Basin, Australia and New Zealand. This event is unique because the limb of Mercury will pass only a few arc-seconds within the Sun for most of this area, and indeed, the southern portions of the visibility zone will see only a partial transit. This circumstance will be very favorable for studying optical phenomena reported during planetary transits, particularly the "Black Drop" effect. Observations are encouraged: visual, photographic, video, and especially CCD. Observers near the "graze line" in Australia, New Zealand and the Southwest Pacific will have exceptionally interesting views. Included in this paper are maps and tables of local circumstances; also, the writer is preparing an "Observer's Guide" for the event.

2 - 3 p.m.

Video Astronomy
by Daniel Joyce,
assistant coordinator, Mars Section

A discussion of some aspects of video astronomy in an open workshop environment.

7 p.m.

ALPO Awards Banquet,
Fernbank Museum Dining Room (lower level; ticket required).

Enjoy dinner, the comradery of your fellow-ALPO members, including ALPO founder Mr. Walter Haas.

After-dinner talk *Telescopes I Wish I Had Known by* Leonard Abbey, member, Atlanta Astronomy Club, founder and first recorder of the ALPO Uranus and Neptune Section. See how a committee set astrophysics back 50 years. Learn how a wealthy British amateur astronomer invented modern astrophotography.

Saturday, July 11

No Business Sessions Scheduled. You are free to explore Atlanta and environs as you wish until Saturday evening.

6 p.m.
Caravan from Holiday Inn Select in Decatur for dinner at *Yesterday's Café*, in Rutledge; with tour of Georgia State University research observatory at Hard Labor Creek State Park immediately afterwards. Standard full-menu restaurant (this is NOT a backwoods coffee shop); dinner is pay-as-you-go; cash and major charge cards accepted; no checks.

Route directions: East on U.S. 78, then south on I-285, then east on I-20. Exit at exit no. 49, left at top of ramp, proceed into Rutledge. Yesterday's Café will be on your right just before reaching town center. After dinner, HLC state park is approximately 1 mile north of Rutledge.

Plato's Hook

Clementine & CCD images shed light on the shadowy mystery of a 45 year old drawing.

by Bill O'Connell

It was a spring night in Paris, nearly half a century ago. April 3, 1952. At 9:30 in the evening, most visitors to the city were probably enjoying some fine dining. But in a nearby suburb, two Englishmen took turns at the eyepiece of one of the world's biggest refractors, the 33 inch telescope of the Observatory of Meudon. One of them, H.P. Wilkins, was sketching the crater Plato. The drawing he produced delighted his companion, Patrick Moore, who confirmed the details Wilkins recorded. Moore later said the drawing "was made under excellent conditions with the great telescope, and may be relied upon as depicting, with accuracy, the relative sizes and intensities of the cratercones, spots and streaks visible under that particular angle of illumination." (1) He went so far as to say that their observation probably constituted "one of the best views ever obtained of Plato." (2)

What Wilkins Saw.

Wilkins was mostly concerned with recording the craterlets on Plato's floor. His drawing shows them well, but also shows something remarkable. He recorded a sharply curved shadow - Plato's Hook - being cast on the floor by one of the peaks on the crater's rim. The drawing was published in Wilkins & Moore's book, The Moon (3). In the descriptive narrative accompanying the drawing, the curved shadow is not mentioned. Note is made that under low light "steeple-like shadows cast by the peaks on the walls" (4) can be seen, but there is silence regarding the conspicuous Hook, which doesn't much resemble a steeple, unless you're thinking of a steeple being toppled by the winds of a Hurricane.

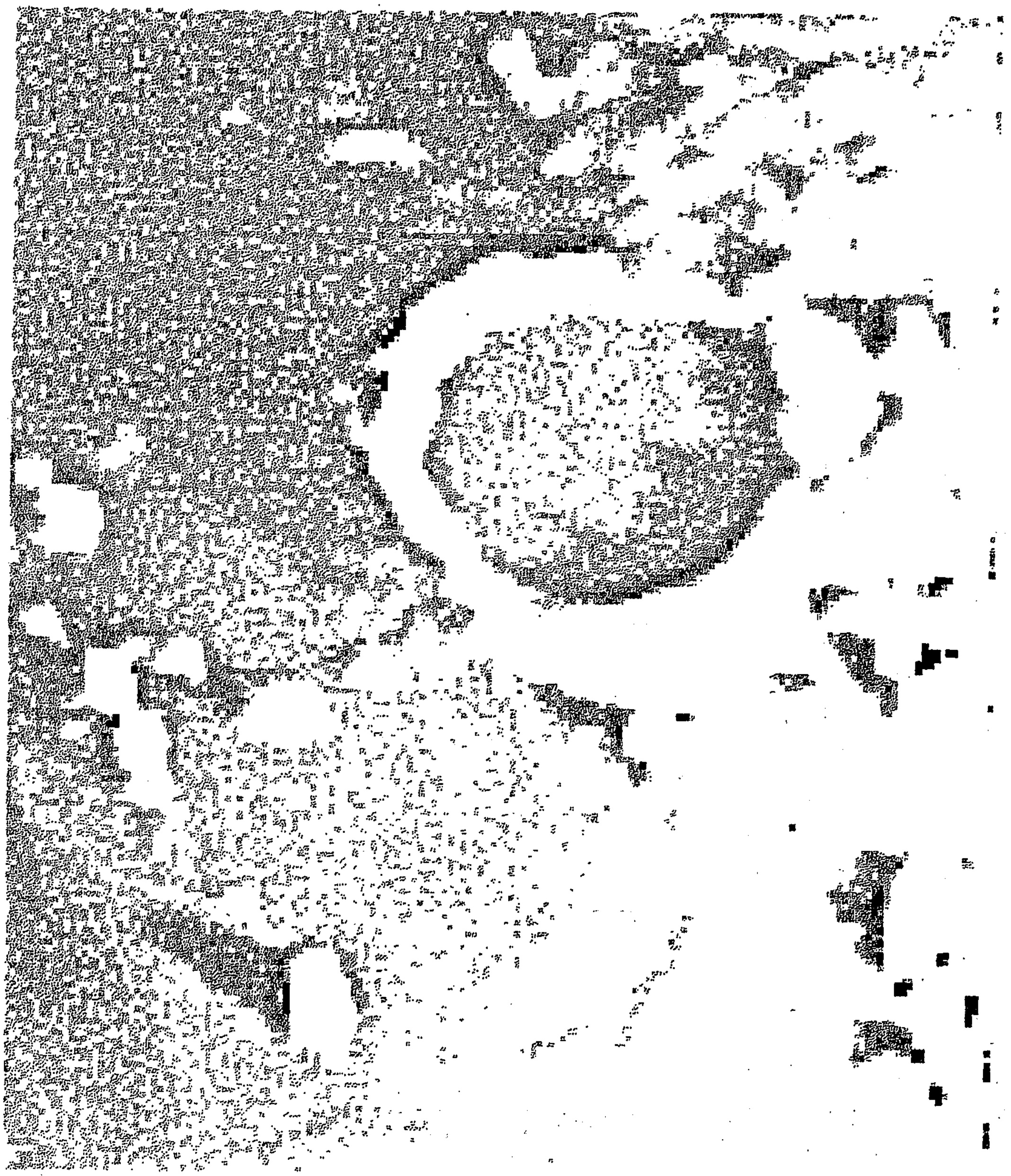
To be sure, curved shadows on the moon are not unknown. Another of Wilkins' drawings from the same book shows curved shadows from the central peaks of Petavius cast on the inside of the crater's wall. It seems pretty obvious that those curves result from the terraces and slopes of the inner crater wall on which the shadow is cast. That's clearly not the case with Plato's Hook though. The Hook is cast on a crater floor considered as flat as any surface on the moon. In Moore's words, it is "remarkably smooth and level" (5). Where could a curved shape arise? Was Wilkins' drawing correct?

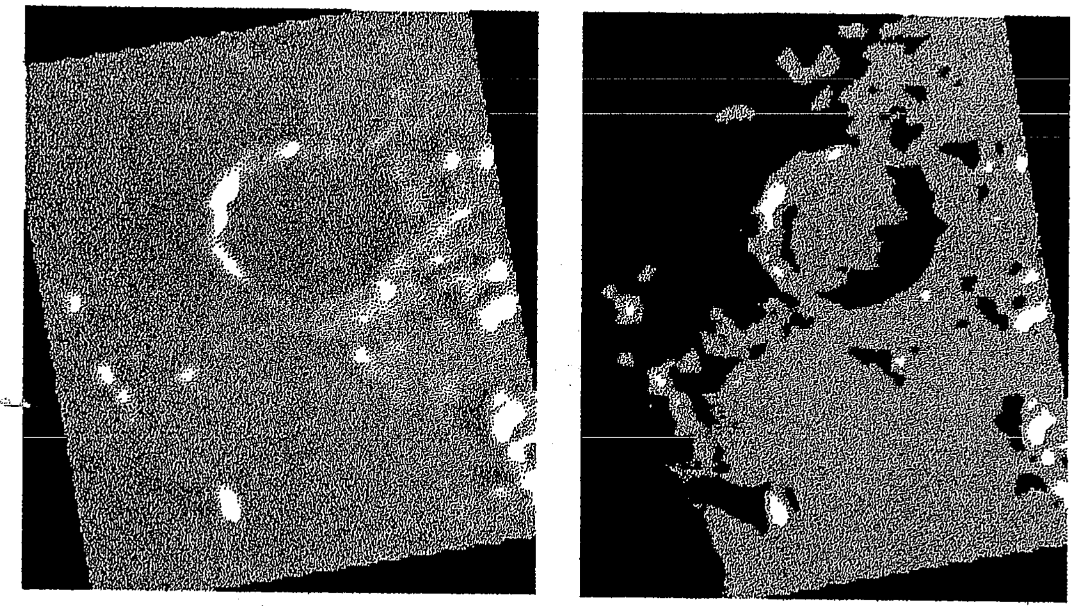
The CCD image.

In a 1955 article in Sky & Telescope (6), Jackson Carle puzzled over the curved shadow Wilkins had recorded, but offered no explanation for the phenomenon. In the nearly 40 years, since The Moon was published, many readers have probably noted in passing the odd shadow in the drawing. It was Gus Johnson, of Swanton, Maryland, who in recent years brought it to the attention of ALPO lunar coordinator Bill Dembowski. Bill spotlighted the feature in an article in his newsletter, The Lunar Observer, in February, 1997, coining the name "Plato's Hook" for the curved shadow, and asking for observations (7). That article prompted me to review my files of CCD moon images. Starting in 1995, I had made numerous images of the crater for the ALPO's Lunar Selected Areas Program run by lunar coordinator Julius Benton, Jr. I reviewed my images, and, much to my surprise, found I had one image that showed Plato's Hook. The contrast of the shadow on Plato's dark floor was minimal, and the printed image submitted to ALPO did not clearly show it. It is, in fact, extremely difficult to print an image of the Hook. With a lot of stretching however, I got the image shown on the next page.

Plato's Hook

CCD Image with 8" SCT @ f 20
1:01 UT, February 16, 1997, Colongitude 13.004
Observer: Bill O'Connell, Whitman, Massachusetts





CCD image prior to contrast enhancement

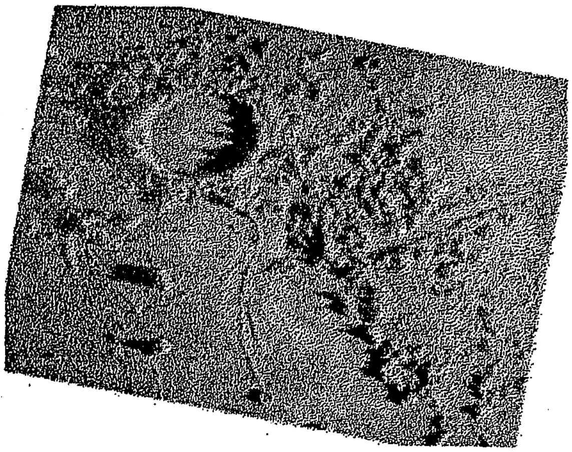
contrast-enhanced CCD image

Note that the shadow is straight for most of it's length. It is really just the tip that is bent, giving the curved effect. Also note that there is a slight break between the straight body and the bent tip

What causes the Hook?

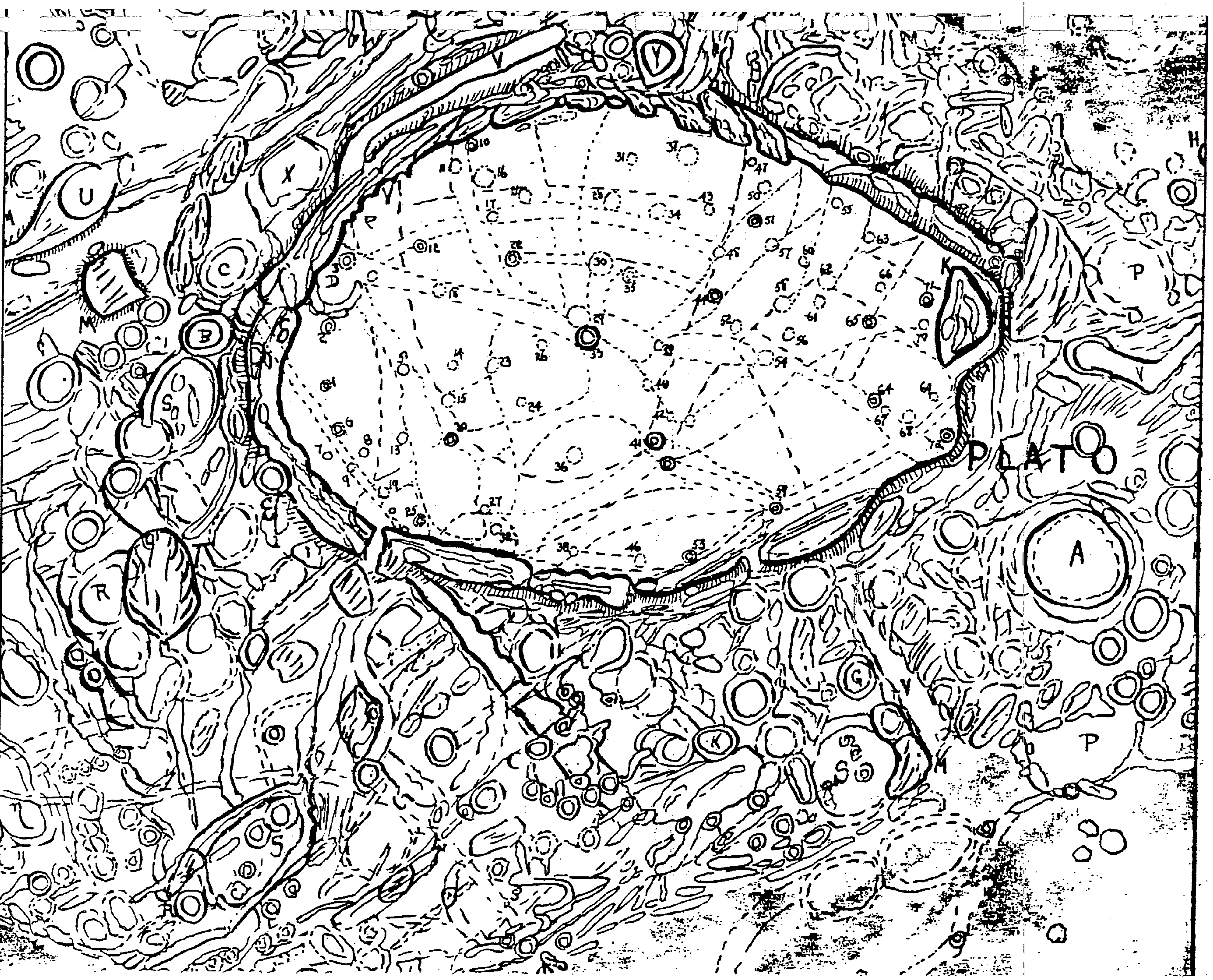
The Hook is not something that can be regularly seen at each sunrise on Plato. The typical appearance of the sunrise shadows of the crater rim is shown in this 1874 illustration by James Nasmyth (8), another great English amateur. Jackson Carle mentions his fruitless hunt for the Hook in the Sky & Telescope article cited above. If the curved shadow were actually cast by a curved peak, it should always be visible. It is not. Could it be then, that the Hook results from a straight shadow falling on some irregularity of the crater floor?

Plato's church-spire shadows as drawn by Nasmyth



The floor of Plato is flat. There are a few small craterlets, but there are no peaks, no rilles, no wrinkle ridges, no chains of craterlets. There don't seem to be any features that might cause the unusual shadow of the Hook. In Wilkin's drawing, we do not find any feature that might explain the Hook. Wilkins also produced an even more detailed reference than the 1952 drawing however. Plato is one of the features for which Wilkins produced a special map as part of his great 300 inch moon map. However, examination of this also discloses no suspicious feature that might explain the Hook.

Facing page:
Wilkins special area map of Plato (9).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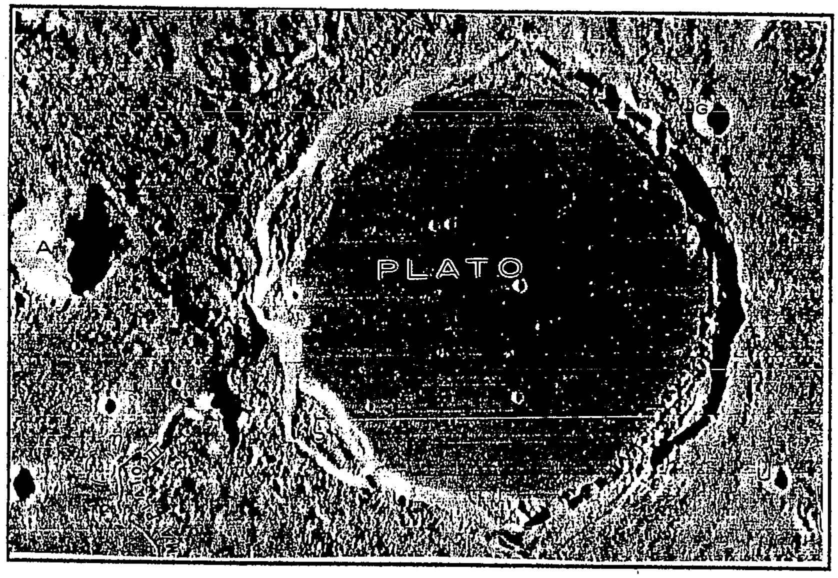
Could the Hook be due to atmospheric distortion? Probably not. Moore extols the seeing at the time the 1952 drawing was made, so it is not likely to have affected the original observation. Distortion in the CCD image would be evident in more than just the shadow of one peak.

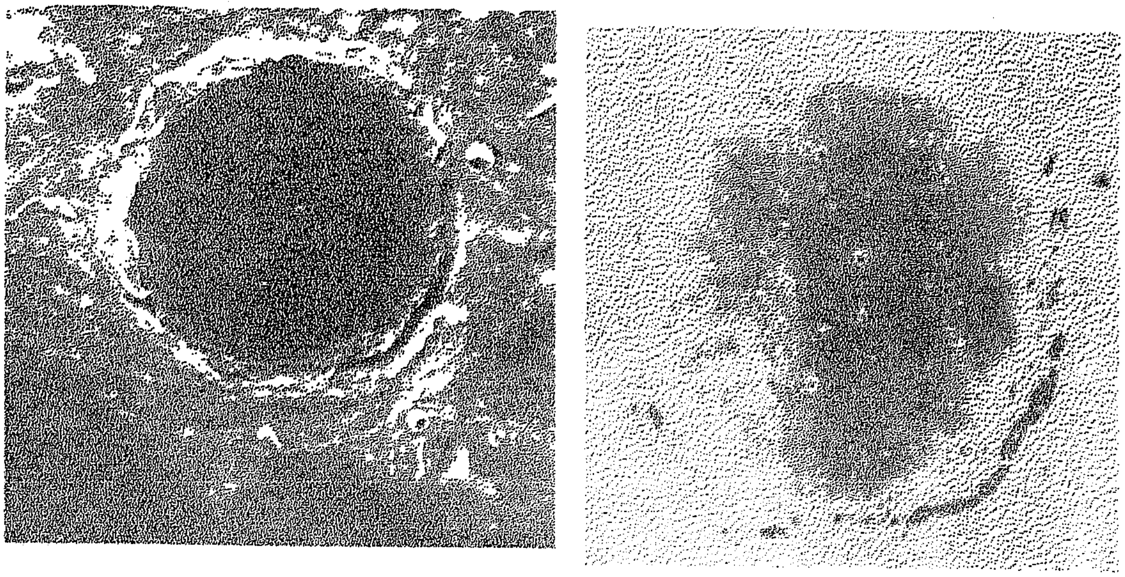
The spacecraft photos.

Both Lunar Orbiter V and Clementine photographed Plato. These pictures can show small details easily surpassing the best earth based observations. The Lunar Orbiter images show nothing on the crater's dark floor that might be a clue to the mystery of the Hook. However, it is possible that the Clementine images reveal a hint

Lunar Orbiter V photo 127-3 of Plato's flat floor



If we stretch the Clementine image, the range of contrast is greatly expanded. Where before we could see only a near uniformly dark crater floor, now a mottled, patchy surface is seen.



Lunar Orbiter V photo 161M

It is possible that there could be a lobate flow front on Plato's floor. Such features are common on the mare surfaces, marking the edge of molten lava flows that finally cooled and froze into place. This is a feature we would not be surprised to find on the lava covered floor of Plato. A section of the small cliff of a lobate flow front might be angled so as to be cast a visible shadow only under certain conditions of lighting. But would the shadow from a front be visible at all from earth? These features were first detected by the Lunar Orbiters, and are beyond the resolution of telescopes on earth. But the long sunrise shadow of a flow front might just be visible.

If there is a flow front, we would expect a slight difference in height between the two surfaces separated by the front. These flow fronts are, on average, 125 feet high, and can be twice this height (10). A cliff 250 feet high, with a rising sun just 5 degrees up in the lunar sky as Wilkins was sketching, would cast a shadow over half a mile, just about enough to be seen as a linear feature.

Is this the explanation of Plato's Hook? I'd like to say yes, but there are a few problems.

Unanswered Questions

Wilkins' drawing and the CCD image were not made under identical conditions of lighting and libration, but the Hook is shown in both of them. This is unexpected and puzzling, but also implies that the Hook's visibility may not be limited to very rare occurrences.

A glance at the two images shows that the shadows are much shorter in Wilkins' drawing than in the CCD image. The drawing was made at a colongitude of 16.479. Wilkins' shows the Hook as being well east of the southernmost craterlet, craterlet 44 (unofficial designation from Wilkins' map), but the CCD image, taken at a of colongitude of 13.004, shows it in the near vicinity of 44. It is possible that this results from the fact that a careful drawing takes time to make, and shadows change while the details are being recorded. Especially when a drawing is finished away from the telescope, a misplacement of the silhouette of the shadow could easily happen.

There is also quite a difference in the librations at the time of the two observations. Wilkins' drawing shows a typically oval shape for Plato, where the CCD image shows a much more round appearance of the crater, indicating a favorable libration. Note also the shadow present along the eastern part of the inner north wall of the crater in Wilkins' drawing, and the absence of the same in the CCD image.

Summary table of illumination and libration information for the two observations.
(data generated with Lunar Observer's Tool Kit software by Harry Jamieson (11))

	Wilkins	*CCD*
Solar Altitude	5.323	2.969
Solar Azimuth	94.949	92.373
Colongitude	16.479	13.004
Earth's latitude	0.34	5.31
Earth's longitude	-3.23	6.57

Future work.

Plato's Hook does exist. Its nature has not yet been shown, however. We cannot even say for sure under exactly what conditions it is visible. I call on other ALPO observers to continue making observations of Plato in hopes of recording recurrences of this unusual feature. This sort of topographical study may not be in the front lines of lunar science in 1998, but questions regarding what an observer is seeing will continue to arise as long as folks point telescopes at the moon. Maybe we can provide an answer to this question.

Many thanks to lunar recorders Bill Dembowski and Julius Benton, Jr. for their inspiration and encouragement.

References

(1) Wilkins, H.P. & Moore, P., The Moon, 2nd Ed., MacMillan Co., New York, 1961, p. 236.
(2) Ibid, p. 235.
(3) Ibid, p. 234.
(4) Ibid, p. 234.
(5) Ibid, p. 234.
(6) Carle, J. "Three Riddles of Plato", *Sky & Telescope*, Vol.14, 1955, pps. 221-239.
(7) Dembowski, W.M., "The Plato Hook", The Lunar Observer, February, 1997, p. 1.
(8) Nasmyth, J.H & Carpenter, James (1840-1899). The Moon :Considered as a Planet, a World, and a Satellite. -- Second edition. -- London: John Murray, 1874.
(9) Wilkins, H.P., Moon Map, 3rd. Edition, 1951, reprinted as ALPO Monograph Number 3.
(10) Heiken, G., Vaniman, D. & French, B.M. Lunar Soucebook, Cambridge University Press, New York, 1991, p. 95.
(11) Jamieson, Harry D., Lunar Observer's Tool Kit software.

Making the Best Lunar Observation

by

Matthew L. Will
ALPO Lunar and Planetary Training Program Coordinator

ABSTRACT

This paper concerns the steps an amateur astronomer should take in performing a general lunar observation. This includes a certain amount of preparation before the observer goes to the telescope and the basics steps in visually recording a lunar observation.

INTRODUCTION

I am not an artist. I am not an artist! I AM NOT AN ARTIST! This admission may help to describe me as a dedicated lunar observer who is interested in reporting just the facts and a simple visual description of a lunar observation. This summation is also generally reversed for those who are afraid to tackle the somewhat intimidating circumstance of drawing lunar features. Today, I would like to break down some barriers and show just how one can get around some of the frustrations of lunar observation and still do a job one can be proud of.

PHILOSOPHY

The prospective lunar observer can contribute to any one of a half dozen or so lunar observing programs that the ALPO manages. Most of these demand some effort in adequately defining the lunar formation one observes, either through drawing or other means. All these programs originated many years ago when drawing was then a primary process for gathering information about these lunar features. Photography continued to advance along with photometry and now electronic imaging with video and CCDs have made their mark as great visual recorders. However, drawing is simply not just a means of collecting data as it is a discipline of analyzing what is being observed. Drawing trains the eye to see detail normally missed if one were just merely recording images to tape, chip, or film. Such on-the-spot analysis forces the observer to appraise what it is he or she is viewing. In addition to data collection and analysis, the method of drawing provides a baseline with the past when drawing was the primary means of recording an observation. Direct comparisons can be made with what could be visually seen back then **[6]**. Finally, drawing is a true "low tech" way to go since it only requires a telescope, some modestly priced writing utensils and an observer willing to try.

PREPARATION

Lunar observation like other pursuits in amateur astronomy requires a certain amount of preparation and planning. The ALPO lunar observing programs' handbooks and literature offer the lunar observer background information about the objectives of the programs along with a host of target sites that need surveillance. Also, there are many popular lunar books that can assist the well-informed lunar observer **[3,7,9]**. Based on curiosity, interest, and knowing something about particular lunar features of interest, the lunar observer can begin to select a lunar site to monitor. Knowing what crater to observe before one goes to the telescope is important. Understanding what your objectives are ahead of time should be a priority in preparing. Is the moon's libration, its orientation to the earth in its orbit, for this particular night important to my observation of this formation? Is the particular lighting angle, the orientation of the sun to the lunar landscape important? These factors may or may not matter depending on the type of observation you plan to attempt. Some studies demand observing a lunar formation under all conditions to thoroughly understand the formation. Others only need observation at certain times and circumstances.

This same idea of preparing also applies to the observation in what you are attempting to express in your drawing before you set out to draw. This can be as much an artistic question as it is a scientific one. Most amateur astronomers that embark on a lunar observation for the first time are overwhelmed by the massive amount of detail they are confronted with when they start drawing. This problem can be dealt with at the outset in many ways as we will see later. Knowing your purpose for an observation and how you want to express it, is paramount. So having some kind of visualization of how to perform the observation prior to starting will help in reaching your goal of a completed lunar drawing **[10]**.

Another step in preparing that is advocated by most observational guide books are pre-made outlines for the observation **[2,4]**. Here the observer traces an outline of a particular formation or crater he or she is interested in. When observing, presumably the major features have been outlined and observer can proceed filling in intensities and other minor features. I don't endorse this practice for performing general observational drawings **[5]**. For one thing, outlines may not match with the particular libration the moon may be experiencing at a certain time. This is particularly true for craters and formations near the moon's east or west limb. Correcting for this at the telescope means erasing much of the outline and wasting time redrawing it correctly. Also, it's hard to find an outline matching a similar lighting condition as will be observed that evening. Even if one makes allowances for this, it still can be quite disorienting to fit what is seen through the telescope and equate it with the outline. The Lunar Selected Areas Programs makes use of outlines to demarcate various features around certain craters. This has an important purpose for identifying specific areas within the formation that need to be monitored. Work initially done at the telescope can be transferred to these outlines. It might be wise to observe these features on their own, using the outlines to assist in identifying certain features of interest after the observation with the finished drawing.

Selection of materials for drawing can also be important. One should have a clipboard or a suitable flat drawing board to steady the paper one uses to sketch with. Of course, one also needs a light to see by, to draw. The red light amateurs use for drawing and reading in the dark for planetary and deep-sky observing is quite satisfactory. However, one can use a dim white light if preferred, since dark adaptation is not a prerequisite for lunar observation, with the moon casting bright ambient light at the observer's site in the first place.

Use of the type of paper should be carefully considered. Most lunar forms the ALPO produces are printed on standard duplicator paper about 20 pound weight. I have found that this type of paper does not do well in the midwestern United States where humidity levels most times of the year are high. The most erasing this paper can take outdoors would be about once or twice over the same spot in. This type of paper seems to scar quite easily with erasures and becomes more unmanageable as the observation session continues, to the point of waffling due to condensation adhering to the paper. Also, it does not take well to the pencil as the evening wears on. I have found Bristol Vellum, a neutral pH, 120 pound weight, two ply art paper to be quite durable and stiff enough to hold up to the worst humidity. Afterwards the observation can be transcribed to the proper form. One important note. When making an observation on some other paper, be sure that you include all information pertinent for that observation so that no information will be lost prior to transferring it to the proper form. One might put factual data about the observation such as the date, time, and the formation being observed, at the top and written notes at the bottom.

Pencils will be important tools to your drawing arsenal. A simple No.2 pencil will suffice to outline a lunar formation. Artist pencils of the "B" and "H" series will be needed to perform the final drawing. More will be said later about their use. Erasers are an important consideration. Naturally, you want to use an eraser that will not rough up the paper if frequent mistakes are made in the process of drawing. A non-abrasive white eraser is best for this task.

Feel free to bring reference maps to the telescope especially if you are attempting to observe a formation for the first time. You will want to locate the formation correctly before you begin your observation. On the other hand, photographs of the actual formation should not be used since you will need to focus on what you see through the eyepiece as opposed to just trying to match what is in the photograph.

PERSPECTIVE

As I have stated earlier, not being an artist should not keep anyone from beginning to attempt drawing lunar formations. We are not, after all, making pretty pictures of the moon nor are we interested in constructing something that is aesthetically pleasing at the expense of disregarding scientific data that must be reported. Instead, we can combine the best of art and science using artistic techniques to reproduce an image that is representative of what is actually observed.

THE TELESCOPE

Some consideration should be given to the telescope one uses and how it will be employed. Generally, a telescope of 6 inch aperture or greater is needed to participate in the ALPO lunar observing programs. But smaller telescopes will still yield dramatic views of the moon. Drawing of lunar formations from these small aperture scopes can provide excellent practice with impressive results while anticipating a larger instrument in the future.

The equatorial mounted, clock driven telescope, is practically indispensable. It frees both hands needed for drawing and one does not want to stop to reposition the scope once every minute or so, to recapture the lunar formation into the field of view again. The observer should use the scope with properly aligned optics. A good eyepiece such as an Orthoscopic and Plössl type, should be used in conjunction with a barlow lens to increase image contrast and eye relief for more comfortable observing. The magnification you use will vary depending on seeing conditions. Higher magnifications will work better at times when the atmosphere is less turbulent. Ideally, 30 to 40 power per inch should be used to take reasonable advantage of your telescope's resolving capabilities. Often, though, larger telescopes tend to magnify the air cells overhead so that low magnifications are needed to limit the intensity of the atmospheric turbulence.

When observing in winter months be sure to allow your telescope to "cool down" to the ambient temperature outdoors if it is normally stored away indoors when not in use. This is particularly true for reflecting telescopes that are open to the night air. This can take as long as two hours for a six inch f/8 reflector where turbulent seeing will be the rule as warmer air exits the tube until properly cooled down.

THE OBSERVATION

1. Preparation

As the observer begins to start his observation of a pre-chosen lunar formation he or she should be comfortably seated at the telescope. Physical comfort is important. Serious observation can only be performed in a state of physical and mental relaxation. Distractions such as the cold weather, mosquitoes, wildlife, seating, eyepiece orientation, et cetera, should be adjusted for, as much as possible. The observer should not have to strain to see through the eyepiece. The whole observing arrangement should be designed to observe in comfort.

When the observer is ready to begin observing, some assessments needs to be made. During this initial phase of the observation the lunar observer examines the lunar formation. This period of time is used to familiarize oneself with the general environs of the formation or crater looking at general shapes, identifying light and dark patches of lunar soil, differentiating craterlets from domes or mountains, terraces from the rims of crater walls, shadows formations from other dark features around the crater, et cetera. An attempt should also be made to note where the light is coming from in identifying such features. In what direction are shadows begin cast? In low lighting situations near the moon's terminator (the light/shadow boundary where sunrise or sunset takes place) lunar domes can be seen with craterlets in the same area. Both features will cast shadows in a totally different manner. A crater's bowl shape will be in shadow on the side where the sunlight is coming from. On the contrary, a raised relief feature such as a dome will be shaded on the side opposite to where the sunlight originates. Keep in mind we are looking at relief features, not just light and dark areas on the moon. Understanding this will help us in articulating what we are seeing when we draw.

Once the observer has assessed the general characteristics of the formation that he or she will draw, then the observer notes the time and records it for this lunar observation. Thereafter, the drawing commences and the observer starts to commit to paper the basic outline of the formation.

How shall we draw this lunar formation? I have found that outlining the structure in every detail, major then minor and assessing intensity estimates, lighting values for individual relief features first, and making the drawing second, to be the best method for performing a lunar observation. If the intensity estimate diagram and written notes adequately cover what is observed, the drawing can be completed away from the telescope. I have found drawing at the telescope to be disadvantageous because: 1) shading features can take longer and intensity estimates can be done quicker. Intensity estimates have to be made anyhow during the course of the observation as they are required for most observational programs. 2) It is difficult to control the media, in this case pencils, at the scope when racing against time and fighting humid weather conditions. 3) When composing a drawing underneath a dim lamp we may not get the tones exactly right as we might drawing under fully lighted conditions. Maximizing our time for intensity estimates allows us the ability to include as much detail involving the lunar formation as possible. One can make an argument that through actually drawing the moon at the eyepiece we can get a better feel for understanding gray tonations in portraying them as relief features. I know this through my own experiences sketching subjects directly to paper as I viewed them in art class. However, if the observer is mindful on the subtleties of the lighting of relief features on the moon, he or she can accommodate more detail into one's drawing by making an intensity diagram first **[11]**.

2. The Outline of Features

The observer begins drawing a basic outline of the formation. If it is a crater, the observer might begin with the overall shape. Larger craters or walled plains will tend to have a polygonal shape which should make them easier to construct than smaller circular craters. Many of the mountains and hillocks will have a blocky form that is easy for estimating and reproducing proportional shape. Work to sketch in all major detail across the formation before attempting to draw minor detail (see Figure 1). This outline of the major detail serves as a "coordinate system" for plotting minor detail later on [4]. Focus on entering major items that distinguished the floor of the crater or formation. These features might simply be changes in brightness in the lunar soil. A boundary might be evident between two soils of slightly contrasting intensity. The central mountains, craterlets, rills, and hillocks plotted properly can all be plotted at proportional distances to the crater's rim and progressively to each other as each feature is plotted. You keep outlining features that are progressively minor until you are satisfied that all features have been drawn. Depending on the size of the lunar formation or crater and the time available, one should consider outlining some detail outside the formation for a fuller look to the ultimate finished drawing. This will make the drawing look complete. Remember, we are just lining out the observation. Again, be aware of how the lunarscape is being lit by the sun, the interplay of light and shadow and gradations in between. This will be very important in the next step. When finished outlining the drawing note the time. This completed phase will be our frame of reference for the placement of all features seen. The extent of shadows and the size and thickness of all features will be frozen at this time in the observation. The outlining phase should not take more than 20 to 25 minutes at most.

Some amateur astronomers when drawing an outline are preoccupied with establishing a scale or sizing the drawing to fit a certain area of the paper. The observer should draw to an extent where he or she can include detail that will fit comfortably into the drawing but will not cramp or obscure that detail. Some guidebooks suggest a scale of so many inches per tens of miles, but this kind of a standard cannot be met since resolving power and hence the recording of detail increases dramatically with telescope aperture. So, size your drawing so that detail can be easily drawn.

3. Intensity Estimates

The next step of this process we repeat our review of this formation, this time making intensity estimates. Intensity estimates are values of brightness or darkness that are assigned by the observer to each feature outlined on his or her paper. An intensity of 10 would be a bright white not normally seen except on certain central mountain peaks like with the crater Aristarchus. A value of 0 would be assigned to shadows cast by most features around the crater. Intensities for 1 through 9 would represent brightness variations from very dark through very light tonations. In the finished drawing they will represented as shades of gray that will convey form and structure. Not much if any color can be seen on the moon especially in lower aperture scopes. Mainly the moon appears a greenish-brown monotone in most telescopes, like a piece of old cheese! So translating a gray scale to what is seen should not be a problem, this being different if you were distracted by a lot of color. We should work around the rim of the crater or walled plain since it will be the largest structure in the drawing and shows the most variation in capturing a wide range of intensities as it makes a complete circuit around the landscape. It's very important to carefully examine each feature for subtle variations of in tone. Simply recording light and dark patches without having an understanding of the character of the structure and how the light is behaving will not effectively reproduce the formation to paper. Again, be aware that we are trying to reproduce relief features, not just merely recording intensities. These intensities can be labeled to the structures on this sketch by writing the number value in place. Your completed intensity diagram should appear as a lined out drawing loaded with number values for each structure (see Figure 2).

4. Details...Details...Details

After your intensity estimates have been completed note the time for the third and last time. This will end the observation at the telescope. The whole observation should have been completed in a space of time not exceeding 45 minutes. Intensity values can actually change over the course of an hour, especially if the lunar formation is close to the terminator. Hence, the reason for keeping our time limit for an observation to 45 minutes and working at a steady pace during the observation! You should now have a completed intensity diagram for all features seen with this formation. At this point it is important to write down any written descriptive notes about features that while delineated in the diagram, may have characteristics that are not apparent. Furthermore, written descriptions can elaborate on circumstances not readily ascertained by the person reviewing the observation. The visibility of features due to seeing or lighting conditions can be commented on. Also, suspected but not necessarily confirmable features can be mentioned. There has always been some difference of opinion among lunarians how one should go about recording suspected detail. Some have said that only features that are seen with absolute clarity should be drawn and anything that is doubtful or not seen well should not be recorded. Others like William Hartmann have suggested that it is justifiable in the spirit of acquiring new information about a lunar formation, to record suspected detail, but with caution **[4]**. Mr. Hartmann suggest "strongly suspected but questionable features may be recorded in the drawing but also identified in the written notes of the observation as only suspected but not seen with certainty. Still more questionable features may be described in the notes but not put into the drawing." The usefulness of such observational remarks is in the comparison to other observations of the same formation under similar circumstances. Confirmation in two or more drawings might lead to an eventual discovery of a new feature or a transient occurrence of some geological event on the moon. We are, after all, interested in acquiring new knowledge about what we are viewing, not unquestioning or necessarily reaffirming what has already been learned about these lunar formations.

5. Documentation

When all written notes are completed, the rest of the documentation for the observation is needed. I have extensively and thoroughly discussed this in my paper *Check...Double Check...RECHECK!*, delivered at last year's convention [12]. Briefly, one should record:

1. *Name of observer.*

2. *Place of observation.*
   The address of the observer and the place of observation.

3. *Date and time in Universal Date and Time.*
   Using Universal Date and Time allows observations to be analyzed more carefully when compared to other observations using this same time standard. There is no confusion about using differing time standards or misunderstandings about interpreting times recorded for different time zones if Universal Date and Time is used. Three times during the observation should be recorded. One time as the observation commences, a second time when the outline is completed, and a final time at the end of the observation.

4. *Seeing and transparency conditions.*
   Seeing is estimated on a 0 to 10 scale, 0 being the worst quality image and 10 being the best seen while observing. It is a measure of the steadiness of the atmosphere, the less air turbulence interferes during the observation the higher the value. It is a subjective scale that can be approach with better objective means as the observer gains more experience at the scope. Transparency deals with the clarity of the atmosphere. It can be simply an estimate of the magnitude of the dimmest star visible near the moon.

5. *Colongitude.*
   This is the moon's longitude at its sunrise terminator. It can be determined through the use of emphemeris data furnish by various sources including those offered in the *Astronomical Almanac* for the present year. It generally needs to be calculated to the nearest minute and can be done so with tables from most lunar handbooks. Colongitude should be recorded for all three times of the observation.

6. *The telescope and magnification used.*

7. *Filters and barlows, if used.*

All the above should be done the night of the observation. The intensity diagram and written notes should not be changed after the observation has been performed. Colongitude should be checked again and rechecked one more time before being send off to the ALPO lunar coordinator. Documentation is critical to any observation. A misdocumented observation or one with missing documentation is of little or no value to an ALPO Lunar Coordinator, since there is nothing to match this observation with another for comparison. This could be important if the observations were both performed during an unusual occurrence on the moon, on the same night or under similar circumstances.

THE DRAWING

Thus far we have a complete diagram of intensity estimates of the lunar formation and we have thoroughly documented the observation with written notes and data defining when the observation took place and what the conditions of the observation were, here on the earth and on the moon. We can now proceed with actual drawing of the formation we have previously observed.

The choice of media is up to the observer. One can use pencils, ink, or ink washes. Also, individual styles and drawing methods can vary. I will describe the use of pencils with some mention about work with ink.

In working with pencil Clark Chapman once said that one should "adopt a style of drawing that makes it very clear what marks he has intended and which are extraneous."[1]. If the intensity diagram is correct in every way, then the drawing should be a "digital" copy of the intensity diagram. Be deliberate in you pencil strokes when making a full drawing. Bear in mind that the drawing is the intensity estimate diagram "coming to life".

Supplies needed for drawing with pencil include a good set of drawing pencils to represent every tone seen across the full spectrum of intensities, 0 through 10. A suggested series of artistic pencils and their reproducible tones are presented below.

0	1-3	2-4	5-7	6-9
8B	4B	HB	2H	6H

As can be seen from the above table, B series pencils produce darker shades while H series pencils produce lighter ones. The degree of darkness associated with a particular pencil would be a function of pressure and the amount of graphite applied to the paper. Shades will appear lighter with lighter pencils stokes and darker shades can be made with heavier stokes for each pencil (see figure 3). Also, one should note that from year to year, depending on the manufacturer, pencil quality will vary so that adjustments in reproducing tones may be needed.

The soft non-abrasive white erasers I mentioned earlier, that don't scuff or scratch the writing surface, are preferable. Some come in their own tubes and can be used separate with the pencils. An additional eraser can be sharpened to a point to help in touching up areas where an adroit hand is needed. This eraser can be sharpened using an Exacto-Blade, a razor with a knife-like handle, which can be purchased at most art supply stores.

One should obtain an artist stump for smoothing out pencil strokes made to paper. This implement is just a tightly rolled blotting paper in the shape of cigar, narrowed to a point at both ends. Rubbing the artist stump across pencil stokes of the same shading will allow them to blend together while retaining the same overall shade. This makes the drawing look less impressionistic and more representable of what was seen. A cautionary note. I have found the "B" series pencils not to respond well to smoothing with an artist stump. The tone tends to change probably due to smearing with these "high clay content" leads. The stump can be effectively use with pencils in the "H" series without any major distortions in shading.

In choosing a paper, we should use the same durable 120 pound Bristol Vellum as suggested earlier for outdoor use. It will be more than adequate for pencil sketching.

With one's completed observation and artistic supplies at hand, the observer can begin the full sketch. This can be done simply by first reproducing the outline of the lunar formation on the paper being used for the sketch. Having a light box to produce a second outline by tracing it to a second paper can speed up the process and at the same time improves accuracy. Place a blank sheet of drawing paper over the intensity diagram on the light box to trace the figure of the lunar formation. Now we have a completed outline from which we can draw. From there it is a matter of applying the proper shading for each intensity associated with each feature seen in the initial observation (see figure 4).

Don't be surprised if after your first drawing, it does not look like anything you viewed. Drawing takes lots of practice and training of the eye to capture visual detail as it really is. Doing it frequently will make you become a better observer. Prescribing the methodology of making a notational sketch of intensity estimates at the telescope and working indoors in creating the drawing itself is not without its drawbacks and critics. This whole process can be frustrating in that the sketch is done after the observation and not during it. I encourage anyone that desires to draw at the telescope, to do so. It may help in appreciating how these features really capture the sunlight on the moon. I offer the other way of doing things as an efficient manner of using one's time to collect the most data concerning the formation and still achieve a decent sketch. I have had a formal training in drawing theory in the past. So estimating the character and proportions of three dimensional structures and recording them to paper in an abstract manner is not too difficult for me to do and to translate this code into a picture later on. But again, you don't have to be an artist to do good lunar drawings and meaningful observations. I have found that knowing something about artistic technique helps.

One alternative to filling in tones from a drawing outline would be to use the erasure technique popularized by Raymond Coutchie [2]. Here the paper is gently rubbed by 2B pencil graphite shavings embedded in a cotton ball. This produces a tone corresponding to a intensity of about "5". An outline is then drawn to the paper. From here the observer sketches in darker areas in with higher "B" pencils while erasing out lighter areas, the lighter the tone the more erasing that needs to be done. While this is a valid style, it take more practice to perform since one does not have as much control over the production of shading as with the sketching method I have proposed.

Ink is another valid technique for visualization of intensity diagrams. Stippling and cross-hatching can be effective in translating tone and dimensionality of lunar formations. Ink washes can be used also. Andrew Johnson and Harold Hill have demonstrated the usefulness of ink and have done outstanding work in this medium [6,7].

As I stated earlier we are not attempting to produce fancy art work nor are we merely gathering data for its own sake. We are using the techniques of artistry to reproduce what we are seeing through the telescope. Through this type of study we are engaged in a form of analysis that draws us nearer toward our subject than simply recording it electronically.

If we are mindful to make our observations complete with careful examination of these lunar features, both through drawing and the written word, the value of the observation is enhanced immeasurably. There are many qualities that the lunar observer can offer to meet that end. Knowledge, skill, neatness, care, perseverance, and self patience if practiced will surely help the prospective lunar observer reach that goal of true value. For lunar observing is a learning experience that affects the observer on many different levels and likewise pays off in many rewards.

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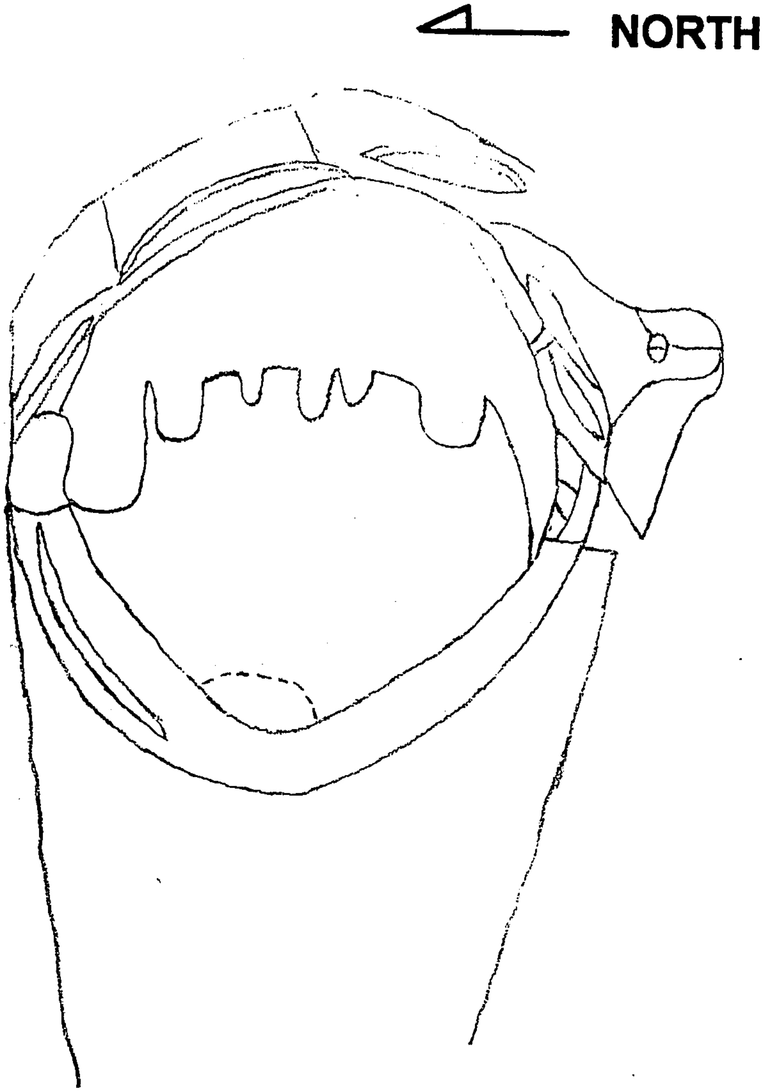

FIGURE 1

The Crater Archimedes - Outlining the Features

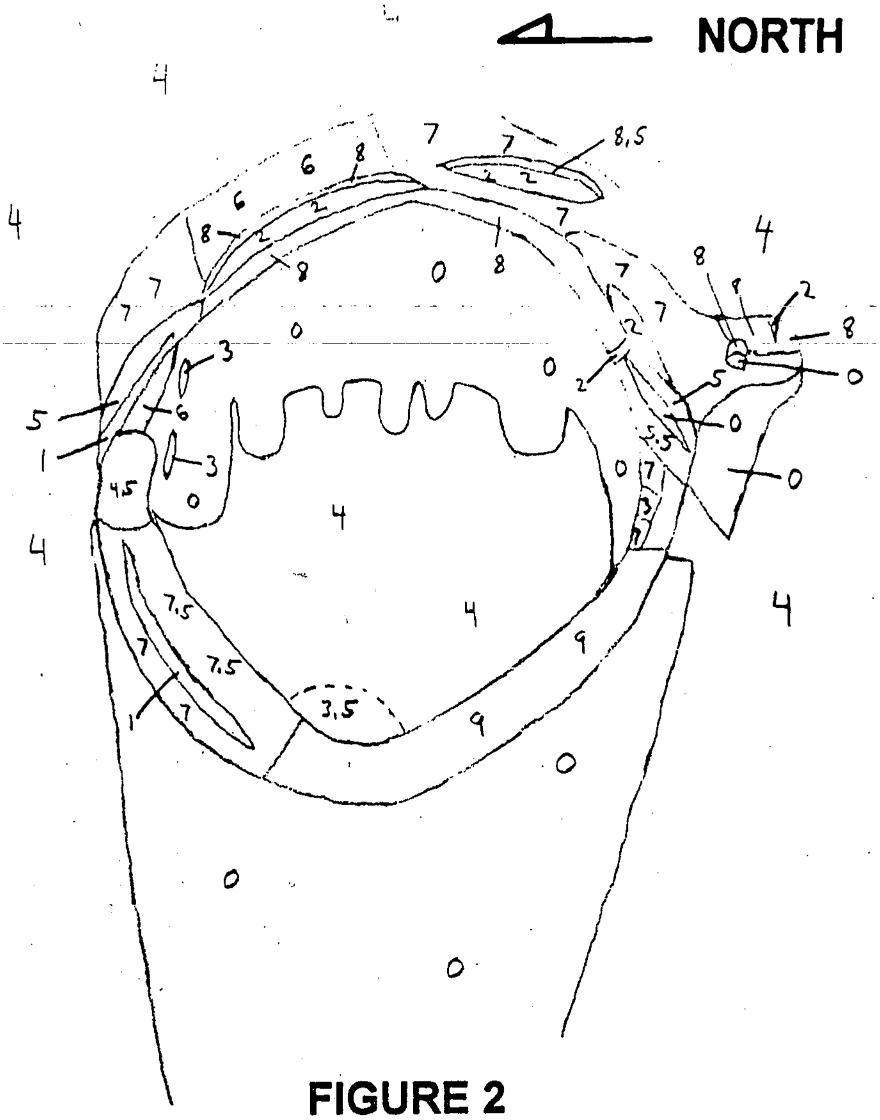

FIGURE 2

The Crater Archimedes - The Intensity Diagram

Date: April 5, 1998, Time: 2:15 - 2:45 - 3:00 UT,
Colongitude: 7.85° - 8.10° - 8.23°,
Sun Angle: Altitude = 3°; Azimuth = 93°,
Seeing: 4-6, Transparency: 2.5,
Instrument: 8 inch f/6 Newtonian reflector, Power: 230

Several terraces were seen around the crater's rim. The basin was flat and practically featureless. Note the peaks protruding out of the shadows on the north end of the crater. Seeing conditions and time limitations were restrictive factors for recording intricate details.

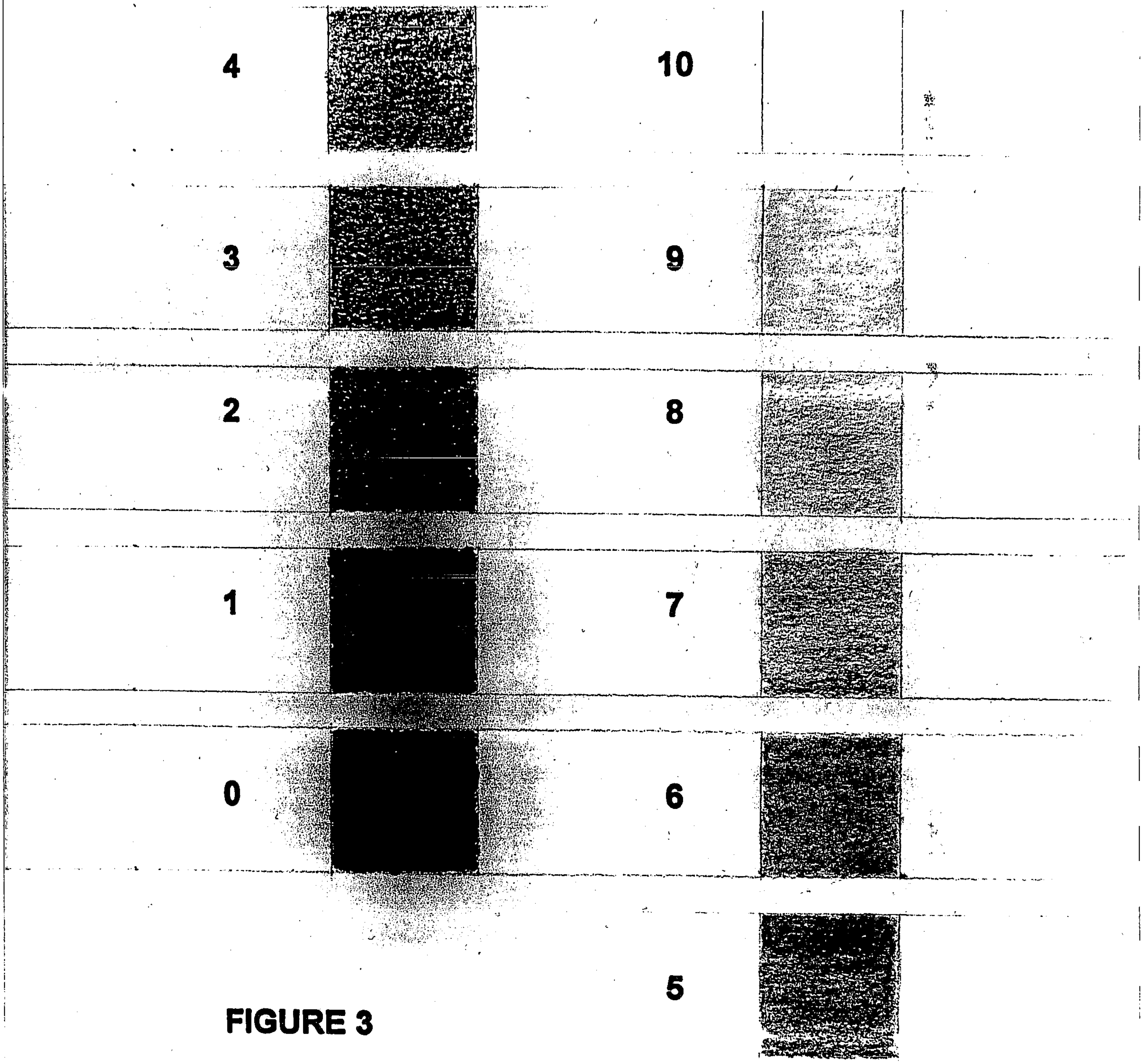

FIGURE 3

Vaule scale.

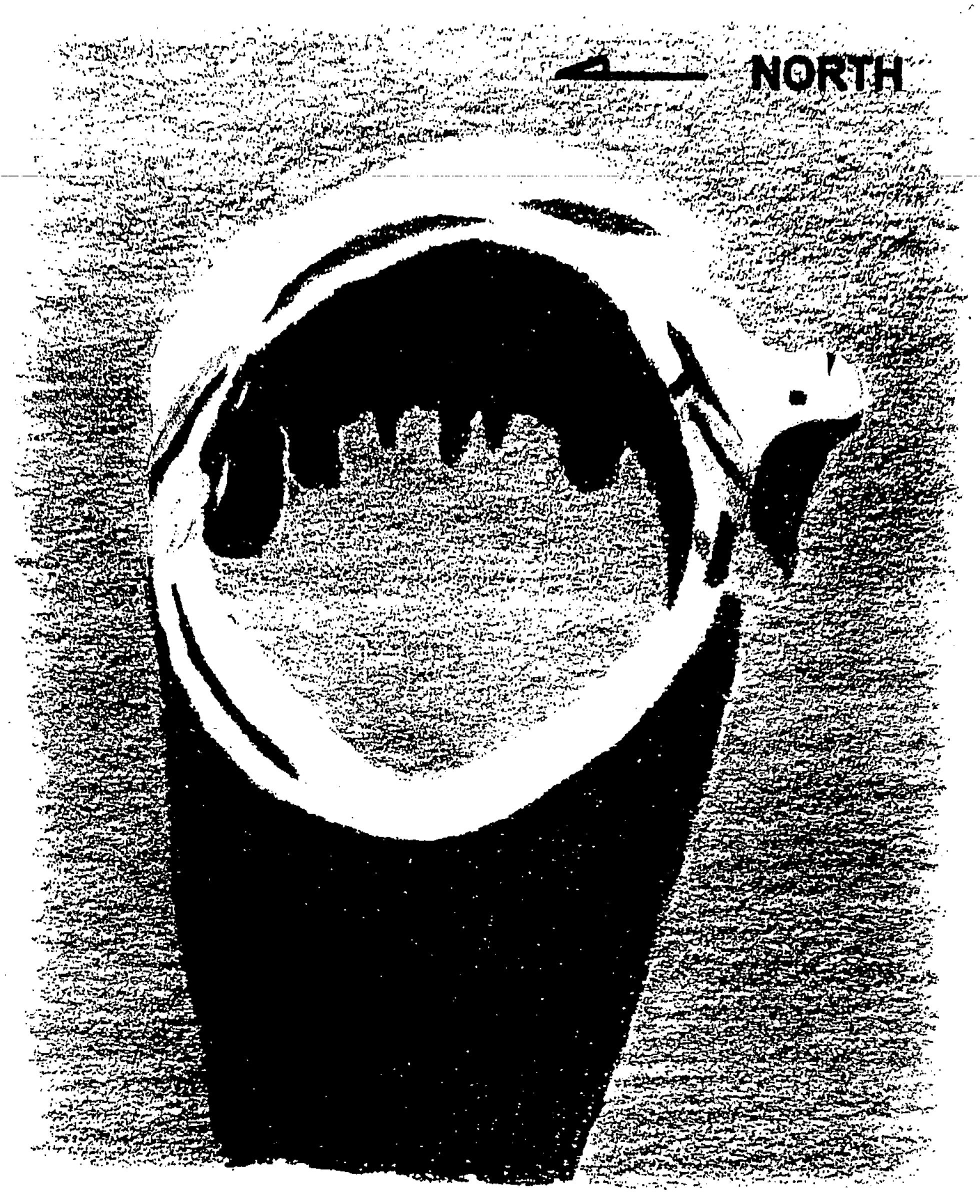

FIGURE 4

The Crater Archimedes - The Pencil Drawing

1998 State of the ALPO Message

By Harry D. Jamieson,
ALPO Executive Director

In the thirteen months since we last met to celebrate our 50th Anniversary in Las Cruces, we have continued to make progress on many of the long- and short-term problems that face us today. I would like to bring you up-to-date on some of these things now, and then invite questions and remarks during the Business Meeting to follow. 1997 was a much less volatile year than 1996, but we nevertheless made considerable progress on several important fronts.

In the Solar Section, we lost Tony Portini to personal problems, but Rik Hill has managed to completely reorganize the Section and add three people to it -- Gordon Garcia, Jeffery Medkeff, and Jeffery Sandal. In addition to overall coordination, Rik now handles the web site, SolNet, the Rotation Report, and the writing of the new Handbook. Gordon now handles correspondence and new observers. Jeff Medkeff generally assists Rik and will be responsible for the computerized archiving of the Section's observational files. And Jeff Sandal will handle the Section's publications. SolNet, the Section's e-mail news service, continues to come out several times a day as observers and staff members have newsworthy things to report. Future goals continue to be the reactivation of the White Light Flare Patrol and, down the road a bit, 24-hour coverage in white light.

In the Mercury Section, we have lost Dr. Oscar Cole-Arnal, who has been given additional teaching responsibilities. However, we have acted upon his recommendation and replaced him with Harry Pulley, a friend of Oscar's who lives nearby. Harry and Oscar have been observing Mercury together for several years, and Oscar says that he will continue to work together with Harry and help him with the Mercury Section. Harry has a strong mathematics and computer science background, and one of his first tasks will be to start on the job of creating a computerized archive for the Section's observations. Oscar will be missed, but as he wants to continue on as a "silent partner" in the Section with Harry, I have high hopes that the Section will continue to advance as it has during the past two years.

The Lunar Section continues it's revival. Bill Dembowski's really excellent newsletter *The Lunar Observer* continues to come out regularly every month and is always enjoyable reading. Newsletters are difficult to maintain without material coming in from contributors, but Bill has been receiving regular observations from quite a few people -- Robert H. Hays' work stands out in my mind -- which have made the newsletter well worth subscribing to. Bill has branched out into vertical studies, and would like to start a formal Lunar Section program to compile and catalog the heights and depths of as many lunar features if possible. He and a few others on the ALPO staff have also been making their presence known in the Shallow Sky listserv organization, which is a non-ALPO-affiliated group of amateurs like ourselves with a less formal approach to lunar and planetary observing.

In another part of the Lunar Section, Julius Benton's revival of the old Bright and Banded Craters and Dark Haloed Craters Programs into the Selected Areas Program is going well. These earlier programs studied craters with bright and dark bands within them as well as craters (such as those within Alphonsus) that are surrounded by very dark ejecta. These additions to the Selected Areas Program will widen observer interest in it as well as enhance the science produced by it.

In the Jupiter Section, Wynn Wacker has had to resign due to the pressures of family and job. We will miss Wynn, who had a lot of good hopes and aspirations for the Section. I have appointed David Lehman to take his place, while our other two Coordinators will remain with us in their current positions. The remaining Coordinators' commitment to the proper running of the Jupiter Section remains strong, as is their commitment to see the Section expand. I expect to see two or three additional Assistant Coordinators appointed soon to take responsibility for the past unwritten Jupiter apparition reports, a Jupiter Section Handbook, and the revival of Jovian radio astronomy. David has already vastly improved the Section's presence and services on our home page, including a regular newsletter. Our goal is to see the Jupiter Section assume its proper place in the ALPO and rival the Mars Section in its number of observers, level of activity, and contribution to planetary astronomy.

In the Computing Section, our new Coordinator Mike McClure has done an outstanding job with the Section's newsletter *The Digital Lens*, with the latest issue being over 60 pages long in .pdf file format. The newsletter is free and available in Adobe Acrobat Reader Version 3.0 format or on the Internet. I am especially proud of this achievement, though of course all of the credit for it must go to Mike and the many people who have contributed material to *The Digital Lens*.

The ALPO's web page has not stood still during the past 12 months either, thanks to the hard work of our Webmaster Richard Hill! It has nearly doubled in size since October. Our web received The Education Index's Award for Excellence last year, and continues to maintain it. Richard has helped all of the Sections to build attractive and useful "Section pages", which in turn have helped to bring in new observers and members (he considers the Mars Section page to be our best!). His biggest need right now is for more post-ready material from Coordinators. Thank you again, Richard..... We owe you a great deal.

While many positive things are happening in the ALPO right now, we still face many challenges. One of the foremost of these is the question of how to publish the *Journal* on a regular schedule. After giving the matter much thought, it was decided last summer to enlarge the editorial staff and reorganize how papers come into and flow through the process of editing. Julius Benton, who already had much on his shoulders, volunteered to act as our Distribution Editor. All papers should now come to him first so that he can distribute them among our new Assistant Editors. After a paper has been edited by the Assistant Editor, it is then returned to Julius for additional checking, after which Julius may return it to the Assistant, return it to the author for rewriting, make additional editorial changes himself, or simply pass it on to Editor-in-Chief John Westfall.

While John may make yet additional changes, it is hoped that this process will at least fix the most obvious problems and result in John getting cleaner material. This in turn should result in him having more time to put the *Journal* together and get it to the printer on schedule. Indeed, I'm proud to say that since we have developed this system, every issue has been on schedule. While additional editorial help has been an important part of the solution, it must be remembered that every equation has two sides. Authors need to take more responsibility for their papers and follow John Westfall's guidelines for authors published recently in the *Journal*.

Papers that don't follow these guidelines or that contain excessive mistakes can (and should) be returned to the author by the editorial staff for reworking. Everyone, including authors, must do their part to keep the *Journal* coming out on schedule. We can no longer afford to make the entire membership wait for the *Journal* because an author cannot spell or write a coherent sentence.

On a much more positive note, I would like to take this moment to thank and praise Leonard Abbey for the work that he did as Editor of our new booklet called *Exploring the Solar System with the ALPO*. Aimed at people who write to me asking for information about the ALPO and how to join it, this booklet gives us for the first time something solid to send to inquirers. Though we've had little pamphlets in the past briefly describing our programs and listing our staff members, this booklet takes a different approach. It more fully describes our programs, but does not list our staff people at all.

This does several things, including keeping the booklet from becoming obsolete when a staff member leaves, and encouraging people to join instead of just submitting observations. A cover sheet giving current dues and other membership information is inserted into the booklet before it is sent. I would also like to thank David Graham for allowing us to use one of his fine Saturn drawings on our front cover, as well as the authors who wrote the various chapters within. These include in no particular order Leonard Abbey, Richard Hill, Richard Schmude, Julius Benton, Wynn Wacker, Oscar Cole-Arnal, Matt Will, John Westfall, Dan Joyce, and Bill Dembowski.

The ALPO still faces one final challenge, and that is the aging of its membership. I said last year that I recalled attending my first convention in Detroit in 1961 and seeing a lot of my peers about the room. I also said that as I look around today I still see a lot of my peers, but now they're all over 50! Unfortunately, little has been done to address this problem in the last year, and as Director I have to assume full responsibility for this. Oh, some very positive steps have been taken by Rik Hill, Jeffery Medkeff, and Bill Dembowski to generate some interest in what we do among the members of the Shallow Sky association, but this effort has been directed at increasing membership in general and not specifically at bringing in young people.

With this in mind, I would like to propose that the ALPO institute a program where volunteers would go into their local high schools and, in cooperation with the school's science teachers, give special astronomy presentations emphasizing the solar system and the bodies that make it up. This idea is not new, and I will admit without shame that I have stolen it from a very similar program that the AAVSO appears to have been conducting for years. What is needed first is someone to volunteer to coordinate such a program and come up with a standardized set of materials to be used during these presentations. The program coordinator would work with the local volunteers, instruct them on presentation methods and materials, and report to the ALPO Board at set intervals. The volunteers would be responsible for making contact with their local high schools and making the presentations. While the presentations would stress real solar system astronomy, the materials and some of the dialog would "plug" to the ALPO These presentations could also be done as a part of the school programs that many local astronomy clubs, planetariums, and museums already have in place.

All in all, I feel that the ALPO is still moving in the right direction. What we need more than anything, though, is for more people to come forward and contribute their time, their skills, and their love ("amateur" is a French word meaning love). Like many other organizations, ours is kept going by the work of only about 5 percent of its membership. Think of what we could be if this percentage were just doubled!

Ultimately, it will be you, the members of this organization, that will decide whether or not it will survive far into the next century.

THE 1997-1998 ANNUAL REPORT OF THE ALPO SOLAR SECTION

By Richard Hill
ALPO Solar Section Coordinator

I am very happy to report that the ALPO Solar Section is very much alive and well. Since our last annual meeting in Las Cruces, New Mexico, there have been many changes -- more than any of the other Sections, making the Solar Section as dynamic as the object of its study, the Sun.

There were great hopes that our activity reports and the Handbook would be back on track after the former Coordinator, Anthony Portoni received the more recent files at the Las Cruces meeting. However, by Thanksgiving, he reported to Director Harry Jamieson that due to new job pressures and some personal difficulties, he was simply unable in good conscience, continue on as Coordinator. At that point, the Director, acting with Machiavellian aplomb, pressed yours truly into service.

The first orders of business were staffing and consolidation of the files. With three Coordinators in two years, the files were literally scattered from coast to coast across the U.S.! It took several tries, but by March of this year, stability reigned and we announced the following staff:

Richard Hill - Acting Coordinator - Observations, Reports, Rotation Report and White Light Flare Patrol

Jeff Medkeff - Acting Assistant Coordinator - Archivist

Gordon Garcia - Acting Assistant Coordinator - Training and Correspondence

Jeffery Sandel - Acting Assistant Coordinator - Handbook

Francis Graham - Coordinator - Eclipses

By April, all of the files were in the hands of the Acting Coordinator, who along with Acting Assistant Coordinator Gordon Garcia, began a big push to reinvigorate observers old and new. Solar activity is picking up, and the observations should be, too. As always, Garcia led the way with arc-second and sub-arc-second quality images taken with his refractor. Watch the future issues of the *Strolling Astronomer* for some of his spectacular results. The push has been very successful. In the last *Rotation Report* we had over 100 observations submitted, including CCD, photographs, drawings, white light flare patrol reports, video observations, and digital (both CCD and photographic). It took three days just to prepare the report!

The first activity summary report in over a year and a half is nearly done. It should be in John Westfall's hands shortly after this meeting. Work will begin immediately on the next one. Unlike other Sections, the Solar Section has no conjunction for a respite. At present, the data in the reports are 3 - 4 years old. It is hoped that this time can be halved soon. The ideal situation would be about a year's lag time.

Back in May of this year,the White Light Flare Patrol received its first observations of potential white light flares from Joao Porto of the Azores, using a 90mm aperture ETX telescope. You can see his work regularly posted on the Solar Section, Recent Observations webpage. They are an inspiration to anyone with a small telescope. The confirmation for one of these flares comes from observers in Florida moving it from a "potential" to a "probable" sighting of a white light flare.

With the addition of Jeff Medkeff, a computer network specialist, the Solar Section has moved into new territory. Work is presently underway to digitally archive observations of the Section. At present, four rotations have been done from the period of the aforementioned activity report (1993-94). We hope that by this time next year, we will have enough for our first CD. This means that the next Solar Section catalog of data, produced twice before through the efforts of former Coordinator Paul Maxson, will be on CD and not paper. This will mean a tremendous savings in cost, time and materiel.

Correspondence in the Section has never been better. We are in regular touch with other Coordinators of the ALPO and most of the observers through email. Gordon Garcia has been keeping many observers energized and in touch through letters and e-mail. This, plus his excellent observations, makes him doubly valuable to the Section.

After a delightful meeting with Jeffery Sandel at Las Cruces, the author was determined to bring him onboard in the Section staff. His article in *Sky and Telescope* shortly thereafter demonstrated that he was a person well-suited to finish the work on the long overdue Handbook. He accepted the position as Acting Assistant Coordinator in charge of completing the Handbook, thereby rounding out the Section staff.

This, then, is the state of affairs in the Solar Section. Observers are observing, data is coming in, we are regularly posting the data on the website and thus promulgating it to the professional community who are using it. It is then being detailed in activity summaries and archived. With all this in place, we look forward to a well-observed Solar Cycle 23.

Respectfully submitted,
Ricahd Hill

THE 1997-1998 ANNUAL REPORT ON THE ALPO WEBSITE

By Richard Hill
ALPO Website Coordinator

In the last year the ALPO website has grown in length, breadth, and depth. The number of pages to the website has nearly doubled in a year. But there is still much room for growth, as many Sections have yet to make effective use of this facility. Our site is now searchable on many engines, but there are others that require up-front payment to add us to their lists. We are looking at ways of getting around this.

The most popular page of the website appears to be the Tons-O-Clubs Links. About half the mail received is about this page, either adding or changing links. In every case the person/club making a request is asked to carry us as a link on their page and to date, all do. We are linked on professional and amateur pages around the world; the BAA, JPL, Solar News, and The American Meteor Society just to name a few.

In response to some recent comments, a streamlined version of "How To Join" was posted and is followed by the detailed comments. This is part of a continuing effort to ensure that the website pages load quickly, are visually pleasing, and contain the necessary information that can be gleaned rapidly. An experiment of using image tiles for backgrounds was tried recently and was a spectacular failure. Tiles, with their repetition on a page, made too noisy a background and it led to many complaints. The notable exception was the Mercury page where a tile of one crater is the background. Such an experiment may be tried on other pages in the coming year. All this is to help the pages load faster and to take less disk space, since a tile typically takes a tenth of the space of an image. Presently, the Website takes up about 15 Mb of room. It can vary by 5 Mb from day to day, depending on images posted. This is not a problem and will not be for the foreseeable future.

Another feature has been decided against as well. Many websites have motion graphics (usually a series of images that are used like a flip-pad) and overlaying icons and boxes. These all slow down the loading of the site. While our members are fairly well-versed in technology, still some are using equipment and browsers that are limited in speed and ability. The ALPO website has been constructed to be usable for the widest possible audience while still maintaining the attractiveness. For this reason, a minimal "text-only" version has been maintained and a lot of the "hot java" and interactive features have not been included. As a result, we have a good-looking site that is downloadable even by a user with a 286 megahertz laptop, an old modem, and a Lynx browser. In the last year, only one person has complained of not being able to get our site loaded; and the hang up appeared to be his equipment's ability to translate the USNO clock.

Development of individual Section webpages is lagging a bit. Leading the way in webpage development are the Lunar, Minor Planet, Solar and, most recently ,the Mercury Sections. Other Sections can make better use of that which is available through the following suggestions.

Alert Notices

Only three Sections at present have provisions for these. Of all the materials submitted for posting, anything marked as an Alert Notice receives top priority and is usually posted within the day so observers can make use of this information the next night. The information is posted in simple text with non-captioned photos, thus making it easier and faster.

Newsletters

Five of the Sections (Comets, Lunar, Solar and Jupiter) post or link to newsletters for that Section. This is a great way to keep in touch with observers and to guide them in effective observing. These can be posted rapidly if the Coordinators either maintain their own site and the ALPO Website links to that, or if they submit HTML documents with photos. Either way is fine. If materials are submitted in plain text, then posting is delayed somewhat while that little ol' webmeister makes the newsletter from scratch.

Images

Posting of images is best done when observers put their names and relevant information within the boundaries of the image. It really slows things down if captions and images have to be posted separately.

Observing Forms

It would be very helpful to have a set of observing forms for your Section posted on your webpage. The best format for this is as a scanned image. Then observers can just drop digital images onto the forms, fill them out with an image editor, and the data and information never become separated.

Keeping Information Current

It is very important that information on the website be kept current. Please let the webmeister know when events and activities no longer need to be posted. Old information can often be worse than none at all. It is impossible for one person to know all of what is current in each Section, therefore it is incumbent on the Coordinators to notify me when there are changes or an announcement is now past usefulness.

Remember, the ALPO Website is the front door for many prospective members. If it is confusing, ambiguous, or uninformative, we lose them. I will continue to do my best at ensuring prompt posting of materials, but as the site grows further I will need the help of all Coordinators in ensuring that the information is accurate, and in a form that can be rapidly posted.

Respectfully submitted,

Richard Hill

Changes in the Jupiter Section

By David J. Lehman

Abstract

The Jupiter Section of the Association of Lunar and Planetary Observers (A.L.P.O.) has undergone a facelift with new staff and a number of new features. This paper outlines the staff changes and introduces the new features. New features include: Jupiter observation forms have been revised; an E-mail network established; the Section has a newsletter; transit timings and drawings can be submitted over the Internet; a Jupiter Observer's Start-Up Kit is available; and unpublished apparition reports are being worked on. Also included is a list of where observers are to submit observations.

Introduction

Over the past two year the Jupiter Section of the Association of Lunar and Planetary Observes (A.L.P.O.) has experienced many changes in both staff members and Section features. The staff changes became necessary as long-time staff members neared retirement. Faced with this situation, in 1996 A.L.P.O. Executive Director Harry Jamieson appointed Wynn Wacker as Coordinator of the Jupiter Section. Wynn Wacker, however, resigned in May 1998; Harry Jamieson then appointed me (David Lehman) Acting Jupiter Section Coordinator.

Staff Changes

The following is the summary of staff changes during this two years period: In 1996 long time staff member and past Coordinator Jose Olivarez retired from the Section. Phillip Budine, Assistant Coordinator for Transit Timing and past Coordinator, stayed on while new staff was appointed; after staffing was in place, Phillip Budine retired in February 1998. Carlos Hernandez stepped down as Assistant Coordinator due to the heavy load of the Mars Section and Medical School. Harry Jamieson appointed Sanjay Limaye to the staff in 1996. Before Wynn Wacker resigned he appointed David Lehman and John McAnally to the Section staff in 1997.

Currently, I am Acting Jupiter Section Coordinator; John McAnally is Acting Assistant Coordinator, Transit Timing; and Sanjay Limaye is Assistant Coordinator, Scientific Advisor. Long-time Assistant Coordinator John Westfall remains in charge of Observations of the Galilean Satellites.

New Observation Forms

Before Wynn Wacker and Carlos Hernandez left the staff, they revised the Jupiter Observation Form, Sectional Sketch Form, and wrote detailed form instructions. In the past a variety of observing forms were used for recording observations of Jupiter. The current staff is attempting to standardize the forms used by observers by encouraging the use of the new forms. The forms and instructions are available on the Section's Web page or by mail from either David Lehman or John McAnally. Please include a self addressed stamped envelope with request for the forms.

E-mail Network

To improve communication among observers, an E-mail network has been established. The network is called J_Net. The network promotes Jupiter observation, allows interactive communication among observers, reports bulletins related to Jupiter observation, and builds unity among Jupiter observers. This communication between observers should generate more attention toward the observation of Jupiter. J_Net will also help to educate new observers to become more proficient at transit timing and disc drawing.

The workings of the network are simple: E-mail is sent to David Lehman, comments are added to the E-mail if appropriate, then it is re-mailed to the entire list. As of this writing, J_Net has 28 members from five countries and growing rapidly. To join: Send an E-mail to DLehman111@aol.com, place 'subscribe J_Net' in the subject field.

Newsletter

In February 1998, the Jupiter Section began publishing a newsletter, the newsletter is called Jupiter. Jupiter provides a timely, permanent record of Section news, and is a means of one way communication from staff to Jupiter observers. The contents of the newsletter are a feature article, recent observations, and Section news. It is published monthly during prime observing season and every other month between apparitions. Recent articles include "Transit Timing" and "Barges of the NEBn." The newsletter is produced in HTML format and is available on the Jupiter Section Web page or by mail. To receive by mail, send self addressed stamped envelopes to: David Lehman, 6734 N. Farris, Fresno, CA 93711.

Internet Submission of Observations

With all this communication and information being provided for Jupiter observers, it only makes sense that a rapid means of sending transit timings be established. This has been accomplished through the Internet. A Transit Timing Submission Form can be accessed from the Section's Web page. The observer simply fills out the form while online; it is designed similar to the paper form filled out while observing at the telescope. By clicking 'send' the observation form is E-mailed to Section staff.

However, because observers also make disc drawings and intensity estimates on the paper Transit Timing Form, the paper form still must be mailed to staff. Consequentially, this requires that all transit timings made by an observer be numbered. Start with number 1 for the first timing of the apparition and continue sequentially throughout the apparition to, say, number 155 (if he records 155 timings that apparition). Most observers number timings already, so this is not added work. Numbering timings eliminates the chance that the recorder might double record timings sent over both the Internet and by mail.

Observers can also transmit complete at-the-telescope paper observation forms via the Internet. The process is simple, scan the form, convert it to JPG format, then transmit it as an attached file to an E-mail message sent to the appropriate staff member (see below). The Jupiter Section's standard format for scanning forms and drawings is: 'Black and white photo,' 100dpi, JPG format.

Section Handbook

The Jupiter Section is in need of an official Observer's Handbook. Therefore, the development of a handbook is a top priority. As a start, staff has assembled a Jupiter Observer's Start-Up Kit. This provides the Jupiter Section with a start-up package for new observers. As a result, observers new to Jupiter observing can get started immediately. In the meantime, the staff is refining and expanding the Start-Up Kit into an official manual.

Topics covered in the Start-Up kit include: Introduction to Jupiter, Transit Timing, Jovian Nomenclature, Jovian Features, Jovian Abbreviations, Drawing the Disk of Jupiter, Instructions to Jupiter Forms, List of Books for Further Reading, Jupiter Forms, Sample Form Filled Out, and Sample Drawings. The Start-Up Kit is available from David Lehman for $3; the price covers printing and postage. It was felt important that the Start-Up Kit be affordable, to encourage new observers.

Apparition Reports

There is a 10 apparition backlog of observations to be evaluated and submitted for publication as apparition reports. Obviously, this is an unacceptable backlog. The past work of dedicated observers must be properly recognized and published. Current observers must feel confident their work will be properly used. The A.L.P.O. Jupiter Section must have a continuous record of apparition reports. Almost all observations from these backlogged apparitions are now in the hands of the current Section staff.

Processing these observations into apparition reports is a major job and major challenge that faces Section staff. However, staff is dedicated to producing these past apparition reports in the most complete presentation possible. The now retired staff of the Jupiter Section carefully preserved these past observations;the task currently faced is possible to accomplish because of the care taken in preserving these valuable works.

Archiving Observations

The archiving of past observations is still in the planning phase. Of main importance now is to assemble all past observations, make backup paper copies, and scan them in to digital format. Copies, both paper and digital, will then be stored with both David Lehman and John McAnally. This will eliminate the possibility that a natural disaster could wipe out decades of priceless work. Later will come the long and tedious task of inputting all the data into a database. Currently the format for such a database is being discussed. To accomplish all this will require the appointment of an Archivist. However, our main concern for now is to organize and preserve all past observations.

Submittals

Make observation submittal to the Jupiter Section as follows:

Mail transit timings monthly to:
John McAnally
2124 Wooded Acres
Waco, TX 76710
E-mail: CPAJohnM@aol.com

Internet submission of transit timings:
Use submission form at:
Link on Jupiter Section Web Page, or
http://users.aol.com/DLehman111/jupiter/jup-form.html

Mail photographs and images at least monthly to:
David J. Lehman
40 E. Minarets, Suite 10
Pinedale, CA 93650
E-mail: DLehman111@aol.com

Mail observations and timings of eclipses of Jupiter's satellites to:
John E. Westfall
P.O. Box 16131
San Francisco, CA 94116
Internet: 73737.1102@compuserve.com

Summary

With the changes in the Jupiter Section made, things have settled down and now the work of the Section is the top priority. Most likely there will be a heightening of enthusiasm toward observing Jupiter over the next few years as Jupiter becomes more favorably placed to northern hemisphere observers. The Jupiter Section is ready.

Addendum
to
Jupiter Report

presented to the
A.L.P.O. *Atlanta Convention*
July 1998
by
John W. McAnally

Collection of Data

During the changes in coordinator and assistant-coordinator the gathering of images and transit data continued with little interruption nor confusion. Previous staff members were very helpful and conscientious. The plotting of transits and drift rates for the 1997-1998 Jupiter apparition is basically completed. The apparition report itself has actually been started with an outline completed and the body being drafted. John W. McAnally will actually write the report with David Lehman co-writing. John and David are presently in the process of exchanging information to ensure that John has the complete body of work from which to write.

Sketches, images, and transit reports are now also coming in for the 1998-1999 Jupiter apparition. As always, many features are being observed. To date, we have plotted transits for Oval BE, and we are tracking at least nine dark features of the NEBn. As a result, we have tentatively recovered all seven dark features of the NEBn of the last apparition. Many of the experienced observers have been heard from already, and we are sure we will hear from the others as well. Additionally, several new observers have surfaced, having found ALPO's Jupiter web site. David Lehman and John McAnally have managed to maintain, what is turning out to be at the least, a weekly dialog with these observers through the internet.

Merging of Ovals BC and DE

As reported by our own Donald Parker,other colleagues, and the BAA as well, it appears that long-lived ovals BC and DE have merged. Our own transit plots and drift rates for the 1997-1998 apparition indeed show this to have been the trend. As also reported by the BAA, our plots show BC and DE to have been approximately parallel and within 16 to 19 degrees of each other through October 17, 1997. After that date, the separation decreased to 15 degrees by November 17, 1997, which is the last observation reported to us. On November 17, 1997, Claus Benninghoven reported BC at 21 degrees SII and DE at 36 degrees SII. Another, less prominent oval, was consistently observed following DE by 22 degrees to 24 degrees from July 11, 1997 to October 21, 1997, our last observation. Oval FA was inconsistently reported following these ovals at 189 degrees SII in July and August 1997.

During the present 1998-1999 apparition, merged oval BE has been observed with some consistency at longitude 294 degrees to 280 degrees SII from May 17, 1998 to June 20, 1998; fairly consistent with other reports. Observers are reporting BE to be exceedingly faint, which is consistent with a recent observation by Donald Parker. This also accounts for the relatively few observers who have seen BE so far this apparition.

Contact with the Professional Community

Sanjaye Lemaye is the official Section Advisor. However, we have also made contact with Dr. Reta Beebe, PhD., at NMSU. We are happy to report that Dr. Beebe was very cordial and very pleased to hear from us. On June 10, 1998, John McAnally introduced himself to Dr. Beebe by e-mail, informing her of his acting position in the Section. This generated an almost immediate reply from her graduate assistant who requested John's phone numbers, which he provided. The next day, Dr. Beebe telephoned John at his office, during which a detailed conversation took place lasting more than twenty minutes. Dr. Beebe was very eager to find out what data we had concerning the white ovals of the STeB. She explained she had imaged the area with the Hubble and was scheduled to do so again in the near future and wanted the information we had regarding their positions. The conversation concluded with John and Dr. Beebe agreeing to stay in touch and with Dr. Beebe requesting that we send her data as we receive it. She provided several e-mail addresses where she or her assistant could be reached, including her address at NASA headquarters. Since that time, we have provided Dr. Beebe with current transit data for oval BE on several occasions.

What most impressed us was that Dr. Beebe did not treat us as amateurs and considered our data to be valuable and timely. This was most gratifying. While members of the Mars Section have already developed a good, working relationship with the professional community, the Jupiter Section, as a Section, has not. We hope this will be the beginning of such a relationship, and fully intend that we will be a valuable resource. We are determined to get " into the game!"

We have also been contacted by Alan McRobert with Sky and Telescope magazine, requesting the position of the GRS, which we provided.

South Equatorial Belt Disturbance

As reported by several observers, we apparently have a classic SEB Disturbance now active on Jupiter! Not only have Donald Parker and John Rogers observed this outbreak, but several other ALPO observers have seen it as well. Several independent observations have confirmed the longitude of the disturbance and are in very good agreement. This includes a CCD image by David Moore and a disk drawing by John McAnally, each indicating a disturbance at the same longitude. The observations were independent and unsolicited. Another observer, on July 5, 1998, observed that the SEB was split into four regions along one section of the belt. This observation has not been independently confirmed.

Condensations/Barges of the NEBn

The observation of condensations/barges in the NEBn has continued with the 1998-1999 apparition. Several observers have reported that the intensity of several of the condensations is much lighter than last apparition. We are now tracking at least nine of these dark features, several having positions which indicate they are enduring features from the previous apparition.

Summary

With the "merged" oval BE, a SEB disturbance underway, and a high occurrence of condensations/barges in the NEBn, Jupiter will certainly be worth watching. We may expect many exciting developments during the 1998-1999 apparition.

Observations of the Remote Planets: 1989-1998

Richard W. Schmude, Jr., Ph. D., A.L.P.O. Remote Planets Coordinator

Gordon College, 419 College Dr., Barnesville, GA 30204

ABSTRACT

Since 1989, over 20 individuals have submitted observations or measurements of the remote planets. The majority of the measurements have been either photoelectric magnitude measurements (811) or eyeball magnitude estimates (1009) of Uranus and Neptune. A small number of photographs, drawings and visual descriptions of the remote planets have also been received. Based on 9 years of photoelectric magnitude estimates, overall average normalized magnitudes for Uranus are selected as: U(1,0) = - 6.34; B(1,0) = -6.58; V(1,0) = -7.17; R(1,0) = -7.00 and I(1,0) = -5.89 while the corresponding values for Neptune are selected as: B(1,0) = -6.51; V(1,0) = -6.93; R(1,0) = -6.61 and I(1,0) = -5.63. Based on 10 years of eyeball magnitude estimates, overall normalized eyeball magnitudes of -7.14 and -6.93 are selected for Uranus and Neptune respectively. It is concluded that careful eyeball magnitude estimates using a variety of comparison stars can yield reliable results.

INTRODUCTION

The remote planets are Uranus, Neptune and Pluto. These planets have approximate visual magnitudes of 5.8, 7.8 and 13.8 and approximate angular sizes of 3.7, 2.3 and 0.1 arc-seconds. Because of the small size of the remote planets as seen from Earth, not much can be done with imaging/photography and so the main thrust of the A.L.P.O. Remote Planets Section has been brightness measurement. This report will concentrate on magnitude measurements made of Uranus and Neptune over the last ten years.

PHOTOELECTRIC PHOTOMETRY

An SSP-3 solid state photometer along with filters closely matching the Johnson U, B, V, R and I scheme were used in obtaining all photoelectric measurements. A total of 499 measurements of Uranus and 312 measurements of Neptune have been made by the A.L.P.O. Remote Planets section since 1989. The overall average normalized magnitudes for both planets through each filter are listed in tables 1 and 2. The normalized magnitude X(1,0) is computed from:

$$X(1,0) = X - 5 \log[r\ d] - c_v\alpha - 2.5 \log[k] \qquad (1)$$

where X is the measured magnitude corrected for both atmospheric extinction and transformation, r is the Planet-Earth distance, d is the Planet-Sun distance, c_v is the solar phase angle coefficient, α is the solar phase angle and k is the fraction of the planet's disc as seen from the Earth which is illuminated by the Sun. Both r and d are measured in astronomical units (AU); an astronomical unit is the average distance between the Earth and the Sun and equals 149.6 million kilometers (93.0 million miles). The filter type (U, B, V, R or I) is used in place of X in equation 1. The advantage of reporting normalized magnitudes is that brightness changes due to changing planet-Earth and planet-Sun distances have already been accounted for in the X(1,0) value. Due to the extreme distance of Uranus and Neptune, the $c_v\alpha - 2.5 \log[k]$ term is very small and has been dropped.

The weighted average magnitudes of Uranus and Neptune though each filter are listed at the bottom of Tables 1 and 2. The average color indexes for Uranus are: U-B = 0.24; B-V = 0.59; R-V = 0.17 and I-V = 1.28. The respective average color indexes for Neptune are: B-V = 0.42; R-V = 0.32 and I - V = 1.30. These results show that both Uranus and Neptune are quite dim in the infrared. The data seem to show some wide fluctuations in the I magnitudes for both planets; however, more data is needed to confirm these variations.

VISUAL (EYEBALL) MAGNITUDE ESTIMATES

Since 1989, the members of the A.L.P.O. remote planets section have made a total of 1009 eyeball magnitude estimates of Uranus and Neptune. These magnitude estimates have been converted into normalized eyeball magnitudes; the symbol for the normalized eyeball magnitude is $V_{vis}(1,0)$. Values of $V_{vis}(1,0)$ for Uranus and Neptune for different years are summarized in Table 3. The results for Uranus have remained relatively steady at around -7.1 or -7.2; however, the results for Neptune have shown some change. The weighted averages of the eyeball estimates are listed at the bottom of Table 3; these values compare well with the overall average V(1,0) values for Uranus and Neptune. (In computing the average values, the weight was proportional to the number of estimates made.)

SUMMARY

Photoelectric magnitude measurements made by members of the A.L.P.O. remote planets section of Uranus and Neptune are summarized in tables 1 and 2. The data show that the brightness of Uranus and Neptune have remained relatively constant through the V filter but that significant changes may have occurred in the I filter. Overall selected magnitudes of Uranus and Neptune show that these planets are very dim at near infrared wavelengths. Careful eyeball magnitude estimates made over the last 10 years match up well with average V(1,0) values for Uranus and Neptune.

Table 1: Average normalized magnitudes of Uranus based on 499 photoelectric magnitude measurements made by the A.L.P.O. remote planets section.

Apparition	U(1,0)	B(1,0)	V(1,0)	R(1,0)	I(1,0)
1989	--	--	-7.16±.01	--	--
1990	--	--	-7.22	--	--
1991	-6.40	-6.62±.02	-7.20±.02	-7.01±.02	-6.22±.05
1992	-6.39±.06	-6.57±.02	-7.17±.02	-6.98±.02	-6.07±.05
1993	-6.28±.03	-6.57±.02	-7.17±.02	-7.03±.02	-5.81±.03
1994	--	-6.56±.04	-7.17±.03	-7.00±.02	-5.78±.02
1995	-6.37	-6.60±.03	-7.17±.03	-6.99±.02	-5.68±.03
1996	--	-6.67±.14	-7.14±.03	-6.86±.02	-5.67
1997	--	--	-7.15±.01	--	-5.93±.01
Weighted avg.	-6.34	-6.58	-7.17	-7.00	-5.89
Total Number	22	101	239	55	82

Table 2: Average normalized magnitudes of Neptune based on 312 photoelectric magnitude measurements made by the A.L.P.O. remote planets section.

Apparition	B(1,0)	V(1,0)	R(1,0)	I(1,0)
1989	--	-6.87±.02	-6.56±.08	--
1990	--	-7.01	--	-5.75±.14
1991	-6.55±.03	-6.91±.02	-6.56	-5.82±.11
1992	-6.48±.04	-6.90±.02	--	-5.64±.12
1993	-6.49±.02	-6.93±.02	-6.61±.03	-5.50±.03
1994	-6.49±.03	-6.93±.02	-6.61±.01	-5.56±.06
1995	-6.50±.04	-6.98±.05	-6.62±.02	-5.37±.05
1996	-6.59±.12	-6.94±.01	--	--
1997	-6.64±.03	-6.96±.02	--	--
Weighted avg.	-6.51	-6.93	-6.61	-5.63
Total Number	68	136	38	70

Table 3: Summary of the average normalized magnitudes based on 1009 eyeball magnitude estimates of Uranus and Neptune. The number of magnitude estimates for each average value are given in the square brackets to the right of the average value.

Apparition	Uranus Vvis(1,0) and [#]	Neptune Vvis(1,0) and [#]
1989	-7.3 ± 0.04 [16]	--
1991	-7.2 ± 0.05 [29]	--
1992	-7.2 ± 0.04 [66]	-6.8 ± 0.05 [3]
1993	-7.2 ± 0.04 [30]	-6.7 ± 0.12 [15]
1994	-7.1 ± 0.02 [394]	-6.8 ± 0.04 [21]
1995	-7.2 ± 0.03 [73]	-6.9 ± 0.05 [54]
1996	-7.1 ± 0.04 [70]	-7.0 ± 0.04 [49]
1997	-7.2 ± 0.02 [109]	-7.0 ± 0.02 [76]
1998	-7.0 ± 0.1 [4]	-7.0 ± 0.1 [4]
Average	-7.14 [791]	-6.93 [222]

Amateur Observations of the Moon: The A.L.P.O. Selected Areas Program

By: Julius L. Benton, Jr.
Lunar Section Coordinator
Selected Areas Program

Abstract

Worthwhile studies of the Moon can still be pursued by amateur astronomers, but programs must be carefully organized and executed. One such program is the A.L.P.O. Lunar Selected Areas Program (SAP). Observers monitor "selected" features on the Moon that have historically been suspected of displaying "seasonal" or long-term variations. The paper summarizes how participants in the SAP log albedo data for as many of the selected lunar features as possible throughout a lunation and for successive lunations, employing systematic and objective methods of observation. With regard to instrumentation, lunar observers benefit more by using a telescope of high optical and mechanical quality than simply aperture alone. So that erroneous results are minimized, observers are encouraged to learn how to recognize scattered or reflected light, irradiation, as well as aberrations caused by the eye, the instrument, and the atmosphere. The text points out that the likelihood of achieving confirmed observations of anomalous lunar events is improved when visual, CCD, video, and photographic techniques are employed in a simultaneous observing program.

Introduction

In discussing the prospect for making lunar observations at recent gatherings of astronomy clubs, the author was confronted frequently with the question: Why observe the Moon? It came as no surprise that most listeners had been so engrossed in deep-sky observing that little or no thought had been given to actually observing the Moon at star parties. Indeed, many deep-sky enthusiasts remarked that they considered the Moon a luminous nuisance! Nevertheless, to answer the question that was posed, the following reasons were given for observing our nearest celestial neighbor:

- The Moon is easy to find and can be observed from virtually anywhere.
- The Moon is bright and has large image size.
- Significant lunar detail can be seen with relatively small apertures.
- Observations of the Moon help train the eye to detect increasingly fine detail on planetary bodies.
- The Moon is usually easier to capture on film, CCD imagers, and video tape than most other solar system bodies.
- Systematic studies of the Moon by amateurs can still generate useful scientific data.
- Observations of the Moon and interesting and fun.

Continuing efforts to acquaint astronomical audiences with the joy and value of observing the Moon and planets seemed to stir some lasting interest in a few individuals. Observers, especially youngsters, discovered that pursuing solar system studies from the convenience (and safety) of their backyard site meant not having to travel to remote locations to find dark skies. It was hoped that many of these observers would become active in the programs of the A.L.P.O. Lunar Section.

In Rockford, IL two years ago, the author presented a paper before the annual A.L.P.O. Convention, inviting observers to participate in the Lunar Selected Areas Program (SAP). Up to that time, observer support for the SAP had diminished significantly, and the prospect of discontinuing the SAP was even being discussed. Since 1996, however, a encouraging level of observer interest in the Moon emerged, perhaps as a result of presentations given before local and national astronomical meetings, but undoubtedly also as a consequence of media publicity of the *Clementine* and *Lunar Prospector* missions.

Today, the SAP has several individuals who are considered regular contributors. Although this recent revival in interest in the Moon is promising, more observers are needed to permit expansion of the SAP so that more lunar features can be systematically monitored throughout a lunar month.

Observational Perspectives and Instrumental Considerations

Unlike the Lunar Transient Phenomena (LTP) Patrol, which is concerned only with short-term variations at the lunar surface, the Lunar Selected Areas Program (SAP) monitors specific lunar features historically suspected of exhibiting "seasonal" or long-term phenomena. An example of a long-term event is a variation in the tone or hue of a given area, which *cannot* be attributed to varying solar illumination and which *does not repeat* systematically from lunation to lunation. These tonal changes may occur where dark radial bands or dark haloes are seen within or around some craters, or where darker regions or patches exist on the lunar surface in limited environments. Unusual changes in the apparent morphology, pertaining to overall size and shape, have been detected in conjunction with tonal or color fluctuations in many, but not all, cases. Thus, intensive studies of features such as Alphonsus, Aristarchus, Eratosthenes, Herodotus, Kepler, Messier-Pickering, and Plato, have occurred in the past. As data accumulated and reports on specific regions were published, new areas were then added to the list (e.g., Atlas, Ross D, Hell, Pico, Piton, Colombo, etc.).

The success of the SAP is dependent upon observers making long-term systematic observations of specific lunar features not only throughout a given lunar month, but also from lunation to lunation for many years. Regular observation familiarizes one with the normal, yet often complex, changes in appearance many features undergo from lunar sunrise to sunset. It will then be easier for observers to recognize anomalous phenomena from one lunation to the next if they occur. Special inherent talents for drawing lunar features, although definitely helpful, are not necessary, nor is exceptional visual acuity. The most fundamental and essential prerequisite for participation in the SAP is the willingness to follow the Moon and the chosen feature(s) for many consecutive lunations, year after year. Scientific objectivity is mandatory, whereby the observer must develop a constant practice of recording precisely what is seen at the eyepiece, not what one might expect to see (as may be derived from one's previous observations or from studies of published reports from other individuals). Should there be any doubt whatsoever about what is perceived, the observer must routinely note such uncertainties. The resulting data will be far more reliable and of lasting value. While initial efforts to detect rather delicate details on the lunar surface may result in some disappointment, persistent observations will bring about the reward of eventual successful perception (i.e., through training of the eye) of subtle features at the threshold of vision. The joy of recording phenomena or details hitherto unrecognized is reserved largely for the person who has maintained the perseverance to observe the Moon regularly.

Although no inflexible minimum size telescope need be specified for active participation in the SAP, most experienced observers are in agreement that the largest aperture available, which can be employed with the existing seeing and transparency conditions, should be used. Even so, a good 10.2cm. (4.0in.) refractor or 20.0cm. (8.0in.) reflector will deliver sufficient resolution of lunar detail for full participation in nearly all aspects of the observing program. No attempt here is made to address the various pros and cons of instrument type or design, and the driving factors in choosing a telescope should be the reliability of the manufacturer, optical and mechanical excellence (giving high-contrast, relatively bright, and crisp images), and reasonable portability.

The Observing Program

The percentage of sunlight reflected by the surface of the Moon, as we have seen, varies as the *phase angle, g*, changes throughout the lunar month. Taken a step further, observers are well aware that one area of the Moon reflects more light (e.g., a crater rim or central peak) than another region (e.g., the maria), regardless of the phase angle, and these areas in turn vary in appearance as the illumination changes. These differences in *tone* are generally more conspicuous at Full Moon (g = 0°), and the investigation of light and dark areas of the Moon is an interesting observational endeavor.

While there is a definite requirement to know how various lunar features change their normal appearance throughout a lunation in response to variations in phase angle, even more intriguing are those lunar features that behave in an unusual, sometimes unpredictable, and non-repeating manner as solar illumination changes. The SAP is chiefly concerned with systematically monitoring regular and cyclical long-term variations during many lunations of specifically designated, or *"selected,"* areas on the Moon. The SAP is designed to intensively study and document for each of these features the *normal* albedo changes in response to conditions of varying solar illumination. The program is equally concerned with the following possible *anomalous* phenomena:

- *Tonal and/or Color Variations*. These are variations in tone or color, or in the size and shape of a region of tone or color, that is not related to changing illumination (i.e., the phenomenon does not exactly repeat from lunation to lunation). Areas in lunar features most subject to such anomalous behavior are *radial bands, dark patches, and nimbi or haloes.*

- *Shape and Size Changes*. These are variations in the appearance and morphology of a feature that cannot be traced to changing solar illumination or libration.

- *Shadow Anomalies*. These are deviations of lunar shadows away from the theoretical normal absolute black condition, or a shadow with an anomalous shape or hue, in most cases not attributable to changing phase angle.

- *Appearance or Disappearance of Features*. Although exceedingly improbable and controversial, these are features that seem to be present now, but appear to be absent on earlier maps or photographs; or, features that are no longer visible today but which are clearly indicated on earlier maps or photographs.

- *Features Exposed to Earthshine*. These are any anomalous tonal or albedo phenomena (any of the categories listed here) that occur under the conditions of Earthshine.

- *Eclipse-Induced Phenomena*. These are features that exhibit anomalous characteristics (categories 1 through 4 above) during and after an eclipse, compared with previous eclipses when the same areas were monitored.

Most of the phenomena listed above are related to anomalous variations in morphology, tone (albedo), or color, which cannot be attributed to changing solar angle (phase angle) or libration, and which clearly *do not* repeat systematically from lunation to lunation. As stated earlier, however, it is essential in our program *to establish a record of both the normal and abnormal behavior of suspect lunar areas* under all conditions of illumination.

As mentioned earlier, several areas had been studied as a part of the original SAP over two decades ago, and a few published reports appeared in the ***Journal of the A.L.P.O.*** Some very interesting data emerged from those observations, but because of inconclusive results, further investigation of many of the same features are worthwhile. There is still a need to establish a consistent, long-term record of normal and possible abnormal albedo variances. Thus, lunar features that are currently designated as the *official* lunar formations that are being monitored as part of the SAP are:

SAP Feature	Selenographic Latitude	Selenographic Longitude	SAP Feature	Selenographic Latitude	Selenographic Longitude
Alphonsus	4°W	13°S	*Plato*	9°W	51°N
Aristarchus	47 W	23 N	*Theophilus*	26 E	11 S
Atlas	43 E	46 N	*Tycho*	11 W	42 S
Copernicus	20 W	9 N			

(the nearby *Herodotus* is also considered a part of the program with its environs)

All of the areas listed above were chosen because they are relatively easy to find, convenient to observe, and instances of past suspected anomalies have been associated with them. Complete outline charts and observing forms are available from the Section Coordinator for each of the features noted.

The intent of the SAP is to visually monitor as many of the selected lunar features as possible during a lunation and for successive lunations, employing established systematic, objective methods of observation. It was stressed earlier in our discussion how important the quality of the instrument being used is, and individuals should be familiar with their telescopes and accessories, how to recognize scattered or reflected light, irradiation, as well as aberrations caused by the eye, the instrument, and the atmosphere.

Standard observing procedures of the SAP may be summarized as follows:

1. Concentrate on one or two features only throughout any given lunation. Each observation should always be placed on the forms provided by the SAP.

2. Observations should be carried out using the same magnification(s), telescope, and accessories throughout any given lunation (and for a succession of lunations, if possible).

3. Careful records should be maintained of the date and time (UT) of the observation, the colongitude (*C*), the field orientation (IAU) of the view in the eyepiece, the seeing and transparency conditions, etc. Space is provided on the SAP forms for this kind of information, and all information requested should be provided as accurately as possible.

4. Observations should be attempted only when the Moon is at least at an altitude of 25° or more above the horizon to avoid the adverse effects of atmospheric dispersion and poor seeing near the horizon.

5. For each standard SAP lunar feature, *Reference Outline Charts* have been provided with the observing forms with several *index points* chosen to help standardize the observations. Points chosen are indicated by letters to refer to the following for each selected area when assigning albedo values:

- A letter has been given to each cardinal point (N,S,E, and W) in the IAU sense on the *inner walls of craters or on the exterior sides of a lunar mountain or dome.*
- A letter has been assigned to the *summit of any central peak or peaks* that may exist (or *summit of a specific mountain*).
- Several points have been selected on the *floors of craters* and in some cases on *surrounding terrain.*

It is exceedingly important for individuals to recognize that these pre-defined features must be consistently utilized when assigning albedo values during the lunation in question, as well as always from lunation to lunation. Care must be taken to insure that the location of the intended index point being estimated is established from using the *Reference Outline Chart*. Also, any additional points of interest, chosen by the observer and assigned to the specific feature, should be carefully denoted in the record to prevent confusion with the standard points. *Elger's Albedo Scale* appears in *Table 1*, with examples at Full Moon ($g = 0°$). Observers should initially familiarize themselves (at Full Moon) with as many of the steps and examples in Elger's scale as possible and establish a *permanent reference gray scale.* This can be done quite easily by using graded exposed black & white film or prints, graded pencil shadings, or a reliable commercial gray scale wedge, to match each step (in integrated light) in Elger's scale. It is essential for one to employ the same telescope, magnification(s), and accessories when setting up the scale as will be used for routine observations. Once established, the scale is used exclusively as a reference standard for albedo estimates, and the observed albedo of every index point chosen for the feature under scrutiny (plus those picked by the observer) is matched to this scale.

During the normal course of a lunation, the assigned N and S points (IAU) of a feature should exhibit albedos of nearly the same value throughout a lunation, possibly brighter at Full Moon or at local noon for the site (both points would be quite similar to one another in behavior). For E and W (IAU) points, mirror-image behavior between the two should be encountered. For example, the E wall of a crater should be dull at sunrise, increase progressively in brightness or albedo, reaching a maximum near sunset. The W wall of the same crater would be most prominent at sunrise, go through a diminution in brightness, and be dullest at sunset. The albedo may, indeed, be greatest at local noon or Full Moon. Behavior of crater floors should follow tonal (brightness) variations that are "normal" for the feature, established after numerous observations through many lunations (a major part of the program). Dark areas periodically brighten at the times of local noon and at Full Moon, but some may darken under a high Sun.

Table 1. Elger's Albedo Scale

Albedo	Lunar Features as Examples
0.0	*Black Shadows*
1.0	*Darkest parts of Grimaldi, Riccioli*
1.5	*Interiors of Billy, Boscovich, Zupus*
2.0	*Floors of Endymion, LeMonnier, Julius Caesar, Cruger, Fournier*
2.5	*Interiors of Azout, Vitruvius, Pitatus, Hippalus, Marius*
3.0	*Interiors of Taruntius, Plinius, Theophilus, Parrot, Flamsteed, Mercator*
3.5	*Interiors of Hansen, Archimedes, Mersenius*
4.0	*Interiors of Manilius, Ptolemaeus, Guericke*
4.5	*Surface around Aristillus and Sinus Medii*
5.0	*Walls of Arago, Lansberg, Bullialdus; surfaces around Kepler and Aristarchus*
5.5	*Walls of Picard and Timocharis; rays of Copernicus*
6.0	*Walls of Macrobius, Kant, Bessel, Mösting, Flamsteed*
6.5	*Walls of Langrenus, Thaetetus, and LaHire*
7.0	*Theon, Ariadeus, Bode B, Kepler, Wichmann*
7.5	*Ukert, Hortensius, Euclides*
8.0	*Walls of Godin, Bode, Copernicus*
8.5	*Walls of Proclus, Bode A, Hipparchus C*
9.0	*Censorinus, Dionysius, Mösting A, Mersenius B and C*
9.5	*Interior of Aristarchus and LaPyrouse*
10.0	*Central peak of Aristarchus*

6. There is also a *Drawing Outline Chart* provided as an observing form along with the *Reference Outline Charts* to be utilized for any "photographic" drawings or sketches that are executed. To perform such drawings will help train the eye to recognize even finer details and will add much to the value of the data. While artistic drawings are pleasing to the eye, accuracy is the main objective when trying to depict the form, position, shape, and tone of the lunar feature with respect to solar illumination. A separate *Albedo and Supporting Data Form* has also been provided to accompany the *Drawing Outline Chart* and *Reference Outline Charts* on which to record albedo data and supporting information for each observation. The *Albedo and Supporting Data Form* and *Drawing Outline Chart* should be sent to the A.L.P.O. Lunar Section following each lunation.

7. Observations should be carried out employing high-quality red, blue, and green filters to monitor features for possible brightness differences in various wavelengths. Filters should always have precisely known wavelength transmissions, and the following *Wratten* filters (or their equivalent) are suggested for regular use in the SAP:

W23A or W25 (red) *W38A or W47 (blue)* *W58 (green)*

Dense filters, such as *W25* or *W47*, should be avoided for the smallest apertures.

8. Descriptive notes should accompany each observation, and they should include information that might not be apparent in examining the drawing or albedo chart. Things worth mentioning are features that are obvious only under low or high solar angles, the nature and extent of bright rays and/or bands visible in the proximity of the feature, and the general morphological appearance of the region and its environment. In particular, any anomalous or unusual aspects should be carefully noted and referenced.

9. Although the program is chiefly concerned with long-term phenomena, any transient events (LTP) that might be noticed in the course of an observation should be carefully recorded. Individuals might evaluate any occurring LTP with respect to time and duration, whether they represent brightenings or darkenings (suddenly), short-term anomalous fluctuations in hue, shadow anomalies, obscurations, etc. In any case, LTP events should be immediately brought to the attention of the A.L.P.O. Lunar SAP Recorder.

10. Observations should always be kept in duplicate, the originals being sent to the Lunar SAP Recorder at the end of any given lunation (only the *Albedo and Supporting Data Form* and *Drawing Outline Chart* need be submitted unless additional albedo index points have been established by the observer).

In recent years, our observers have expressed a strong desire to have greater freedom of choice among features to follow as part of the SAP. In compliance with this request, the A.L.P.O. Lunar Section has developed special observing forms for this purpose, whereby the identity of the feature being studied is entered at the top of the sheet in the blank provided. These forms are essentially identical to the standardized ones that depict a prepared outline chart containing assigned index points for estimating albedo values. In this instance, however, the observer must draw his own outline chart on the form (in the space provided) using an appropriate lunar atlas for reference and then assign index points analogous to the locations of those set on the pre-drawn outlines for standard features. The same outlines and index points should always be used for all observations of the lunar feature in question. Other than this requirement, the observing methods and techniques remain the essentially the same.

A more complete discussion of the SAP can be found in ***The A.L.P.O. Lunar Selected Areas Program: A Manual for Visual Observations***, available from the A.L.P.O. Lunar Section. Individuals interested in participating in our programs are encouraged to contact the author for further information and assistance.

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Dr. Julius L. Benton, Jr.
Coordinator, A.L.P.O. Lunar Section
Selected Areas Program
ASSOCIATES IN ASTRONOMY
305 Surrey Road
Savannah, GA 31410
E-Mail:74007.3446@compuserve.com
Phone: (912) 897-0951

SPECTROGRAPHIC STUDY OF COMET HALE-BOPP'S TAIL

Tom Buchanan
Professional Engineer
1310 Mayfield Manor Drive
Alpharetta, Georgia 30004

ABSTRACT

This article describes spectra taken of the tail of Comet Hale-Bopp with a slitless spectrograph. Images were taken on eight different dates between 09 March 1997 and 05 May 1997. The slitless spectrograph providing spectral reference marks is described. Observation data and representative spectrograms are presented. The spectra show seven identifiable forked tails of CO^+ and an unforked sodium tail. The orientations and ~~relative~~ angles of these tails were measured, tabulated, and shown graphically. The angle between limbs of the CO^+ ion tail is about 14°, although this angle was measured to be 23° on 05 May. The sodium tail is generally lies close to the western limb of the CO^+ ion tail, but maintains a near-constant angle of 16° with the eastern limb.

INTRODUCTION

The author designed and built a versatile spectrograph that is capable of recording reference marks alongside spectra taken in the slitless mode (1). The spectrograph is self-contained and has been used for different light sources under various field conditions. The author previously took spectra of Comet Halley and contributed them to International Halley Watch (2). The brighter Comet Hale-Bopp presented a more favorable opportunity to obtain useful spectra of both the coma and the tail.

DESCRIPTION OF INSTRUMENT

Light Beams and Reference Marks

Figure 1 shows the light beams in the spectrograph when used in the slitless mode. All optical elements are mounted in the plane that is perpendicular to the grooves of the diffraction grating. The first beam of light from the target object strikes the diffraction grating and passes through a camera lens that focuses the dispersed light onto the film. The other three beams are directed so that only the zeroth order of each reaches the film; these serve as reference marks along the spectrum. The second beam forms the first reference mark near the Fraunhofer-B line of oxygen (6870 Å). The third beam forms the second reference mark on the film near the hydrogen-zeta line (3889 Å). The fourth beam forms a third reference mark that provides for making small corrections in the positions of the other two reference marks. The reference marks are analogous to lines of a comparison spectrum for a slit spectrograph. The mathematical details are included in an unpublished manuscript (3).

Figure 2 shows a spectrum of Sirius with three spectral reference marks. Figure 3 shows a spectrum of the coma of Comet Hale-Bopp with three spectral reference marks, the right and left two of which lie at the same wavelength positions as in Figure 2. Strongest lines in the spectrum of the coma were calibrated with the reference marks for comparison with published data (4, 5).

Capability of Imaging Orders

The spectrograph can be operated in either the slitless mode or the slit mode. The instrument can image the entire visible first order in one exposure. The camera can be rotated about the vertical axis of the grating and locked at several positions, providing the capability of imaging halves of the second order at each of two positions and fifths of the third order at each of five positions. Various filters are used as appropriate to minimize the overlap of orders. Use of the third order has been found to be practicable only for bright light sources when the spectrograph is operated in the slit mode.

Reducing Effects of Sky Glow

A shield containing a circular hole is normally placed at the entrance to the spectrograph structure to limit contamination of the spectrum from the sky surrounding the target object. When a shield with a smaller hole is used, the aperture of the camera is reduced, requiring an increased exposure time. In this study, the hole in the shield vignetted the length of the tail image. This effect was more severe for a smaller hole.

Except when the calibration with Sirius was made, as described above, a cover was placed to block the three beams causing reference marks, in order to eliminate possible interference with the spectral images.

Other Information

The wooden housing of the spectrograph measures 66 cm by 33 cm by 17 cm and weighs 7.3 kg, including camera and lens. A slit unit weighing 2.5 kg can be inserted. The camera lens and both lenses of the slit unit have a focal length of 135 mm and an aperture of 71 mm. The objective diffraction grating has 600 grooves per mm, and is blazed for 4800 Å in the first order.

METHODS OF OBTAINING SPECTRA

Field Work

The location of the observing site were: latitude 33° 47’ 26” N, longitude 84° 56’ 06” W, and altitude 323 meters. The faintest star visible at the zenith with the unaided eye was magnitude 6.1. The spectrograph was fastened to a German equatorial mount with a battery operated motor drive. In most cases the drive was operated at 100% sidereal rate. However, in some cases the drive was stopped for one second at regular intervals so that the spectrum would trail for better exposure results. An attached four-power spotting telescope with cross-hairs was used to align the spectrograph toward the target light source. Under normal operation, the resulting spectrum was spread along a right ascension line, either south to north or north to south. This arrangement showed the comet’s tail well when the tail made a large angle with its right ascension line. However, on 30 March, 04 April, and 10 April, this angle was small. Therefore, several images were taken with the spread of the spectrum oriented east to west, to cause the spread of the spectrum to have a large angle with the tail. To accomplish this orientation, a star was selected which lay along a line that intersected and was perpendicular to the right ascension line through the comet, and was tangent to its declination line. Then the axis of the mount was directed precisely between the star and the comet. During the exposure, the mount was manually driven by means of turning the declination knob. These exposure times were limited to 8 minutes in order to avoid significant deviation from the curvature of the comet’s declination line. Table I contains details of the spectra obtained of Comet Hale-Bopp and comparison spectra.

Developing and Printing

Kodak technical pan film was used for all exposures. All film was hypersensitized except roll # E-146 which was intended primarily for the bright coma. All film was developed in D-19 at

24° C. The hypersensitized film was developed for 5.5 minutes; the non-hypersensitized film was developed for 11 minutes.

Positive prints were made directly from the more lightly exposed negatives. The negatives having overexposed areas were duplicated onto second stage negatives while the lightly exposed areas were masked, in order to recover detail from the overexposed portions. Negative prints were made from these second stage negatives. Neither "unsharp masking," nor computer enhancement was used. The author made all negative duplications. Commercial photographic processors made all prints.

RESULTS

Sodium Tail

The discovery of the sodium tail was announced for 16 April 1997 (6). However, pre-discovery images of the sodium tail had been obtained by the author as early as 09 March, 38 days previously. Figure 4 shows the sodium tail on 09 March 1997. The faint sodium tail can be seen best when viewed at an angle of 10° toward the print and along the spread of the spectrum, rather than normal to the print. Figure 5, taken on 30 March 1997, shows the sodium tail along with a forked ion tail. The sodium line was relatively strong on the spectra taken on 30 March and thereafter.

Figure 6, taken on 08 April, shows the second order from green to red. The C_2 line at 5165 Å is on the left, followed by magnesium absorption lines of the sun at 5167 Å, 5173 Å, and 5184 Å. The hydrogen absorption lines of the sun is on the right at 6563 Å. The sodium doublet at 5890 Å and 5896 Å is in the center. The sodium line was verified by a comparison with a solar spectrum (E-19-27). Figure 7, taken on 01 May, shows the sodium tail and the forked ion tail.

Forked CO^+ Ion Tail

Figure 5, taken on 30 March 1997, shows seven identifiable forked tails along the spectrum. All wavelengths match the positions of CO^+ groups when compared to published spectral wavelengths (5, 7). The seven groups include lines at the following wavelengths:

Group 1:	4000, 4018, 4020 Å
Group 2:	4249, 4252, 4272, 4274 Å
Group 3:	4539, 4566 Å
Group 4:	4683, 4711 Å
Group 5:	4849, 4880 Å
Group 6:	5040, 5072 Å
Group 7:	6189, 6239 Å

Figure 7, taken on 01 May, shows that the angle between the limbs had increased from earlier dates.

Figure 8 was taken on 30 March 1997, showing the second order, from violet to green. On the coma spectrum, the right part of the double dot on the left is the CN line at 3883 Å, while the prominent dot on the right is the C_2 line at 5165 Å. A comparison of the spectrum on Figure 8, spread north to south, with the spectrum on Figure 5, spread east to west, indicates that Figure 8 shows only the eastern limb of the fork.

Relative Positions of the Sodium Tail and the CO^+ Ion Tail

The position angles of the were measured from the spectrograms, with the assumed uncertainty of 2 ° for an individual measurement. The sodium tail appears sharp, in contrast to the forked shape of the CO^+ ion tail. The sodium tail is approximately parallel to the western (right) limb of the CO^+ ion tail.

Table II lists the orientations of the sodium tail and the CO^+ ion tail, for all dates in which the angles could be determined. Figure 9 is a graphical plot of the same information. The mean angular separation between the limbs of the CO^+ ion tail was 14°, except on 01 May 1997 when it was 23°. The sodium tail remained about 16° from the western limb of the CO^+ ion tail for all dates. The strength of the sodium tail appeared, by visual inspection, to remain in a constant relationship to the strength of the CO^+ ion tail.

DISCUSSION AND CONCLUSIONS

1. The CO^+ ion tail was forked. The eastern and western limbs were separated by about 14°. The forked appearance hinted at the possibility of a three-dimensional cone. The ions would dwell mainly along the surface of the cone, and a greater thickness of ions viewed edgeways at the two sides of the cone would yield the two-dimensional forked appearance.

2. Perhaps the images taken on 09 March are the earliest existing images indicating sodium in the tail of the comet. The dimness the sodium images taken on 09 March and 16 March was probably due to two causes. First, on these dates, the comet lay in the northeast where sky glow caused by light pollution was greater than the sky glow in the northwest where the comet lay on the later dates. Second, the sodium output might have increased near the perihelion on 27 March.

3. The sodium generally lay along the western limb of the CO^+ ion tail. In published photographs, the close-in portion of the western limb was usually overpowered by the dust tail. Relatively few photographs show a forked tail as distinctly as the spectra showed.

4. In early May the angle between the limbs of the CO^+ ion tail had increased.

5. The sodium tail stayed near the same angle, 16°, from the western limb of the CO^+ ion tail.

6. The reverse curvature on Figure 9 occurred near the perihelion date of March 27.

7. A relatively small slitless spectrograph can provide useful data, as shown by this study.

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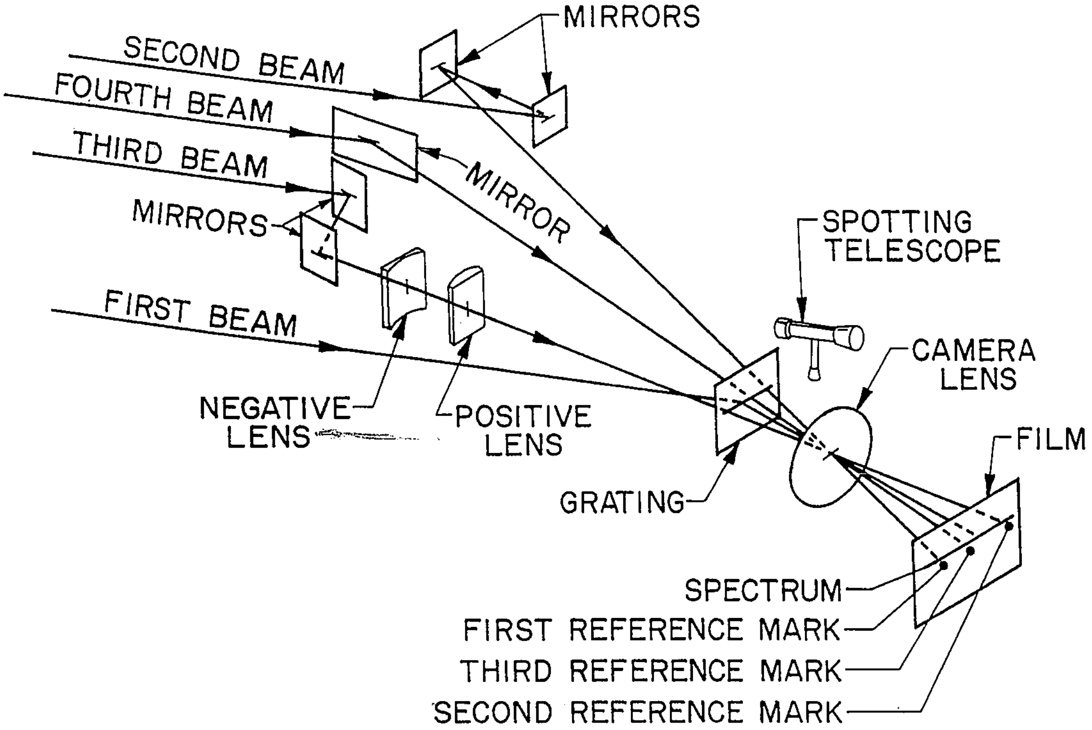


Figure 1. Isometric Drawing of Light Beams in Spectrograph

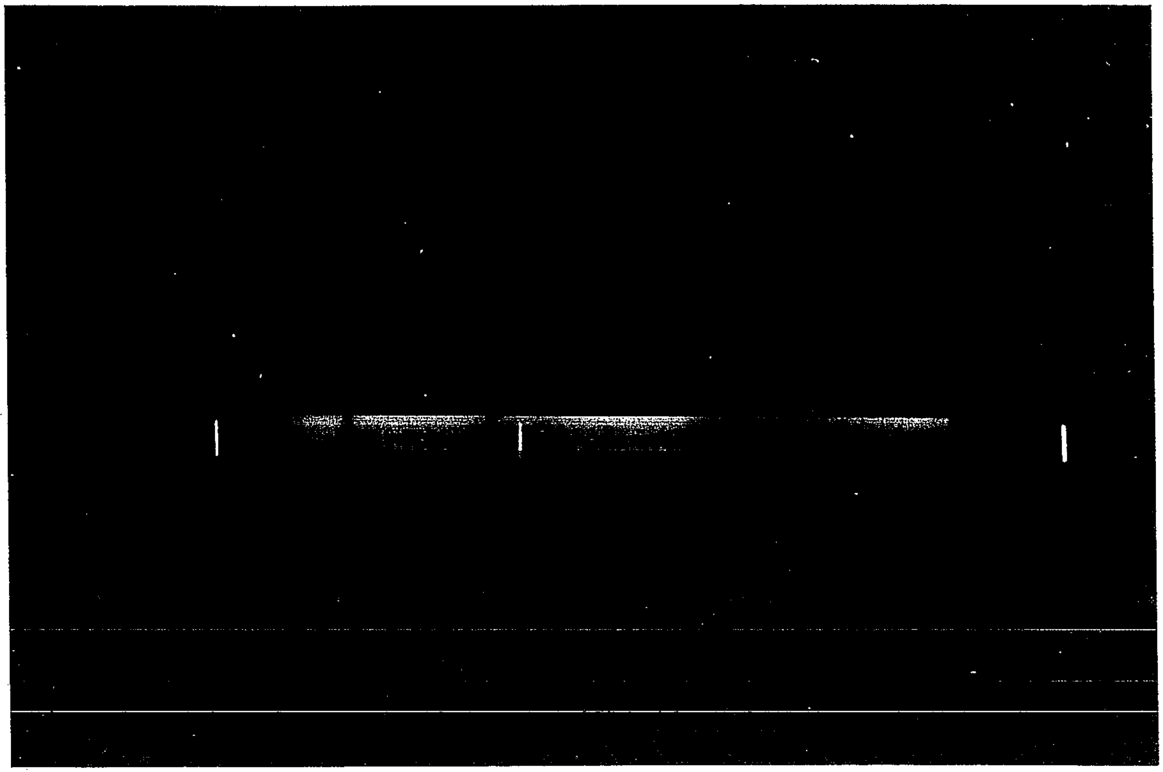


Figure 2. Spectrum of Sirius with three spectral reference marks. (ID # E-146-20)

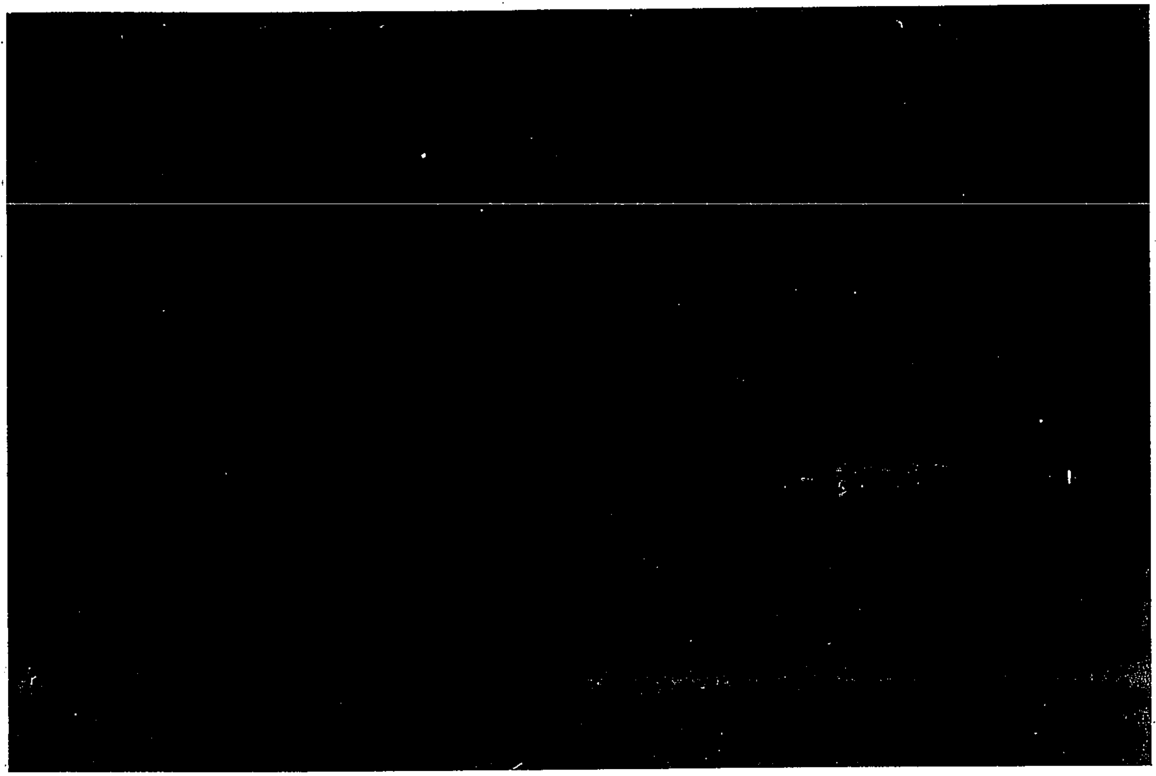


Figure 3. Spectrum of the coma of Comet Hale-Bopp with three spectral reference marks (ID # E-146-21)

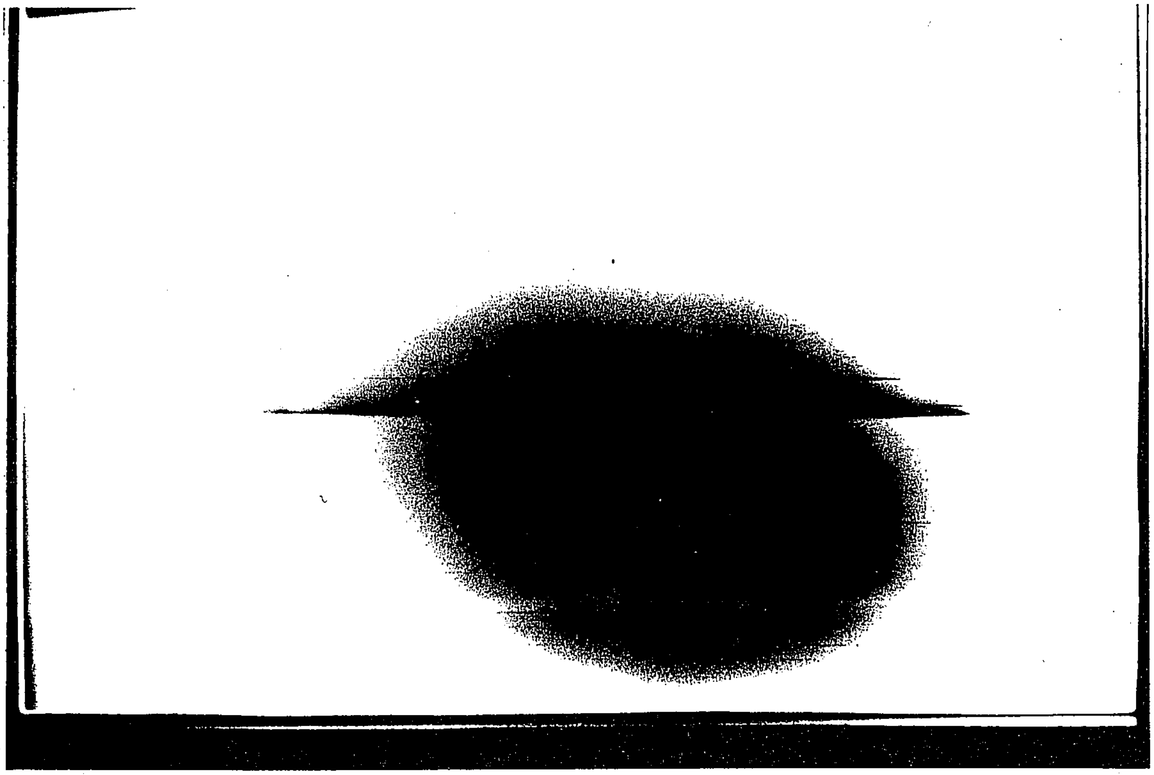


Figure 4. Spectrum Showing the Sodium Tail on 09 Mar 1997. (ID # E-145-02)

Figure 5. Seven identifiable forked tails along the spectrum, and an unforked sodium tail, on 30 March 97. (ID # E-145-24)

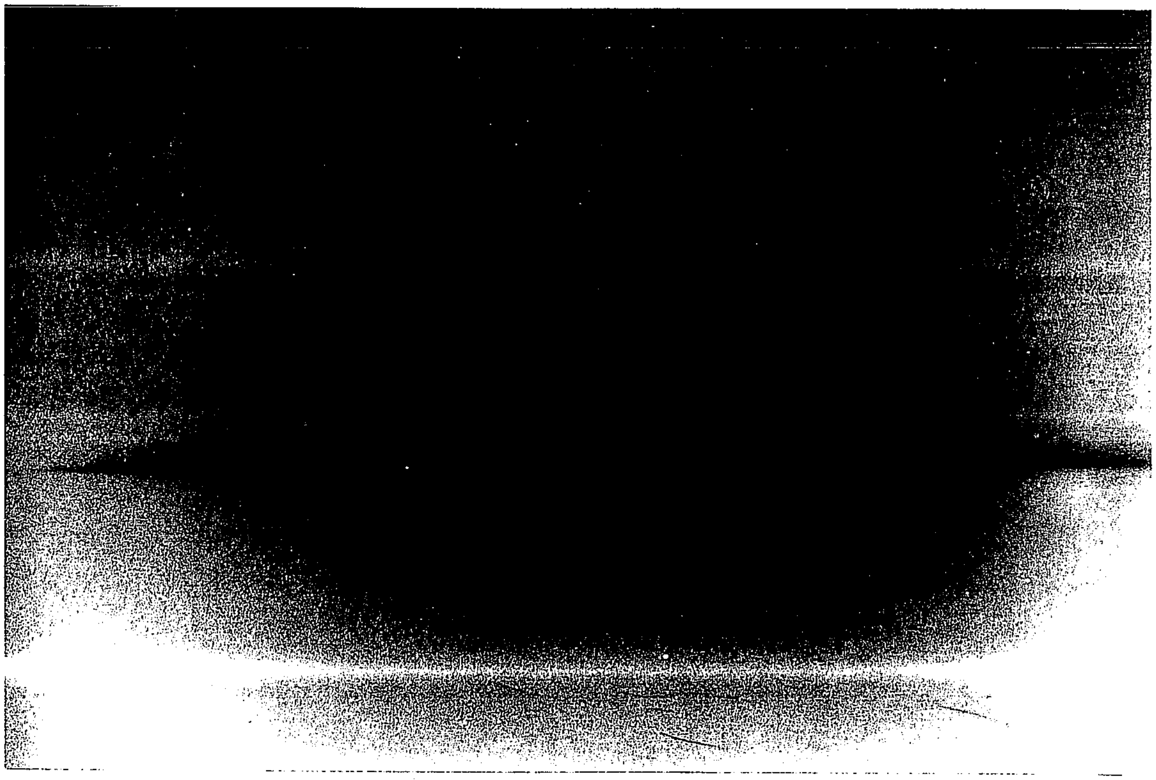


Figure 6. Second order spectrum from green to red, with the C_2 line at left and the hydrogen absorption spectrum of the sun at the right at 6563 Å, on 08 April 97. The sodium doublet at 5890 and 5896 Å is in center. (ID # E-147-01)

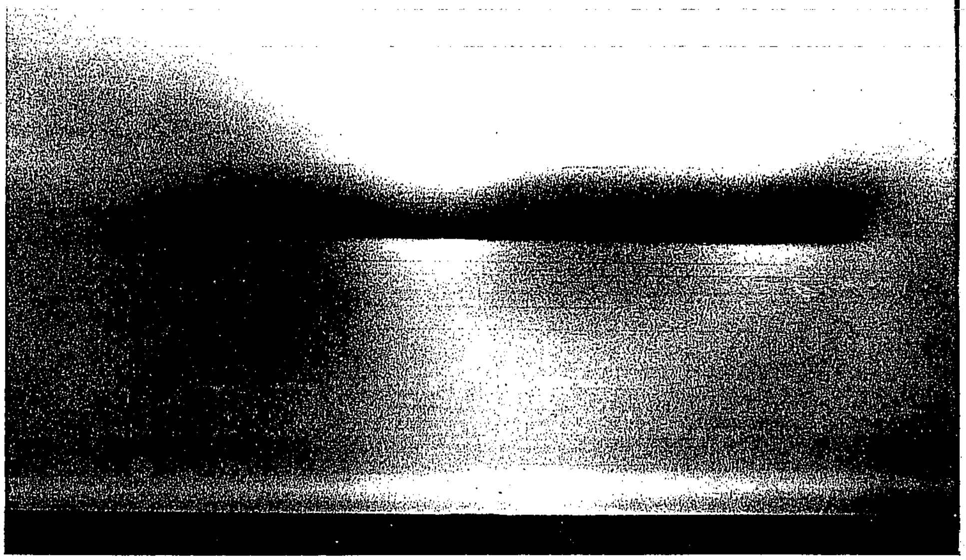


Figure 7. Spectrum of the forked ion tail, along with a narrow sodium tail, on 01 May 97. (ID # E-148-02)

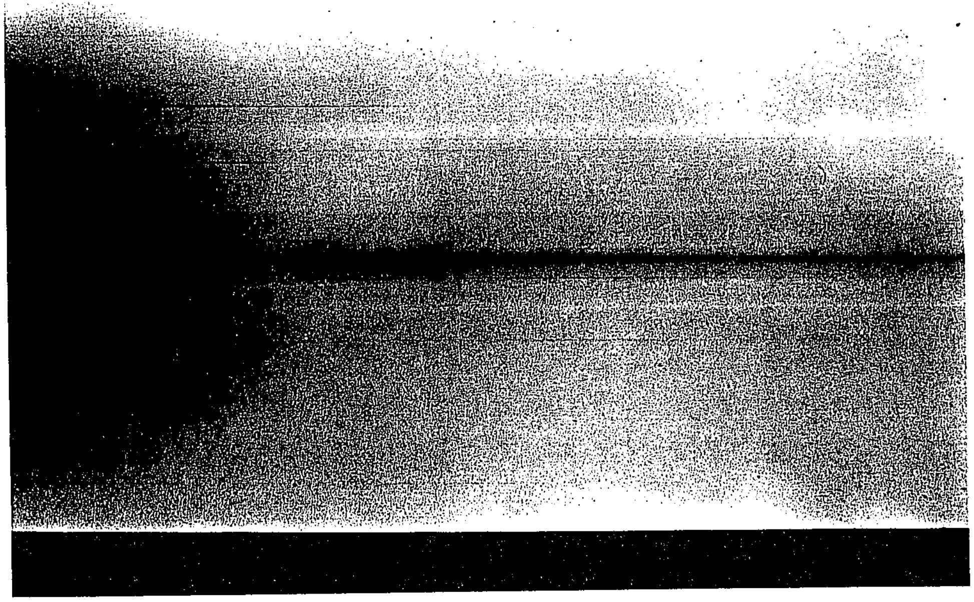


Figure 8. The second order, from violet to green of the east limb of the ion tail, on 30 March 97. On the strong horizontal line, the coma spectrum, the right part of the double dot on the left is the CN line at 3883 Å, while the strong dot on the right is the C_2 line at 5165 Å. (ID # E-145-22)

Figure 9. Orientations of Ion and Sodium Tails

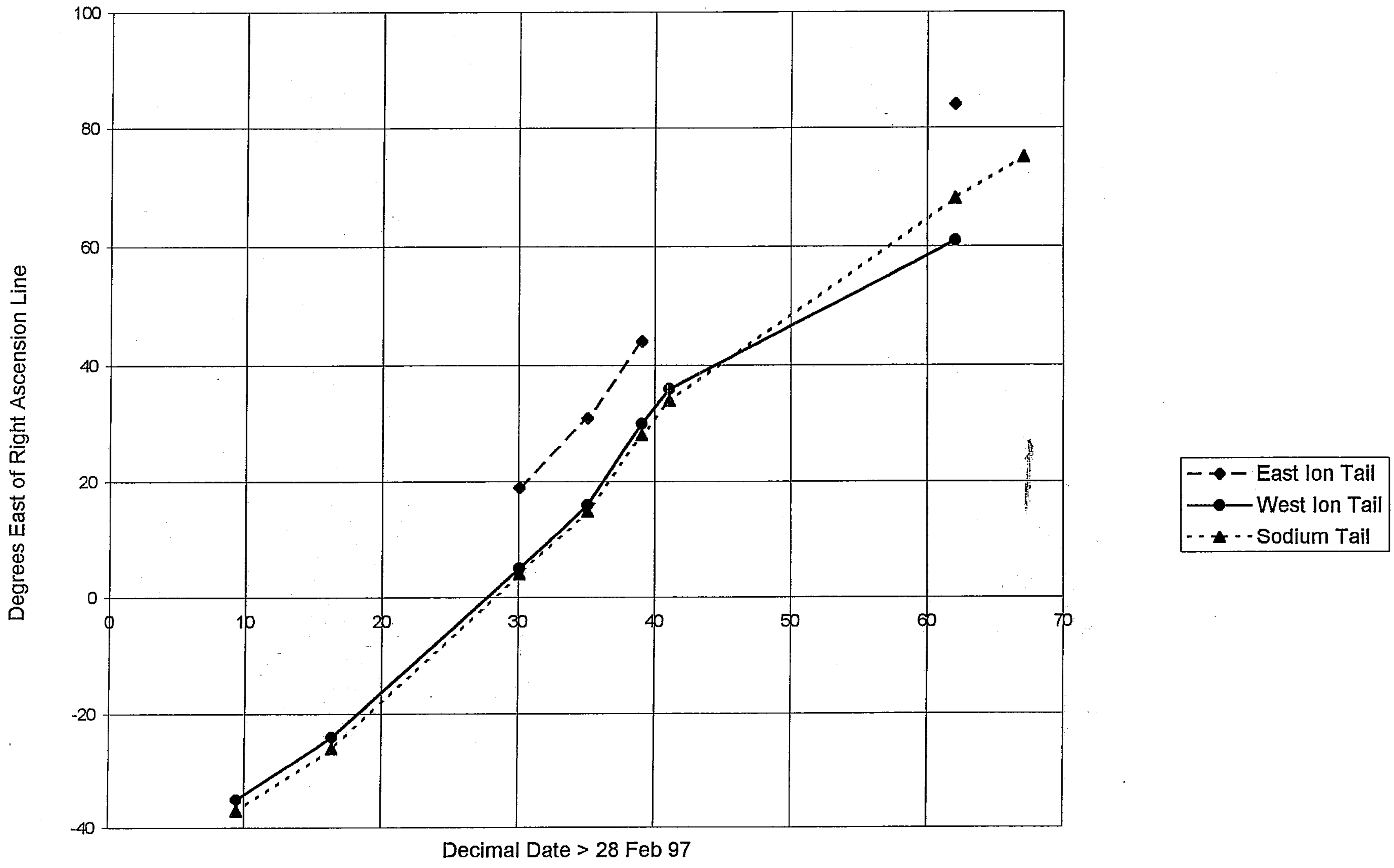


Table I. Spectrograms of Comet Hale-Bopp

Photo ID	Film Type	Subject Name	Date Taken	Time Taken	Shutter Speed	Aperture	Driven % Sidereal	Shield Hole Dia	Filter Used	Order	Spectrum Direction
E-145-01	Kodak TechPan Hypered	Comet Hale-Bopp	09-Mar-97	0955	7m	f/1.9	100			1	north-south, violet-red
E-145-02	Kodak TechPan Hypered	Comet Hale-Bopp	09-Mar-97	1004	8m	f/1.9	100	75mm		1	north-south, violet-red
E-145-03	Kodak TechPan Hypered	Comet Hale-Bopp	09-Mar-97	1015	24m	f/1.9	100	75mm		2	north-south, violet-green
E-145-10	Kodak TechPan Hypered	Comet Hale-Bopp	16-Mar-97	0940	2m	f/2.8	100	54mm		1	north-south, violet-red
E-145-11	Kodak TechPan Hypered	Comet Hale-Bopp	16-Mar-97	0942	4m	f/2.8	100	54mm		1	north-south, violet-red
E-145-12	Kodak TechPan Hypered	Comet Hale-Bopp	16-Mar-97	0947	8m	f/2.8	100	54mm		1	north-south, violet-red
E-145-13	Kodak TechPan Hypered	Comet Hale-Bopp	16-Mar-97	0958	7m	f/2.8	100	54mm		2	north-south, violet-green
E-145-15	Kodak TechPan Hypered	Comet Hale-Bopp	16-Mar-97	1010	15m	f/2.8	100	54mm		2	north-south, violet-green
E-145-22	Kodak TechPan Hypered	Comet Hale-Bopp	30-Mar-97	0123	15m	f/2.8	100	54mm		2	north-south, violet-green
E-145-24	Kodak TechPan Hypered	Comet Hale-Bopp	30-Mar-97	0149	8m	f/1.9	100	75mm		1	east-west, violet-red
E-145-31	Kodak TechPan Hypered	Comet Hale-Bopp	04-Apr-97	0201	5.5m	f/1.9	100	75mm		1	east-west, violet-red
E-145-32	Kodak TechPan Hypered	Comet Hale-Bopp	04-Apr-97	0208	6.5m	f/1.9	100	75mm		1	east-west, violet-red
E-146-02	Kodak TechPan	Comet Hale-Bopp	04-Apr-97	0112	5m	f/1.9	100	75mm		1	south-north, violet-red
E-146-03	Kodak TechPan	Comet Hale-Bopp	04-Apr-97	0118	5m	f/1.9	100	75mm		1	south-north, violet-red
E-146-20	Kodak TechPan	Sirius	10-Apr-97	0220	2m	f/1.9	0	75mm		1	south-north, violet-red
E-146-21	Kodak TechPan	Comet Hale-Bopp	10-Apr-97	0226	2m	f/1.9	50	75mm		1	south-north, violet-red
E-146-22	Kodak TechPan	Comet Hale-Bopp	10-Apr-97	0228	5m	f/1.9	80	75mm		1	south-north, violet-red
E-146-23	Kodak TechPan	Comet Hale-Bopp	10-Apr-97	0235	10m	f/1.9	90	75mm		1	south-north, violet-red
E-147-01	Kodak TechPan Hypered	Comet Hale-Bopp	08-Apr-97	0145	30m	f/1.9	100	75mm	#12 Wratten	2	south-north, yellow-red
E-147-02	Kodak TechPan Hypered	Comet Hale-Bopp	08-Apr-97	0225	7.5m	f/2.8	95	54mm		1	east-west, violet-red
E-147-09	Kodak TechPan Hypered	Comet Hale-Bopp	10-Apr-97	0200	11m	f/1.9	100	75mm	#12 Wratten	2	south-north, yellow-red
E-147-12	Kodak TechPan Hypered	Comet Hale-Bopp	10-Apr-97	0224	8m	f/2.8	100	54mm		1	east-west, violet-red
E-148-01	Kodak TechPan Hypered	Comet Hale-Bopp	01-May-97	0135	1.5m	f/1.9	100	75mm		1	south-north, violet-red
E-148-02	Kodak TechPan Hypered	Comet Hale-Bopp	01-May-97	0138	11m	f/2.8	100	54mm		1	south-north, violet-red
E-148-09	Kodak TechPan Hypered	Comet Hale-Bopp	05-May-97	0133	14m	f/1.9	99	75mm	#12 Wratten	2	south-north, yellow-red
E-148-10	Kodak TechPan Hypered	Comet Hale-Bopp	05-May-97	0152	17m	f/4	100	40mm		1	south-north, violet-red
E-19-27	Kodak TechPan	Sun	06-Jan-83	1900	1/15s	f/4		slit	#12&fine NGG*	2	yellow-red
Photo-6	Kodacolor Gold 400	Comet Hale-Bopp	05-May-97	0133	15s	f/2.8	0				
Photo-13	Kodacolor Gold 400	Comet Hale-Bopp	05-May-97	0152	15s	f/2.8	0				
Note									*non-glare glass		

Table II. Orientation of Ion Tail and Sodium Tail of Comet Hale-Bopp

	Date > 2/28	Degrees East of Right Ascension Line			Degrees Difference		
Date	Decimal Date	East Ion Tail	West Ion Tail	Sodium Tail	East-West	East - Na	West - Na
3/9/97	9.42		-35	-37			2
3/16/97	16.42		-24	-26			2
3/30/97	30.08	19	5	4	14	15	1
4/4/97	35.08	31	16	15	15	16	1
4/8/97	39.07	44	30	28	14	16	2
4/10/97	41.08		36	34			2
5/1/97	62.07	84	61	68	23	16	-7
5/5/97	67.08			75			

Saturn: Programs and Recent Observations

By Julius L. Benton, Jr.
Coordinator
A.L.P.O. Saturn Section

Abstract

The planet Saturn, together with its majestic Ring System, exhibits numerous features that invite well-organized observational attention. In a telescope of moderate aperture, a series of bright zones and darker belts can be seen running across the globe roughly parallel to the equator, as on Jupiter, and the rings are subdivided into three main components, the outer two separated by Cassini's division. Although Saturn requires about twice the magnification needed for viewing Jupiter, the planet is far from being a dull and unchanging world. A list of results gleaned from over fifty years of A.L.P.O. studies of Saturn are cited, and a summary is given of current observing programs, including an appeal for simultaneous observations. Since the 1995-96 edgewise presentation of the rings, increasingly favorable views of the southern hemisphere of Saturn's globe and the south face of the rings have been possible. Some of the more interesting observations of Saturn during the last two apparitions are described.

Introduction

Considered solely as a globe, Saturn is a somewhat smaller, dimmer, and relatively quiescent replica of the giant Jupiter. Especially in smaller telescopes, Saturn frequently looks barren and changeless, seldom displaying the wealth of activity that is so common on Jupiter. It is the majestic and symmetrical ring system encircling the planet that contributes to its reputation as an object of exquisite and unsurpassed beauty, holding a particular magnetism for visual and photographic observers alike.

At opposition, the globe of Saturn subtends an angle of about 17" (seconds of arc) in equatorial diameter, while the ring system's major axis spans nearly 42". Consequently, those experienced at observing Jupiter will discover that Saturn requires about twice the magnification needed for the Giant Planet so that a disc of comparable proportions is produced. When viewed with moderate-size apertures, numerous features emerge on the globe and within the rings that demand persistent and meticulous observation, and if one knows where to look, one may be able to all of the brighter eight satellites of Saturn.

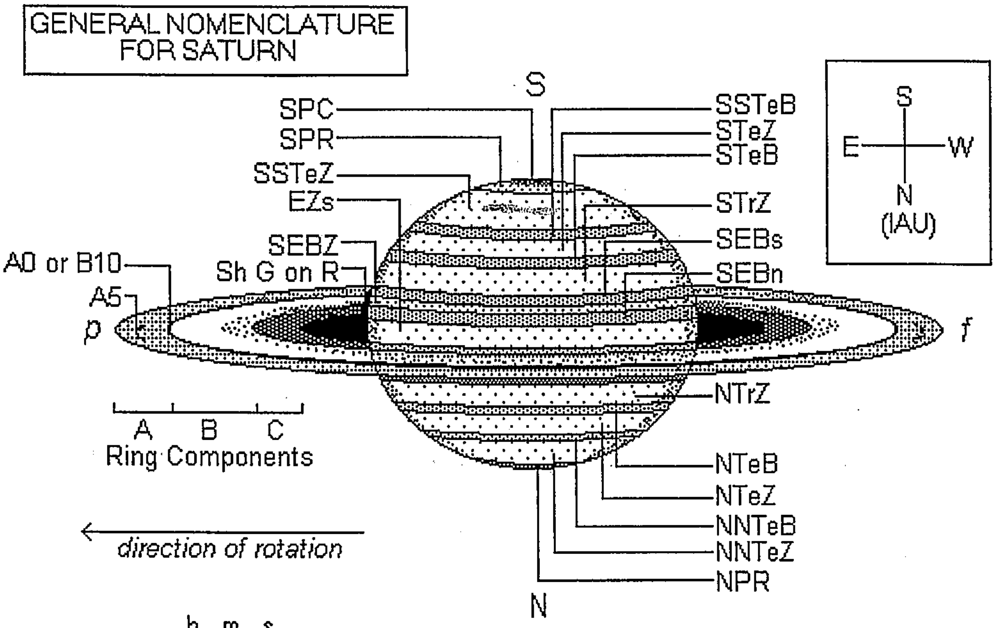
Instrumental Considerations

It is quite hazardous to try to establish some inflexible minimum with respect to aperture, particularly when it is recalled that extraordinary results have been obtained in past years by experienced observers using extremely small instruments. Almost any optical assistance will show Saturn's spectacular ring system, and the major disc features are revealed with a 7.5cm. (3.0in.) refractor, including perhaps a major belt and a zone or two near the equator of the planet. Cassini's Division should also be visible in the rings with such an instrument. Moving up to a 10.2cm. (4.0in.) refractor or a 15.2cm. (6.0in.) reflector, the observer will discover that he has found about the minimum aperture that will prove to be suitable for routine and beginning detailed studies of Saturn. Of course, when seeing and transparency conditions allow, the larger the aperture, the bigger will be the image scale and the greater the resolution and image brightness. Experienced observers have found that a 15.2cm. (6.0in.) refractor or a 25.4cm. (10.0in.) reflector is an ideal instrument for observing Saturn. More important than instrument design is optical and mechanical quality, and the prospective Saturn observer should obtain the best telescope he can afford. Excellent optics and a stable mounting are of far greater importance that sophistication of electronics in the mounting or exotic substrates or coatings for the lenses or mirrors. Some observers in recent years, for example, have successfully used simple, but premium-quality, Dobsonian reflectors when observing Saturn. The novice should spend some time in experimental work with the telescope he intends to use for following Saturn, seeking to establish the best combination of magnification, filters, and image size, brightness, and contrast. These topics, and many others, are discussed in considerable detail in ***The Saturn Handbook***. After a bit of experience in observing Saturn, individuals will want to become familiar with the more advanced methods and techniques described in that book.

Observing Saturn

Like Jupiter, Saturn displays in an appropriate telescope a series of bright zones and darker belts that run roughly parallel to the equator. Much of the fundamental nomenclature assigned to the specific zones and belts of Jupiter applies to Saturn. A complete familiarization with the names of features, where they are located relative to one another, and their abbreviation is essential. Refer to *Figure 1* below.

Figure 1



System I: $10^h14^m00^s$ (IAU) Regions in Equatorial portion of Globe (e.g., EZ, SEB, NEB)
System II: $10^h38^m25^s$ (ALPO) Regions North or South of System I

Saturn appears as it would with a ring tilt of **B** = –12°, and the standard nomenclature for globe and ring features is shown. **B** is the planetocentric latitude of the Earth referred to the ring plane, where **B** is positive (+) when the northern portions of the rings are seen and negative (–) when the south face of the rings is inclined toward our line of sight. Note that **B** is equal to 0.0° when the rings are edgewise to our line of sight. **B** can be found in a suitable ephemeris for any date of the year, and it is required that one refer to values of **B** when selecting drawing blanks. Over a span of about 14 years, **B** values will vary from 0.0° (edgewise presentation of the rings) through ± 27° (maximum inclination to our line of sight). ***The Saturn Handbook*** gives more detail on the specialized uses of all of the terminology and nomenclature for Saturn, as well as the varying aspect of the Ring System.

In *Figure 1*, the view of Saturn is as it would appear in a normal inverting telescope in the Northern Hemisphere of the Earth. Features move across the globe of the planet from right to left, and Saturn, like Jupiter, has two regions of rotation defined as System I and System II. The symbolism used in the nomenclature of features is as follows:

N (North)	**B** (Belt)	**R** (Region)	**Te** (Temperate)	**n** (North component)	***p*** (preceding)
S (South)	**Z** (Zone)	**P** (Polar)	**Tr** (Tropical)	**s** (South component)	***f*** (following)

Usage is exemplified as follows:

SEB	(South Equatorial Belt)	EZ	(Equatorial Zone)
NEBn	(North component, North Equatorial Belt)	Ring A	(Ring component A)
A0 or B10	(Cassini's Division between Ring A and B; 0/10ths out from globe in Ring A or 10/10ths out in Ring B)	A5	(Encke's Division; 5/10s out from globe in Ring A)
Sh G on R	(Shadow of Globe on Rings; note that "R" here is "Rings")		

Throughout Saturn's 29.5^y period, the intersection of the Earth's orbit and the plane of the ring system takes place only twice, at intervals of 13.75^y and 15.75^y. The two periods are of unequal length because of the ellipticity of Saturn's orbit about the Sun, and the rings are edgewise to our line of sight at these times (B = 0.0°). During the shorter 13.75^y period, which Saturn entered following the 1995-96 edgewise apparition, the south (S) face of the rings and the southern hemisphere of the globe is inclined toward the Earth. Saturn passes through perihelion during this interval, which will occur on July 26, 2003, followed by the next edgewise ring presentation on September 4, 2009. Thereafter, Saturn enters the longer 15.75^y period when the north (N) face of the rings and northern hemisphere of the globe is exposed to observers on Earth. During this longer portion of its orbit, Saturn passes through aphelion, which next occurs on April 17, 2018.

Before discussing current observational programs, it is perhaps meaningful to consider some of the accomplishments of A.L.P.O. observers in the past that have helped clarify some of the controversial problems about Saturn:

- Observations of numerous spots and festoons have been accumulated, most showing up in the equatorial latitudes of Saturn's globe. CM transit timings of the persistent spots have helped confirm rotation rates in certain latitudes.
- Variability has been noticed in the rotation rate of the SEB through observations of some long-enduring spots.
- Fluctuations have been noted in belt and zone intensities that seem to be attributable to a seasonal effect on Saturn.
- Ring C has been observed at the ansae as well as in front of the globe of Saturn with small to moderate apertures.
- Shadow intensity anomalies have been observed on quite a few occasions.
- Definite confirmation of several "intensity minima" in the rings was accomplished prior to the *Voyager* missions.
- Reasonably good confirmation occurred of the very tenuous, elusive Ring E (formerly known in A.L.P.O. literature as Ring D′) exterior to Ring A, prior to the *Voyager* flybys.
- Identification of a remarkable series of dusky radial "spokes" in Ring B (and sometimes suspected in Ring A), occurred prior to the views by *Voyager*.
- Although the real cause of the phenomenon is still not established, visual and photographic confirmation of the bicolored aspect of the rings has occurred, and many of these sightings were simultaneous observations.

It is important to recognize that one Saturnian year equals 29.5^y on Earth, which means that seasons on the planet are extremely long by our terrestrial standards. Accordingly, observational programs for Saturn are lengthy commitments. For instance, since the founding of the A.L.P.O. in 1947, only about 1.72 Saturnian years have elapsed, which means that we've only witnessed a few seasons on the planet! Thus, the need for continued long-term data acquisition should be obvious.

Present observational pursuits by the A.L.P.O. Saturn Section include:

- Visual numerical relative intensity estimates of belts, zones, and ring components.
- Full-disc drawings and sectional sketches of global and ring phenomena (the Saturn Section furnishes templates with the correct global oblateness and ring geometry to facilitate drawing). All drawings submitted for publication must be originals, not xerox copies.

- Central meridian (CM) transit timings of details in belts and zones on the globe of Saturn (utilized to determine or confirm rotation rates in various latitudes).

- Latitude estimates or filar micrometer measurements of belts and zones on the globe of Saturn.

- Colorimetry and absolute color estimates of globe and ring features.

- Observation of "intensity minima" in the rings (in addition to observations of Cassini's and Encke's divisions).

- Observational monitoring of the bicolored aspect of the rings of Saturn.

- Observations of stellar occultations by Saturn's rings.

- Specialized observations of Saturn during edgewise ring presentations in addition to routine studies.

- Visual observations and magnitude estimates of the satellites of Saturn.

- Routine photography, CCD imaging, photoelectric photometry, and videography of Saturn and its ring system.

- Simultaneous observations of Saturn.

Over the past several years, the A.L.P.O. Saturn Section has sought to reduce the level of subjectivity inherent in visual studies of the planet. The challenge has been to increase the incidence of confirmed data, so the Simultaneous Observing Program was organized in recent years to accomplish this task. *Simultaneous observations* are achieved by observers working independently, doing systematic studies of Saturn using the same methods, equipment, and standardized reporting techniques at the same time on the same date. In addition to visual methods, observers should carry out photography, CCD imaging, videography as part of the simultaneous observing program.

Some Recent Observations of Saturn

Ever since Saturn's edgewise ring presentations during 1995-96, increasing portions of the planet's southern global hemisphere, and especially the south face of the rings, have become accessible to our telescopes. In the years to come, the rings will continue to "open up" until they reach a maximum inclination of –27° to our line of sight by about 2002, then they will gradually close as they approach the next edgewise orientation in 2009.

Essentially all observational reports for the 1996-97 apparition of Saturn have been received, logged into the Saturn Section database, and now await a detailed analysis. Also, a substantial number of observations for 1997-98 have begun arriving following Saturn's conjunction with the Sun on April 13, 1998. Even though the analysis is far from complete for the last two apparitions, Saturn's atmosphere has shown moderate activity over the past two years. Here are some noteworthy examples (supporting illustrations for are presented in the slide program):

- Dark Spots or Disturbances: During September 1996, observers reported several dark festoons projecting into the EZs from the extreme north edge of the SEBn. CM transit data are being used to determine a rotation rate at this latitude. Transient dark spots associated with the SEBn were also detected intermittently from November 1996 through February 1997. A few observers felt that the SEBn was fragmented as it extended across the globe, especially during late September and early October when white spot activity (see below) was detected in the EZs. For the same period, observers also called attention to a fairly dark EB broken here and there along its linear extent.

- White Spots: White spot activity was noticed in the EZs after September 25th and throughout much of October. Whitish disturbances arise when large convection cells lift NH_3 (ammonia) into Saturn's colder upper atmosphere where it condenses to form brilliant ice clouds. The last major white spot outburst occurred in the EZ during 1990, although there was a less spectacular occurrence in 1994. Data suggests that significant white spot activity recurs every Saturnian year (i.e., at intervals of about 30 terrestrial years). Diffuse white spots were first suspected during 1996-97 in late September when the EZs noticably brightened. During October the spots were obvious to most observers, eventually spreading out along the EZs from limb to limb by the end of the month. The white spots of 1996 were not nearly as prominent as the huge storm of 1990, however. In the latter half of January and early February 1997, observers repeatedly suspected small white spots in the SSTeZ. CM transit data for the white spots are being reduced to rotation rates for these latitudes.

- Bicolored Aspect of the Rings: From a preliminary analysis of visual numerical intensity estimates, it appears that the southern hemisphere of Saturn was slightly dimmer in 1996-97 than in the previous apparition, with the notable exception of the EZs.

Concluding Remarks

Saturn is now well on its way into a new apparition, and members of the A.L.P.O. Saturn Section have already begun their routine studies of the planet. The Saturn Section is always eager to enlist new observers, and anyone interested in our programs should contact the author for information on how to get started. To facilitate planning, *Table 1* gives the Geocentric Phenomena in Universal Time for Saturn during the 1998-99 apparition.

Table 1.

Geocentric Phenomena in Universal Time (UT) for the 1998-99 Apparition of Saturn

Conjunction	1998	Apr	$13^{d}12^{h}$ UT
Opposition		Oct	23 19
Conjunction	1999	Apr	27 00

Data for 1998 Oct $23^{d}19^{h}$ UT

Constellation	Pisces	Major Axis (Rings)	45″.5
Stellar Magnitude	−0.0	Minor Axis (Rings)	12″.0
Equatorial Dia. (Globe)	19″.9	**B**	−15°.3
Polar Dia. (Globe)	17″.9	**B′**	−15°.6

NOTE: For Saturn, **B** is the planetocentric latitude of the Earth referred to the plane of the rings, positive (+) when north (when **B** is +, the visible surface of the rings is the northern face); **B′** is the planetocentric latitude of the Sun referred to the ring plane, positive+() when north (when **B′** is +, the north face of the rings is illuminated by the Sun.

Individuals interested in participating in the A.L.P.O. Saturn programs should contact:

Dr. Julius L. Benton, Jr.
Coordinator, A.L.P.O. Saturn Section
ASSOCIATES IN ASTRONOMY
305 Surrey Road
Savannah, GA 31410
E-Mail:74007.3446@compuserve.com
Phone: (912) 897-0951

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An Error Study of Jupiter Central Meridian Transits by Taking Transits of Galilean Satellites and Their Shadows, 1939-1998

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

Abstract

One method of studying the random and systematic errors in central meridian transits of the surface features on Jupiter is to observe similar transits of the four Galilean satellites and their shadows since the positions of these bodies are known to a high order of accuracy. This paper examines the differences between observation and computation for 207 such transits recorded in the time span 1939-1998 with different telescopes ranging in aperture from 13 to 46 cm. Average values and standard deviations of the time errors are determined. Possible correlations of these errors with such parameters as aperture, seeing, magnification, and the phase angle of Jupiter are investigated.

Text

A considerable amount of our knowledge of atmospheric currents at the visible surface of Jupiter has come from the method of visual central meridian (CM) transits. Indeed, almost all of the data prior to the 1960's is from this source. The method is described well in B. M. Peek's classic book.[1] Briefly, the observer times when a surface feature, moving as Jupiter rotates, is exactly midway between the illuminated edges of the planet, the limb and the terminator. Usually the time is estimated to the nearest whole minute. While the eye has had many failures in planetary observation, such as with the canals of Mars, it does rather well in this simple comparison of two distances. Tables quickly convert the observed times into longitudes on Jupiter.

It is proper to seek to determine the errors of such simple visual central meridian transits. One method is to compare the simultaneous observations of two independent observers. Occasionally observed longitudes as functions of time have been fitted with regression lines, and the residuals from the line may be regarded as random errors if one assumes for the feature being studied a constant period of rotation. Comparisons of the longitudes from CM transits with measures of photographs or CCD images should be an obvious test, but I know of no published results of such comparisons.

Now the planet actually does offer us frequent opportunities to observe transits of objects whose positions are known to a very high degree of accuracy. These are, of course, the four large Galilean satellites and their shadows. When we compare the observed time of a satellite or shadow CM transit with the computed time, in other words with the actual time, we have the error of that particular visual CM transit. When enough observations are secured, we can make a statistical study of the errors. An obvious goal is the determination of the "personal equation" of each transit observer. Over the years I have made intermittent efforts to persuade A. L. P. O. Jupiter Section staff members to urge observers to record Galilean satellite and shadow transits and then to use the results in improving the reduction of CM transit data. The Galilean transits can easily be recorded incidentally in the course of regular Jupiter observations.

I can claim no originality for this error study. B. M. Peek proposed many years ago that experienced observers could determine their own "personal equations" by recording CM transits of satellites and shadows[2] .

However, it is not clear from his text to what extent the Jupiter Section observers in the British Astronomical Association actually did so.

Now what do our Galilean objects actually look like near the CM of their primary? Io, or Jupiter I, varies in visibility according to whether it is projected against a dark belt or a bright zone. It is darker than most surface detail and may often be recognized through its roundness. Europa, or Jupiter II, is a very difficult object for ordinary apertures, matching its background entirely too well. Ganymede, or Jupiter III, is dark and often conspicuous, much darker than most surface detail. Callisto, or Jupiter IV, is so black and prominent that it is often falsely taken to be a shadow. The four shadows are naturally black and conspicuous except as they are degraded by small apertures and poor observing conditions. The shadows of Jupiter III and Jupiter IV are noticeably larger than those of Jupiter I and Jupiter II.

The objection has been raised that these eight Galilean objects may be too unlike the majority of Jovian surface detail to give us the same observational errors. My response would be that this question has not been examined empirically and that the Galilean objects are what we have available for an overdue error study.

This study has been limited to my own personal observations. While I know of a few Galilean CM transits by others, I think it best to study a more homogeneous data sample at this time. It may well be that other observers will have smaller errors, both systematic and random.

Table 1 summarizes my personal observations up to the middle of May, 1998. A better listing than by years might have been by apparitions, the periods when Jupiter is observed between consecutive conjunctions with the Sun. A very few of the observations were at locations and with telescopes not shown in the table. The "number of transits" column includes observations of all four satellites and all four shadows. It will be noted in Table 1 that activity varied greatly over the years, reflecting both changing personal circumstances and varying interest in this project -- for example, Mars received much more attention than Jupiter in 1986 and 1988. There were no doubt even occasions when a satellite or shadow in transit was not identified or timed.

The principal telescopes used were:

1. Two 15-cm, F7.9 Newtonian reflectors, one with optics by E. A. Miller of Youngstown, OH and the other with optics by S. S. Kibé in Japan.
2. A 20-cm, F8 Dynascope, a Newtonian reflector
3. A 32-cm, F8.1 Cave Newtonian reflector
4. The 46-cm, F16.7 Brashear refractor at the Flower Observatory of the University of Pennsylvania in 1941 - 46.

We have spoken glibly of knowing the positions of the Galilean satellites. Of course, no one publishes the CM transit times; but many almanacs list to the nearest minute the transit ingress and transit egress times for both satellites and shadows[3]. These are the times when the center of the satellite or shadow is at the two visible illuminated edges of Jupiter, i.e., the limb and the terminator. Such times naturally depend upon what source ephemeris is used. For many years the American Ephemeris and Nautical Almanac used Sampson's 1910 Tables of the Four Great Satellites of Jupiter. Some more modern ephemerides are naturally a little better. I have been very fortunate in having been furnished transit ingress and egress times for all 207 observations over the interval 1939 - 1998 based upon J. H. Lieske's GALSAT Ephemeris E-5[4].

For a satellite the computed time (TC) of CM transit is, accurately enough, simply the mean of the ingress time (TI) and the egress time (TE).

For a shadow the situation is more complicated, and B. M. Peek has supplied a mathematical analysis[5]. His formula for TC, the computed time of the shadow's transit, can be modified to become:

$$\mathrm{DIFF} = (2\sin I - \sin^2 I)/2(1+\cos I), \text{ and}$$

$$\mathrm{TC} = \mathrm{TI} + (\mathrm{TE}-\mathrm{TI})(0.5 \pm \mathrm{DIFF}),$$

where the plus sign is chosen when Jupiter is observed before opposition and the minus sign afterwards. Here "I" is the difference in the Jovicentric right ascensions of the Earth and the Sun, or it can also be regarded as being, nearly enough, the phase angle at Jupiter between directions to the Earth and to the Sun. This angle is at most about 12 degrees.

We necessarily observe timing errors in transits of the Galilean objects, but our real interest is in timing errors for features on the Jovian surface at the same positions. We shall make several approximations, permissible in this rough application. Each satellite will be regarded as in a circular orbit, and the velocity of the satellite or shadow near the observed CM will be taken to be the satellite's orbital velocity. Jupiter will be a sphere with radius equal to its equatorial radius.

The "raw error" ET is just the difference between the observed and computed times of transit, Thus:

$$\mathrm{ET} = \mathrm{TO} - \mathrm{TC}.$$

The error in timing results from an error ED in an estimated distance; and if VS is the orbital velocity of the satellite, one has:

ED = ET x VS.

If VJ is the rotational velocity of Jupiter at its equator, the velocity at latitude LAT will be VJ x cos (LAT), where the kind of latitude will not matter for this rough application. The error in timing at that latitude becomes:

ETLAT = ED/VJ ~~x cos~~ (LAT), or

ETLAT = ET x (VS/VJ)/cos(LAT)

The ratio VS/VJ is a constant for each satellite.

It remains to determine LAT, which depends upon the radius RS of the satellite orbit, the radius RJ of Jupiter, and the tilt D of the axis of Jupiter toward the Earth for satellites. For shadows we take the tilt toward the Sun. We may also think of D as the Jovicentric latitude of the Earth (Sun).

If ANGLE is the angle between the radius of Jupiter and the direction of the transiting satellite or shadow, then a simple diagram will verify these formulas:

sin(ANGLE) = (RS/RJ) sin D,

where ANGLE is always in the second quadrant.

LAT = 180° - ANGLE - D.

Of course, RS/RJ is a constant ratio for each satellite. Note further that LAT is south when D is north, and conversely.

Table 2 then furnishes from ephemeris data[6] the relative orbital radii and velocities. The standard is a feature in "orbit" on Jupiter's equator. The period of revolution there is simply the Jovian System I.

Table 3 is a sample of observed Galilean CM transits. Actually, it comprises all the transits recorded since 1995 and up to May 15, 1998. The first two columns provide the U.T. date of the observation and the object watched. The third and fourth columns are the computed ingress and egress times respectively, given in Ephemeris Time and based upon J.H. Lieske's GALSAT Ephemeris E-5. It should be noted that the date of ingress can be one day earlier and the day of egress one day later, than the date of the ~~CM~~ transit. The fifth column is the observed Universal Time of the CM transit, and the sixth column is the actual or computed time. The seventh column is their difference in the sense observed minus computed, in minutes, where the listed tenth of a minute has very limited significance. The eighth column is the phase angle, the angle at Jupiter between vectors to the Earth and the Sun, which affects the computation of the shadow transits. The ninth column is the approximate Jovian latitude of the transit, which may be either north or south of the equator of Jupiter. Finally, the tenth column gives the timing error in minutes adjusted to match the rotational velocity of Jupiter at the position of the transiting shadow or satellite, as discussed above.

Expanding Table 3 to include all 207 observed transits might make this paper look entirely too much like a telephone directory!

Table 4 presents for each of the four satellites, for each of the four shadows, for all satellites combined, and for all shadows combined the average timing error in minutes (just the arithmetic mean of all the observations), the standard deviation of a single observation in minutes, and the standard deviation of the mean (found by dividing by the square root of the number of observations). Observations are rejected if they differ from the mean by more than three standard deviations (one percent level of confidence). No significance can be attached to the results in Table 4 for Jupiter II (2 observations), and limited meaning must apply to Jupiter IV (6 observations), the shadow of Jupiter IV (7 observations), and even Jupiter III (11 observations).

A few comments on Table 4 may be in order. It looks as if I record Galilean CM transits about five minutes too early, with a standard deviation (random error) of about five minutes. No doubt other observers may have smaller "personal equation"and smaller random errors. Five minutes is about three degrees of longitude on Jupiter. It also looks as if satellites and shadows are observed about equally well, shadows with a smaller systematic error and satellites with a smaller random error.

Figure 1 is a graphic display of the data in Table 4. There is here plotted the average transit timing error and its vertical error-bars one sigma, i.e., one standard deviation, in length. For example, if the average error was -6 minutes and if the standard deviation of this mean was 1.5 minutes, the error bars would extend from -4.5 minutes to -7.5 minutes. We would then expect about two-thirds of our measures to fall between -4.5 and -7.5.

A thorough statistical analysis of all the data is beyond the scope of this paper. However, it appears worthwhile to investigate whether the errors can be correlated with such observational parameters as telescope apertures, atmospheric seeing and transparency, magnification, phase angle of Jupiter, Jovian latitude of the transit, etc. To keep our sample more homogeneous (maybe needlessly), we shall chiefly use the most observed Galilean object - the shadow of Jupiter I with the 87 observations.

Table 5 repeats the format of Table 4; the timing errors for the shadow of Jupiter I are now related to four selected aperture intervals (but really almost wholly to four apertures). It is curious that the timings are 6 to 7 minutes too early for both 15 and 46 cm, and a number of minutes later for intermediate apertures of 20 and 32 cm. The random error is smallest for the largest aperture.

Table 6 relates the timing errors for the shadow of Jupiter I to five selected intervals of magnification. It is certainly plausible that our errors may vary with the size of the image of Jupiter. When two different magnifying powers were employed in an observation, their average was used in Table 6. There does not appear to be any clear relationship between the random and the systematic timing errors and magnification.

Table 7 relates our timing errors to seeing or atmospheric steadiness, estimated on an admittedly subjective scale of 0 (worst) to 10 (perfect). When the estimated seeing varied during an observation, its average was used in Table 7. Thus if seeing ranged from 3 to 4, we made it 3.5. One might expect smaller timing errors in the better seeing. Note that the seeing was never estimated to be better than 6. Unfortunately, Table 7 gives little evidence for either smaller systematic errors or smaller random errors with the better seeing.

In Table 8 we are concerned with how our timing errors may be related to atmospheric transparency. The transparency was estimated on a subjective scale where it is equal to the stellar magnitude of the dimmest star visible to the naked eye at the position of Jupiter, with efforts to allow for the effects of moonlight and twilight when necessary. If the estimated transparency varied, the mean of its extreme values was used in Table 8. There does not appear to be any clear relationship between timing errors and transparency. Possibly better transparency led to earlier transit estimates (i.e., more negative adjusted timing errors) and smaller random errors.

Careful observers of long-lasting features on Jupiter have found a systematic effect caused by the phase of the planet - the defect of illumination at the terminator exceeds the geometric amount.
A mathematical correction for this error was used in the 1970's in measuring longitudes on classical photographs of Jupiter at the New Mexico State University Observatory. Let us recall that upon a simply inverted telescope image with south at the top, and celestial west to the left, Jovian detail moves from right to left as the planet rotates. After opposition the illuminated limb is on the left; the terminator, on the right. If the more dimly lit terminator is partly invisible, markings will be observed to be on the CM when really to its left; the timed transit will be too late, and the effect on the timing error will be positive as an Observed - Computed residual. Before opposition the terminator is on the left, the transit timing will be too early, and the error will become more negative.

Table 9 displays the relation between timing errors and the phase of Jupiter. The phase angle is again the difference in the directions of the Sun and the Earth from Jupiter; it is defined as negative after opposition, and positive before. More than half of the observations used were made close to a quadrature at phase angles between 9 and 12 degrees. We do indeed appear to have evidence in Table 9 that transit timings are earlier near a post-opposition evening quadrature than near a pre-opposition morning quadrature. The difference is <u>about</u> 3 minutes (-3.7 minutes vs -6.4 minutes). Thus when the phase is largest, the error caused by this exaggerated geometric defect of illumination might be one-half as much or <u>about</u> 1.5 minutes of time, thus 0.9 degrees of Jovian longitude.

Of course, this estimate might be refined with a more sophisticated analysis and/or a better set of observed data. One might also expect that there should be a dependence on the brightness of the disc of Jupiter and hence some correlation with sky transparency, magnification per cm (per inch for traditionalists) of aperture, changing sky brightness during morning or evening twilight, etc.

We may also wonder whether our errors vary with the latitude of the observed transit. If we are to use a single Galilean object, the shadow of Jupiter I is no longer a good choice because its transits are never far from the equator. The best object is the shadow of Jupiter III, bearing in mind that we want as many observations as possible and that the shadow of Jupiter III varies more in transit latitudes than does the shadow of Jupiter II. We shall bravely combine observations on opposite sides of the equator of Jupiter. Table 10 would suggest that the random error of a transit timing stays much the same near 4 minutes at all Jovian latitudes until we get far from the equator, where surface features are seldom recorded. It would also suggest that the systematic error is numerically several minutes larger, and earlier, near Jupiter's equator.

A more sophisticated analysis of the data might reveal more relations between the timing errors and various parameters which affect the observations, It might even be rewarding just to use all the observations in each correlation examined.

Of course, we cannot be sure that the transit timing errors have remained constant over the years. There may even be hints that they have not. For example, while the very great majority of the 207 transits in our set have been timed too early, in 1990 and 1991 out of 11 transits, 8 were recorded too late.

I would invite others to join this error study. The results of any one observer must always be suspect, and a larger and better set of observations might tell us much more about CM timing errors. The observations are routine for any Jupiter observer, and it should be easy to obtain 15 or 20 Galilean CM transits in a year. (I have secured 8 since the middle of May.) Of course, the observer should <u>never</u> inform himself or herself in advance of the exact time of a satellite or shadow transit.

I especially want to thank Dr. E. Myles Standish of the Jet Propulsion Laboratory for listings of transit ingress and egress times according to the GALSAT E-5 Ephemeris. I am also indebted to Mr. Scott Murrell of the New Mexico State University Observatory staff for access to old ephemeris data on Jupiter and to Mr. Vincent Dovydaitis of Las Cruces, New Mexico for adapting my ancient BASIC computer programs to a Compaq 4640.

Walter H. Haas
July 4, 1998

Table 1.
Galilean CM Transit Data: How Many, When, Where, and With What

Year	No. Transits	Chief Locations	Chief Telescopes
1939	2	Des Moines, IA	14-cm Reflector
1940	5	New Waterford, OH	15-cm Reflector
1941	9	New Waterford, OH	15-cm Reflector
		Philadelphia, PA	46-cm Refractor
1942	22	Philadelphia, PA	46-cm Refractor
1943	16	Philadelphia, PA	46-cm Refractor
1944	28	Philadelphia, PA	46-cm Refractor
1945	11	Philadelphia, PA	46-cm Refractor
1946	2	Albuquerque, NM	15-cm Reflector
1947	15	Albuquerque, NM	15-cm Reflector
1948	5	Albuquerque, NM	15-cm Reflector
1949	15	Albuquerque, NM	15-cm Reflector
1950	1	Albuquerque, NM	15-cm Reflector
1951-53	0		
1954	1	Las Cruces, NM	32-cm Reflector
1955	2	Las Cruces, NM	32-cm Reflector
1956-59	0		
1960	9	Edinburg, TX	15-cm Reflector
1961	6	Edinburg, TX	15-cm Reflector
1962	5	Edinburg, TX	32-cm Reflector
1963	5	Las Cruces, NM	15-cm Reflector
		Las Cruces, NM	32-cm Reflector
1964	0		
1965	3	Las Cruces, NM	32-cm Reflector
1966	1	Las Cruces, NM	32-cm Reflector
1967-71	0		
1972	1	Las Cruces, NM	15-cm Reflector
1973	0		
1974	3	Las Cruces, NM	32-cm Reflector
1975-83	0		
1984	2	Las Cruces, NM	32-cm Reflector
1985	0		
1986	1	Las Cruces, NM	20-cm Reflector
1987	1	Las Cruces, NM	20-cm Reflector
1988	0		
1989	1	Las Cruces, NM	15-cm Reflector
1990	5	Las Cruces, NM	20-cm Reflector
			32-cm Reflector
1991	6	Las Cruces, NM	20-cm Reflector
1992	2	Las Cruces, NM	32-cm Reflector
1993	2	Las Cruces, NM	20-cm Reflector
			32-cm Reflector
1994	3	Las Cruces, NM	32-cm Reflector
1995	0		
1996	6	Las Cruces, NM	32-cm Reflector
1997	9	Las Cruces, NM	32-cm Reflector
1998	2	Las Cruces, NM	32-cm Reflector

Table 2.
Relative Orbital Radii and Velocities of Galilean Satellites

	Io or Jupiter I	Europa or Jupiter II	Ganymede Jupiter III	Callisto or Jupiter IV	Jupiter at Equator
Radius of Orbit (km)	$4.218\text{x}10^5$	$6.711\text{x}10^5$	$1.070\text{x}10^6$	$1.883\text{x}10^6$	$7.149\text{x}10^4$
Relative Radius	5.90	9.39	15.0	26.3	1.00
Circumference of Orbit (km)	$2.650\text{x}10^6$	$4.217\text{x}10^6$	$6.723\text{x}10^6$	$1.183\text{x}10^7$	$4.492\text{x}10^5$
Sidereal Period of Revolution (min.)	$2.547\text{x}10^3$	$5.113\text{x}10^3$	$1.030\text{x}10^4$	$2.403\text{x}10^4$	$5.905\text{x}10^2$
Orbital Velocity (km/min)	$1.041\text{x}10^3$	$8.247\text{x}10^2$	$6.527\text{x}10^2$	$4.924\text{x}10^2$	$7.607\text{x}10^2$
Relative Orbital Velocity	1.37	1.08	0.858	0.647	1.00

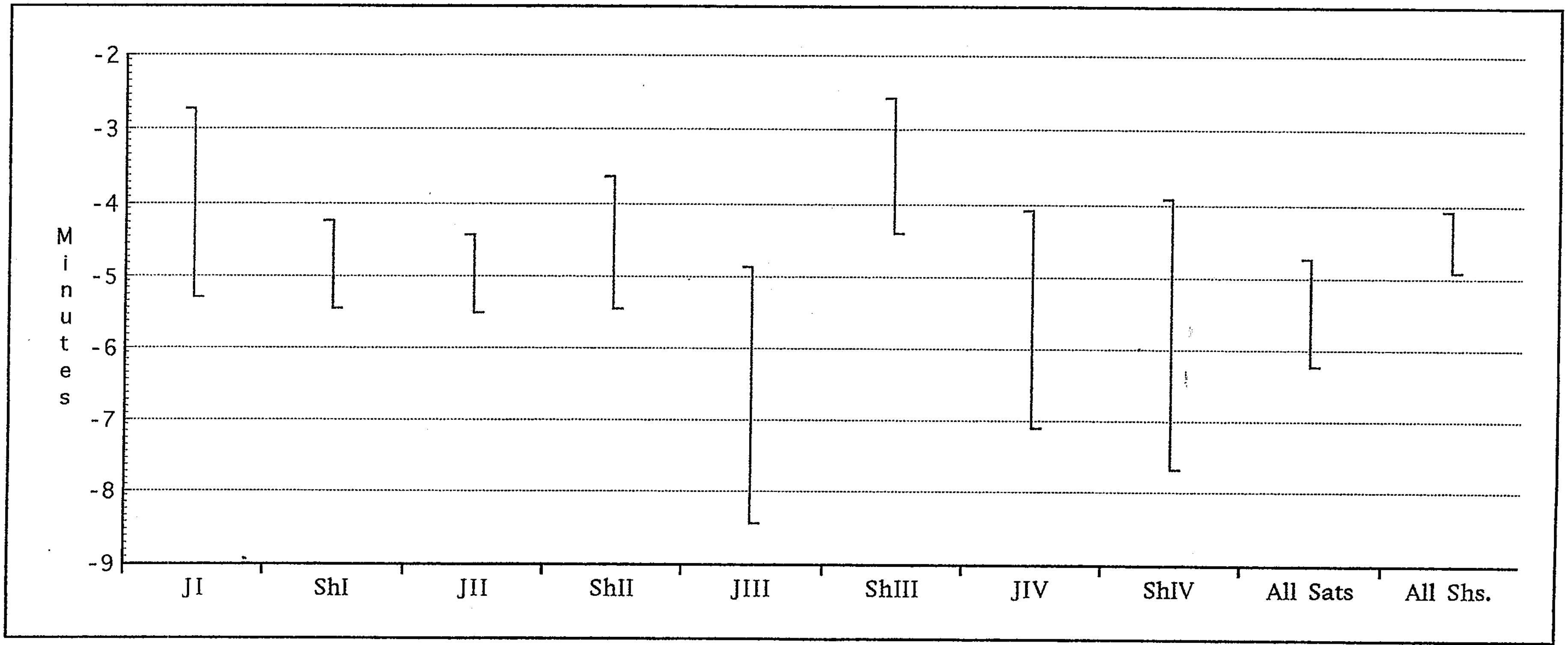
Table 3. Sample Observed CM Transits of Galilean Satellites and Their Shadows

UT Date	Object	Ingress E. T.	Egress E. T.	Observed Transit UT	Computed Transit UT	Error O-C (min.)	Phase Angle (degrees)	Approx. Latitude	Corrected Error (min.)
1996 Sep 07	ShIII	2:52	6:07	4:11	4:12.5	-1.5	10.3	21.9N	-1.4
1996 Oct 12	ShII	0:24	3:16	1:28	1:34.0	-6.0	11.0	11.6N	-6.6
1996 Oct 16	ShI	0:08	2:25	0:58	1:03.7	-5.7	10.9	6.7N	-7.9
1996 Nov 08	ShI	0:23	2:39	1:17	1:19.7	-2.7	9.4	6.1N	-3.7
1996 Nov 13	ShII	0:11	3:03	1:15	1:23.6	-8.6	8.9	10.5N	-9.4
1996 Nov 25	ShIII	22:56	2:20	0:21	0:24.2	-3.2	7.7	17.1N	-2.9
1997 Sep 29	ShIII	2:48	6:28	4:18	4:20.7	-2.7	9.2	3.2S	-2.3
1997 Oct 08	JIV	2:09	7:00	4:22	4:33.5	-11.5	--	0.3S	-7.4
1997 Nov 11	ShIV	2:10	6:54	3:57	4:05.7	-8.7	11.3	10.7S	-5.7
1997 Nov 14	ShII	2:08	4:59	3:14	3:17.4	-3.4	11.2	3.8S	-3.7
1997 Nov 18	JIII	1:41	5:20	3:25	3:29.5	-4.5	--	0.6S	-3.9
1997 Nov 20	ShI	23:59	2:17	0:51	0:55.0	-4.0	11.0	2.4S	-5.5
1997 Dec 09	ShII	23:17	2:08	0:25	0:28.0	-3.0	9.9	4.9S	-3.3
1997 Dec 13	ShI	0:14	2:32	1:06	1:11.4	-5.4	9.5	2.9S	-7.4
1997 Dec 17	ShIII	23:09	2:47	0:32	0:41.0	-9.0	9.1	8.6S	-7.8
1998 Jan 10	ShII	23:04	1:55	0:08	0:19.4	-11.4	6.4	6.1S	-12.4
1998 May 12	ShI	10:48	13:04	11:59	12:05.9	-6.9	10.1	6.3S	-9.5

Table 4. Average Values and Standard Deviations of Galilean CM Transit Errors

	J1	Sh1	JII	ShII	JIII	ShIII	JIV	ShIV	All Sats	All Shs.
No. Observations	20	87	2	36	11	38	6	7	39	168
No. Rejected	0	0	0	0	0	0	0	0	1	0
Average Error (min.)	-4.00	-4.83	-4.95	-4.52	-6.63	-3.47	-5.57	-5.79	-5.47	-4.49
Standard Deviation (min.)	5.72	5.69	0.78	5.46	5.96	5.53	3.70	4.95	4.68	5.56
Standard Deviation of Mean (min.)	1.28	0.61	0.55	0.91	1.80	0.90	1.51	1.87	0.76	0.43

Figure 1. Graphical Display of CM Transit Errors for Each Galilean Object: Average Values and One-Sigma Error Bars



J = Jupiter Satellites
Sh = Shadow

Table 5. Relation Between CM Transit Errors of Shadow of Jupiter I and Aperture

	13 - 15 cm	20 - 25 cm	31 - 32 cm	46 cm
No. Observations	33	10	17	27
No. Rejected Observations	0	0	0	0
Average (min.)	-6.74	2.12	-2.94	-6.26
Standard Deviation (min.)	4.83	7.24	5.91	3.31
Standard Deviation of Mean (min.)	0.84	2.29	1.43	0.64

Table 6. Relation Between CM Transit Errors of Shadow of Jupiter I and Magnification

	125x - 175x	175x - 225x	225x - 275x	275x - 325x	325x - 375x
No. Observations	24	33	6	23	1
No. Rejected Observations	0	0	0	0	0
Average (min.)	-5.77	-3,78	+0.50	-6.48	-10.8
Standard Deviation (min.)	4.86	5.57	7.85	5.28	--
Standard Deviation of Mean (min.)	0.99	0.97	3.20	1.10	--

Table 7. Relation Between CM Transit Errors of Shadow of Jupiter I and Seeing

Seeing	1.0 - 2.0	2.5 - 3.0	3.5 - 4.0	4.5 - 5.0	5.5 - 6.0
No. Observations	5	23	37	17	5
No. Rejected Observations	0	0	0	0	0
Average (min.)	-5.26	-5.57	-4.93	-2,49	-8.24
Standard Deviation (min.)	3.25	4.44	6.36	6.36	3.01
Standard Deviation of Mean (min.)	1.45	0.93	1.05	1.54	1.35

Table 8. Relation Between CM Transit Errors of Shadow of Jupiter I and Transparency

	1.2 - 2.2	2.2 - 3.2	3.2 - 4.2	4.2 - 5.2	5.2 - 6.2
No. Observations	4	35	33	11	4
No. Rejected Observations	0	0	2	0	0
Average (min.)	2.68	-5.24	-6.83	-4.45	-0.45
Standard Deviation (min.)	7.03	5.26	3.46	7.31	4.40
Standard Deviation of Mean (min.)	3.52	0.89	0.62	2.20	2.20

Table 9. Relation Between CM Transit Errors of Shadow of Jupiter I and Phase Angle of Jupiter

Degrees	-11.9→ -9.0	-8.9→ -6.0	-5.9→ -3.0	-2.9→ 0.0	0.1→ 3.0	3.1→ 6.0	6.1→ 9.0	9.1→ 12.0
No. Observations	35	10	7	6	2	2	6	19
No. Rejected Observations	0	0	0	0	0	0	0	0
Average (min.)	-3.70	-2.66	-5.13	-4.70	-4.75	-8.70	-8.57	-6.40
Standard Deviation (min.)	5.76	8.79	4.30	2.73	5.30	5.52	4.95	4.57
Standard Deviation of Mean (min.)	0.97	2.78	1.63	1.11	3.75	3.90	2.02	1.05

Table 10. Relation Between CM Transit Errors of Shadow of Jupiter III and Latitude of Jupiter

Degrees	0 - 15.0	15.1 - 25.0	25.1 - 35.0	35.1 - 45.0	45.1 - 90
No. Observations	10	5	11	6	6
No. Rejected Observations	0	0	0	0	0
Average (min.)	-6.57	-3.56	-3.63	-2.05	0.67
Standard Deviation (min.)	4.09	3.70	4.76	3.92	9.09
Standard Deviation of Mean (min.)	1.29	1.65	1.44	1.60	3.71

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[2] B.M. Peek, The Planet Jupiter, 1958, pp. 50-51
[3] Observer's Handbook, 1998, the Royal Astronomical Society of Canada, pp. 160-167
[4] Private communications from E. Myles Standish, Jet Propulsion Laboratory, April 9, April 27, and May 5, 1998.
[5] B.M. Peek, The Planet Jupiter, 1958, Appendix II, pp. 272-273
[6] The A.L.P.O. Solar System Ephemeris: 1997

Small Telescopes and Planet Observing

By Craig D. MacDougal

The Association of Lunar & Planetary Observers has been in existence for over 50 years. There is no question that many things have changed since its inception. In those early years the planets were mysterious, quivering orbs in even the best telescopes staffed by professionals.

It was thought that Mercury kept one side eternally facing the sun. While not everybody thought that Mars had an intricate system of canals built by a dying civilization, many were comfortable with the idea that it may harbor some form of plant life. Uranus and Neptune were small blue-green dots. This was better than recently discovered Pluto, which didn't even show a disk. Even the origin of the craters on our nearby moon had not been explained to everybody's satisfaction. There was much to learn about our solar neighborhood. There was also much excitement about unraveling the secrets of the planets. While there were a number of observatories whose mission was to expand our knowledge of the solar system, they could not study all the planets all the time.

The excitement carried over to amateur astronomers as well. Groups like the Association of Lunar & Planetary Observers helped the professionals by adding their own observations. These observations were collected in a consistent systematic fashion and made available to all. In the earliest years, members of the Association of Lunar & Planetary Observers and other groups used basically the same techniques as the professionals. The main difference was that their instruments were smaller. An 20 cm telescope was considered to be a BIG scope for an amateur. Some of these amateurs may had carried aspirations of becoming professional researchers. Many were quite settled in their careers and simply enjoyed being part of the process of discovery.

As time went on, the professional astronomers gained larger telescopes, and more sophisticated data gathering techniques. The average amateur could not possibly afford to "keep up" in terms of equipment, but they still had something the professionals found in short supply - TIME. There was still the problem that there were only so many observatories and they couldn't study all the planets all the time. As the researchers gained more sophisticated instruments, they found it necessary to focus their studies on narrow aspects of certain planet. The days of basic data gathering had ended for the professionals, but there was still a need for just that. The amateur had the luxury of being able to decide to look at Saturn every clear night, "just to see if something interesting is happening."

In the past 10 years or so, the landscape has changed again. The combination of rising standards of living in the industrialized nations, and the electronics "revolution" has put bigger telescopes and better equipment within the financial reach of many people that are considered simply "middle class."

With a telescope in the 15 - 25 cm range one can do all this plus:

* Sketch the inner planets, Jupiter and Saturn. Also determine the longitude of features in Jupiter's clouds (central meridian transit timing). In this day of up close images taken by spacecraft one might question the value of sketching planets, especially with such a modest telescope. There are a variety of reasons why sketching is still important. To be able to find long term patterns, one must have consistent data. Since the planets have been sketched for hundreds of years, modern sketches can be directly compared. Even though we now can obtain images that show details beyond the reach of an observer with a small telescope and a pencil, these images cannot be easily related to observations of the past. A companion visual sketch of an interesting phenomenon observed by the Hubble Space Telescope (for example) will provide a way of determining if this had occurred in the past. Perhaps the biggest advantage the amateur with a sketch pad has is, once again, TIME. To perhaps beat this point to death, the funded researchers are not able to simply look at a planet every clear night "just to see."

While the impact of comet Shoemaker-Levy 9 into Jupiter's clouds created a flurry of excitement, one can only imagine the excitement generated if the comet had not been discovered BEFORE impact. It is not idle speculation to say that the first reports of "sudden dark spots" on Jupiter would have most likely come from amateurs. Furthermore, it would have been observers from groups like the Association of Lunar & Planetary Observers that would have provided the professionals with information needed (in a suitable form) to allow them to quickly turn their telescopes to view the phenomenon.

All this being said, let us not delude ourselves into thinking that there is a wealth of "cutting edge" science to be done with a 20 cm telescope and a #2 pencil. Visual observations in this age have only a limited scientific value. Yet, these observations fill a niche that would not be covered otherwise. Furthermore, this type of observing is not extremely time-consuming, nor is it particularly expensive. It IS, however, quite fun. It is fun to be a part of the long and venerable line of planet observers. It is fun to be adding your own little bit of data to the quest to understand our universe. It is perhaps most of all, fun to see the wonders of Jupiter or Mars with your own eyes, and not just a picture in a magazine.

We have almost come full circle. Amateurs are doing same work as the professionals, using basically the same techniques, just with smaller telescopes. However, in this case these "smaller" telescopes are in the 30 - 50 cm range. It is not unusual to flip through the pages of popular astronomy magazines and find images of Mars or Jupiter, taken by amateurs, that rival images taken by the best funded observatories.

While this is exciting, one may be left that feeling that you MUST have a sizable telescope with a CCD, and image processing software on your computer to be able to contribute to the science of planetary astronomy. This is not so. There are a number of observing programs that can be done with smaller instruments.

One project that requires NO instrument is meteor observing. All one needs is a dark location, the proper equipment to gaze at the sky for extended periods (as in a lawn chair or sleeping bag), and a way to record meteors seen. There are several well known showers, and many lesser ones to observe. Each meteor stream is the debris ejected from a comet. The parent comet has been identified for some of these streams. Tracking the behavior of these meteor streams can shed some light on the past behavior of the comet.

With a telescope near 10 cm in aperture (or even smaller) one can:

* Track the brighter comets that appear, making estimates of its magnitude and report its activity. The behavior of comets is mysterious in many ways. Since they are thought to be reasonably well-preserved specimens of the primordial solar system, any increase of our understanding of comets will help define the initial conditions of our own formation.

* Time the eclipses of the Galilean satellites of Jupiter. The orbits of all the bodies in our solar system are slightly chaotic. Even though this chaos is not expected to manifest itself in anything like a human lifetime, the mathematical model of the Jovian system needs to be constantly checked for accuracy. The simplest way to do this is for a large number of observers to time the eclipses.

* Estimate the magnitude of Uranus and Neptune. While this doesn't sound very flashy, if a major storm erupted on either of these planets it may show up first as a change in magnitude. This is a relatively quick and easy observation to make, and may be the only way that the professionals would be alerted.

A MOST UNUSUAL GRAZE: THE TRANSIT OF MERCURY ON 1999 NOV 15

By: John E. Westfall, Coordinator, A.L.P.O. Mercury/Venus Transit Section

EVENT CIRCUMSTANCES

Next November's Transit of Mercury will be the fourteenth and final time in this century that the planet passes in front of the Sun as seen from the Earth. Thus it is clear that a typical transit of Mercury is a fairly rare event, but not so unusual that a person should not expect to see several in their observing lifetime. What makes the 1999 Transit of Mercury something that one should not miss is that it will be a graze; part of the Earth will see the planet enter entirely within the Sun's disk, but the remainder of the visibility zone will experience only a partial transit. This is the first time such an event has taken place since the invention of the telescope, and we do not expect another such through at least the Twenty-Third Century. [Meeus, 1989] The 1937 MAY 11 Transit of Mercury was somewhat similar, but then no place on Earth saw Mercury entirely within the Sun's disk, and only observers in the South Indian Ocean and parts of Australia and Southeast Asia could see any transit at all.

Many observers will wish to watch the 1999 event simply because it is extremely rare. However, there are several forms of observation for which this transit is particularly suited, simply because Mercury will be very close to the solar limb, both inside and outside the disk, for an extended period and will also enter and leave the Sun's disk at a very gradual pace. This situation will provide a generous amount of time for making drawings, taking photographs, or acquiring video or CCD images, particularly in the form of sequences of views over time.

Figure 1 shows the portion of the Earth from which this transit will be seen, basically the so-called "Pacific Rim." [Modified from: Nautical Almanac Office, 1996.] Beside many Pacific Ocean islands, virtually all of Australia, and most of the Americas, can observe this event, given clear skies. Note particularly the line crossing the South Pacific Ocean that divides the "Total Transit" zone to its north from the "Partial Transit" zone to its south. Observers near this line in Australia, New Zealand, and some South Pacific islands will experience what might well be called a "Planetary Graze."

Unusually for a planetary transit, the track of Mercury across the face of the Sun will be strongly affected by where the observer is located. *Figure 2* shows Mercury's path as seen from three sample locations. In all cases, the planet moves from left to right (east to west in the sky). The initial contact of the planet's limb with the Sun's limb is called "First Contact," while the last as it leaves the Sun is "Fourth Contact." For the imaginary geocentric observer these two contacts happen at about 21h 15m UT (P.A. 032°) and 22h 07m UT (P.A. 014°), respectively. These contact times and position angles differ by only ±4 minutes and ±2° for observers anywhere in the visibility zone, and the time and position angle of closest approach of Mercury to the center of the Sun's disk vary even less with location.

What do differ markedly with location are the times of the two interior contacts ("Second Contact" and "Third Contact"), the duration of Ingress (between First and Second Contacts) and of Egress (between Third and Fourth Contacts), and the maximum separation between Mercury's limb and the Sun's limb at mid-transit. Indeed, for the partial-transit zone, Second and Third Contacts will not occur and Mercury will never be entirely within the Sun's disk.

St. Louis, Missouri, is used in *Figure 2* as a sample observing site in the Contiguous United States, throughout which Ingress and Egress will last about 11.4 minutes and the maximum distance between Mercury's limb and that of the Sun will be about 6 arc-seconds; less than the planet's 9.9 arc-second diameter at the time. The second diagram is for the Transit at Honolulu; about as close to the graze zone as one can get within the United States (although the American possessions of Guam and Samoa will be closer yet). Finally, the Sydney, Australia, view is in the partial-transit zone, where the mid-transit limb-to-limb distance is *negative* and there are no Second or Third Contacts.

WHERE TO OBSERVE

The most important location-based consideration for those viewers in the Continental United States and Canada is "How high above the horizon will the Sun be during the transit?" This question is answered for mid-event in *Figure 3*. The Sun will be above the horizon throughout the United States except the northeast, and for Canada excluding Quebec and the Maritimes. Nonetheless, the Sun will be low in the eastern portions of those countries, so an unobstructed southwestern horizon will be necessary, and the seeing may be poor due to the long atmospheric path length. If his or her primary telescope is portable, the best advice for an observer in the eastern United States and Canada is "go southwest as far as you can." However, if your major telescope is permanently mounted and you wish to conduct the high-resolution observations described later, it may be wisest to stay put unless the transit will actually be invisible from your location. There is also the question of the weather. Again, within the Lower 48 States, the southwest will be the most favorable location, with the November daylight cloud-cover mean below 40 percent in southeastern California, southern Arizona,southwestern New Mexico, and westernmost Texas in the United States; as well as Baja California and Sonora in northwestern Mexico. (Of course, the *actual* weather on November 15, 1999, may well differ from the mean!)

On the other hand, what better month than November for a trip to the South Pacific, where it will be Springtime? *Figure 4* shows that the transit will approach a graze condition more and more closely the farther southwest one travels in the Pacific Basin. For example, the maximum limb-to-limb separation will be just 2.28 arc-seconds in Tahiti, where incidentally the solar altitude will be 89°. In Pago Pago, American Samoa, the separation will have decreased to 1.86 arc-seconds; and to 1.27 arc-seconds in Suva, Fiji.

The zone between the +1".0 and 0".0 lines in Figure 4 contains the locations that are the most interesting for observing the "Black Drop" effect, described later. Island sites in their dry season in November that are located in this zone include Port Moresby, Papua-New Guinea (0.78 arc-seconds) and Nouméa, New Caledonia (0.64 arc-seconds).

The observing situation gets yet more interesting in the Northern Territories and Queensland in Australia, and the North Island of New Zealand, through which the graze limit passes. The graze limit passes very close to Brisbane in the first case, and near Palmerston North in the second. In such areas, the Ingress and Egress stages may last over 20 minutes, and the "Black Drop" effect may persist for several minutes. Interesting comparative observations could be made by individuals spaced at several-kilometer intervals in Queensland, starting near Brisbane and extending northward; a giant version of the arrangement used for profiling the moon's limb during a graze occultation by the Moon.

Finally, wherever you observe this transit, record your position to an accuracy of 1 arc-minute in latitude and longitude, together with your approximate elevation (say to ±100 meters).

HOW TO OBSERVE THE 1999 TRANSIT

Observing a transit resembles sunspot observing because, after all, you are looking at a dark spot on the Sun; indeed even darker than sunspot umbrae. There is also a similarity to solar eclipse viewing because you have to do the observing at a particular time and may have to do considerable traveling, although the exact location is less critical than for a total solar eclipse.

As with all solar observation, eye safety is a prime consideration. Eyepiece projection is relatively safe and can be used for general or group viewing, but remember that Mercury's disk will be quite tiny; its diameter only about 1/200 that of the Sun. For serious transit observing, what is needed is a telescope with a full-aperture solar filter, either aluminized glass or aluminized mylar. With so much light, a clock drive is not absolutely necessary for photography or electronic imaging, although it is an almost-necessary convenience for tracking the tiny planet for more than a few minutes. With Mercury's angular diameter less than 10 arc-seconds, good seeing, excellent optics, and high magnification are all needed to observe the phenomena of this transit.

Because Mercury's disk will be so small and so near the edge of the Sun, in order to find the planet one should take note of the predicted Contact I position angle and carefully turn the telescope to that portion of the limb. Once Mercury's "bite" into the Sun becomes apparent, center the planet and then frequently reset the telescope to keep the planet centered as it crosses the face of the Sun. A sidereal drive rate is better to use than a solar one, but there will still be drift; indeed, Mercury is moving *westward* in the sky faster than the Sun is moving eastward!

WHAT TO OBSERVE

There are several projects that one can choose from during this transit. They fall into the two categories of: (1) observations that are personally interesting and challenging; and (2) those that may actually extend out knowledge. Naturally, drawing a line between the two types is definitely debatable!

The "interesting and challenging" category includes, but is not limited, to :

1. Timings of Contacts II-IV.—Here, the best advice about what to time was written almost 40 years ago:

> "Useful timings of contact I are not possible, as this stage is already past when the planet first becomes visible as a notch in the solar limb. For contact II, the time to record is the breaking of the "black drop" that apparently connects the disk of Mercury with the solar edge. If no black drop is seen, the observer should note the instant when Mercury appears to be internally tangent to the sun's disk.
>
> At contact III, the events of II occur in reverse order. The phase to time is the breaking of the thread of light separating Mercury's black disk from the sun's edge. Contact IV is final disappearance of the notch in the solar limb, as Mercury moves off the sun." [Anon., 1960, p. 217]

The contact timings should be recorded to a precision of 0.1 second, probably best done with voice comments on an audio tape with a radio time signal such as WWV in the background. If videotaping, the time signal can be recorded on the audio track.

An observer's contact timings may be compared with the predicted event times. In a "normal" transit of Mercury, agreement to within a few seconds is frequent. However, given the leisurely nature of Ingress and Egress for the 1999 transit, observed-predicted differences will probably be greater.

The comparison of contact timings of planetary transits by widely-spaced observers once was the most accurate method we had for determining the value of the "solar parallax," which gives the distance of the Earth from the Sun in everyday units such as miles or kilometers. Transits of Venus were preferred for this purpose, because Venus in transit has a greater topocentric parallax than does Mercury. However, timings of Venus' contacts are made uncertain by the effect of Venus' atmosphere; also, transits of Venus are much rarer than those of Mercury; the next Transits of Venus occur in 2004 and 2012, the first since the 1874-1882 pair.

Using radio ranging, we know the distance from the Earth to Mercury far more accurately than by transit contact-timing, so this method no longer has scientific value except in developing an appreciation of the problems this method presented to Eighteenth- and Nineteenth-Century observers, and to gauge the accuracy of their results. To use the 1999 transit to estimate the solar parallax will require a pair of observers, spaced several thousand kilometers apart southwest-northeast within the total-transit zone. To go to extremes for an example, an observer in Edmonton, Alberta, teamed with another in Darwin, Australia, would make a good pair of positions for a solar parallax estimate. The critical value that should be used by them to calculate the solar parallax is the difference between their timings of the duration between Contact II and Contact III, which for this transit is the parameter that is the most sensitive to the value of the solar parallax.

As it turns out, we can demonstrate the parallax effect without doing any calculations at all. A pair of observers spaced as described above can simply take high-magnification photographs or images of Mercury at exactly the same time. When converted to the same scale and orientation, the two pictures can be mounted together, providing a three-dimensional view of Mercury suspended in space in front of the Sun.

2. Observing Mercury off the Sun's limb.—Sometimes Mercury has been reported as silhouetted against the inner corona or the chromosphere during a transit, either before Contact I or after Contact IV. [e.g., Ashbrook, 1970] (Indeed, this phenomenon could be used to anticipate Contact I and actually make an accurate timing of it!) Obviously, such an observation would be very challenging, but the very slow approach of Mercury toward and away from the solar limb in the 1999 transit will be helpful in detecting it off the solar limb. Observers with Hydrogen-α filters may wish to employ them in this project as they should improve the image contrast and thus increase their chances for success.

Then, there are several observing projects that can claim some scientific values because they may help us better to understand phenomena which, although perhaps illusory, have been repeatedly reported by observers of past transits. Visual drawings can be used here, although the supposed objectivity of photographs or video images may provide better data. Better yet would be sequences of CCD images, carefully calibrated with dark and background frames, which could give quantitative photometric information; as far as I know, nobody has yet obtained CCD frames of a planetary transit. The slower effective "frame rate" of sequential CCD images, as compared with the video rate of 30 frames per second, should not be a disadvantage because of the very slow rate of ingress and egress in the 1999 transit.

3. Light or dark aureoles around Mercury during transit.—Such phenomena were regularly reported through the Nineteenth and early Twentieth Centuries, and more rarely thereafter. [e.g., Anon., 1974; Antoniadi, 1974] Since Mercury's atmosphere is next to non-existent, these almost certainly are contrast effects. You may see such phenomena visually, as your eyes are subject to contrast effects; presumably photographic film or silicon chips will not record them, unless of course they are caused by the optics of one's telescope or projection system (i.e., Barlow lens or projection eyepiece). A very unlikely "real" phenomenon that might conceivably be recorded would be a thin bright limb band outlining the portion of Mercury outside the photosphere, caused by sunlight scattered by dust electrostatically suspended above Mercury's surface.

4. Mercury's disk not completely black during transit.—These phenomena range from a single light spot near the disk center, to one or more off-center spots, to the entire disk appearing other than black. [e.g., Gaherty, 1962; Antoniadi, 1974] Again, it is difficult to explain such phenomena other than as optical effects. If you see such an appearance visually, so if moving the telescope or changing the eyepiece affects the phenomenon. If they are caused by the telescopic or projection optics they might well be recorded photographically or electronically.

5. Solar diameter.—Although a project that involves making a personal estimate of the value of the solar parallax is mentioned above in the contact timing section, in reality we know the value of the distance to the Sun to 11 significant figures. We also know Mercury's diameter to an accuracy of about one kilometer, thanks to radar ranging and the Mariner 10 space mission. [Kopal, 1979, p. 101]; presumably we know Mercury's orbital position to at least that degree of accuracy. The only remaining parameter that could affect the contact times for a Transit of Mercury is the diameter of the Sun itself. Some solar astronomers believe that the Sun's diameter varies by as much as 0.4 arc-second. [Anon., 1996] Transits of Mercury, and especially the grazing transit of 1999, appear a very sensitive tool to detect any such changes.

A remaining scientifically useful project deserves to be treated by itself:

THE BLACK DROP

This ominous-sounding term refers to a dark umbilicus that connects Mercury's limb with that of the Sun, both after theoretical Contact II and before Contact III, at times when the planet should appear completely silhouetted against the solar photosphere. This optical effect was first noted in the 1677 Transit of Mercury and has been regularly reported ever since. It appears when the two limbs are very close together, which will be the case for prolonged periods during the 1999 transit.

Because Mercury's atmosphere is optically negligible, the event of separation between the Mercurian and solar limbs should be instantaneous were their images perfectly defined. This is, of course, never the case. Were the seeing perfect, and one's optical system also perfect, diffraction would blur the limbs of Mercury and the Sun, creating a false connection between the two limbs even when they should be separated. And even with an infinite aperture, the limitations of one's eyes, film, or CCD chip would still blur the two limbs and create something like the famous "Black Drop." No matter how proud you may be of your telescope, and perhaps even your eyes, the laws of physics dictate that even a perfect point source will never appear as a perfect point. Indeed, what is puzzling about the Black Drop effect is not its existence, but the fact that observers sometimes report that it is absent! Perhaps such observers, through familiarity with their telescopes and seeing conditions, subconsciously attempt mentally to correct for these blurring effects, talking themselves out of seeing something that theoretically should always appear!

The Black Drop effect can be simulated by assuming that the actual blurring of the limbs of Mercury and the Sun follows a Gaussian (normal) distribution, which appears to be borne out by the writer's brightness profiles of his CCD images of well-defined features such as the limb of the Moon. The results of a Black-Drop simulation are shown in *Figure 5,* with five different spacings of the limbs and five different amounts of blurring. It appears that the Black Drop will appear, at least briefly, whenever the image is other than perfectly well-defined, which means that it should always appear.

Thus, one of the advantages of the coming Transit of Mercury is that the Black Drop should not only appear, but should be visible for an extended period, perhaps several minutes in the vicinity of the zero-maximum-limb-spacing line. This will allow careful photography, video framing; and, best of all, CCD imaging, which can be used for thorough measurement of the timing and photometric characteristics of this phenomenon.

FURTHER INFORMATION

The literature about Transits of Mercury is not vast, probably because they have attracted less attention than their more famous cousins, the Transits of Venus. Some books, unfortunately sometimes out of print, that provide information about this topic are listed in the References section below. The writer is preparing an "Observer's Guide" for the 1999 Transit of Mercury, which will give more details on observing techniques and programs, along with tables and maps of information about the transit circumstances. In fact, if interested observers provide their latitudes, longitudes, and elevations above sea level, he will be willing to compute their predicted local circumstances. (His addresses are: Snail-mail [please send a stamped self-addressed envelope] = P.O. Box 16131, San Francisco, CA 94116 U.S.A.; E-mail = 73737.1102@compuserve.com . He will also post information on the A.L.P.O. Webpage = http://www.lpl.arizona.edu./alpo/)

Finally, the Appendix at the end of this paper gives local-circumstance predictions of the November, 1999, Transit of Mercury for some selected locations in the United States, selected Pacific islands, Australia, and New Zealand.

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APPENDIX. TRANSIT OF MERCURY, 1999 NOV 15: LOCAL CIRCUMSTANCES FOR SELECTED SITES.

Note: These predictions use ΔT = +65s and are based on the formulae and parameters given in Meeus, 1989. Within the United States, the times agree to ±1-2 seconds with those in *Astronomical Phenomena for the Year 1999*. Near the zero-maximum-separation line the differences are greater; e.g., that publication predicts a *total*, rather than a partial, transit for Brisbane. The differences may be due to Meeus taking Mercury's diameter as 2439 km [Meeus, 1989, p. 16] instead of 2439.7 km as used by the U.S. Nautical Almanac Office [U.S. Nautical Almanac Office, 1997, p. E-88]. A negative maximum limb-to-limb distance indicates a partial transit. In the column "Ing./Egr. Dur.", the values are the means of the ingress and egress duration; or only the ingress duration if egress is unobservable; the two differ at most by a few tenths of a second. Times are given as mm:ss. Altitudes are unrefracted.

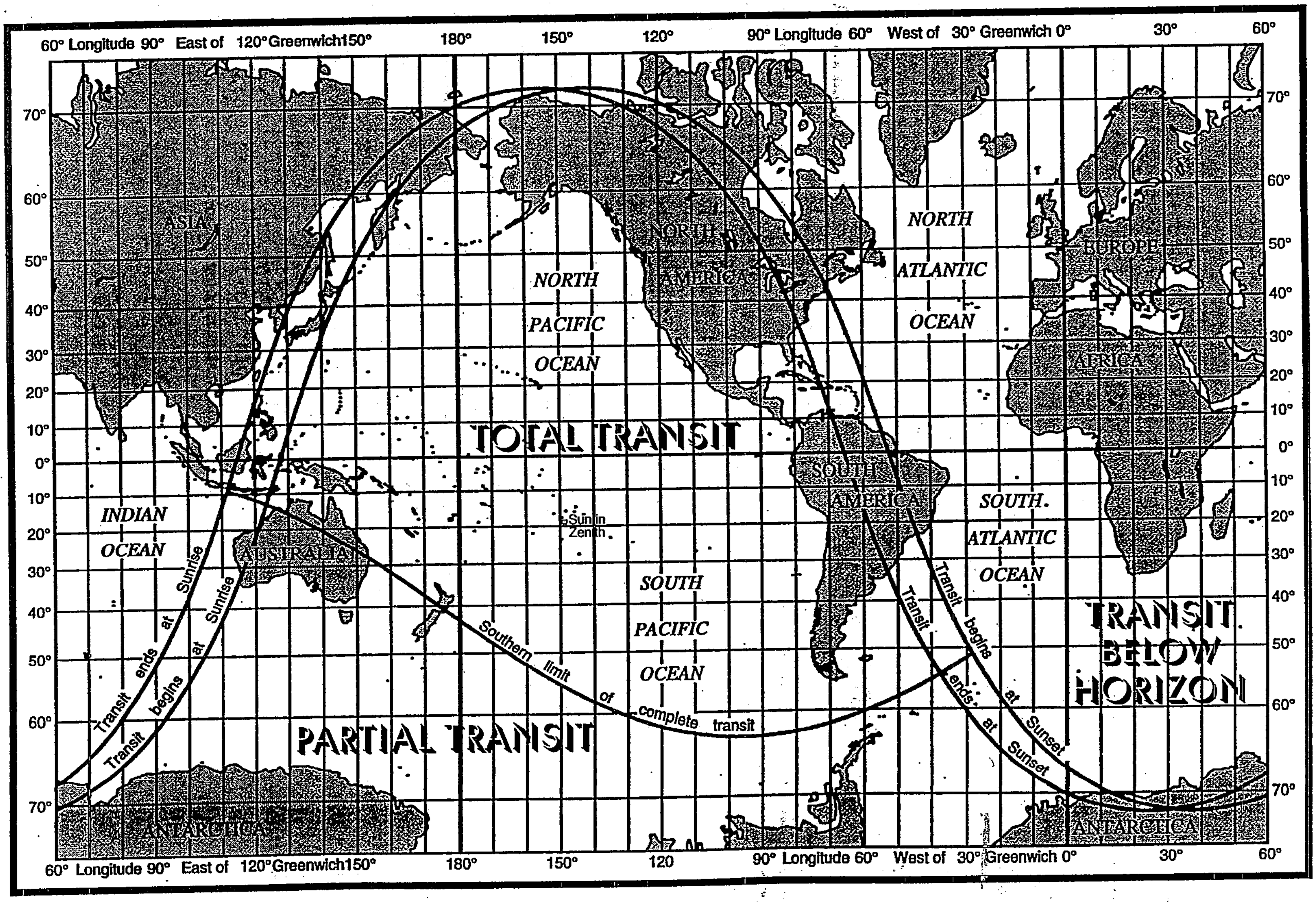
	Contact I		Max. Limb-to-Limb Dist.				Contact IV		Ing./Egr.
Location	UT	P.A.	Dist.	UT	P.A.	Alt.	UT	P.A.	Dur.
	21h	°	″	21h	°	°	22h	°	sec
United States									
Atlanta, GA	11:10	033.2	5.88	40:32	022.9	+9.3	09:55	012.5	690
Chicago, IL	11:02	033.3	6.13	40:38	022.9	+7.3	10:15	012.5	682
Denver, CO	11:15	033.3	6.06	40:47	022.9	+18.7	10:19	012.5	683
Fairbanks, AK	11:42	033.2	6.03	41:13	022.8	+6.7	10:44	012.4	685

	Contact I		Max. Limb-to-Limb Dist.				Contact IV		Ing./ Egr.
Location	UT	P.A.	Dist.	UT	P.A.	Alt.	UT	P.A.	Dur.
	21h	°	″	21h	°	°	22h	°	sec
United States—Continued									
Honolulu, HI	13:21	033.3	4.41	41:20	022.8	+49.2	09:19	012.9	748
Houston, TX	11:21	033.2	5.77	40:36	022.9	+19.3	09:52	012.6	694
Las Cruces, NM	11:27	033.2	5.82	40:45	022.9	+25.6	10:04	012.5	692
Los Angeles, CA	11:37	033.2	5.78	40:53	022.8	+29.8	10:09	012.5	693
Memphis, TN	11:10	033.2	5.95	40:36	022.9	+12.6	10:02	012.5	688
Miami, FL	11:21	033.1	5.55	40:25	022.9	+9.7	09:30	012.7	702
New Orleans, LA	11:17	033.2	5.77	40:33	022.9	+15.4	09:49	012.6	694
New York, NY	11:02	033.3	6.01	40:32	022.9	-1.3	-----------		686
Philadelphia, PA	11:02	033.3	6.01	40:32	022.9	-0.1	-----------		686
St. Louis, MO	11:06	033.3	6.05	40:38	022.9	+10.7	10:10	012.5	684
San Francisco, CA	11:37	033.2	5.85	40:57	022.8	+28.4	10:17	012.5	690
Seattle, WA	11:25	033.3	6.10	41:00	022.8	+19.5	10:34	012.4	682
Tucson, AZ	11:31	033.2	5.79	40:47	022.8	+27.5	10:04	012.5	692
Washington, DC	11:03	033.3	5.99	40:32	022.9	+1.6	-----------		687
Canada									
Edmonton, Alberta	11:13	033.3	6.27	40:57	022.9	+11.5	10:41	012.4	677
Toronto, Ontario	10:59	033.3	6.13	40:36	022.9	+1.2	-----------		682
Vancouver, B.C.	11:25	033.3	6.13	41:00	022.8	+18.4	10:36	012.4	681
Winnipeg, Manitoba	11:03	033.3	6.29	40:47	022.9	+7.8	10:32	012.4	676
Latin America									
Asunción, Paraguay	14:18	032.0	2.18	40:04	022.9	+6.8	05:50	013.9	891
Bogotá, Columbia	12:14	032.7	4.40	40:14	022.9	+13.0	08:13	013.1	750
Buenos Aires, Argen.	14:59	031.7	1.56	40:05	022.9	+10.0	05:12	014.1	951
Caracas, Venezuela	11:59	032.8	4.65	40:12	022.9	+4.2	-----------		739
La Paz, Bolivia	13:33	032.2	2.96	40:07	022.9	+33.6	06:40	013.6	831
La Paz, Mexico	11:36	033.1	5.51	40:37	022.9	+26.8	09:38	012.6	703
Lima, Peru	13:13	032.4	3.37	40:11	022.9	+20.8	07:10	013.4	804
Mexico City, Mexico	11:44	033.0	5.32	40:34	022.9	+28.1	09:25	012.7	710
Montevideo, Uruguay	15:02	031.7	1.52	40:05	022.9	+8.4	05:09	014.1	956
Quito, Ecuador	12:29	032.7	4.16	40:14	022.9	+18.6	08:00	013.1	762
Valparaíso, Chile	14:45	031.8	1.86	40:09	022.9	+20.4	05:34	014.0	920
Pacific Islands									
Agana, Guam	16:00	031.8	2.14	41:44	022.8	+17.5	07:28	013.8	894
Apia, W. Samoa	15:57	031.7	1.86	41:21	022.8	+67.9	06:45	013.8	916
Hanga Roa, Easter I.	14:36	032.0	2.34	40:31	022.8	+52.7	06:25	013.7	874
Kiritimati, Kiribati	14:23	032.3	3.30	41:16	022.8	+68.1	08:10	013.3	806
Nouméa, N. Caledonia	17:22	031.3	0.64	41:28	022.8	+48.4	05:34	014.3	1081
Pago Pago, Amer.Samoa	15:56	031.7	1.86	41:20	022.8	+68.9	06:45	013.8	915
Papeete, Tahiti	15:13	031.9	2.28	41:04	022.8	+88.9	06:55	013.7	878
Port Moresby, N.Guinea	17:24	031.3	0.78	41:38	022.8	+27.9	05:54	014.3	1060
Suva, Fiji	16:38	031.5	1.27	41:25	022.8	+59.3	06:12	014.1	981

	Contact I		Max. Limb-to-Limb Dist.				Contact IV		Ing./ Egr.
Location	UT	P.A.	Dist.	UT	P.A.	Alt.	UT	P.A.	Dur.
	21h	°	"	21h	°	°	22h	°	sec
Australia									
Adelaide, South Aus.	18:55	030.7	-0.73	41:24	022.8	+24.8	03:54	014.9	----
Alice Springs, N.T.	18:34	030.9	-0.35	41:31	022.8	+18.9	04:29	014.8	----
Brisbane, Queensland	18:09	031.0	-0.03	41:28	022.8	+36.5	04:48	014.6	----
Bundaberg, Queensland	18:03	031.0	0.08	41:30	022.8	+35.7	04:57	014.6	1263
Caboolture, Queensland	18:08	031.0	-0.01	41:28	022.8	+36.5	04:50	014.6	----
Cairns, Queensland	17:51	031.1	0.32	41:35	022.8	+28.4	05:19	014.5	1166
Canberra, A.C.T.	18:37	030.8	-0.50	41:23	022.8	+33.4	04:11	014.8	----
Darwin, N.T.	18:03	031.1	0.16	41:36	022.8	+13.3	05:11	014.5	1228
Gympie, Queensland	18:07	031.0	0.01	41:29	022.8	+36.2	04:52	014.6	1316
Hobart, Tasmania	18:56	030.7	-0.83	41:18	022.8	+31.8	03:41	015.0	----
Humpy Bang, Queensland	18:08	031.0	-0.02	41:28	022.8	+36.5	04:49	014.6	----
Kingston, Norfolk I.	17:40	031.1	0.32	41:23	022.8	+49.7	05:07	014.5	1160
Mackay, Queensland	17:58	031.1	0.18	41:32	022.8	+32.4	05:07	014.5	1213
Maryborough, Qld.	18:05	031.0	0.05	41:29	022.8	+36.2	04:55	014.6	1286
Melbourne, Victoria	18:50	030.7	-0.70	41:22	022.8	+30.1	03:54	014.9	----
Nambour, Queensland	18:07	031.0	0.01	41:29	022.8	+36.4	04:51	014.6	1320
Perth, Western Aus.	19:16	030.6	-1.05	41:22	022.8	+5.6	03:30	015.1	----
Rockhampton, Qld.	18:02	031.0	0.10	41:31	022.8	+33.9	05:00	014.5	1250
Sandgate, Queensland	18:08	031.0	-0.02	41:28	022.8	+36.6	04:49	014.6	----
Sydney, N.S.W.	18:30	030.8	-0.38	41:24	022.8	+35.2	04:19	014.8	----
Townsville, Queensland	17:57	031.1	0.22	41:34	022.8	+29.9	05:11	014.5	1201
New Zealand									
Auckland, North Island	17:47	031.1	0.12	41:16	022.8	+53.5	04:46	014.5	1238
Blenheim, South Island	18:01	031.0	-0.13	41:13	022.8	+51.1	04:26	014.6	----
Christchurch, S.I.	18:09	030.9	-0.25	41:12	022.8	+49.4	04:16	014.7	----
Dunedin, South Island	18:19	030.8	-0.41	41:11	022.8	+47.0	04:04	014.8	----
Hamilton, North Island	17:48	031.0	0.09	41:15	022.8	+53.6	04:43	014.6	1252
Hastings, North Island	17:50	031.0	0.04	41:13	022.8	+53.9	04:37	014.6	1287
Napier, North Island	17:49	031.0	0.05	41:13	022.8	+54.0	04:38	014.6	1280
New Plymouth, N.I.	17:54	031.0	-0.01	41:15	022.8	+52.2	04:36	014.6	----
Palmerston North, N.I.	17:55	031.0	-0.04	41:13	022.8	+52.5	04:32	014.6	----
Waipukurau, N.I.	17:51	031.0	0.01	41:13	022.8	+53.6	04:36	014.6	1307
Waitangi, Chatham I.	17:47	031.0	-0.00	41:08	022.8	+55.8	04:29	014.6	----
Waitara, North Island	17:54	031.0	-0.00	41:15	022.8	+52.3	04:36	014.6	----
Wellington, N.I.	17:59	031.0	-0.10	41:13	022.8	+51.8	04:28	014.6	----

TRANSIT OF MERCURY OF 1999 NOVEMBER 15

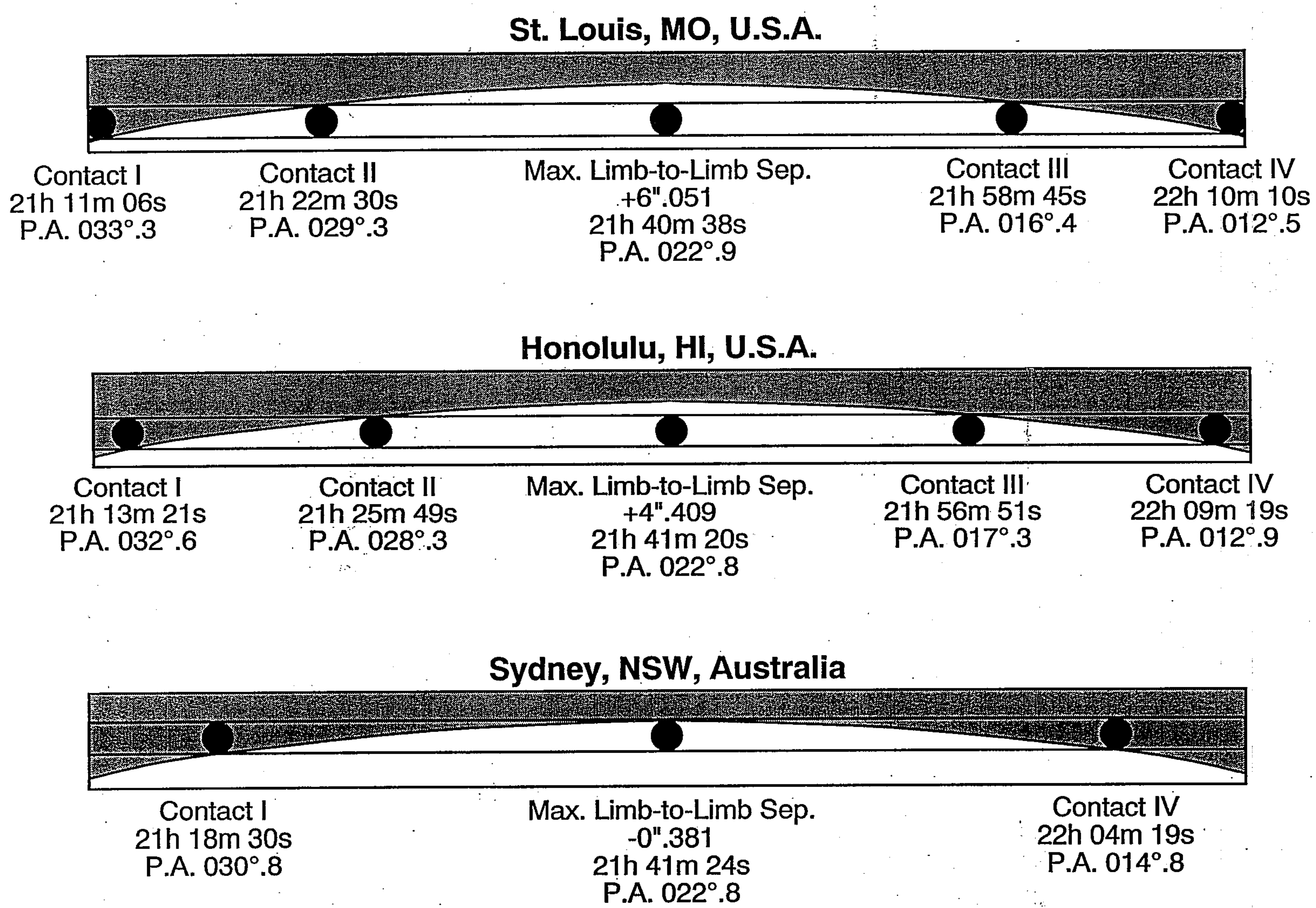
Modified from
Astronomical Phenomena
for the Year 1999



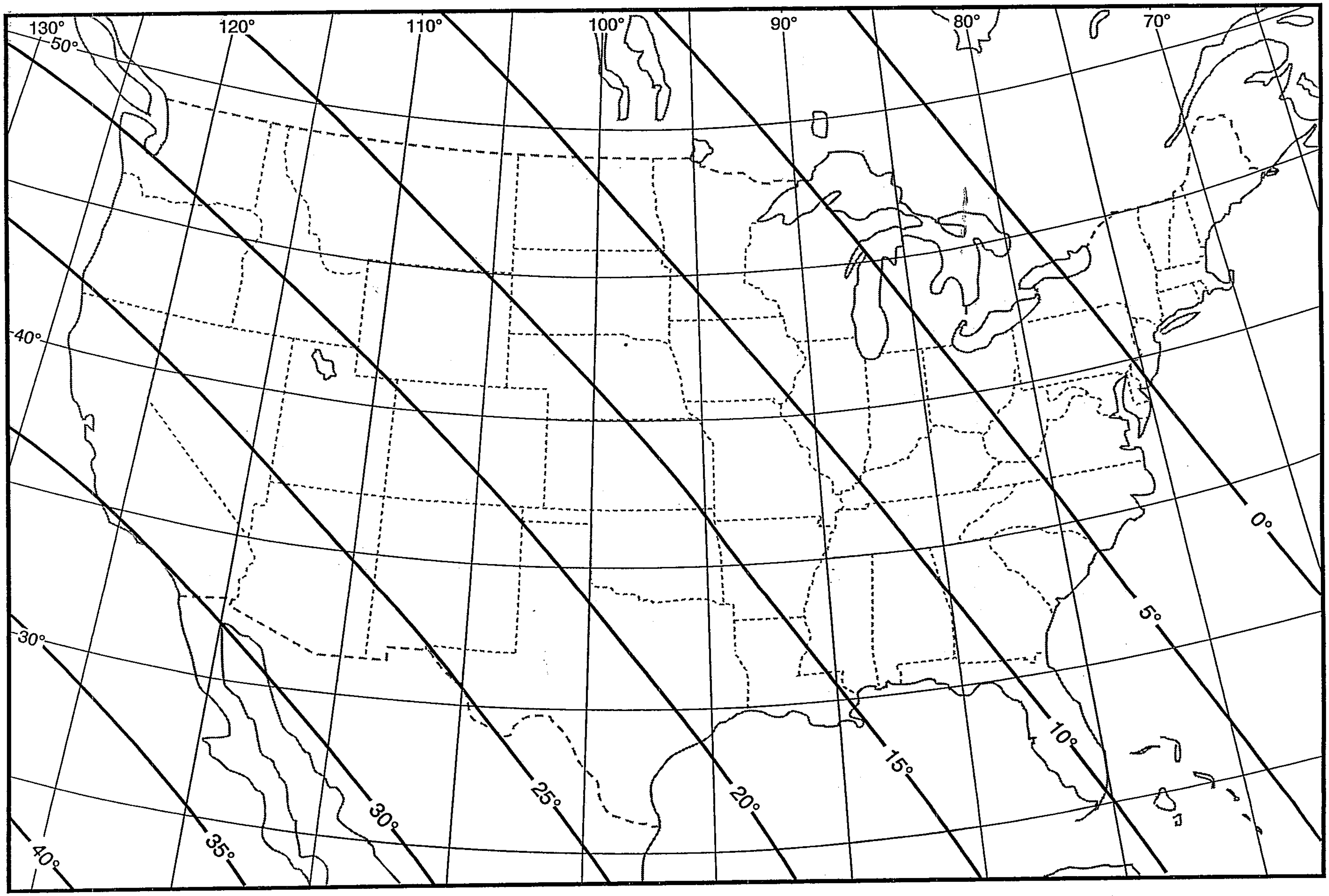
J. Westfall — Figure 1

Apparent Path of Mercury Relative to the Solar Limb, Transit of 1999 Nov 15

(Movement is from left to right; NNE [P.A. 022°.8] is at top.)

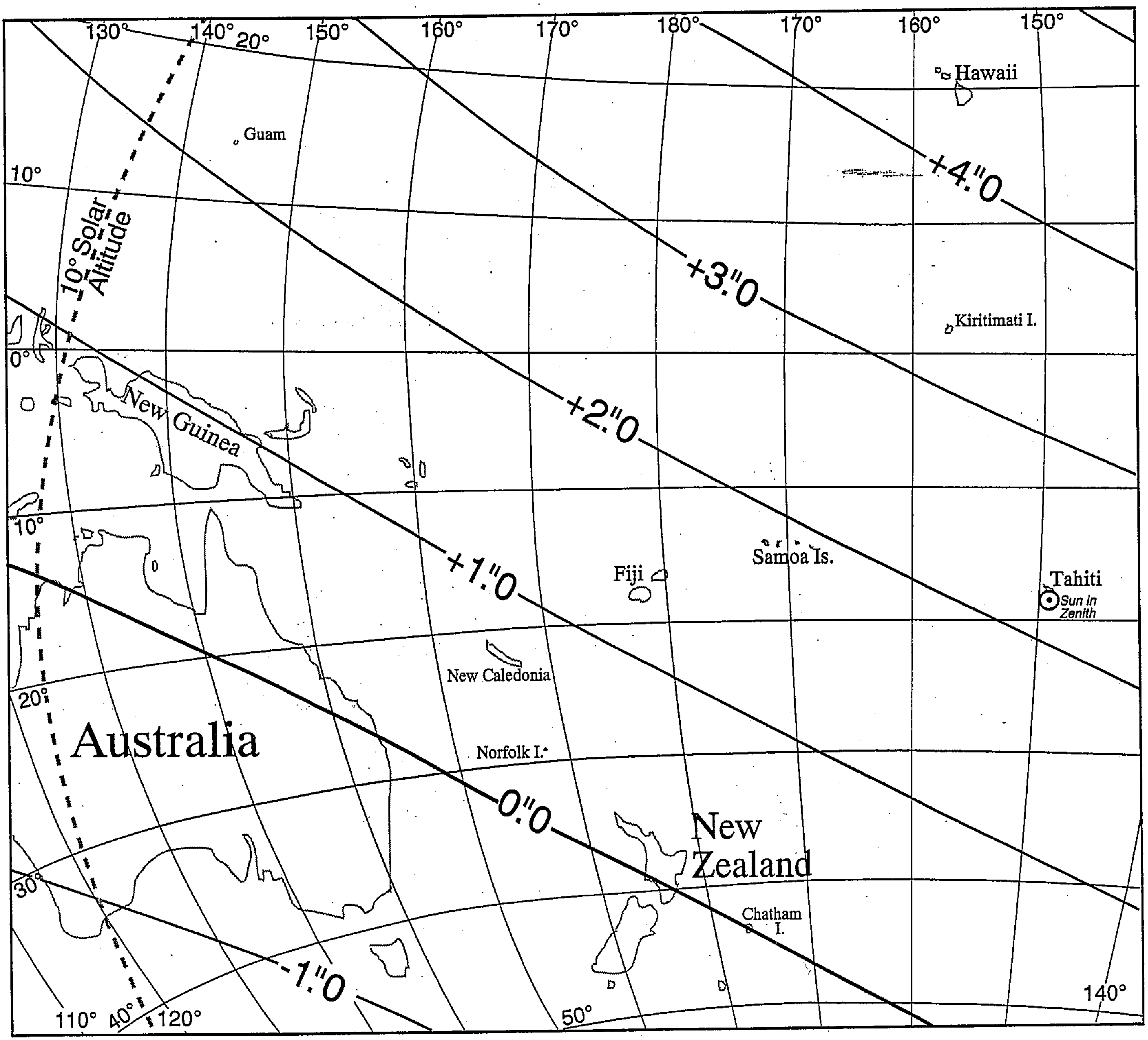


J. Westfall — Figure 2



Altitude of Sun at Time of Minimum Separation: Transit of Mercury, 1999 Nov 15

J. Westfall — Figure 3

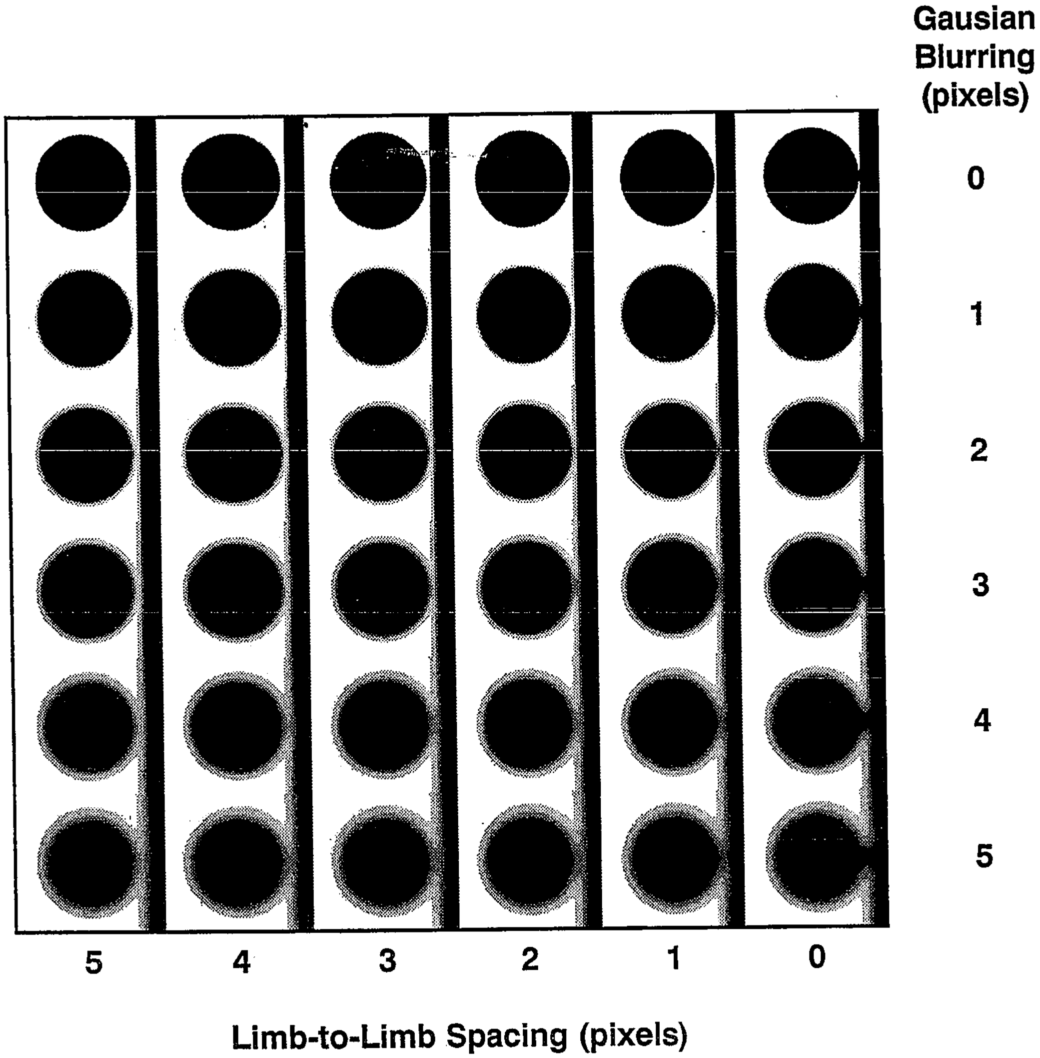


Maximum Limb-to-Limb Separation During Transit of Mercury, 1999 Nov 15 (negative values indicate partial transit)

J. Westfall — Figure 4

Simulated Black Drop Effect

(Scale: Planet's Diameter = 100 Pixels)



J. Westfall — Figure 5