Journal of the Association of Lunar & Planetary Observers

The Strolling Astronomer

Volume 43, Number 1 Winter 2001

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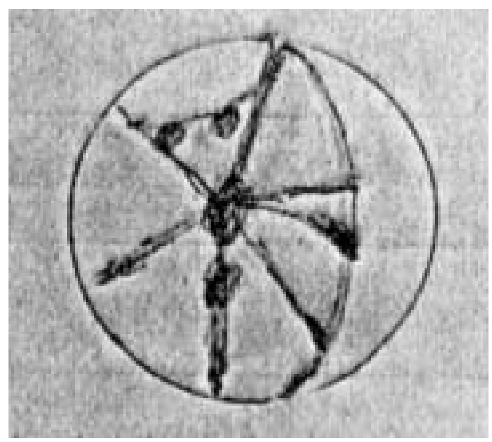
Inside . . .

The Spokes of Venus



In 1896, Percival Lowell revealed his belief that markings he saw while observing Venus "radiate like spokes" as shown in one of his drawings (above). Compare this with an image taken April 30, 1999 by Frank J. Melillo using a Celestron 8-inch Starlight Xpress MX-5. See report by Richard Baum inside.

Also . . . A new *Journal of the ALPO* debuts, report on the Mercury transit, a tour of the lunar Aristarchus Plateau, Mars perihelic apparition report, observing Phobos and Deimos, report on a new solar filter, book review on *Wide Field Astrophotography,* plus ALPO section news, a Call-for-Papers for the ALPO/ALCON conference and much, much more.

Journal of the Association of Lunar & Planetary Observers, The Strolling Astronomer

Volume 43, No. 1, Winter 2001
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This publication is the official journal of the Association of Lunar and Planetary Observers (ALPO).

The purpose of this journal is to share observation reports, opinions, and other news from ALPO members with other members and the professional astronomical community.

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http://www.lpl.arizona.edu/alpo

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Guest Column:

Walter Haas

Founder and Director Emeritus, Assn. of Lunar & Planetary Observers

Every issue, we plan to feature in this column the views of an ALPO member about matters of import to our organization and amateur astronomy.

In 1947 a small group of corresponding enthusiastic amateur observers of the Moon and the bright planets formed the Association of Lunar and Planetary Observers (ALPO). The basic idea was to send observations to a central place, to study them there, and to publish results in a monthly bulletin with the whimsical title of *The Strolling Astronomer*. This concept found a friendly, receptive, and even enthusiastic amateur astronomy audience in the following years; the bulletin improved in size and content to become a respectable journal , and reader membership grew. It soon became necessary to have more personnel to supervise the observational efforts, and we imitated the selection of Section Recorders, employed so successfully by the British Astronomical Association.

Of course, growth brings both opportunities and problems.We early established ties with individuals and observing groups all over the world (e.g., the British Astronomical Association, the Oriental Astronomical Association in Japan, and the Vereinigung der Sternfreunde in Germany). We began to hold annual conventions in 1956, almost always with our friends in either the Astronomical League or the Western Amateur Astronomers. There was an unending need to instruct and to train new observers. Some of our volunteer staff gave selfless , earnest, and scientifically sound service for years; and others soon found conflicts with jobs, family responsibilities, and personal priorities. Generous Sponsors and Sustaining Members helped us survive severe financial difficulties.

The original field of study has expanded to include much of Solar System astronomy, in so far as the instrumentation and methods available to most amateur astronomers can apply. (Amateurs seldom discover asteroids fainter than stellar magnitude 20.) Over the years, we have added sections for minor planets, the Sun, the three remote planets beyond Saturn, comets, meteors, and meteorites.

(Continued on page 3)

The ALPO Pages

Member, section and activity news

A Call for Papers: ALPO at ALCON Approaches

As most of you know, the ALPO will be joining the Astronomical League for ALCON2001, which begins on Wednesday, July 25, 2001 and ends Saturday, July 28, 2001, located at the Holiday Inn-FSK Conference Center in Fredrick, MD. I would like to encourage those of you planning to attend to make your reservations early so that your accommodation requirements can be met satisfactorily. Registration forms and other details are available on the ALCON2001 official website vai a link on the ALPO website.

We have set aside all day Thursday, July 26th, for our ALPO presentations. Accordingly, I would like to encourage all of you who can to think about submitting brief papers (presentations are limited to 20 minutes) that tell about interesting observing projects, programs, equipment, etc., to support this meeting. A major theme of this meeting is "Youth in Astronomy," and interested young people are encouraged to attend and participate. Bringing your family to this gathering should prove interesting and informative, not just from an ALPO perspective, but from that of astronomy in general. The interface between professional and amateur astronomers who attend such meetings has proven to be enjoyable and intellectually stimulating in the past for young and old alike.

Those wishing to submit and present papers should send titles and abstracts to me and Harry D. Jamieson by no later than May 1, 2001. A final camera-ready printed copy of the paper, as well as an ASCII text file of the paper, should be submitted by no later than June 1, 2001. As stated, presentations will be limited to 20 minutes maximum, although some exceptions can be made for special topics. Presenters should make their requirements known by May 1, 2001 for audio-visual or other special equipment that will be needed.

Your support and cooperation is appreciated, and I hope to see as many of you as possible at what should prove to be a very meaningful conference this year.

History Section

In an open letter to the ALPO board recently, Executive Director Julius Benton writes the following:

“One of the goals that I presented to the Board at the last Convention was to identify and select an author who has the willingness, enthusiasm, knowledge, and gifted writing skill to develop and complete a history of the ALPO during the lifetime of Walter Haas, founder and director-emeritus of the ALPO. Certainly, this is a project very near and dear to all of us, and in the selection process, I have tried to find someone who will do it justice and make it something we can all be immensely proud of.

“Accordingly, I have had considerable discussion with our colleague, Mr. Richard Baum, about this endeavor. Richard Baum, who many of you know, is an avid astronomical historian and very gifted writer, particularly in the area of lunar and planetary astronomy. Based on his expressed willingness to undertake such a challenge, I have asked Richard Baum to write the history of the ALPO, and he has cheerfully accepted. Walter, I know, will be delighted with this very pleasant news.

“ I have appointed (and he has accepted) Richard Baum as Acting Coordinator of the ALPO History Section, effective immediately. Under his direction, the History Section will proceed solely with the purpose of writing the History of the ALPO, and because of the importance of this venture, the History Section shall not be accepting additional tasks until the History of the ALPO is fully complete and published in a year or two. I hereby recommend that we waive the "Acting" designation for Richard Baum on the basis that he is a life member of the ALPO, has faithfully served on our staff in the past, and has been a member for nearly half a century.”

Other points contained in Mr. Benton’s letter to the Board are detailed below.

Solar Section

Jeffery Sandel and Jeff Medkeff, both of the ALPO Solar Section, have resigned for various personal reasons. The ALPO and its Solar Section are sorry to see these two fine gentlemen leave.

Also, ALPO Solar Section Coordinator Rik Hill has added a new Acting Archivist, Mr. Rich Gossett, to the Solar Section.

Mercury Section

Executive Director Julius Benton has appointed Frank Mellilo as coordinator of the Mercury Section, thus filling the vacancy created by the resignation of Harry Pulley.

Jupiter, Youth and Remote Planets Sections

The ALPO regrets to announce that David Lehman has found it necessary to resign his position as Coordinator of the Jupiter Section, effective immediately. He has done a very good job for us, but business pressures have imposed increased demands on David's available time to administer the Section.

In his place, ALPO Executive Director Julius Benton has appointed Richard Schmude as Acting Coordinator of the ALPO Jupiter Section.

John McAnally wishes to continue in his current role as Assistant Coordinator (transits), while the rest of the Jupiter Staff (Craig MacDougal and Damian Peach) remains unchanged.

In preparation for this, Richard Schmude has left the History Section as well as his position as acting coordinator in the Youth Section. These changes will permit him to focus more on the considerable workload of management of the Jupiter Section, plus alleviating the backlog of apparition reports. Richard, of course, will continue as Coordinator of the Remote Planets Section and as Mentor on Photoelectric Photometry.

A potential candidate is being considered for the Youth Section vacancy created by Richard's resignation.

"Richard is very enthusiastic about this new opportunity," says Mr. Benton, "and I am very confident that he will do an excellent job administering the Jupiter Section. Please join me in welcoming Richard to this new post."

ALPO Website News

In an effort to bring more ready resources to the attention of amateur planetary astronomers we have added a new link to the main ALPO webpage. This is the JPL Solar System Simulator. With it, you can see any major body in the solar system as it looks at any time from any other major body! This should be especially helpful to those trying to understand what the various dark markings on Mars are at any given time.

But for the serious Mars observer there is an even better Mars image generator on the Mars page at
http://www.lpl.arizona.edu/~rhill/alpo/mars.html
under "Mars Artificial Image Generator." This one will generate pretty good images for any date/time with or without a Aerocentric coordinate grid.

It is run off the Cornell website that provides the amateur community (and professional community for that matter) with Mars Watch.

The Mars Section has been very busy with publishing the *Martian Chronicle* which, unlike its namesake, is dedicated to serious articles on Mars' features and observable weather phenomena. You can see these free at:

http://www.lpl.arizona.edu/~rhill/alpo/marstuff/marschron.html

The Solar Section has just posted some of the latest information on not only current activity on the Sun (which we do daily) but a recent submission by Patrick McIntosh of Helio-Synoptics and McIntosh Squared Graphics, that summarizes the H-alpha activity for Carrington Rotation 1973 (2001-02-14 to 2001-03-13) and gives an analysis of coronal activity and changes in Solar cycle 23.

Guest Column (continued from page 1)

Over the years, we have added sections for minor planets, the Sun, the three remote planets beyond Saturn, comets, meteors, and meteorites. Other sections for those with different interests include computing , history, instruments, transits of Mercury and Venus, solar and lunar eclipses, and youth programs. Several sections have professional scientists as advisors on their staffs.

At this beginning of a new century the ALPO is thus offering more services than ever before to those interested in systematic studies of the Solar System bodies.May it also be an advantage that you can watch Mars rotate in spite of your neighbor's 200-watt porch light, which assuredly wipes out views of a galaxy that actually looks much as it did five million years ago? We have projects for all levels of skills and interests. Our simplest program , that of counting meteors, requires no equipment but the eye. On a more advanced level you can time when the Earth's umbral shadow covers a lunar feature, or how the brightness of a comet compares to that of nearby stars.If you are knowledgeable, ambitious, and properly equipped, you can even learn to obtain CCD images of Mars, Jupiter, and Saturn which resolve finer detail than did the very best professional photographs as recently as five or ten years ago.

It would be most remiss not to call attention to the dozens and dozens of ALPO pages on the World Wide Web. The address is www.lpl.arizona.edu/alpo/

Here you will find excellent instructional and informational materials, observing forms, physical data important in planetary observations, news of imminent astronomical events, and much more.

The chief role in science of the ALPO has probably been to provide a long-term record of data on Solar System neighbors. These records were at first mostly visual, later became partly photographs, and recently have come to include many CCD images. A number of past young staff members have gone on to distinguished professional careers. A few ALPO members have discovered comets, and some others have written valuable books. Mars Section staff members have been invited to give papers at professional meetings. D.P. Avigliano's 1954 map of Mars was highly regarded, and Elmer Reese's ideas on subsurface sources for periodic South Equatorial Belt Disturbances on Jupiter generated considerable professional theoretical interest. ALPO papers at Astronomical League and WAA Conventions have been invited regularly, and have received much praise.

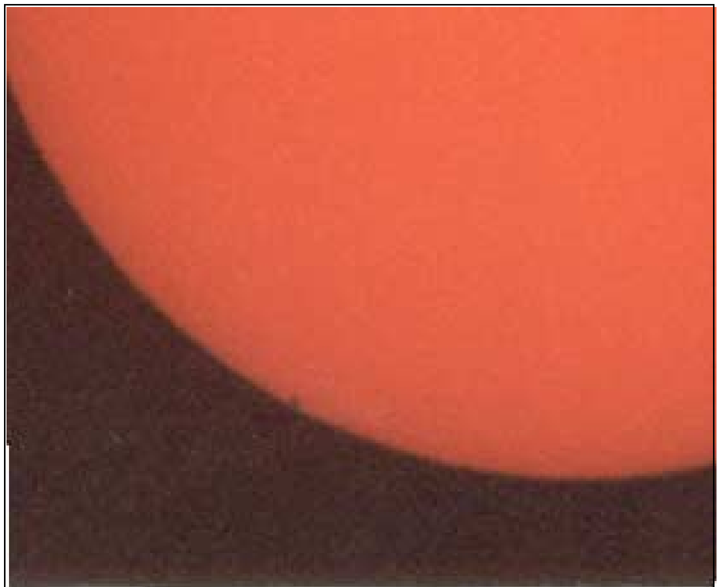
This issue marks some major chances in publication procedures.If you are getting this first issue of our electronics "Digital Journal of the ALPO", we are anxious to hear your comments and criticisms. If you still receive the traditional paper "Journal of the ALPO", there are some substantial alterations in format; and we again welcome your comments and criticisms. Almost all staff members have an electronic mail (e-mail) addresses listed elsewhere in this issue; use them for INSTANTANEOUS communication. Forget our 20th century struggles with air mail, telephone, radio, and telegrams!

You are most cordially invited to take part in those ALPO projects which interest you, and we shall appreciate your contributions.Let us enjoy the new century , and its certain surprises, together!

Walter H. Haas, haasw@zianet.com, April 14, 2001

Mercury — Finding That Little Rock

By Jim Lamm



Mercury transits the Sun November 15, 1999; photo taken with 6-in. University Optics refractor equipped with a Thousand Oaks Type 2+ solar filter, 26-mm eyepiece and Olympus OM-1 35-mm camera. Photo by the Jim Lamm.

Mercury is fairly small as planets go. Because of its proximity to the sun and our orbit, it's not a regular target of amateur astronomers. Not, like Venus, Mars, Jupiter or Saturn.

Well, on November 15, 1999, some of us had the privilege of seeing Mercury as most of us have never seen it before – on the face of the Sun. For the first time in 26 years in the Western Hemisphere, Mercury "grazed" the space in front of Sol giving us a new way of seeing it. Most of us have experienced the transit of one of the Galliean moons on the face of Jupiter but the Mercury transit was different. Unless I'm mistaken, what we were able to see wasn't the planet's shadow but the planet itself. For the detailed information on the transit, see the November 1999 issue of *Astronomy* magazine, page 76.

On the afternoon of November 15th, George Fleenor, director of the Bishop Planetarium here in Bradenton, and I gathered at the observatory in downtown Bradenton. See our website at: http://www.sfmbp.com/ and go to Planetarium; then Observatory. The transit was due to start at 4:11:19 p.m., so we arrived around 3:30 p.m. and needed every minute to set up. We started by installing our filters on each of the scopes. The H-Alpha filter went on the 6-inch Astrophysics APO (f/12) and the Type 2+ solar filter went on the 8-inch Brandt (f/13.3) refractor. Then we installed the Astrovid CCD video camera on the 8-inch so we could video the event. Finally, George wanted still shots and installed his 35-mm camera on the Astrophysics. That's where the problems began. You guessed it – a balancing act became the prime focus, so to speak (that's a joke).

"Right on cue, the tiny planet 'notched' . . . the corner of the Sun and grew in size over the next few minutes."

But with a little bit of ingenuity and a few stray weights, we solved the problem. I set up the trusty 'ol University Optics refractor on the deck surrounding the observatory and installed my Type 2+ filter and my Olympus OM-1 (I still gotta get that focusing screen replaced inside to be able to get sharper focusing). During the event, I switched off between the 26, 12 and 9-mm eyepieces to achieve different magnifications. Finally, with about a minute or two to spare, we were ready.

Basically, we were observing using the video camera versus eyepieces. They were all tied up anyway with equipment stuck in them. It was really the first time I had done any extensive observing using the live camera and it was totally awesome! Right on cue, the tiny planet "notched" (called Contact I) the corner of the Sun and grew in size over the next few minutes. Looking at where it came on to the face, we figured that it would take longer than the 50 or so minutes of projected transit time but we didn't realize that the "graze" really was a graze. The total planetary image itself was only visible over a very small portion of the top edge of the Sun. The total space between the "black dot" and the edge of the Sun was minute, lasting only about 20 minutes of the total 52 minute event.

The rest of the time was spent coming onto or leaving the visual surface. During the event, our biggest challenge was keeping the scopes balanced and the image centered while we transferred the video camera to the H-Alpha filter. The video will need some editing, for sure! Once we changed the Astrovid over to the H-Alpha, we were able to get some really "stellar" images. We got the entire final internal and external egress with a huge prominence off to the side of the egress point. It was awesome!

In addition to the video, we both were able to capture some decent still color images. This was a great day for solar and inferior planet observers. I hope many of you were able to witness it as I did. Now, I can't wait until the next transit – especially the Venusian transit in 2004 – the first in 121 years. Clear skies!

About the Author

Jim Lamm has been an ALPO member for several years with a primary interest in lunar and solar observation. His interest in astronomy took root in the early 1960s with some of his fondest memories being lunar observations with his dad from their backyard in Baltimore, MD. He volunteers at the Bishop Planetarium in Bradenton, FL, where he conducts some of the weekend planetarium shows, evening observations and solar observing programs. Jim owns several telescopes and is most proud of his restored '60's vintage 4-inch Criterion Dynascope. E-mail to jlspacerox@aol.com

Transits of Mercury, 2000-2098

Following are the dates of the transits of Mercury for all events from 2000 to 2098.

Important safety tip: All times are in Dynamical Time (TD), not UT. This is because UT has odd changes in the distant past and future, because the Earth's rate of rotation is not constant (and no one was measuring it very precisely in ancient times). The difference is about a minute for modern times, and grows in either direction from the present. Also, all dates are in the Gregorian calendar.

TRANSIT starts at 7 May 2003 5:11
TRANSIT ends at 7 May 2003 10:36

TRANSIT starts at 8 Nov 2006 19:12
TRANSIT ends at 9 Nov 2006 0:12

TRANSIT starts at 9 May 2016 11:11
TRANSIT ends at 9 May 2016 18:45

TRANSIT starts at 11 Nov 2019 12:35
TRANSIT ends at 11 Nov 2019 18:06

TRANSIT starts at 13 Nov 2032 6:41
TRANSIT ends at 13 Nov 2032 11:09

TRANSIT starts at 7 Nov 2039 7:17
TRANSIT ends at 7 Nov 2039 10:18

TRANSIT starts at 7 May 2049 11:03
TRANSIT ends at 7 May 2049 17:48

TRANSIT starts at 8 Nov 2052 23:54
TRANSIT ends at 9 Nov 2052 5:08

TRANSIT starts at 10 May 2062 18:16
TRANSIT ends at 11 May 2062 1:01

TRANSIT starts at 11 Nov 2065 17:25
TRANSIT ends at 11 Nov 2065 22:51

TRANSIT starts at 14 Nov 2078 11:43
TRANSIT ends at 14 Nov 2078 15:43

TRANSIT starts at 7 Nov 2085 11:44
TRANSIT ends at 7 Nov 2085 15:30

TRANSIT starts at 8 May 2095 17:22
TRANSIT ends at 9 May 2095 0:55

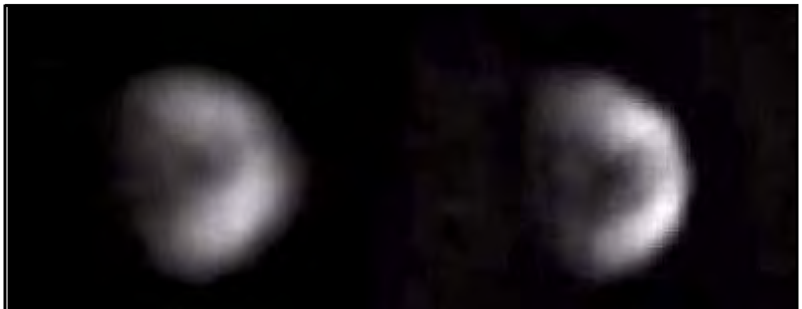
TRANSIT starts at 10 Nov 2098 4:37
TRANSIT ends at 10 Nov 2098 10:01

Source: (Internet) http://www.projectpluto.com/transits.htm

ALPO Feature: Venus — CCD/UV Images of Venus Revive Interest in a 104-Year-Old Mystery

By Richard Baum

Images of Venus obtained by Frank J Melillo, Holtsville, New York, on April 25, 1999, have shed important new light on the controversial pattern of radial markings first reported by Percival Lowell in 1896, and subsequently observed by J. Camus (1930), R. Barker (1932 and 1934), A. Danjon (1943), A. Dollfus et al at the Pic du Midi (1945 - 1956), and R. Baum (1953).



Venus in ultraviolet light showing the the Spoke System of 1999 "Lowell Markings." Both images were 2-seconds at f/25 and were taken using Celestron C-8 (8-inch/15.2 mm) Schmidt-Cassegrain telescope equipped with Starlight Xpress MX-5 ccd camera. Image at left taken April 25, 1999; disk illumination = 72 percent, disk size = 15.2 arc seconds, seeing = 9; image at right taken April 30, 1999; disk illumination = 70 percent, disk size = 16.0 arc seconds, seeing 9-10 (10 = best). Both images by Frank J. Melillo.

It is perfectly natural to assume that discovery invariably equates with proximity. Not so. We examine the landscape for signs of known previous settlement but see only irregularity and move on, troubled by a sense of disappointment. Yet all the while the object of our search was underfoot – the irregularity we had regarded as commonplace. It is all too easy to overlook what aerial archaeology teaches, and to forget that in observing the expressions that diversify the face of the planetary worlds, a great deal depends on the scale at which they are studied. Increase the scale and an effect is lost.

Here then is a reasoned analogy by which the Lowellian markings of Venus are finally to be understood and explained. This is the import of Melillo's low resolution imagery. It conveys both the fact and the fiction - a fiction that disappears at high resolution – and enables us to reconstruct how the celebrated spoke system that so outraged astronomers of the late nineteenth century came into existence.

There is however, one other important consequence that follows on from this disclosure. What Lowell saw from Flagstaff 1896 October 28 closely parallels the contents of Frank Melillo's images of 1999 April 25. It is in the fine nuance of this fact that a long held suspicion is substantiated. In the late summer of 1953 Patrick Moore, Colin Reid and myself participated in an experiment to determine the threshold of human ability to see into the UV. It was found that Moore had a cut-off at 400nm, Reid at 370nm, whilst mine was at 320nm. Could I thus be obtaining sight of the UV markings first registered by F. E. Ross in 1927? There was a problem. Lowell used a refractor, my observations too were made with a small refractor. But glass is opaque to UV it was argued. The result was only too obvious. Since it was always seen at the threshold of vision the radial pattern was attributed to illusion imposed by psycho-physical effects.

Now we know differently. It is acknowledged that some human eyes can "see" in the near UV, and of course, we all know that optical glass is not totally opaque to all of the UV. Given the accordance between Lowell and Melillo a most interesting proposition arises. Dr. William Sheehan, puts it most elegantly. 'I am quite sure Lowell saw the UV markings;

his problem was that of stylized representation. He depicted them as spindly and straight markings – the way they seemed. He recorded them to the best of his ability. Unfortunately, to the mass of observers for whom these markings are completely invisible he might just as well have been drawing figures in the carpet. Across the great divide there was no communication.'

The logical conclusion is that Lowell like others since, glimpsed the underlying truth of the Venus markings, but influenced by various factors distorted its reality, in much the same way as a child schematizes a human face. The representation has little resemblance to reality, yet in the figuring of mouth, nose, ears, mouth and eyes there is truly a presentation of truth. It would thus seem the crux of the matter is that the limit of human ability to see into the UV falls – by coincidence – occurs at just about the point where these dark markings begin to appear. If that is so what are the implications for optical study of the planet? Dr. William Sheehan and I are currently working on a paper in which these and other factors will be considered in the context of the observational history of the subject.

More on Lowell's Vision of the 'Spokes' Venus

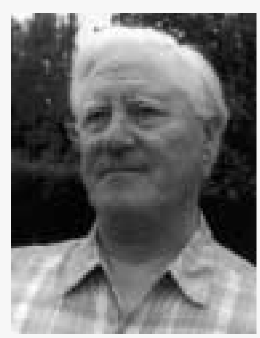
An article by Richard Baum and William Sheehan in *Astronomy Now* magazine recounts Percival Lowell's fixation with this phenomenon. Baum and Sheehan tell of Lowell's report in October 1896 to the Boston Scientific Society: "The markings proved surprisingly distinct; in the matter of contrast as accentuated, in good seeing, as the markings on the Moon and, owing to their character, much easier to draw." He later wrote, "Alarge number of them, but by no means all, radiate like spokes from a certain center."

But Sir John Herschel wrote in 1850 of Venus "yet we see clearly that its surface is not mottled over with permanent spots like the Moon; we notice in it neither mountains nor shadows, but a uniform brightness, in which sometimes we may indeed fancy, or perhaps more than fancy, brighter or obscurer portions, but can seldom or never rest fully satisfied of the fact."

Lowell later doubted his own beliefs of the spokes in 1902, but then by 1914 (two years before his death), he reveresed himself once more and wrote more strongly of his belief in them.

About the Author

Richard Myer Baum is a resident Chester, England) and joined the ALPO back in the late 1940s. His particular interests include lunar and planetary observing and his primary field is observational history of Solar System objects, notably the Moon, planets and their satellites. Mr. Baum is a member of the British Astronomical Association (BAA) since 1947 and is a Fellow of the Royal Astronomical Society since the early 1950s. He was Director of the BAA's Terrestrial Planets Section from 1978 through till the early 1990s, then Director of the BAA's Mercury & Venus Section until 2000. Mr. Baum was was also vice-president of the BAA, and awarded the BAA Lydia Brown Medal back in the 1980s. He published *The Planets:some myths and realities* (1973, UK & USA), and (with W. Sheehan) *In Search of Planet Vulcan:the ghost in Newton's clockwork universe* (1997). He contributed chapters to *The Observational Amateur Astronomer* (Springer, 1995), and *Images of the Universe* (Cambridge UP, 1991). Mr Baum contributed to *Nortons' Star Atlas, The Astronomy Encyclopaedia* (Mitchell Beazeley), *Philip's Astronomy Encyclopaedia* (revised edition forthcoming), and other similar publications. He has papers in the Journal of the British Astronomical Association, Journal for the History of Astronomy, Journal of the Association of Lunar & Planetary Observers, and publications in Canada, Germany, etc. He also has articles in *Sky & Telescope, Astronomy, Astronomy Now, Urania* and other magazines. He is currently working on *The Haunted Observatory* (Cambridge UP) and papers on the naked eye visibility of the Galilean moons of Jupiter, the discovery of the Mare Orientale (Moon), the selenographical background to H G Wells' *The First Men in the Moon*, and the Lowellian markings of Venus. E-mail Richard Baum at richardbaum@julianbaum.co.uk



ALPO Feature: The Moon — The Aristarchus Plateau

by Eric Douglass

One of the most popular features to visit on the moon is Schroter's Valley, which is the largest rille on the moon. But did you ever notice that it is surrounded by different tones of gray and various textures? Or that it is contained in a large, square area -- the Aristarchus Plateau -- that rises from the Mare Imbrium lavas?

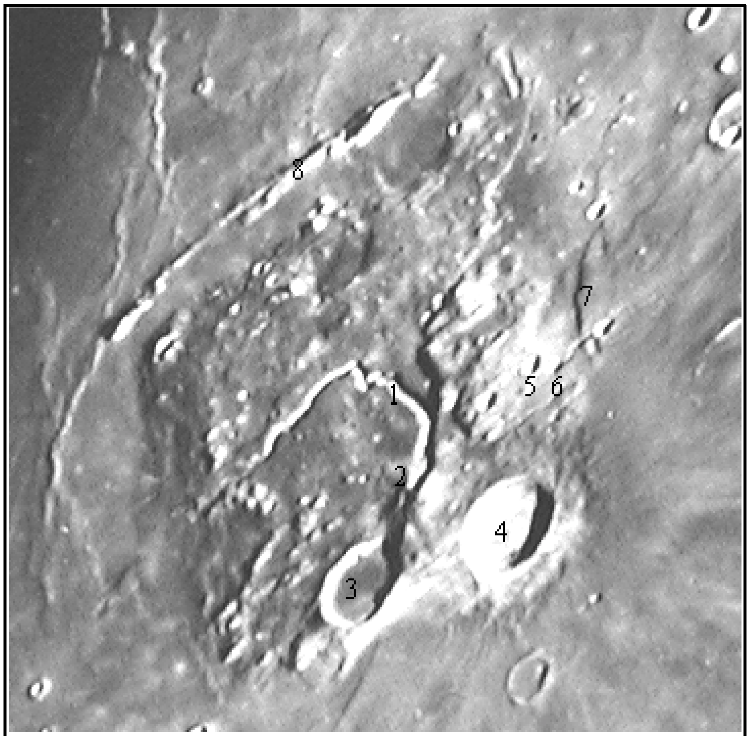


Figure 1. The Aristarchus Plateau as seen from Earth. Note the overall quadrilateral shape of the area of raised terrain. The unevenness of the albedo is evident in this view. The numbered features are as follows: 1, Schroter's Valley; 2, Cobra Head; 3, Herodotus crater; 4, Aristarchus crater; 5, Vaisala crater; 6, vent; 7, Rupes Toscanelli; 8, Montes Agricola. Image from the Digital Consolidated Lunar Atlas, ed. Kuiper; digital version ed. Eric Douglass; copyright LPI.

The geologic history of this region is rather complex. Little doubt exists that this region was primarily shaped by the massive Imbrium Impact, which occurred approximately 3.85 billion years ago. This impact produced the Imbrium Basin, which is a multi-ring basin whose probable outer ring is now visible as Montes Alpes and Montes Apenninus. Inner rings are marked by a variety of individual peaks such as Mons Piton and mare ridges such as Dorsum Heim. At the western edge of the Imbrium Basin sits the Aristarchus Plateau (Figure 1). Some planetary geologists, including the present author, feel that this area actually represents a block of material that was lifted by the Imbrium impact, so that it was high enough to survive the later inundation by mare lavas.

Because this plateau was formed by the Imbrium impact, it originally stood high above the Imbrium basin. However, over the next several hundred million years, lavas began to track up the deep faults which this basin produced. These lavas eventually reached the surface, and erupted in large sheet flows, covering the bottom of the basin. Indeed, these lavas were so massive in volume that they eventually covered the inner rings of the Imbrium basin, and even broke over the massive outer ring. They also flooded the low-lying parts of the Aristarchus plateau. This explains the line of massifs off the northwest side, called the Montes Agricola, which are separated from the plateau by a lava region.

During this time, the plateau itself was not quiescent, but was undergoing the same volcanic processes as the Imbrium basin. It has many areas that are imprinted with volcanic signatures. The most obvious of these is the large rille running through the plateau in a broad arc: Schroter's Valley (Figure 2). This massive rille is probably a large lava channel (or unroofed lava tube; note that other possible explanations for this structure exist). Lava tubes of this magnitude do not occur on earth, but can occur on worlds with lower surface gravity. This rille emerges from the Cobra Head, which is the

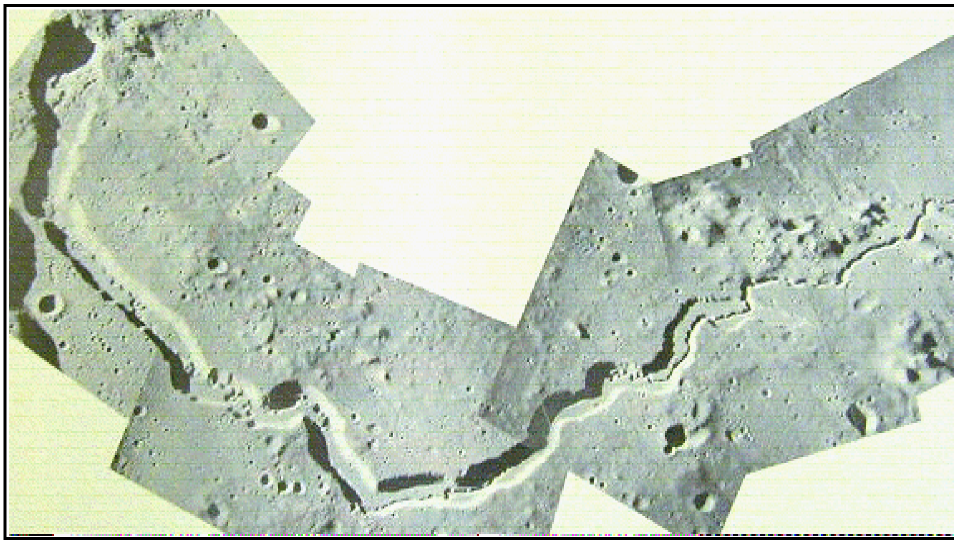


Figure 2. All of Schroter's Valley is shown in this composite of astronaut views. The Cobra Head is the crater-like end of the valley at the far upper left. Note the small rille inside the large one. Image from Apollo 15: Preliminary Science Report, p 25; NASA.

source region for the lavas. Note that a similar crater-like vent is found just to the east of crater Vaisala on the eastern edge of the Aristarchus Plateau (Figure 3). This feature has a rille emanating from its east side, which runs to the northeast onto the Imbrium lavas. Note that this rille cuts through the mare ridge Rupes Toscanelli, briefly tracks along its opposite side, and then empties out into the Imbrium Basin. Both the vent and part of the rille are visible with earth based telescopes. Running in the floor of Schroter's Valley is another thin rille, which is not visible from earth as it hugs the side of the larger rille (Figure 2). This feature, clearly visible in spacecraft imagery, is a sinuous rille much like Hadley Rille -- a lava flow feature.

Figure 3. A Lunar Orbiter view of part of the eastern edge of the Aristarchus Plateau. Illumination is from the right. The Rupes Toscanelli runs from the top left, where the white half-moon shape is a peak, to the lower right of center. Crater Vaisala is at lower left. To its right is a vent, from which a sinuous rille meanders toward the upper right, bifurcating and passing through craters. Image from The Lunar Orbiter Photographic Atlas of the Moon; NASA.

Close examination of the Aristarchus Plateau also reveals a variety of albedo changes. The lightest materials, especially seen on the eastern side of the plateau, are the oldest. These have more craters, clearly showing their greater age. On the other hand, the darker areas of the plateau have fewer craters, indicating that some process has resurfaced the plateau, covering over the older craters. Examination of spacecraft images reveals that this process occurred in patches on the plateau, with softening of the underlying structural features (Figure 4). This type of resurfacing is characteristic of fire fountaining. Fire fountaining, as occurs in the Hawaiian volcanoes on earth, occurs when gasses trapped in lavas are allowed to escape by the sudden release of confining pressures. The lava is thus fragmented and propelled high above the lunar surface. Here the lava cools quickly, so that crystals do not have time to form. This forms volcanic glass, which upon returning to the surface, produces a characteristic dark color. Further, as they fall as small beads, they give the surface on which they land a 'softened' appearance.

Having gone through this geology, we are now in a position to produce a geologic history of

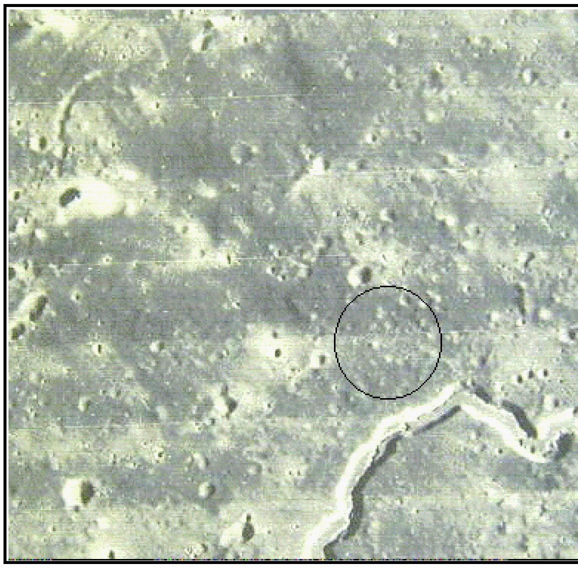


Figure 4. A Lunar Orbiter view of a part of Aristarchus Plateau near its center. The albedo is irregular, and all the darker areas are fire fountaining areas, with fewer craters than the lighter areas. A large dark area near the top center has almost no visible craters. In the circle are a number of craters with a 'softened' appearance. A part of Schroter's Valley is seen in the lower right. Image from The Lunar Orbiter Photographic Atlas of the Moon; NASA.

the region. The event that created the Aristarchus Plateau was the massive Imbrium impact. Parts of the plateau were later flooded with Imbrium lavas, covering over the low lying parts. The lavas covering the Imbrium Basin occurred over a long period of time, and early in this period rising lavas also erupted on the Aristarchus Plateau. These formed many of the geologic features on the Plateau, including the Cobra Head, which was drained by Schoter's Valley, and the smooth areas where fire fountaining occurred. At a later time, smaller lava flows were drained by the thin sinuous rille running through Schroter's Valley. Finally, the Aristarchus impact occurred, which was within the last billion years, and so is seen as a bright ray crater.

The Aristarchus Plateau is a fascinating place, covered with many types of geological features from several different time periods. It is an excellent spot to spend an evening with an eyepiece.

About the Author

Eric Douglass (ejdftd@mindspring.com) has published articles and/or photographs in Sky and Telescope, JALPO, Astronomy, and Selenology. The majority of these deal with planetary geology, but have also included materials on videoastronomy and seeing prediction systems. He is a coauthor in the new book "Videoastronomy" (published by Sky and Telescope), is the editor of the Digital Consolidated Lunar Atlas (on line at: http://www.lpi.usra.edu/research/cla/menu.html; to be released on CD rom later this year by the Lunar and Planetary Institute), supplied the lunar atlas images to "Observing the Moon" (by Peter Wlasuk), and supplied images and geologic interpretation for the computer program "Lunaview" (by Steve Massey). His primary telescope is a 12.5 inch, f/6 Newtonian. For images, he uses eyepiece projection onto an Astrovid 2000 videocamera. The feed from this goes into a digital video processor and in recorded on SVHS. Images are taken from the tape using a Snappy, and processed on the computer. Eric's primary interests are in planetary geology and photogeologic interpretation.

The 2001 Perihelic Apparition of Mars: A Request for Observations

By: Jeffrey D. Beish
With contributions from
Donald C. Parker, MD

Abstract

The current apparition of Mars is the most favorable since 1988, providing amateur and professional astronomers alike with a superb opportunity for comparatively close-up study, using both electronic and standard means of data gathering and recording. Subjects of attention this time include condensates and their effects on the Martian atmosphere, polar cap thawing, apparent storm cloud behavior, and various surface features which predictably change color and size and gradually move across the Martian surface over long periods of time. Participating in a coordinated observing program this time are members of several amateur astronomy organizations scattered around the world.

Introduction

Only two planets of our Solar System display surface features, Mercury and Mars. Of the two of them, Mars is more conveniently placed than Mercury for Earth-based observing. Mars appears more Earth-like to observers, displaying surface features, atmospheric clouds and hazes, and polar caps. Indeed, for many years, observers have seen the brilliant white Martian polar caps, composed of CO_2 and underlying water ice (in the north at least), wax and wane during the Martian year.

Due to celestial mechanics, the orbits of Mars and Earth periodically bring the two planets so close together that valuable scientific data can be obtained by Earth-based astronomers. Even with telescopes of 15.25 to 30.48 cm (6 to 12 in.) in aperture and a set of color filters, amateur astronomers are able to produce professional quality telescopic work in planetary research. Furthermore, a well-equipped observer using charge-coupled device (ccd) imaging technology has the opportunity to produce professional quality observations.

Amateur planetary astronomers have contributed greatly to man's knowledge about current weather and surface conditions on the planet Mars for many years. With the current 2001 Mars apparition being one of exceptional closeness, amateur and professional planetary astronomers are urged to use this opportunity to the fullest to study, record and contribute orderly and consistent observations to those bodies coordinating the observing program.

Who Will Be Watching

Organized observing activities are expected to be coordinated by two umbrella groups -- the International Mars Patrol (IMP) and the International Mars Watch. (IMW).

The IMP is an international cooperative effort coordinated by the ALPO Mars Section. It was established in the late 1960's by the Charles F. Capen and has contributed more than 30,000 observations of Mars. Today, the ALPO Mars Section archives holds the records of 15 apparitions of Mars covering a span of 35 years.

The IMP is comprised of interested individual amateur and professional astronomers located in 47 foreign countries and U.S. territories cooperating in a 24-hour watch. Besides the ALPO, these observers are members of the British Astronomical Association (BAA), the Arbeitskreis Planetenbachter (Germany), and Japan's Oriental Astronomical Association (OAA).

The IMP coordinates and instructs cooperating observers in using similar visual, photographic, photometric, and micrometric techniques employing color filters and standard methods for reporting their observations. The result is homogeneous sets of observing data that have good analytic value for subsequent study.

The other major group behind coordinated Mars observations this apparition is the International Mars Watch (IMW) program. The primary purpose of the IMW is to promote frequent ccd imaging of Mars using V, B,G,R other standard filters, as well as visual drawings and photos to monitor the planet's atmospheric dust and cloud activity.

The IMW was initiated in electronic form in 1996 through the collaboration of astronomers at Cornell University, the Jet Propulsion Lab Mars Pathfinder Project, and the ALPO/Mars Section as a vehicle with which Mars astronomers worldwide could upload their observations to a JPL World Wide Web homepage and archive site called *MarsNet*.

Here reside images of Mars contributed by amateurs and professional, tools to aid in planning Mars observations, current and past issues of the *International Mars Watch Electronic Newsletter*, and links to other Mars-relevant sites on the Internet.

The goal is to have participants submit one or more of their images (or entire data sets) to this site for access to and by NASA project personnel, professional astronomers, amateur astronomers, news and print media, educators and schoolchildren, and the general public. Another general project goal is to post at least one new ccd Mars image on the Web every day for the duration of the apparition.

Even better would be one "daily global view" per day, composed of two or three Mars images taken on the same night but from observatories widely separated in longitude. This will require a dedicated and geographically diverse network of observers.

Secondary goals include imaging or spectroscopic characterization of the surface color and mineralogy, characterization of the growth and retreat of the polar caps, and analysis of atmospheric water vapor content.

The web site address for the IMW is: mpf-www.jpl.nasa.gov/mpf/marswatch.html

The Astronomical League web site also features IMW information at: http://www.astroleague.org/marswatch/) IMW information.

Note that website address changes for years 2000 and 2001 will be announced on the ALPO web site at http://lpl.arizona.edu/alpo and in the *Martian Chronicles* newsletter, published by the ALPO/Mars Section.

What is a Martian Apparition?

The term "apparition" refers to the time span during which a planet is observable, that is, from when one first can view the planet after it emerges from conjunction into the morning dawn sky to the time just before the next conjunction, when the planet is seen low in the western sky after sunset. (A “conjunction” is the time when a body is in line with the Sun as seen from Earth and thus, unobservable.)

Mars has an average 15.8-year seasonal opposition cycle, which consists of three or four *aphelic* oppositions (when Mars and Earth are both paired together at their furthest distance from the Sun) and three consecutive *perihelic* oppositions (when the two are paired together at their nearest distance from the Sun).

The closest Earth-to-Mars distance at these oppositions varies so that the apparent diameter of the Martian disk as seen from Earth will be either very small or comparatively large and bright. Practically speaking, quality telescopic observations of Mars commence when its apparent diameter is greater than 6 seconds of arc.

Furthermore, at the extremes of the apparition, such as the next few apparitions, Mars is low in the sky where the turbulence of Earth's atmosphere is severe. Despite this poor placement of the planet in our sky, ALPO astronomers are encouraged to make observations even at these times.

Characteristics of the 2001 Mars Apparition

The 2001 Mars apparition is considered p*erihelic* because the orbital longitude at opposition is only 73 degrees from the perihelion longitude (250° Ls). *Opposition* occurs on June 13, 2001, with an apparent planetary disk diameter of 20.4’’; and a maximum diameter of 20.8 seconds of arc occurs eight days later on June 21. Mars has an observable disk diameter greater than 6 seconds of arc during the entire year. A useful disk diameter of 10 seconds of arc for film-photography exists for a period of 6 months, from March through October. Imaging by CCD devices may begin with a disk diameter of 8 seconds of arc or less, commencing on March 5th. The geometry of the heliocentric aspects of Mars relative to Earth is shown in Figures 1 and 20.

In June of 2001, Mars will approach the Earth closer than at any time since the perihelic apparition of 1988. For nearly three months, from May 14th until August 8th, the red planet's apparent size will be larger than it has been in over these past 13 years. Mars will be at a distance of 0.45016 A.U. or 41,844,902 miles (67,342,977 km) from Earth at c*losest approach*. [Note: 1 A.U. equals 92,955,621 miles or 149,597,870 km.]

Although Mars has a favorable apparent disk diameter for observing, it will be relatively low on the horizon during the entire apparition for observers in the middle northern latitudes, which will make the quality of astronomical seeing below average. The apparent declination of Mars ranges from -12° to -17° throughout January, 2001; Mars then continues southward until it reaches -26° in mid-June (opposition time) until the first week in August when it settles to -27°; and then it slowly rises to -7° by the end of December 2001. The maximum altitude of Mars when on the terrestrial meridian will be approximately 22° to 35° for an observer in the United States. Consequently, observers located in the Southern Hemisphere will have the plane-

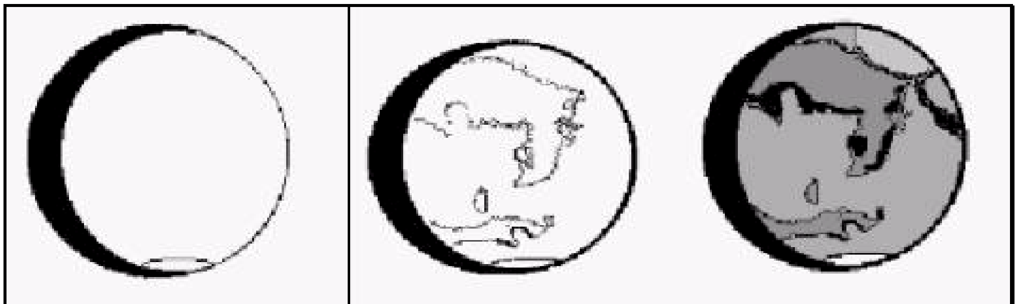


Figure 1. As it approaches Earth, it will swell from a small apparent disk in January 2001 to a maximum size on June 21, 2001, and then shrink as it moves away. April thoughtout September are the prime observing months.

tary disk high in the sky, where observing conditions can be ideal.

The aspects and range of the axial tilt of the globe of Mars make it possible to observe both poles and equatorial region during the 2001 apparition. The global tilt is synonymous to the apparent declination of the Earth (De) as viewed areocentrically ("areo" is a prefix often employed when referring to Mars or "Ares"), which is also the sub-earth point or latitude of the center off the Martian disk.

The De is tabulated in the Mars Section of the ALPO's Internet Web Page at http://www.lpl.arizona.edu/~rhill/alpo/mars.html and published in the ALPO Mars Section newsletter, *The Martian Chronicle*. Look under the heading, "Ephemeris for Physical Observations - 2001," in the "Mars Observing Ephemeris for 2001." The sub-earth and sub-solar points are graphically represented in Figure 2.

Because Mars rotates at nearly the same rate as the Earth, and also has a dynamic atmosphere that exhibits hourly, daily, and seasonal changes, frequent observations from observatories spanning the widest possible range of longitudes are desired.

An Overview of Mars

Martian Days

The Martian solar day, also called a "sol" by space scientists, is about 40 minutes longer than a day on Earth. Thus, Mars rotates through only 350° of longitude in 24 hours, causing an illusory retrograde rotation in about 36 days. This means an astronomer on Earth who observes a particular surface feature on Mars on a particular night sees the same feature 10° further to its west (closer to its morning limb) the next night. Thus, any given Martian region can be observed for about 10 days at intervals of about 36 terrestrial days.

The Martian day, as measured by the Viking spacecraft, has been found to be 24 hours, 37 minutes, 22.663 seconds.

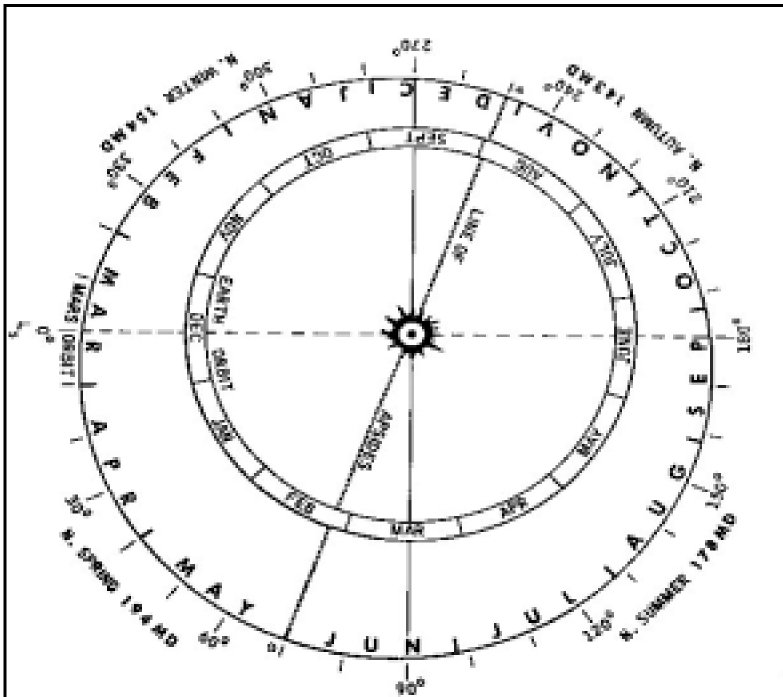


Figure 2. A Graphic Ephemeris for the 2001 Aphelic Apparition of Mars showing the apparent diameter (solid line) in arc-seconds, the latitude of the sub-earth point (De) or the apparent tilt (dashed line) in areocentric degrees, and the latitude of the sub-solar point (dash-dot line) in areocentric degrees. The areocentric longitude (Ls) of the Sun, shown along the right edge of the graph defines the Martian seasonal date. The value of Ls is 0°at the vernal equinox of the northern hemisphere, 70° when Mars is at aphelion, and 90° at the summer solstice of the northern hemisphere. Graph prepared by C.F. Capen

Martian Seasons

Mars and Earth have four comparable seasons because their axes of rotation are each tilted at about the same angle to their respective orbital planes (the axial tilt of Mars is 25.2° while that of Earth is 23.5°). While Earth's seasons are nearly equal in duration, the length of a Martian season can vary by as much as 51 days because of the greater eccentricity of the Martian orbit.

The axial tilt, or declination, of the planet Earth (De) as seen from Mars defines the axial tilt of Mars relative to Earth. The De also equals the *areographic latitude* of the center of the Martian disk, called the "sub-earth point." The areographic latitude is positive (+) if the north pole is tilted toward Earth and negative (-) if the south pole is tilted toward Earth. This quantity is an important factor when drawing Mars or when trying to identify certain features.

The Martian axis does **not** point at Polaris, our north star, but instead is displaced about 40° towards Alpha Cygni. Because of this celestial displacement, the Martian seasons are 85° out of phase with the Earth seasons; this comes out to about one season in advance of ours. Thus, an observer watching Mars during our spring and summer sees summer and autumn, respectively, in the Martian northern hemisphere.

The orbital position of Mars at any given time discreetly defines the Martian seasonal date. It is expressed as the planetocentric (a*reocentric)* longitude of the Sun (Ls), in degrees, measured along the ecliptic of the Martian celestial sphere. ("areo-" is a prefix often employed when referring to Mars or "Ares", the Roman god of war.)

Similar to terrestrial seasons, the Ls system is reckoned directly from the Sun's ascending node, or Martian northern spring equinox position, where Ls = 0°. Each beginning season is 90° from the next one, e.g., Vernal Equinox (0° LS), Summer Solstice (90° LS), Autumn Equinox (180° LS), and Winter Solstice (270° LS) in the north hemisphere of Mars.

The Martian Year

The orbits of Earth and Mars are elliptical, with Mars having a highly eccentric orbit while Earth's is more nearly circular. The distance between the Earth and Mars varies from 398,957,121 km (247,900,000 miles), when Mars is in conjunction with the Sun, to within 55,796,061 km (34,670,000 miles) during perihelic apparitions, or 98,170,167 km (61,000,000 miles) during aphelic apparitions.

The Martian year is nearly twice as long as ours, so that Martian seasons are similarly longer. A year on Mars is equal to 1.88089 tropical Earth years, and consists of 668.592159 Martian days ("sols") or 686.9804 Earth days; its mean synodic period is 779.94 mean days. We find the synodic period from the mathematical expression:

1/s = 1/Pe - 1/Pm, where Pe = 365.25636 days and Pm = 686.9804 days

Martian Meteorology

Clouds and Hazes -- The Martian atmosphere is ever changing. White water ice clouds, yellowish dust clouds, bluish limb hazes, and bright surface frosts have been studied with increasing interest in the past two decades. Clouds seem to be related to the seasonal sublimation and condensation of polar-cap material. The ALPO/Mars Section, using visual data and photographs from professionals and amateurs around the world, has conducted an intensive study of Martian meteorology. The first report, published in 1990, analyzed 9,650 IMP observations submitted over eight Martian apparitions between 1969 and 1984 [*Beish* and *Parker*, 1990]. This study has now been expanded to include 24,130 observations between 1965 and 1993. Statistical analysis indicates that discrete water ice crystal cloud activity and near-surface fog occurrence is significantly higher in the spring and summer of the Martian northern hemisphere than the same seasons for the southern hemisphere.

For inclusion in this unique study, it is essential that ALPO astronomers employ blue filters when making visual, photographic, or ccd observations.

Discrete clouds have been observed on Mars for over a century. In 1954, a remarkable W-cloud formation was found to be recurring each late-spring afternoon in the Tharsis-Amazonis region. A decade later, C.F. Capen proposed that the W-clouds are orographic (mountain-generated), caused by wind passing over high peaks. Indeed, in 1971 the Mariner 9 spacecraft probe showed them to be water clouds near the large volcanoes Olympus Mons (longitude 133° west, latitude 18° north), Ascraeus Mons (104°W, 11°N), Pavonis Mons (112°W, 0°N), and Arsia Mons (120°W, 9°S). Although often observed without filters, they are best seen in blue or violet light when they are high in altitude and in yellow or green light at very low altitudes. Other orographic clouds are observed over the Elysium Shield.

In addition to the dramatic orographic clouds, Mars exhibits many localized discrete clouds. These rotate with the planet and are most often found in northern spring-summer in Libya, Chryse, and Hellas. One remarkable example of a discrete topographic cloud is the "Syrtis Blue Cloud," which circulates around the Libya basin and across Syrtis Major, changing the color of this dark albedo feature to an intense blue. Originally named the "Blue Scorpion" by Fr. Angelo Secchi in 1858, this cloud usually makes its appearance during the late spring and early summer of Mars' northern hemisphere. It has been prominent during the 1995 and 1997 apparitions and is best seen when the Syrtis is near the limb.

Viewing this cloud through a yellow filter causes the Syrtis to appear a vivid green (yellow + blue = green).

Limb brightening or "limb arcs" are caused by scattered light from dust and dry ice particles high in the Martian atmosphere. They should be present on both limbs often throughout the apparition and are also best seen in blue-green, blue or violet light. These arcs are often conspicuous in orange light when dust is present.

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

These bright features are viewed best with a blue-green, blue, or violet filter. Occasionally, very low morning clouds can be seen in green or yellow light.

Evening clouds give the same appearance as morning clouds, but are usually larger and more numerous than morning clouds. They appear as isolated bright patches over light desert regions in the late Martian afternoon and grow in size as they rotate into the late evening. They are best seen in blue or violet light.

The size and frequency of limb clouds appear to be related to the regression of the northern, rather than the southern, polar cap. Both limb arcs and limb clouds are prominent after aphelion (70° Ls), but limb clouds tend to rapidly decrease in frequency after early summer, while limb hazes become more numerous and conspicuous throughout the northern summer.

Equatorial Cloud Bands (ECB's) appear as broad, diffuse hazy bands along Mars' equatorial zone and are difficult to observe with ground-based telescopes. Observations made with the Hubble Space Telescope have revealed that these clouds may be more common than we have suspected in the past. Their prevalence during the 1997 apparition led some conferees at the Mars Telescopic Observations Workshop-II (MTO-II) to postulate that many limb clouds are simply the limb portions of ECB's.

ALPO astronomers are encouraged to watch for these elusive features during this apparition. Are they really more common, or are our improved technologies merely allowing us to detect them more easily?

New technologies, such as ccd cameras, sophisticated computer hardware and software, and large-aperture planetary telescopes have given rise to a virtual explosion in advanced techniques of studying our Solar System. Never before have we been able to readily detect the delicate, wispy Martian Equatorial Cloud Bands so well as we do now with ccd imaging.

ECB's are best detected visually through a deep blue (W47 and W47B) Wratten filters and may be photographed or imaged in blue or ultraviolet light.

Dust storms, according to recent surveys, including our Martian meteorology study, have shown that dust events can occur during virtually any season [*Martin* and *Zurek*, 1993. *Beish* and *Parker,* 1990]. The main peak (285° Ls) occurs during Mars' southern summer, just after southern summer solstice, but a secondary peak has been observed in early northern summer, around 105° Ls. Classically, the storms occurring during southern summer are larger and more dramatic: they can even grow rapidly to enshroud the whole planet. It should be remembered, however, that these global dust storms are quite rare — only five have been reported since 1873, and these have all occurred since 1956. Much more common is the "localized" dust event, often starting in desert regions near Serpentis-Noachis, Solis Lacus, Chryse, or Hellas. During the 1997 apparition, ccd and HST observations revealed localized dust clouds over the north polar cap early in northern spring.

Identifying the places where dust storms begin and following their subsequent spread is most important to future Mars exploration missions. The following criteria apply in the diagnosis of Martian dust clouds:

The *sine qua non* of Martian dust clouds is <u>movement with obscuration</u> of previously well-defined albedo features. Absence of this criterion in the present study disqualified a candidate from inclusion under dust clouds.

They must be bright in **<u>red light</u>**. In the past, astronomers have identified Martian dust clouds and/or obscurations as "yellow clouds." It is incorrect to describe the color of Martian dust clouds as "yellow." While they may appear yellowish when observed without the aid of color filters, they are, in fact, brighter in red and orange light than they are in yellow light. Dust clouds brighten faintly in yellow filters and display well-defined boundaries through orange and red filters. During the initial stages of formation, they often appear very bright in violet and ultraviolet light, suggesting the presence of ice crystals.

There are numerous reports of anomalous transient albedo features appearing near dust clouds, especially when the solar phase angle was reasonably large. When these clouds reach heights of several kilometers, they may cast shadows that are observable from Earth.

More on dust clouds later in this report.

Dr. Richard McKim (BAA) has written an excellent review of Martian dust storms [*McKim,* 1996].

Blue Clearing

Normally the surface (albedo) features of Mars appear vague through light blue filters, such as the Wratten 80A. With a dark blue (W47) or violet (380-420 nm) filter, the disk usually appears featureless except for clouds, hazes, and the polar regions. When a little-understood phenomenon known as the “blue clearing” occurs, however, Martian surface features can be seen and photographed in blue and violet light for periods of several days. The clearing can be limited to only one hemisphere and can vary in intensity from 0 (no surface features detected) to 3 (surface features can be seen as well as in white light). The Wratten 47 filter or equivalent is the standard for analyzing blue clearing.

Recently there has been renewed professional interest in blue clearing. We encourage ALPO Mars observers to watch for this phenomenon during this apparition.

The Central Meridian

The Martian Central Meridian (CM) is an imaginary longitudinal line passing through the planetary poles of rotation and bisecting the planetary disk and is used to define what areographic longitudes are present on the disk during an observing session. It is independent of any phase, which may be present (the CM will appear to be off center if Mars presents a gibbous phase). The CM value is the areographic longitude in degrees which is on the central meridian of the disk as seen from Earth at a given Universal Time (U.T.). It can be calculated by adding 0.24/min (14.6° degrees /hr) to the daily CM value for 0h U.T. as listed in *The Astronomical Almanac*.

The terminator (phase defect) is the line where daylight ends and night begins. The terminator phase, or “defect of illumination", is given in seconds of subtended arc on the apparent disk, or in degrees (i) or the ratio (k), to define how much of the geometrical Martian disk is in darkness. The sunset terminator appears on the east side, or evening limb, before opposition; after opposition, the terminator becomes the sunrise line on the morning limb on the west side. There is no perceptible phase defect at opposition.

Observing Mars and Identifying Features

The ancient art of visual observation at the telescope is still a most useful tool to the modern astronomer, and is the forte of the amateur astronomer. The authors, attending various professional meetings over the past few years, were pleasantly surprised to find that carefully-made amateur drawings were considered to be useful sources of data by Mars professionals.

Even at its best, Mars is challenging to observe. The disk is tiny and its markings are blurred by the Earth's atmosphere. A telescope for planetary work should pro-

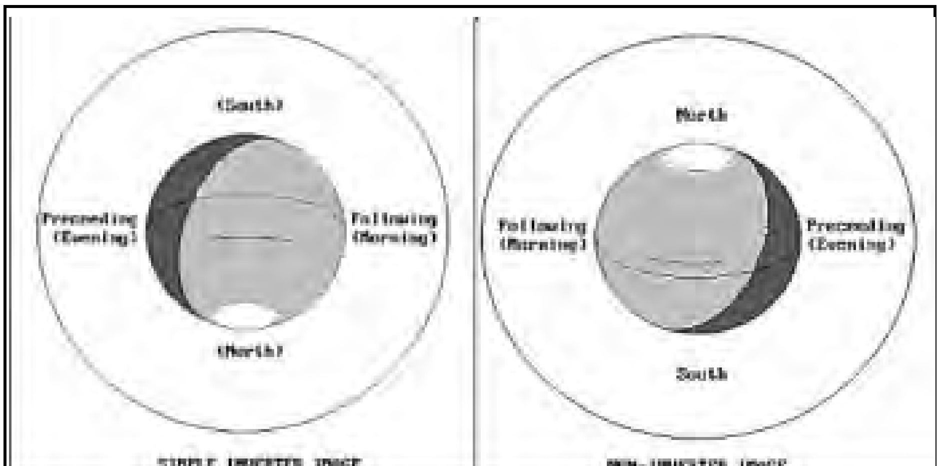


Figure 3. The Martian Disk and Useful terms. The orientation and nomenclature of the Martian globe as seen from Earth through an astronomical telescope. The figure indicates a simple inverted view of the disk of Mars, where south is at the top, bottom is north, the right side is terrestrial east or the Martian west (morning limb), and the left side is terrestrial west or Martian east (evening limb). Mars appears to rotate from Martian west to east, or right to left. Most classical charts of Mars show this same orientation.

vide sharp images with the highest possible contrast. A long-focus refractor is generally considered the best, followed by a long-focus Newtonian or Cassegrain reflector. Telescopes with large central obstructions do less well.

Table 1: Eastman Kodak Wratten filters and characteristics for Mars observations.

Wratten Filter	Remarks
Yellow (W12, W15)	Brightens desert regions; darkens bluish and brownish features.
Orange (W21, W23A)	Increases contrast between light and dark features; penetrates hazes and most clouds, and limited detection of dust clouds.
Red (W25, W29)	Gives maximum contrast of surface features.
Green (W57)	Darkens red and blue features, enhances frost patches, surface fogs, and polar projections.
Blue-Green (W74)	Helps detect ice fogs and polar hazes.
Blue (W80, W38, W38A)	Shows atmospheric clouds, discrete white clouds, and limb hazes, equatorial cloud bands, polar cloud hoods, and darkens reddish features.
Deep Blue (W46, W47)	Same as blue (above) plus W47 is the standard filter for detection and evaluation of blue or violet clearing.
Magenta (W30, W32)	Enhances red and blue features and darkens green ones; improves polar region features, some Martian clouds, and surface features.

It is highly recommended that all observers -- visual as well as photographers and CCD camera users -- use at least a basic set of tricolor filters according to the following guide: red or orange (W-25 or W-23A); green (W58); blue-green (W-64); blue (W-38A or W-80A); and violet (W-47). Observers with smaller telescopes, such as 3 to 6-inch apertures may find a yellow (W-15) useful and may provide better performance than the deep red filter (see Table 1). Those employing larger instruments, such as 8 to 16-inch apertures, will find the deep red and blue filters most useful for fine surface details or atmospheric cloud detection [*Capen, et al*, 1984].

A red (Wratten 25 or equivalent) filter lessens the apparent seeing effects and improves image contrast, since red wavelengths are refracted less,. While little or no fine detail can be discerned when the planet is low and of small apparent size, gross features, such as Syrtis Major, can be seen. If the observer has been regularly recognizing such features and suddenly notes their disappearance, one is led to suspect an obscuration, such as a dust storm.

Today's modern technology, such as a CCD camera, has increased the efficiency of telescopes that in the past were considered less than desirable for visual observations. Employing computer image processing many of the undesirable elements, such as low contrast and field illumination, can be reduced using image processing programming. Because the CCD devices can capture an image much faster than by conventional means (film), atmospheric turbulence is less likely to spoil the images -- another plus.

The dark surface markings were once thought by some astronomers to be great lakes, oceans, or vegetation, but space probes in the 1970's revealed the markings to be vast expanses of rock and dust. Windstorms sometimes move the dust, resulting in both seasonal and long-term changes.

Among the areas where yearly variations have been recorded are Trivium-Elysium, Solis Lacus, Syrtis Major, and Sabaeus-Meridiani. The Syrtis Major is the planet's most prominent dark area. Classical observations have revealed seasonal variations in the breadth of this feature: maximum width occurring in northern midsummer (145° Ls), and minimum during early northern winter, just after perihelion (290° Ls) [*Antoniadi*, 1930, *Capen*, 1976]. However, recent observations by ALPO astronomers and by the Hubble Space Telescope (HST) suggest that no such variations have occurred since 1990 [*Lee, et al.*, 1995. *Troiani, et al.*, 1997].

Solis Lacus, the "Eye of Mars", is notorious for undergoing major changes. In 1977, amateur observers discovered a new dark feature in the Aetheria desert at longitude 240° west, 25° north, between Nubis Lacus and Elysium. It was subsequently found on Viking Orbiter photographs taken in 1975, apparently undetected by Viking scientists. This is an example of the importance of ground-based observations of the Solar System.

Another feature that is of great interest to professional Mars researchers is the Trivium-Cerberus, on the southern rim of the Elysium shield. A classically dark feature 1300 x 400 km in size, it has all but disappeared during the 1990's [*Moersch et al.*, 1997. *Troiani et al.*, 1997].

Martian Dust Storms

Numerous reports of yellowish hazes have appeared in the literature and in the I.M.P. archives. Mars observers frequently report "albedo features" lacking in contrast, the planet is "washed out," or Mars' atmosphere is "dusty." The ALPO Mars Observing Coordinators have employed these terms in the past. While such descriptions may have merit, generalized yellow hazes and temporary losses in surface contrast is usually omitted in our reports. Photographic evidence for these phenomena is also weak, since the proper sensitometric calibration is usually lacking.

In the past observers referred to dust storms as "yellow clouds" and "yellow dust storms." We felt that this description was misleading and began to change our observing techniques and reporting methods for Martian dust clouds.

First, it is virtually impossible to see or even photograph accurate colors on Mars without employing very specialized techniques. Traditionally, observers have employed yellow filters to better reveal dust clouds. The problem is that nearly every light feature on Mars appears bright through a yellow filter!

Martian dust clouds form rapidly when finely divided surface materials are raised by the Martian wind. These clouds may be small, localized, and short-lived, or they may expand to cover most or the entire planet in a matter of days. Dust clouds brighten faintly in yellow filters and reveal sharpened boundaries through orange and red filters. During the initial stages of formation, they often appear very bright in violet and ultraviolet light (photo graphic), suggesting the presence of ice crystals. Thus dust clouds are frequently confused with bright white areas, frosts, or high-localized clouds on Mars. Because these dust clouds are often confused with bright surface deposits it becomes more difficult to determine the extent of the dust cloud expansion once the observer identifies it as dust on the move. Fresh surface deposits of dust tend to brighten the area where its

Table 2: Guidelines for interpreting Martian dust clouds and dust storms.

	REMARKS
Type of Observation	1. White cloud or bright areas mistaken for dust cloud
	2. Visual observation(s) of dust clouds in a dust storm.
	3. Instrumental observation(s) of dust cloud/storm (Includes photographic, polarimetric, spacecraft data, or other data obtained by instrumental means).
Martian dust clouds	1. Obscuration (obstruction)--Not sure if surface or atmospheric.
	2. Dust Haze--Partial obscuration with displacement.
	3. Bright dust cloud--Bright obscuration with displacements.
	4. Limb projection/terminator protrusion by dust cloud.
Martian dust storms	1. Local--Dust storm with major axis not to exceed 2000 km (1,243 miles or less than 34 degrees).
	2. Regional--Dust storm with major axis that exceeds 2000 km (1,243 miles or less than 34 degrees) but not encircling either or both hemispheres.
	3. Planet Encircling--Dust storm with major axis that completely encircles either one or both hemispheres of Mars.

has fallen and appears to blend with the dust cloud on the move.

While working with Leonard Martin and Richard W. Zurek (JPL) on problems of correctly identifying and classifying Martian dust clouds or storms, new guidelines have been established by the ALPO Mars Observing Coordinators for interpreting Martian dust clouds and dust storms, they are classified as:

If we consider the color of Mars is predominately red, with a mix of features displaying dark gray-orange and brown hues, it becomes interesting when attempting to describe Martian dust clouds as "yellow."

So, we may wish to define Martian dust clouds by their color, movement, and in some cases, the two-dimensional aspect of the clouds. As a general rule, a Martian dust cloud will qualify if it 1) is bright in red light, 2) shows movement with obscuration of previously well-defined albedo features, and 3) may cast a shadow.

Recording Observations of Mars

Anyone who observers Mars will find it rewarding to make a sketch of whatever is seen, both to create a permanent record and to help train the eye in detecting elusive detail. Start with a circle 1.75 in. (42 mm) in diameter. Draw the phase defect, if any, and the bright polar caps or cloud hoods. Next shade in the largest dark markings, being careful to place them in exactly the right locations on the disk. At this stage, record the time to the nearest minute. Now add the finer details, viewing through various color filters, starting at the planet's sunset limb. Finally, note the date, observer's name, the instrument(s) used, and any other relevant information.

Observational data consist of color filter photography, visual disk drawings, visual photometry (intensity estimates on the standard ALPO scale: 10 = polar brightness, 8 = desert mean brightness, 0 = night sky), micrometry, and CCD imaging. Great emphasis is placed on quality photographs in red, blue, and violet light, full-disk drawings using standard color filters, polar cap measurements made with the astronomical micrometer, and with modern observing techniques such as full-disk photometry and CCD imaging.

Data records of each visual and photographic observations (includes CCD imaging) are very important. A complete, written record should be made in some chosen order each night, and never left to memory for the following day. The Universal Date and Time, telescope used, ocular power (magnification) or Barlow lens, “astronomical seeing,” sky transparency, filters employed, and a description of the observed Martian disk appearance in different color filters are recommended data whether or not they accompany a visual drawing.

However, the ancient art of visual observation at the telescope is still a most useful tool to the modern astronomer, and is the forte of the amateur astronomer. This year we are fortunate in that Mars is very favorably positioned for telescopic study. This is especially important in view of the space missions to Mars currently under way and planned missions for the next century.

Each apparition, the ALPO Mars Section receives thousands of individual observations consisting of visual disk drawings made with the aid of color filters, black-&-white and color photographs, intensity estimates of light and dark albedo features, color contrast estimates, and micrometer measurements of polar caps, cloud boundaries, and variable surface features during the 12-month observing period. The chronological filing of this large quantity of data requires the observation information obtained for each night Universal Date be recorded on one or two standard observing report forms!

It is with this regard that the ALPO Mars Coordinators have prepared a simple, efficient and standard Mars Observing Report Form. This standard form, or its format, can be used for reporting all types of observations such as micrometry, transit timings, intensity estimates, etc. Photographs may also be attached to the top or back of the form and the relevant information blanks filled in at the telescope. Planetary aspect blanks can be filled in at other times than while observing.

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Table 3: Calendar of Events -- Mars in 2001.

DATE	LS °	REMARKS
2001 Jan 25	107.	Mars at 6 arc-seconds apparent diameter; apparition begins for begin for observers and up; begin low resolution CCD imaging; views of surface details well-defined; northern hemisphere early summer; NPC in rapid retreat?; are limb arcs increasing in frequency, intensity./; use filters!; Antarctic hazes, hood?; cloud activity high?.
2001 Mar 05	125	Mars at 8 arc-seconds apparent diameter; is Maria Acidalium broad and dark?; bright spots in Tempe-Arcadia-Tharsis-Amazoins regions?; "Domino Effect" appears around 120° - 125° Ls.
2001 Mar 29	137	Mars at 10 arc-seconds apparent diameter; quality photos possible; both polar caps visible, haze canopy?
2001 Apr 16	146	Mars at 12 arc-seconds apparent diameter; mid-summer; northern clouds frequent; Syrtis Major broad; are both polar hoods visible?
2001 Jun 13	176	Mars at Opposition and 20.4 arc-seconds apparent diameter; late-southern winter; NPH and SPH present; does SPH or frost cover Hellas?; W-clouds present?
2001 Jun 20	180	Mars at Northern Autumn Equinox (Southern Spring Equinox); South Polar Cap (SPC) maximum diameter; subtending ~65° latitude; North Polar Hood present.
2001 Jun 21	181	Mars at closest approach and 20.79 arc-secondsapparent diameter; south cap emerges from darkness of winter; SPH thinning.
2001 Jul 07	190	SPC should be free of its hood; possible W-clouds in Tharsis-Amazonis; wide Syrtis Major shrinks on eastern border; NPH bright.
2001 Jul 24	200	SPC shrinking; Syrtis Major continues to shrink; W-clouds possible; apparent diameter 18.2 arc-seconds.

Table 3: Calendar of events – Mars in 2001 (continued)

DATE	LS °	REMARKS
2001 Aug 09	210	SPC develops dark Magna Depressio at 270° longitude; -80° latitude; Syrtis Major narrows rapidly; W-clouds?; at 215° Ls a dark rift, Rime ustralis, appears connected with Magna Depressio from 20° to 240° longitude; and SPC develops bright projection at 10° - 20° longitude in Argenteus Mons; dust cloud in Serpentis-Hellaspontus?
2001 Aug 26	220	Bright SPC projection Novissima Thyle 300° - 330° longitude; dark rift Rima Augusta connected from 60° to 270° longitude; W-clouds possible; dust clouds?; apparent diameter 14.1 arc-seconds.
2001 Sep 11	230	Rapid regression of SPC; bright elongated Novissima Thyle reaches from SPC and becomes the isolated Novus Mons ("Mountains of Mitchel"); Rima Australis broadens and Magna Depressio becomes dusky feature; Syrtis Major retreats on Easterner; North Polar Hood prominent.
2001 Sep 26	240	SPC rapid retreat; Novus Mons small, bright, and high-contrast; Rima Australis widens; SPC isolated bright spot at 155° longitude?; any white patches near –20° latitude may brighten; atmosphere of Mars very clear during Ls 240°- 250°; occasional morning limb hazes; apparent diameter 11.2 arc-seconds.
2001 Oct 12	250	Mars at Perihelion; SPC in rapid retreat, ~20° in diameter; Novus Mons smaller; dust clouds expected over Serpentis-Hellaspontus (Ls 250° - 270°); Syrtis Major narrow; W-clouds possible.
2001 Oct 28	260	Novus Mons reduced to a few bright patches and soon disappears; Hellas bright spots?; numerous bright patches; windy season on Mars begins, dust clouds present?; Mars 9 arc-seconds apparent diameter.

Table 4. Motion of the Central Meridian of Mars. Add the following degrees to the Ephemeris CM values below.

HR	DEGREE	HR	DEGREE	MIN	DEGREE	MIN	DEGREE
1	14.62	13	190.07	1	0.24	10	2.44
2	29.24	14	204.69	2	0.49	20	4.87
3	43.86	15	219.31	3	0.73	30	7.31
4	58.48	16	233.93	4	0.97	40	9.75
5	73.10	17	248.55	5	1.22	50	12.18
6	87.72	18	263.17	6	1.46		
7	102.34	19	277.79	7	1.71		
8	116.96	20	292.41	8	1.95		
9	131.58	21	307.03	9	2.19		
10	146.20	22	321.65				
11	160.83	23	336.27				
12	175.45	24	350.89				

Refer to the *The Ephemeris for Physical Observations of Mars (0 hr UT) - 2001* located on the ALPO Mars Section Web Page at: http://www.lpl.arizona.edu/~rhill/alpo/marstuff/ephems/ephem2001.html

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In terms of content, we deal with the objects in the Solar System; the Sun, Moon, major and minor planets, comets, and meteors. Our emphasis is on observations and observing techniques rather than theory or cosmology. Ordinarily, submissions should not exceed a total of 10-12 printed pages including illustrations; allow about 1,000 words per printed page.

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Feature: Mars (Part 1) Tides and the Future of Phobos

by Roger Venable

The orbit of Earth's moon is gradually enlarging. In contrast, the inner moon of Mars, Phobos, is gradually falling toward the planet and will collide with it in 40 million years. Why isn't Phobos' orbit stable, and what accounts for the difference in the behavior of these two moons?

Let's explore this by thinking first about the Earth-Moon system. Luna's gravity raises a tidal bulge on the near side of Earth, because its nearness makes it the most strongly attracted part. The far side of the Earth is the part least attracted, so that it bulges away from the moon.

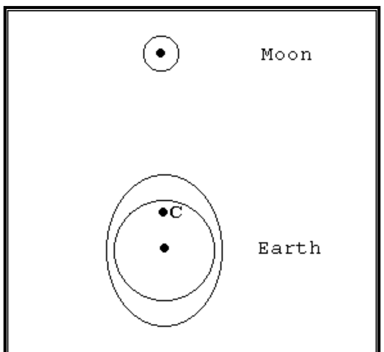


Figure 1

This is depicted in Figure 1, where point C is the center of mass of the Earth-Moon system. The tidal effect changes neither the position of C nor the distance of either body's center of mass from C it's a zero-sum effect.

Now put the two bodies into motion, as depicted in Figure 2. As seen from above the North Pole, the Earth's rotation and the moon's revolution are both counterclockwise, but there are 27 rotations for every revolution. The tidal bulge cannot adjust instantaneously to this fast rotation it is carried forward by the rotation to a position in advance of the moon. Imagine yourself standing on the Earth's equator at point X in Figure 2. You are carried counterclockwise so that the moon crosses your meridian a few hours before you arrive at the position of high tide. Look for this effect the next time you spend a day at the beach.

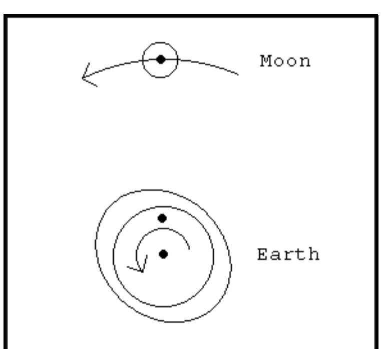


Figure 2

Now let's investigate how this affects the lengths of the day and month. Figure 3 is Figure 2 overlaid with lines that depict the distances and angles of the Earth-Moon system. The first crucial fact is that line a is shorter than line b. This means that the gravitational force between the moon and the Earth's tidal bulge along line a is greater than that along line b.

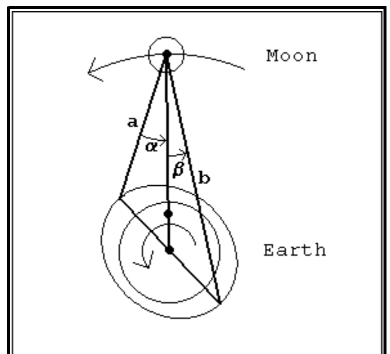


Figure 3

The second crucial fact is that angle a is greater than angle b. This means that the direction of the force along line a renders it more effective than the force along line b to affect the speeds of Earth's rotation and Luna's revolution. Thus, the force along line a dominates the force along line b, and causes a slowing of Earth's rotation and an acceleration of the moon. Ironically, when the moon accelerates, its momentum carries it to a more distant orbit, and this motion against the Earth's gravity results in the slowing of its orbital speed. The total energy of the system remains unchanged, but some of the Earth's rotational energy transfers to the moon's orbital energy. This has been going on for 4.4 gigayears, so that the Earth's rotation is much slower, and the moon much more distant, than they were initially.

You may have heard that the Earth's rotation is slowing due to the loss of energy in the lapping of waves against the shore, but that is not true. Waves are energized by wind, which has no relation to the tides. However, the tides create a trillion watts of friction at the sea bed that warms the ocean imperceptibly and contributes slightly to the slowing of the Earth's rotation. The friction contributes nothing to the enlargement of the moon's orbit.

When we consider similar tidal effects in the Mars-Phobos system, we encounter an interesting twist. While Mars rotates in 24.62 hours, Phobos revolves in only 7.65 hours, so that it precedes the tidal bulge that it raises on Mars, as depicted in Figure 4. If we draw lines a and b and angles a and b on Figure 4 as we did in Figure 3, we get Figure 5. Here, using the same reasoning we applied to Figure 3, we can see that the gravitational force along line b dominates that along line a -- opposite to the effect in the Earth-Moon system. This causes Phobos to slow in orbit and Mars' rotation to accelerate. The slowing of Phobos causes it to fall closer to the planet, which brings an acceleration that stabilizes it in its new, lower orbit. Thus, Phobos transfers some of its orbital energy to the rotation of Mars. Eventually it will strike the planet, unless. . . .

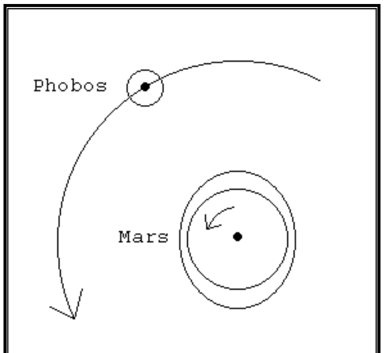


Figure 4

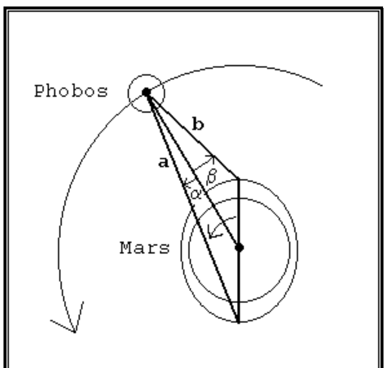


Figure 5

Unless it breaks up first. If a small object like Phobos is held together solely by its own gravity and not by material cohesiveness, there is a limit to how closely it can approach a large body. At close range, the gravity of the massive body pulls on the near side of the small object more strongly than it pulls on the far side, and the difference between the force on the two sides can tear the small object apart. For a rigid, round, small object without material cohesiveness, the breakup distance is 1.26 radii of the larger object, measured from its center. For a liquid small object, the breakup distance is 2.44 radii. Phobos is probably rigid, and Mars' radius is 3390 km, so the critical distance is 1.26 x 3390, or 4270 km. With its nearly circular orbit 9380 km from the center of Mars, Phobos appears to be safe.

But there are problems. This breakup distance is correct when the large and small objects have the same density, but Mars is 2.07 times denser than Phobos. Correcting for the density difference results in a breakup distance of 5460 km. Also, Phobos is oval with dimensions of 27.0 km by 21.6 km by 18.8 km, and an oval body has weaker surface gravity than a spherical body of the same mass. It rotates synchronously with its revolution, with its long axis pointing toward the planet, as shown

Figure 6 -- A "lateral view" of Phobos above the limb of Mars, taken by the Russian Phobos 2 spacecraft on March 25, 1989, from a distance of 195 km. Original in three spectral bands, processed by the Planetary Data Image Processing Lab of the Russian Space Research Institute. Copyright, IKI (Space Research Institute, Russia: http://arc.iki.rssi.ru), used with permission.

Figure 7 -- A view of Phobos with phase angle about 90 degrees. Crater Stickney is at left, and numerous grooves are visible radiating from it. Taken by the Viking 1 Orbiter on June 10, 1977, from a distance of 1590 km. Viking Orbiter image 357A64. Source: NASA. Public domain.

in the Phobos 2 spacecraft image (Figure 6).

Figure 8 -- A closer view of Phobos. The part shown is about 13 km from top to bottom. The fissures radiating from Stickney are here seen to converge at the antipode to the crater. Taken by Viking 1 Orbiter on February 25, 1977, from a distance of 435 km. Viking Orbiter image 249A03. Source: NASA. Public domain.

This orientation increases Mars' tidal force on it. Considering these factors, its theoretical breakup distance is 6680 km if it is rigid. So Phobos will break apart long before it strikes Mars unless it is held together by cohesiveness of its rocks. But there is more. The Phobos 2 sensors detected a steady outgassing from the moon, probably of water -- it is losing mass, so its gravity is weakening and its breakup distance is increasing.

The image taken by the Viking 1 orbiter (Figure 7) shows Phobos' largest crater, named Stickney after the wife of Asaph Hall. At 10 km in diameter, it is huge relative to the size of the moon.

Radiating from Stickney are cracks hundreds of meters across, some of which converge on the side of the moon opposite Stickney (Figure 8). The Stickney impact fractured Phobos deeply, and presumably these fractures weaken its cohesion. If it is so pulverized that it is not rigid -- that is, if it is loose rubble that is free to deform under tidal forces -- its breakup distance will resemble that of a liquid moon. At its low density, that critical distance is 10,540 km! If it breaks up, it will likely form a ring around the planet.

In June, Earth will overtake Mars in the dance around the sun, and those of us with large telescopes will look for Phobos again. Will this be the year we don't find it?

About the Author

Roger Venable, a stargazer since 1962, is now active in the ALPO, the International Meteor Organization (IMO), the International Occultation Timing Assn. (IOTA), and in the Astronomy Club of Augusta whose newsletter he publishes. With his 11-inch SCT, he shows the night sky to hundreds of school children each year, while he uses his 16-inch Newtonian located at his rural observatory for personal observing. Roger practices general medicine in Augusta, Georgia, USA, , USA, and has interests in music, aquaria, and in his family and church.

Feature: Mars (Part 2): Observing Phobos and Deimos

by Roger Venable

Spotting them

Many observers have succeeded in spying these moons, and here is how they did it. First, they blocked the bright disc of the planet, either by positioning it just outside the field of view or by using an occulting bar. Second, they used high magnification to spread out the diffuse glare, diminishing its intensity so that they could detect a faint point of light. Increasing the magnification until star images appeared bloated was helpful, but increasing beyond that wasn't. Third, they used motorized drives on both of the telescope's axes. Keeping Mars' disc just outside the field of view or just behind the edge of an occulting bar required finer positioning of the telescope than they could do by hand.

Deimos, though dimmer than Phobos, is easier to see because it is farther from the planet. Its maximum apparent separation is slightly closer than three times Mars' diameter. For 2.5 hours before and 2.5 hours after each time of maximum apparent separation, its separation is greater than 85% of maximum. Outside that interval it is quite hard to see. Its magnitude is 12.8 on May 4, brightens to 12.0 on June 11 and stays near that brightness through July 7, and then fades to 12.7 on August 22. Using the observing techniques described above, this writer has found Deimos to seem about a magnitude dimmer than its nominal magnitude, due to the glare of the planet. Many people have seen it with Schmidt-Cassegrain telescopes of 200mm aperture.

Phobos' maximum apparent separation from Mars is slightly less than the diameter of the planet. It moves fast. For 30 minutes before and 30 minutes after the time of maximum apparent separation, its separation is greater than 86% of maximum. Outside that interval it is very hard to spot. Its magnitude is 11.7 on May 4, brightens to 10.9 on June 12 and stays near that brightness through July 7, and then fades to 11.6 on August 22. When using a 400mm telescope, this writer has found Phobos to seem about 3.5 magnitudes dimmer than its nominal magnitude, due to the glare of the planet.

The table

These tiny moons are so close to Mars that they are usually hidden in its glare. Only when they are at the easternmost or westernmost reaches of their orbits can we detect their feeble sparkles. To find them, we have to know when they are so positioned. The following table lists the universal times of their greatest apparent separations from the planet from May 4 through August 22, 2001. For each entry, the four digits are the universal time, and the letter "E" or "W" denotes whether the moon is east or west of Mars. This is the direction on the sky, which is opposite to the IAU areographic direction.

The time of greatest apparent separation is a few minutes different from the time of greatest elongation. We measure the latter with respect to Earth's right ascension coordinate. In the months of May through August the orbits of Mars' moons are tipped about 30 degrees away from the east-west direction, so that greatest eastern separation is at position angle 120 degrees, near the east southeast compass point, and greatest western separation is at position angle 300 degrees, near the west northwest compass point. Rotate your occulting bar accordingly.

Because A.L.P.O. members observe from points all around the globe, the table lists all times of maximum separation. For any observing site, a majority of these times will occur while Mars is below the horizon or the sun is in the sky. As you plan to observe these moons, be sure you choose a time when Mars is in your sky and the sun is not! And when you convert the universal time to your local time, be sure you convert the date also!

The project

The factors that affect the visibility of these moons are not clear. In an effort to elucidate them, the author will keep a record of his observations during the next three apparitions. Readers are invited to e-mail their observations to rjvmd@knology.net, or mail them to: Roger Venable, 3405 Woodstone Place, Augusta, GA 30909

Reports of inability to see them are as valuable as reports of successful sightings. Please include the following:

- Your location
- Time of the observation (preferably to within a few minutes)
- Telescope aperture
- Telescope type
- Magnification used
- Estimate of the seeing
- Estimate of the naked eye limiting magnitude in the vicinity of Mars

If you see a moon, it is especially valuable to observe it until you can no longer see it and note the time of its loss from view.

U.T. Date **U.T.'s of Greatest Angular Separation, with Sky Direction**

|<================== Phobos ===================>| **<== Deimos ===>|**

U.T. Date	Phobos							Deimos	
May 4	0006W	0354E	0745W	1133E	1525W	1912E	2304W	0630E	2139W
May 5	0251E	0643W	1031E	1422W	1810E	2202W		1249E	
May 6	0149E	0541W	0928E	1320W	1708E	2059W		0358W	1907E
May 7	0047E	0439W	0826E	1218W	1605E	1957W	2345E	1016W	
May 8	0336W	0724E	1116W	1503E	1855W	2242E		0125E	1634W
May 9	0234W	0621E	1013W	1401E	1752W	2140E		0743E	2253W
May 10	0132W	0519E	0911W	1258E	1650W	2038E		1402E	
May 11	0029W	0417E	0809W	1156E	1548W	1935E	2327W	0511W	2020E
May 12	0315E	0706W	1054E	1446W	1833E	2225W		1129W	
May 13	0212E	0604W	0951E	1343W	1731E	2122W		0238E	1746W
May 14	0110E	0502W	0849E	1241W	1628E	2020W		0856E	
May 15	0007E	0359W	0747E	1138W	1526E	1918W	2305E	0004W	1513E
May 16	0257W	0644E	1036W	1424E	1815W	2203E		0622W	2131E
May 17	0154W	0542E	0934W	1321E	1713W	2100E		1240W	
May 18	0052W	0440E	0831W	1219E	1610W	1958E	2350W	0349E	1857W
May 19	0337E	0729W	1116E	1508W	1855E	2247W		1006E	
May 20	0235E	0626W	1014E	1406W	1753E	2145W		0115W	1624E
May 21	0132E	0524W	0911E	1303W	1651E	2042W		0732W	2241E
May 22	0030E	0421W	0809E	1201W	1548E	1940W	2327E	1349W	
May 23	0319W	0707E	1058W	1446E	1837W	2225E		0458E	2007W
May 24	0217W	0604E	0956W	1343E	1735W	2122E		1115E	
May 25	0114W	0502E	0853W	1241E	1632W	2020E		0224W	1732E
May 26	0012W	0359E	0751W	1138E	1530W	1917E	2309W	0841W	2350E
May 27	0257E	0648W	1036E	1427W	1815E	2207W		1458W	
May 28	0154E	0546W	0933E	1325W	1712E	2104W		0606E	2115W
May 29	0051E	0443W	0831E	1222W	1610E	2002W	2349E	1223E	
May 30	0341W	0728E	1120W	1507E	1859W	2246E		0332W	1840E
May 31	0238W	0626E	1017W	1405E	1756W	2144E		0948W	
June 1	0135W	0523E	0915W	1302E	1654W	2041E		0057E	1605W
June 2	0033W	0420E	0812W	1200E	1551W	1939E	2330W	0713E	2221W
June 3	0318E	0709W	1057E	1449W	1836E	2228W		1330E	
June 4	0215E	0607W	0954E	1346W	1734E	2125W		0438W	1946E
June 5	0113E	0504W	0852E	1243W	1631E	2022W		1054W	
June 6	0010E	0402W	0749E	1141W	1528E	1920W	2307E	0203E	1711W
June 7	0259W	0647E	1038W	1426E	1817W	2205E		0819E	2327W
June 8	0156W	0544E	0935W	1323E	1714W	2102E		1436E	
June 9	0054W	0441E	0833W	1220E	1612W	2000E	2351W	0544W	2052E
June 10	0339E	0730W	1118E	1509W	1857E	2248W		1200W	
June 11	0236E	0628W	1015E	1407W	1754E	2146W		0308E	1816W
June 12	0133E	0525W	0913E	1304W	1652E	2043W		0925E	
June 13	0031E	0422W	0810E	1201W	1549E	1941W	2328E	0033W	1541E
June 14	0320W	0707E	1059W	1446E	1838W	2226E		0649W	2157E
June 15	0217W	0605E	0956W	1344E	1735W	2123E		1305W	
June 16	0114W	0502E	0853W	1241E	1633W	2020E		0413E	1921W
June 17	0012W	0359E	0751W	1139E	1530W	1918E	2309W	1029E	
June 18	0257E	0648W	1036E	1427W	1815E	2206W		0137W	1645E
June 19	0154E	0546W	0933E	1325W	1712E	2104W		0753W	2302E
June 20	0052E	0443W	0831E	1222W	1610E	2001W	2349E	1410W	
June 21	0340W	0728E	1119W	1507E	1858W	2246E		0518E	2026W
June 22	0238W	0625E	1017W	1405E	1756W	2144E		1134E	
June 23	0135W	0523E	0914W	1302E	1653W	2041E		0242W	1751E
June 24	0032W	0420E	0811W	1159E	1551W	1938E	2330W	0858W	
June 25	0318E	0709W	1057E	1448W	1836E	2227W		0007E	1515W
June 26	0215E	0606W	0954E	1345W	1733E	2124W		0623E	2131W
June 27	0112E	0504W	0852E	1243W	1631E	2022W		1239E	
June 28	0010E	0401W	0749E	1140W	1528E	1919W	2307E	0348W	1856E
June 29	0258W	0646E	1038W	1426E	1817W	2205E		1004W	
June 30	0156W	0544E	0935W	1323E	1714W	2102E		0113E	1621W

U.T. Date	U.T.'s of Greatest Angular Separation, with Sky Direction								
	|<================== Phobos ===================>|							<== Deimos ===>|	
July 10053W	0441E	0832W	1220E	1612W	2000E	2351W	0729E	2237W	
July 2	0339E	0730W	1118E	1509W	1857E	2248W		1346E	
July 3	0236E	0627W	1015E	1406W	1755E	2146W		0454W	2003E
July 4	0134E	0525W	0913E	1304W	1652E	2043W		1111W	
July 5	0031E	0422W	0810E	1201W	1550E	1941W	2329E	0219E	1728W
July 6	0320W	0708E	1059W	1447E	1838W	2226E		0836E	2345W
July 7	0217W	0605E	0956W	1345E	1736W	2124E		1453E	
July 8	0115W	0503E	0854W	1242E	1633W	2021E		0602W	2110E
July 9	0012W	0401E	0752W	1140E	1531W	1919E	2310W	1219W	
July 10	0258E	0649W	1037E	1428W	1816E	2207W		0328E	1836W
July 11	0156E	0547W	0935E	1326W	1714E	2105W		0945E	
July 12	0053E	0444W	0832E	1223W	1612E	2003W	2351E	0053W	1602E
July 13	0342W	0730E	1121W	1509E	1900W	2249E		0711W	2219E
July 14	0239W	0628E	1019W	1407E	1758W	2146E		1328W	
July 15	0137W	0525E	0916W	1305E	1655W	2044E		0437E	1946W
July 16	0035W	0423E	0814W	1202E	1553W	1941E	2332W	1054E	
July 17	0321E	0712W	1100E	1451W	1839E	2230W		0203W	1712E
July 18	0218E	0609W	0958E	1349W	1737E	2128W		0821W	2330E
July 19	0116E	0507W	0855E	1246W	1635E	2025W		1439W	
July 20	0014E	0405W	0753E	1144W	1532E	1923W	2312E	0548E	2057W
July 21	0302W	0651E	1042W	1430E	1821W	2209E		1206E	
July 22	0200W	0549E	0939W	1328E	1719W	2107E		0315W	1824E
July 23	0058W	0446E	0837W	1226E	1616W	2005E	2356W	0933W	
July 24	0344E	0735W	1123E	1514W	1903E	2253W		0042E	1551W
July 25	0242E	0633W	1021E	1412W	1800E	2151W		0701E	2210W
July 26	0140E	0530W	0919E	1310W	1658E	2049W		1319E	
July 27	0038E	0428W	0817E	1208W	1556E	1947W	2335E	0428W	1938E
July 28	0326W	0715E	1105W	1454E	1845W	2233E		1047W	
July 29	0224W	0613E	1003W	1352E	1743W	2131E		0156E	1705W
July 30	0122W	0510E	0901W	1250E	1640W	2029E		0815E	2324W
July 31	0020W	0408E	0759W	1148E	1538W	1927E	2318W	1434E	
Aug 1	0306E	0657W	1045E	1436W	1825E	2215W		0543W	2053E
Aug 2	0204E	0555W	0943E	1334W	1723E	2113W		1202W	
Aug 3	0102E	0453W	0841E	1232W	1621E	2011W		0312E	1821W
Aug 4	0000E	0351W	0739E	1130W	1519E	1909W	2258E	0931E	
Aug 5	0249W	0637E	1028W	1417E	1807W	2156E		0040W	1550E
Aug 6	0147W	0535E	0926W	1314E	1705W	2054E		0659W	2209E
Aug 7	0044W	0433E	0824W	1212E	1603W	1952E	2343W	1318W	
Aug 8	0331E	0722W	1110E	1501W	1850E	2241W		0428E	1938W
Aug 9	0229E	0620W	1008E	1359W	1748E	2138W		1048E	
Aug 10	0127E	0518W	0906E	1257W	1646E	2037W		0157W	1707E
Aug 11	0025E	0416W	0804E	1155W	1544E	1935W	2323E	0817W	2327E
Aug 12	0314W	0703E	1053W	1442E	1833W	2221E		1436W	
Aug 13	0212W	0601E	0951W	1340E	1731W	2119E		0546E	2056W
Aug 14	0110W	0459E	0849W	1238E	1629W	2017E		1206E	
Aug 15	0008W	0357E	1747W	1136E	1527W	1915E	2306W	0315W	1825E
Aug 16	0255E	0645W	1034E	1425W	1814E	2204W		0935W	
Aug 17	0153E	0544W	0932E	1323W	1712E	2102W		0045E	1555W
Aug 18	0051E	0442W	0830E	1221W	1610E	2000W	2349E	0705E	2215W
Aug 19	0340W	0728E	1119W	1508E	1858W	2247E		1325E	
Aug 20	0238W	0627E	1017W	1406E	1757W	2145E		0435W	1945E
Aug 21	0136W	0525E	0915W	1304E	1655W	2043E		1055W	
Aug 22	0034W	0423E	0814W	1202E	1553W	1942E	2332W	0205E	1715W

Product Review: A New Solar Filter Material — Baader Planetarium Astrosolar

by Gordon Garcia,
Assistant Coordinator, Solar Section

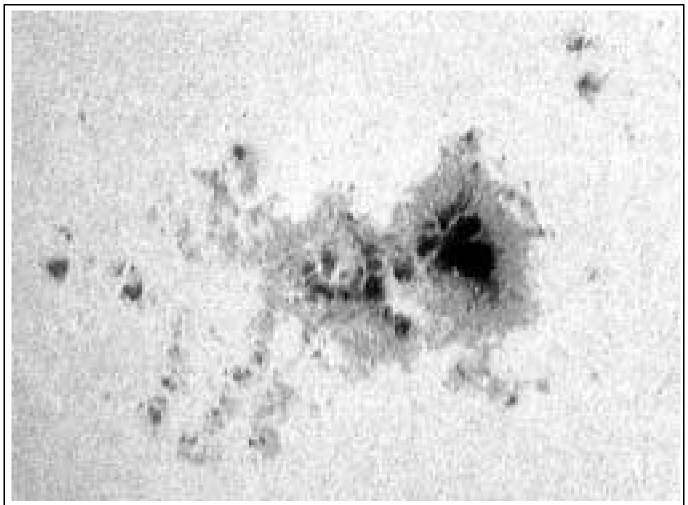
In 1981, with a newly purchased full aperture solar filter, I turned my C8 telescope to the Sun for the first time. I was amazed by what I could see on the fiery surface of our daytime star. I was also amazed at how quickly it changed. It took me only a year to add a solar hydrogen-alpha filter to my observing arsenal. I was hooked.

Years have come and gone, and many new, high quality, solar observing devices and materials have been introduced into the amateur market. Among the leaders in this have been the folks at Baader Planetarium near Munich, Germany. They have produced superb full-aperture, glass solar filters, energy rejection filters for H-alpha filters, and an outstanding two-inch Herschel wedge prism. For viewing solar prominences, they make an H-alpha coronograph that was reviewed by Don Trombino in the June 1994 issue of *Sky & Telescope* magazine.

All these devices are prized by experienced solar observers. During my recent visit to Astro-Physics in Rockford, Illinois, owner Roland Christen told me of Baader's new, low cost, foil material for solar viewing -- the Baader Astrosolar Safety Film. My initial response was not enthusiastic, but Roland insisted that I view the Sun through the film that he had mounted across the aperture of his 5-inch refractor.

Seeing is believing! The Baader filter produced a very sharp image of the Sun with excellent contrast and little scattered light. The sky next to the solar limb was jet black. Roland gave me a sheet of the new material that was of photographic density (ND 3.8). The next day I called Astro-Physics to see whether the film was available in a visual density. I was pleasantly surprised to hear that Thomas Baader of Baader Planetarium had agreed to send me some of the material in a visual neutral density (ND5).

Baader Planetarium provided the following information on AstroSolar. The substrate is not Mylar, but a different plastic material. Before coating, the film is changed to a dark grey color by an ionizing process. This coloring minimizes internal reflections. Then the film is annealed by heating almost to the melting point. As with optical glass, the heating releases internal stresses, improving its optical performance.



Active Region 9169, September 21, 2000, 14:43 UT; taken with 130 mm Astro-Physics F/8 EDT refractor equipped with Baader AstroSolar filter, TeleVue 4X Powermate and AVA Astrovid 2000 camera. Photo by Gordon Garcia.

The manufacturer's interferomtric testing of the uncoated film revealed a Strehl ratio of 0.941 at 632.8 nanometers. Lastly, the film is coated on both sides with a metal deposit. The double coating prevents pinholes from appearing. Technical information can be found at Baader Planetarium's web site, www.astronomie.com/baader/details_e.htm. I expressed interest in knowing more about the composition of the substrate and coatings, but Mr. Baader stated that this is proprietary information.

He did say that he tested several hundred types of film on a Zeiss double pass autocollimator before finding one that would withstand the treatment process without affecting the wavefront. Patents are pending on the film in all 19 European countries. It has been tested for eye safety by the German National Bureau of Standards.

I mounted a piece of the material I received from Baader in a cardboard cell. My initial test of it was on an evening shortly before sunset. I first checked the material by holding it up to the Sun. Seen through the film, the sun was white in color with little scattered light. There were no pinholes, and I judged it to have a neutral density of about five. I then mounted it securely to my 5.1-inch, f/8 Astro-Physics refractor and pointed the scope towards the Sun.

Viewing the Sun through the telescope with a star diagonal but no eyepiece, I again examined the filter. There was little scatter, but there was a tiny pinhole in one side of the coating. Because the coating is two-sided, this imperfection was faint and did not require darkening with a felt tip pen. I then placed a 19-mm Panoptic eyepiece into the star diagonal and brought the Sun into focus. At 53x, the Sun's image was an off-white color with a slight blue-grey tint similar to what you see through a Herschel wedge prism with neutral density filters. The image was sharp with black sky next to the solar limb.

Although seeing was not particularly good this late in the day, granulation was easily seen, as were the sharp boundaries between the umbrae and penumbrae of sunspots. Faculae, which are usually most readily seen near the limb, were easily seen far onto the disk. The image was bright -- as it should be at such low magnification, so that at higher magnification, it is not too dim.

Several days later, I had another opportunity to test the material in conditions of two arc-seconds seeing, 10% cloud cover and slight haze. Observing at approximately 100x with a 10-mm orthoscopic eyepiece in the same refractor, I found the image to be very sharp with little scatter along the Sun's limb. Some scatter was seen from the slight sky haze, but the sky next to the limb was very dark.

As before, faculae were easily seen far from the Sun's limb. I switched to 250x with a 4-mm orthoscopic eyepiece and found that the image was still sharp. Granulation and detail in umbrae and penumbrae were easily seen. Examining Active Region 8611, I counted 53 sunspots in the group. (The official NOAA counts that day was only 39 for AR 8611.) The image at 250x was slightly dim -- a head covering to cut ambient light would have helped.

In summary, I found the new Baader AstroSolar Safety Film to be of excellent quality for solar observing. Judging from the manufacturer's claimed Strehl ratio of better than 94%, it may yield diffraction-limited images.

Astro-Physics, Inc., distributes the material in the U.S. to dealers and to individuals. Although dealers now sell it mounted in cells for telescopes of various sizes, the film is provided by Astro-Physics in unmounted sheet form, with instructions for making a cell to attach the filter to your telescope. The price of a sheet large enough to cover a seven-inch aperture is $30 U.S., while 500 x 1000-mm sheets are available for $70 (October 2000 prices).

It is offered in both visual and photographic neutral densities, ND 5 and ND 3.8. Also offered is the clear, uncoated plastic substrate, called "Turbofilm," useful for closing open tubes and protecting lens surfaces. Astro-Physics sells through its web site, www.astro-physics.com, or by mail at 11250 Forest Hills Rd, Rockford, IL 61115, USA.

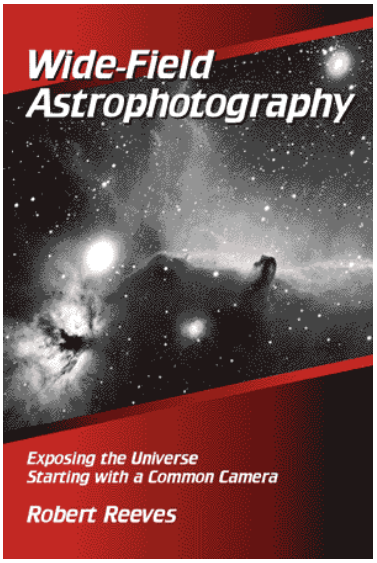
Whether you buy the filter mounted in a cell or unmounted, be very careful when observing the Sun. Make sure your solar filter is securely mounted to your telescope so that it cannot fall off or be blown off by a gust of wind. Inspect your filter before every use. The Sun is dangerous to observe. Please do not underestimate this fact.

About the Author

Gordon Garcia has been an active solar observer since 1981. “I began observing with a white light glass filter and C8 telescope. In 1983 I joined the American Association of Variable Star Observers and began submitting sunspot counts to AAVSO Solar Division. In 1984 I also began sending my whole disk and active region drawings to the ALPO Solar Section.” Mr. Garcia purchased a DayStar hydrogen-alpha solar filter in 1982 so I could observe the solar chromosphere. “I continued doing sunspot counts and drawings until 1987 when I purchased an Olympus OM1 camera body. I then began photographing the Sun. I later began doing CCD and video imaging. In January 1998 I was named an Assistant Coordinator in the ALPO Solar Section, a position I still hold. Since 1984 I have submitted approximateky 1,100 observations to the Solar Section.”
Mr. Garcia remains a member of AAVSO Solar Division, but discontinued the sunspot counts in favor of imaging in 1990.

New Books Received

***WIDE-FIELD ASTROPHOTOGRAPHY* by Robert Reeves, 534 pages, published by Willmann-Bell, Inc., Richmond, Va., 2000; hardcover, $29.95. Reviewed by Klaus Brasch**



After a protracted drought, astrophotographers have been treated to a virtual flood of new books on their favorite topic this past year. In addition to the long awaited, second edition of Michael Covington's Astrophotography for the Amateur in 1999, two entirely new works appeared in 2000. Practical Astrophotography by Jeffrey Charles, is the 15th in a series of volumes under the "practical astronomy" theme published by Springer-Verlag, New York. Together with Robert Reeves' Wide-Field Astrophotography, these books are likely to be the last primarily devoted to film-based astro-imaging, although all three also touch on electronic imaging to varying degrees.

Of the three works, Reeves' is by far the longest and most unusual. As the title implies, this 500-plus-page tome does not deal with "high resolution, narrow field" imaging, be it solar system or deep sky. Instead, it is devoted almost exclusively to the "big picture". Milky Way, star field and nebula photography are treated in great depth, as are comet and meteor imaging. However, this somewhat specialized focus should not discourage anyone interested in those other aspect of astrophotography from acquiring this excellent book. Reeves very capably covers all the basics, including theory and practice. Cameras, lenses and films are treated very thoroughly, as are telescopes, mounts, polar alignment, guiding and much more. The author does this not only by sharing years of hands-on experience, but also by touching on the myriads of small and sundry details, so crucial to successful photography.

Moreover, he accomplishes this by wrapping even the driest, most technical aspects of his craft in lively and engaging prose.

In addition to a beginning section titled "An Astrophoto Philosophy", in which he conveys his own low-key, but deeply enthusiastic approach to imaging the night sky (a sentiment that will resonate favorably with most readers), Reeves ends the book with an insighfful historical perspective on "Our Astrophotographic Legacy". This serves as a most appropriate reminder of just how far and how much photography, both professional and amateur, has helped advance astronomy during the past 100 years. Although film based astronomical imaging is now largely the domain of the amateur, the outstanding emulsions currently available, coupled with image scanning and electronic processing, is sure to extend this fulfilling avocation for many more years.

About the Author

Active amateur astronomer and member of ALPO since 1958, Robert Reeves is a former ALPO Mars Recorder. He is mainly interested in astro imaging –- both film-based and digital –- of deep sky and solar system objects. He is a professor of biology and director of technology transfer at California State University in San Bernardino. His academic interests include issues related to the origin of life on Earth and other other possible abodes like Mars, the Jovian moon Europa and Saturnian moon Titan.

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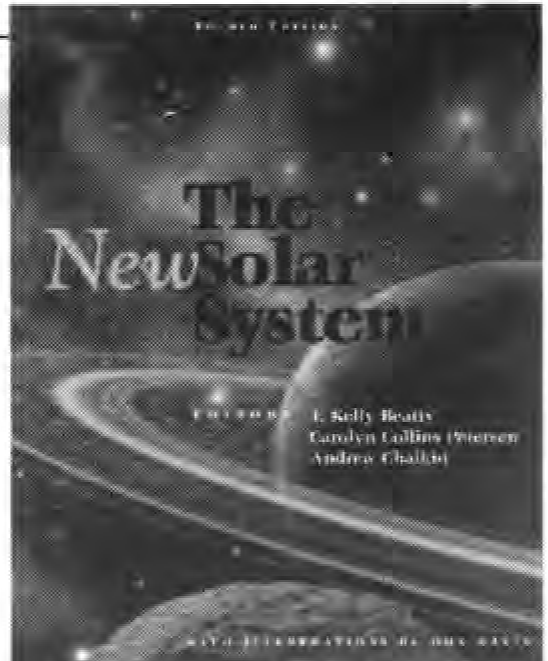
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