ISSN-0039-2502

Journal of the Association of Lunar & Planetary Observers

The Strolling Astronomer

Volume 45, Number 1, Winter 2003

Now in Portable Document Format (PDF) for MacIntosh and PC-Compatible Computers

Inside...

More on lunar domes

While not the subject of this month's dome study, we present here a view of lunar dome Mons Gruithuisen Delta (named for Franz von Paul Gruithuisen, a German physician-turned-astronomer) taken from an orbiting Apollo spacecraft. See page 12 for details.

•

Also . . .

Cover Graphic: John Sanford

* An ALPO project team to study Saturn's rings

* Isophotes of the Sun

* Getting ready for the upcoming Mercury/Venus transits

* Getting ready for the Mars apparition

* Jupiter and Saturn apparition reports

. . . plus reports about your ALPO section activities and much, much more.

THE ASSOCIATION OF LUNAR AND PLANETARY OBSERVERS (ALPO)

P.O. Box 13456, Springfield, Illinois 62791-3456 U.S.A.

Thank you for your interest in our organization. The Association of Lunar and Planetary Observers (ALPO) was founded by Walter H. Haas in 1947, and incorporated in 1990, as a medium for advancing and conducting astronomical work by both professional and amateur astronomers who share an interest in Solar System observations. We welcome and provide services for all individuals interested in lunar and planetary astronomy. For the novice observer, the ALPO is a place to learn and to enhance observational techniques. For the advanced amateur astronomer, it is a place where one's work will count. For the professional astronomer, it is a resource where group studies or systematic observing patrols add to the advancement of astronomy.

Our Association is an international group of students that study the Sun, Moon, planets, asteroids, meteors, and comets. Our goals are to stimulate, coordinate, and generally promote the study of these bodies using methods and instruments that are available within the communities of both amateur and professional astronomers. We hold a conference each summer, usually in conjunction with other astronomical groups.

We have "sections" for the observation of all the types of bodies found in our Solar System. Section Coordinators collect and study submitted observations, correspond with observers, encourage beginners, and contribute reports to our Journal at appropriate intervals. Each Coordinator can supply observing forms and other instructional material to assist in your telescopic work. You are encouraged to correspond with the Coordinators in whose projects you are interested. Coordinators can be contacted through our web site via email or at their postal mail addresses listed in back of our Journal. Out web site is hosted by the Lunar and Planetary Laboratory of the University of Arizona which you are encouraged to visit at http://www.lpl.arizona.edu/alpo/. Our activities are on a volunteer basis, and each member can do as much or as little as he or she wishes. Of course, the ALPO gains in stature and in importance in proportion to how much and also how well each member contributes through his or her participation.

Our work is coordinated by means of our quarterly Journal (*The Strolling Astronomer*). Membership dues include a subscription to the Journal. The ALPO offers a printed version of the Journal that is sent by regular mail. An identical digital (pdf) version is available over the internet at reduced cost. Subscription rates and terms are listed below.

We heartily invite you to join the ALPO and look forward to hearing from you. For your convenience, the form below may be filled out, detached, and mailed. Again, thank you for your interest in the ALPO

Membership dues include a subscription to this Journal and option to participate on the ALPO-Member-Discussion e-mail listserv. Membership dues are:

$US100 – Sponsor member level, 4 issues of the digital and paper Journal, all countries
$US50 – Sustaining Member level, 4 issues of the digital and paper Journal, all countries
$US46 – 8 issues of the paper Journal only, USA, Mexico and Canada
$US26 – 4 issues of the paper Journal only, USA, Mexico and Canada
$US60 – 8 issues of the paper Journal only, all other countries
$US33 – 4 issues of the paper Journal only, all other countries
$US19 – 8 issues of the digital Journal only, all countries, e-mail address required
$US11 – 4 issues of the digital Journal only, all countries, e-mail address required

Please make payment by check or money order, payable (through a U.S. bank and encoded with U.S. standard banking numbers) to "ALPO" There is a 20-percent surcharge on all memberships obtained through subscription agencies or which require an invoice.

Please Print:
Name____
Streeet Address______________________________________
____
Cit, Statte, ZIP ______________________________________
E-mail Address_______________________________________
Phone Number____
Please share your observing interests with the ALPO by entering the appropriate codes on the blank line below.
Interest____
Interest Abbreviations
0 = Sun 5 = Jupiter A = Asteroids R = Radio Astronomy 1 = Mercury 6 = Saturn C = Comets S = Astronomical Software 2 = Venus 7 = Uranus H = History T = Tutoring 3 = Moon 8 = Neptune M = Meteors P = Photography 4 = Mars 9 = Pluto I = Instruments D = CCD Imaging

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

Volume 45, No. 1, Winter 2003
This issue published in February 2003 for distribution in both portable document format (pdf) and also hardcopy format.

This publication is the official journal of the Association of Lunar & 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.

For membership or general information about the ALPO, contact:

Matthew Will
ALPO Membership Secretary/Treasurer
P.O. Box 13456
Springfield, Illinois 62791-3456

E-mail to: will008@attglobal.net

Visit the ALPO online at:
http://www.lpl.arizona.edu/alpo

In This Issue:

Inside the ALPO

Features

ALPO Resources

Inside the ALPO
Member, section and activity news

Association of Lunar and Planetary Observers (ALPO)

Board of Directors

Executive Director (Chair); Donald C. Parker
Associate Director, Richard W. Schmude, Jr.
Founder/Director Emeritus; Walter H. Haas
Member of the Board; Julius L. Benton, Jr.
Member of the Board; Richard Hill
Member of the Board; Ken Poshedly
Member of the Board; John E. Westfall
Member of the Board, Secretary; Elizabeth W. Westfall
Member of the Board, Treasurer and
Membership Secretary; Matthew Will

Publications

Acting Editor & Publisher, Ken Poshedly

Primary Observing Coordinators, Other Staff

(See full listing in *ALPO Resources* at end of book)
Lunar and Planetary Training Program: Coordinator;
Timothy J. Robertson
Solar Section: Coordinator, *Website, SolNet, Rotation Report,* handbook; Richard Hill
Mercury Section: Acting Coordinator; Frank Melillo
Venus Section: Coordinator; Julius L. Benton, Jr.
Mercury/Venus Transit Section: Coordinator;
John E. Westfall
Lunar Section: Coordinator; *Selected Areas Program;* Julius L. Benton, Jr.
Mars Section: Coordinator, *all observations, U.S. correspondence;* Daniel M. Troiani
Minor Planets Section: Coordinator; Frederick Pilcher
Jupiter Section: Coordinator; Richard W. Schmude, Jr.
Saturn Section: Coordinator; Julius L. Benton, Jr.
Remote Planets Section: Coordinator; Richard W. Schmude, Jr.
Comets Section: Coordinator; Gary Kronk
Meteors Section: Coordinator; Robert D. Lunsford
Meteorites Section: Coordinator; Dolores Hill
Computing Section: Coordinator; Mike W. McClure
Youth Section: Acting Coordinator;
Timothy J. Robertson
Historical Section: Coordinator; Richard Baum
Instruments Section: Coordinator; R.B. Minton
Eclipse Section: Coordinator; Michael D. Reynolds
Webmaster: Coordinator; Richard Hill

Point of View: A Road Well-Traveled

By Jeff Beish, ALPO Mars Section

During the years of on-again, and off-again ALPO staff participation I sometimes lose sight of who are contributors of our organization and forget to applaud those who make a difference. The ALPO staff is an all-volunteer workforce which, for the most part, exists for personal satisfaction and a feeling of camaraderie with like-minded observers.

One of the toughest jobs in ALPO is editing this Journal (*The Strolling Astronomer*), the centerpiece of our organization; its editors usually go without phrases of gratitude from the membership.

This is most likely caused by forgetfulness, but many of us realize that it is hard work and we should thank those involved.

First of all, I wish to thank our founder, Walter Haas, for his more than half-century of guidance and editing of *The Strolling Astronomer.* Without Walter we would only be a label on a dog food can. Instead, he set us on the road to success and happineess for which we all share in today.

And who can forget all the many years John Westfall edited this Journal? His continuing excellent editorship and guidance in ALPO should be applauded by the entire membership. Without John, who would know what a map of the Moon was supposed to look like?

Last -- but not least -- is Ken Poshedly who is current editor-in-chief of *The Strolling Astronomer.* Ken has done an excellent job and appears to be applying a more professional approach to the Journal in several ways. By utilizing the ALPO Publications Section editors, he provides increased credibility to our Journal, and we should offer a big thanks to Ken for his time and effort in this matter. Who would ever guess what the words, "etymology and orthography," really mean?

Listed on the ALPO Web Page Publications Section, are a number of editors, several of whom are experienced professionals and who are also amateur astronomers and who understand and appreciate the work of ALPO as well. I wish to thank Dr.. Klaus R Brasch, Dr. Richard K. Ulrich, and Dr. John E. Westfall for their time and effort in editing the Journal and keeping it to the high standard that it has always been.

(Continued on page 12)

Inside the ALPO
Member, section and activity news (continued)

Reminder: Address changes

Unlike regular mail, electronic mail is not forwarded when you change e-mail addresses unless you make special arrangements.

More and more, e-mail notifications to members are bounced back because we are not notified of address changes. Efforts to locate errant members via online search tools have not been sucessful.

So once again, if you move or change Internet Service Providers and are assigned a new e-mail address, please notify Matt Will at will008@attglobal.net as soon as possible.

****

New Dues Structure

Faced with increased costs all around, the ALPO membership dues structure has changed effective January 1, 2003.

Please see the last page of the *ALPO Resources* section of this Journal for complete details.

Our Advertisers

As we all know by now, there is no free lunch. Everything costs money. This Journal and various matters of the ALPO require funding. One way to help offset the costs of producing and mailing the hardcopy version of this publication is through advertising.

Please show your support of them as they show their support for us.

ALPO Conference News

The next annual meeting of the Assn. of Lunar & Planetary Observers will be Thursday through Saturday, August 7 - 9, 2003, at the Holiday Inn- Boardman, Ohio, 7410 South Avenue.

A block of rooms has been reserved for the meeting at a special rate of $89 per night; this rate is good until July 17, 2003. All attendees should make their own reservations directly with the hotel. It is preferred that rooms be held with any major credit card.

While a larger writeup of the event will appear in the next Journal, this event will have special significance. ALPO founder and director emeritus Walter Haas was born in New Waterford, Ohio, about 15 miles to the south of this meeting site. While this will not be Walter's first return to the area, it will be one in which he will have his ALPO friends and family joining him. We hope that all ALPO members will consider attending this special meeting.

The registration fee and other details are being finalized now. Contact the Holiday Inn at 330-726-1611, website: www.hiboardman.com

Note that the website URL and phone number as given here are corrected from what appeareed in the last Journal.

Observing Section Reports

Solar Section

Rik Hill, coordinator

Solar activity has been declining through the last quarter of 2002. But the members of the ALPO Solar Section have been busy recording what activity there was. Most notably, Ed Reed has been making drawing from 20-25 days a month and a number of observers have been imaging the sun almost daily. We have about three dozen observers that contribute observations and around 60 that have added to our database in the last year.

Though the activity dropped to about half what it was last summer still our data have increased due to email submission of images. The Solar Section has members watching the sun 24 hours a day now. This is a big improvement over a few years ago. Now as we head into solar minimum (due in a few years) it is still important that any and all activity be documented.

As this goes to press the next Rotation Report has just been finished and the next Solar Activity Report is being prepared. This will be the first such report that will be largely reliant on digital observations whether scanned images and drawings, video capture or direct CCDimages.

In November our long time email list address changed to Solar-ALPO@yahoogroups.com If you are interested in the up-to-the-date happenings on the sun and in the Solar Section you should be on this list. Daily sunspot designations are mailed to that list as well as alerts and warnings about impending sunspot activity and solar-terrestrial events. You can join by going to www.yahoogroups.com

Inside the ALPO
Member, section and activity news (continued)

Mercury Section
By Frank J. Melillo, coordinator

Dr. Ann Sprague of Lunar and Planetary Labratory in Tucson and Dr. Johan Warell of Uppsala University in Sweden have announced the special “first time” professional-amateur collaboration of Mercury observing ever! The ALPO Mercury section was invited to participate in this rare opportunity to provide valuable observations of Mercury for the professional.

The target dates were May 2 - 5th, 2002 (evening apparition) and June 22nd - 25th, 2002 (morning apparition).

All observations were received and we have a significant increase in the number of very excellent high resolution drawings and CCD images. In addition, a number of observers have been doing simultaneous observations and we have confirmed seeing the same aldedo features!

Results of the Mercury Observing Compaign will be included in the Mercury 2002 Apparitions Report to be published in an upcoming Journal.

Meteors Section
Robert Lundsford, coordinator

The ALPO Meteors section recently sponsored an expedition to the Mojave Desert to view the Quadrantid meteor shower. The main purpose of this expedition is to get observers together to compare ideas and methodologies. This was also the first opportunity the two ALPO Meteors Section coordinators were able to get together in the field to compare notes. Despite some interference from high clouds many meteors were seen and a good time was had by all. Another expedition is being planned for the Eta Aquarids in early May, before the temperatures become too intolerable.

The attached picture shows Robin Gray (L) and Bob Lunsford (R).

ALPO Meteors Section Acting Assistant Coordinator Robin Gray (left) with section coordinator Robert Lunsford.

Venus Section
By Julius Benton, coordinator

Venus 2002 Eastern (Evening) Apparition Ends; 2002-2003 Western (Morning) Apparition Begins

Observers have been sending in images and drawings of Venus as the 2002 Eastern (Evening) Apparition drew to a close on 2002 October 31 (Inferior Conjunction). Analysis of observational reports will begin soon, and observers are encouraged to submit all data, images, and drawings as soon as possible. Venus is now well-placed in the morning sky, marking the 2002-2003 Western (Morning) Apparition. Observers are urged to keep Venus under close surveillance during 2002-2003 for Ashen Light phenomena, and ultraviolet imaging of Venus in conjunction with integrated light imaging and photography, is especially important to monitor elusive atmospheric featrures.

All observational reports should be promptly submitted to the ALPO Venus Section. Forms and instructions on how to observe Venus can be obtained by visiting the Venus Page on the ALPO Website at http://www.lpl.arizona.edu/alpo. The Venus Handbook is also the main source for information on observing methods and techniques, and on how to plan and execute systematic observing programs (available from the ALPO Venus Section). Enthusiasts are encouraged to join the ALPO Venus Section e-Group at Venus-ALPO@yahoogroups.com to share information, observational notes, and generally keep up with recent announcements and alerts.

Summary of the ALPO Venus Observing Programs

Observations of the atmosphere of Venus are organized into the following routine programs:

Inside the ALPO
Member, section and activity news *(continued)*

1. Visual observation and categorization of atmospheric details in dark, twilight, and daylight skies.

2. Drawings of atmospheric phenomena.

3. Observation of cusps, cusp-caps, and cusp-bands, including defining the morphology and degree of extension of cusps.

4. Observation of dark hemisphere phenomena, including monitoring visibility of the Ashen Light.

5. Observation of terminator geometry (monitoring any irregularities).

6. Studies of Schröter's phase phenomenon.

7. Visual photometry and colorimetry of atmospheric features and phenomena.

8. Routine photography (including UV photography), CCD imaging, photoelectric photometry, and videography of Venus.

9. Observation of rare transits of Venus across the Sun.

10. Simultaneous observations of Venus.

Individuals interested in participating in the ALPO Venus programs should contact the ALPO Venus Section Coordinator at the address (e-mail and regular mail addresses providded in the ALPO Resources section of this Journal).

Meteorites Section: 2002 Annual Report
Dolores H. Hill, acting coordinator

The Meteorite Section of the ALPO was established as a provisional section in 2001. Dolores Hill has been the acting coordinator since that time. A web page was created to answer often-asked, general questions about identification of typical meteorites. It was designed to provide a reference for those without any scientific background as well as for advanced amateur astronomers who may be interested in pursuing a new dimension of their avocation. The latter are introduced to the most current meteorite classification scheme in use. Even amateur astronomers are surprised to learn that most meteorites that fall on the earth are, in fact, stony with only small flecks of iron-nickel metal rather than the solid iron-nickel meteorites they may have read about in astronomy books. As the public becomes more educated about meteorite types, the professional community of meteoriticists has the opportunity to study rare specimens that would otherwise go undetected.

We currently field several inquiries of a specific nature per month. The most common being "Is my rock a meteorite?" Thus far, no new meteorites have been identified in the course of investigation. However, this rate is quite typical of institutional public service inspections. In addition, there has been interest in records and historical accounts of "meteorites that have hit people or manmade structures". Certainly hazards and threats posed by large and small meteorite impacts relate in a very practical way to the purview of the Minor Planets Section and amateur Near Earth Asteroid searches.

Amateur astronomers are keenly aware of the role of asteroid and meteoroid impacts in the Solar System. Since we *do* have samples ejected from the Moon and Mars, it is natural to wonder if we also have samples of other bodies such as Mercury, Venus, or comets. Several observers have made inquiries on the nature of the meteorites that may be produced from such impacts. Such explorations of possibilities are an important means to their discovery. If history is any guide, it will most likely be amateurs that recover meteorites ejected from other planets.

A frequent topic of discussion and inquiry, especially approaching the ever popular Leonid and Perseid meteor showers, is that of backyard collection of micrometeorites. This is another area that is far more complicated than is realized. An article for the JALPO is in progress that will include historical methods and results along with techniques that the amateur can try at home.

Mr. Walter Haas has very generously donated early issues of *Meteoritics* and other scientific papers from his collection. There is plenty of resource material for future articles on historical meteorite recoveries and research. It is amazing to note that meteoriticists may have a more detailed knowledge of compositions, time scales, and relationships among meteorites, but still have many of the same basic questions from sixty-five years ago. We encourage young people to take up the continuing search for answers by exposing them to the excitement of meteorites.

It is hoped that future directions of the Section will include support in the way of continued education and opportunities for meteorite enthusiasts and collectors to see examples of meteorites on the web

Inside the ALPO
Member, section and activity news (continued)

page and JALPO. Other Sections have access to regularly observable Solar System objects and contributing Section members. The Meteorite Section must rely on the available inventory already collected by individuals, curated by institutions, and collected as new specimens recovered in sporadic fashion around the world. We are still developing ways in which the amateur can regularly contribute in meaningful ways to the scientific community. While the astronomer's tools capture photons in various ways, we, too, may look at the photons passing through a microscope thin section. It gives a new perspective on the Solar System to be able to physically hold a meteorite and explore its secrets up close. The ALPO web site allows the ALPO to reach many more people worldwide than ever before.

Lastly, I thank the ALPO board and Mr. Walter Haas, especially, for their enthusiastic support of the fledgling Meteorite Section and for their patience during this start up period.

Mars Section

By Dan Troiani, coordinator

This Section is bracing for the historic rendezvous with the Red Planet this summer. Neanderthal Man was around the last time Mars has been this close. In fact, Earth at that time would have been barely recognizable to modern humans. A full 59,540-year gap has elapsed since that time, more than 780 Halley's Comet apparitions! Truly, this will be an apparition in which the term "perihelic" will be a drastic understatement and one that will serve to underscore just how elusive Mars can be. There is such a drought, seemingly, between times we can perceive in such fine detail the familiar features we so long to re-charge our retinae with.

Already observations and reports have come in, and there will no doubt be enough to conquer the memory banks of HAL the computer (from the classic 1968 movie, “2001: A Space Odyssey”). Though of course, the reports so far are of a relatively diminutive, distant planet, it will be six arc-seconds or greater for nearly a year starting at the end of February and will spend an entire two-month period closer than at any time in the last 14 years. It seems now that Mars will take center stage just as the era of electronic imagery reaches full maturity. There are many new products to take advantage of in the electronic industry field.

Such is the extent of this apparition that more seasonal changes will be observable than normal. The most noticeable during the most favorable period will be the retreat of the South Polar Cap. But those who choose to watch in the early going will have a strong possibility of detecting water vapor clouds, including orographics. Limb brightenings are also possible. Dust storms historically occur some weeks past perihelion, and we would hope not for a repeat of last apparition's obscuration. Though not likely to be as propitious as those witnessed in 2001, specular flashes are expected shortly before opposition.

The Section is preparing for the expected media coverage of this event. We are hoping to have plenty of imagery to show to the public and will make it known as many ways as possible how to get to the Section's web site.

Minor Planets Section

Frederick Pilcher, coordinator

There will be a very close approach of minor planet 5381 Sekhmet to the Earth May 13-24, with the object moving rapidly southward and most favorably observed from the northern hemisphere in the first few days of this window. Sekhmet will be brighter in May than at any time in the rest of the 21st century. Interested individuals may obtain further information from the Section coordinator at pilcher@hilltop.ic.edu.

Minor planet observers are continuing to obtain quality CCD lightcurves of minor planets and derive new or improved rotation periods from them. In the year 2003 the Minor Planet Bulletin enters its 30th year of uninterrupted publication.

Jupiter Section

Richard W. Schmude, Jr.
Jupiter Section coordinator

Several people have submitted Jupiter observations either electronically or by postal mail. People are reminded that electronic submissions should be sent to the individual recorders and not just to the Jupiter listserv. There have been a number of images that were password protected and as a result were not received by the staff.

Jupiter has undergone several changes between November and January 2003. These changes include: 1) the fading of the NTB, 2) the development of new ovals in the SEB following the Great

Inside the ALPO
Member, section and activity news (continued)

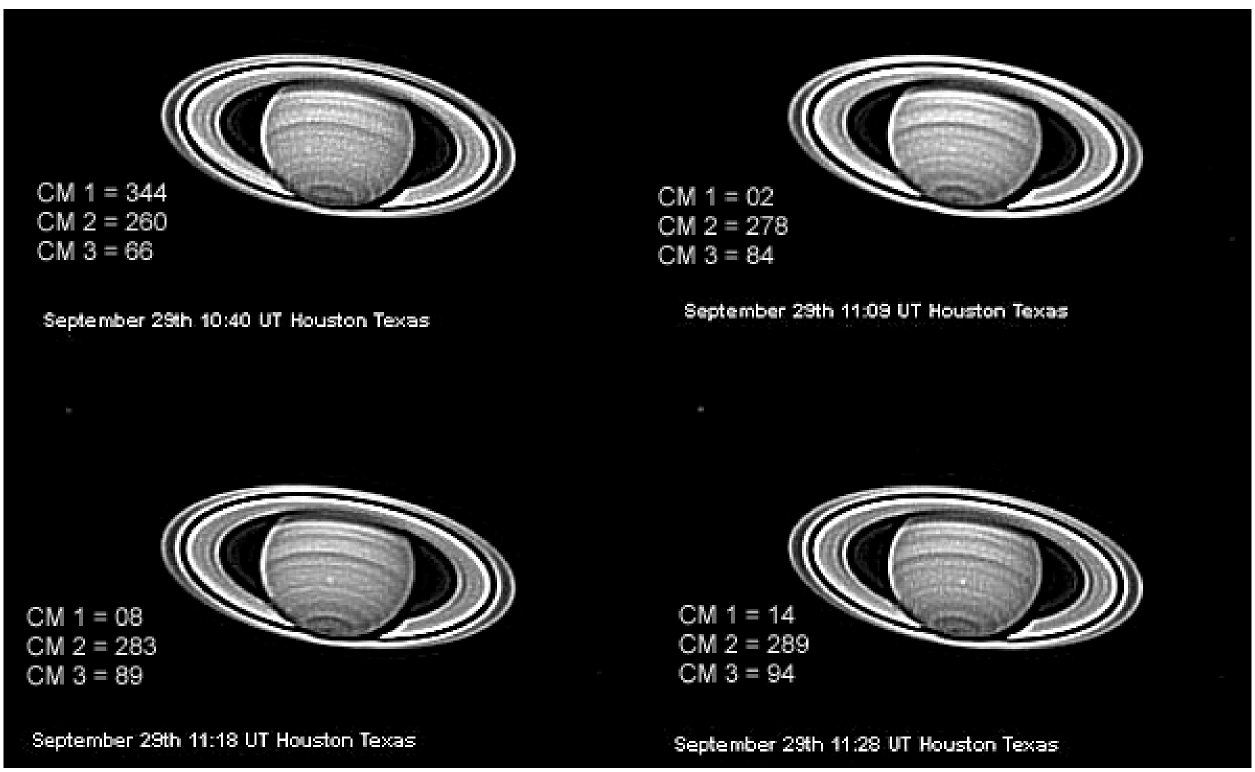
Red Spot (GRS), 3) the slowing down of oval BA in November, 2002 and 4) detail imaged in the GRS. Craig MacDougal sent out a Jupiter newsletter in mid-January and is planning to send out newsletters monthly until about June. Damian Peach has been busy imaging Jupiter while John Westfall continues to collect visual transit timings of Jupiter's 4 brightest satellites. John McAnally has been busy with analyzing transit timings of Jupiter and has also been in contact with the two newest staff members: Ed Grafton and Clay Sherrod. Ed and Clay will assist with analyzing transit timing data and other projects as needed.

In the months of March through May, people are asked to continue to monitor the Great Red Spot for color changes. Dr. Schmude would also appreciate seeing images of Jupiter showing the moons Europa, Io and Ganymede transiting the disc. People are also asked to monitor the longitude of oval BA and to watch the area where the North Temperate Belt resides.

Saturn Section
By Julius Benton, coordinator

Observers have started sending in observations, drawings, and CCD images of small white spots and other disturbances in Saturn's Southern Hemisphere during the current 2002-2003 apparition. This has prompted many to speculate that activity on Saturn's globe may be increasing slightly. For example, Ed Grafton of Houston, TX, using an ST5 CCD, 14-inch f/11 Celestron SCT, Barlow Projection @ f/27 (approximately 0.21 arc seconds per pixel) imaged a small high-latitude white spot on Saturn on 2002 September 29 11:28UT (CM I 014 degrees, CM II 289 degrees, CM III 94 degrees). The spot was very near the CM at the time of the images. See accompanying images taken by Ed Grafton.

Observers are strongly urged to keep Saturn under close scrutiny in the next several months, immediately sending all observational reports to the A.L.P.O. Saturn Section. Forms and instructions on how to observe Saturn can be obtained by visiting the Saturn Page on the ALPO Website at http://www.lpl.arizona.edu/alpo. *The Saturn Handbook* is also the



Saturn images by Ed Grafton. See text of Saturn section report for details. (North at top, IAU east at right.)

Inside the ALPO
Member, section and activity news (continued)

main source for information on observing methods and techniques, and on how to plan and execute systematic observing programs (available from the ALPO Saturn Section). Enthusiasts are encouraged to join the ALPO Saturn Section e-Group at Saturn-ALPO@yahoogroups.com to share information, observational notes, and generally keep up with recent announcements and alerts.

Remote Planets (Uranus, Neptune and Pluto)

Richard W. Schmude, Jr.
Remote Planets Section coordinator

Approximately 20 people have already submitted observations of the remote planets during the 2002 apparition. Based on the results received in the last six months, the main highlights have been: 1) The sighting of at least one albedo irregularity on Uranus and 2) a slight dimming of Neptune.

Mario Frassati and his son Lorenzo submitted a video image of Uranus in late November that shows a dark area near the north limb. Parker and Venable have also noticed limb irregularities on Uranus, while Haas and Schmude have suspected irregularities on Uranus. Melillo continues to make valuable photometric measurements of the remote planets and their moons.

Uranus, Neptune and Pluto will all be visible in the early hours of the morning during March through May. I am especially interested in the following types of observations:

- Magnitude/color measurements of the three remote planets
- CCD images of Uranus
- Methane band images of Uranus and Neptune
- Telescopic observations under excellent seeing conditions.

Interest Section Reports

Lunar & Planetary Observing Training Program

By Tim Robertson, coordinator

The ALPO Training Program currently has four active students at various stages of training. And in the past 12 months, we have had requests for 32 copies of the *Novice Observers Handbook*.

Statistics show that about 30% of those who order the *Novice Observers Handbook,* actually start the training program, and out of that, 20% actually complete the Novice phase of the program. In my informal poll of some of the past and current students, it seems that personal commitments and time to observe constraints hinder the advancement in the program.

The ALPO Training Program is a two-step program, and there is no time requirement for completing the steps. But I have seen that those students that are motivated usually complete the steps in a short amount of time. The motivation comes from the desire to improve their observing skills and contribute to the pages of the Journal of the ALPO.

The Lunar and Planetary Training Program is open to all members of the ALPO, beginner as well as the expert observer. The goal is to help make members proficient observers. The ALPO revolves around the submission of astronomical observations of members for the purposes of scientific research. Therefore, it is the responsibility of our organization to guide prospective contributors toward a productive and meaningful scientific observation.

The course of instruction for the Training Program is two-tiered. The first tier is known as the “Basic Level” and includes reading the ALPO's *Novice Observers Handbook* and mastering the fundamentals of observing. These fundamentals include performing simple calculations and understanding observing techniques. When the student has successfully demonstrated these skills, he or she can advance to the "Novice Level" for further training where one can specialize in one or more areas of study. This includes obtaining and reading handbooks for specific lunar and planetary subjects. The novice then continues to learn and refine upon observing techniques specific to his or her area of study and is assigned to a tutor to monitor the novice's progress in the Novice Level of the program. When the novice has mastered this final

Inside the ALPO
Member, section and activity news (continued)

phase of the program, that person can then be certified to Observer Status for that particular field.

For more information on the ALPO Training Program, contact Tim Robertson at: cometman@cometman.net, or Tim Robertson, 2010 Hillgate Way #L, Simi Valley CA, 93065.

Computing Section

By Mike McClure, coordinator

New links are now available on the ALPO Computing Section Website (www.m2c3.com/alpocs) Ephemeris Page:

Space Calendar
Jovian Satellites Occultations
Jupiter Central Meridian Longitudes (this web-calculator will calculate the central meridian longitudes for each of the three Jovian systems (I, II, & III)).

In addition, the following articles are now available: www.m2c3.com/alpocs --> Library --> Articles (Note – These articles are re-printed/re-linked from our old Computing Section newsletter):

- CPU's in Space Exploration by Bill O'Connell
- Measuring Celestial Dimensions with Micrometers By: Jeff Beish
- Practical Calculations for the Newtonian Secondary Mirror by Jeff Beish
- Nuts and Bolts of Computing the Ephemeris Part 1 by Jeff Beish
- Nuts and Bolts of Computing the Ephemeris Part 2 by Jeff Beish
- Nuts and Bolts of Computing the Ephemeris Part 3 by Jeff Beish
- Nuts and Bolts of Computing the Ephemeris Part 4 by Jeff Beish
- Astronomical Time-Keeping
- The Solar Ephemeris - A BASIC Program for Observers of the Sun by Brad Timerson
- Windows International Mars Patrol Astronomical Calculator (WIMP) by Jeff Beish

Events of Interest

2003 PEACH STATE STAR GAZE

With a decade of success now behind it, the Peach State Star Gaze proudly celebrates its 10th anniversary this coming October with a repeat visit by the author of the world-famous "Atlas of the Moon", Antonín Rükl, Dr. Brian G. Marsden of the International Astronomical Union, and Dr. Richard Schmude, observing coordinator of the ALPO's Jupiter and Remote Planets observing sections. Dr. Schmude is also an associate professor at Gordon College's Department of Science and Physics (Barnesville, Georgia). His presentation will be about the this year's Mars apparition.

The event is scheduled for Wednesday - Sunday, October 22 - 26, at Whitewater Express, an outdoor activities venue located about on the Georgia/Tennessee line. Lodging and outdoor camping is available onsite. There will also be various workshops and other talks.

With this being the 10th anniversary PSSG, a full-color cloth patch celebrating the event is being issued and will be presented free to the first 200 persons who pre-register (limit 2 per family). Additional copies of this ceremonial patch will be available for sale at the event itself.

Preregistration is required and no walk-ins are permitted

More news about the PSSG will be published in the coming weeks and months on the official website of the Atlanta Astronomy Club at http://www.atlantaastronomy.org (click on the link for "PSSG2003"). Plus, all are invited to join the PSSG listserv; simply send a subscribe message to PSSG-Discussion-subscribe@yahoogroups.com, or contact Ken Poshedly at poshedly@bellsouth.net .

Letters

The opinions expressed in the "Letters" section of this Journal are those of the writer and do not necessarily reflect the official policies of the ALPO.

The Moon, Pluto and Charon

Sirs:

I read with interest both Richard Schmude's report on the Remote Planets in JALPO44-3 and the letter by Stephane LeComte in JALPO44-4 and thought there

Inside the ALPO
Member, section and activity news *(continued)*

might be some value in the experience Seth Hansell and I had in viewing Pluto some years back. There are a handful of observations that one makes in their life that stand out and are remembered vividly. This was one of those.

I frequently worked on the 61-inch Catalina Telescope back then (now called the Kuiper telescope). This is the telescope that Alika Herring and Ewen Whitaker used on the Moon back in the 1960's. It is nothing short of a spectacular instrument! The optics leave little to be desired.

It was May 4/5, 1996 and what a night it was. The sky was clear and steady. Venus was at greatest brilliancy with Mercury between it and the twilight horizon. Seth was a grad student working on observing lightning flashes on Venus with a special coronagraphic instrument. I had volunteered to help him out since I knew the software that ran the camera. When Venus had set and we were done with our requisite observations we began a tape back up of the data which would take a few hours. This gave us time to use the telescope visually. With one of the old World War II Erfle eyepieces, that gave just under 300x, we first looked at a number of old favorites (M13, M3, NGC 4565, 6207, 6210 to name a few). We also took a look at solar system objects, most particularly Pluto and the Moon.

At the location of Pluto we found a close faint double star. Both stars were clearly visible but very close. We tried to figure out which one might be Pluto when it dawned on us that it might just be Charon! A look at the Astronomical Almanac and a quick calculation convinced us that we had Charon at elongation. The two objects were seen as small stars, just touching aligned SW/NE. A check the next day with some of our software, confirmed that we had indeed seen Pluto and Charon at greatest separation of 0.7 arc seconds with a PA of about 160 degrees!

Before quitting we turned the telescope on the Moon at about 0800 UT. The Moon was near perigee and just two days past full and Petavius was on the terminator. This was the first thing I ever photographed astronomically back in 1965. Then I was just able, with my RV-6, to capture the crack that runs from the central peaks to the crater wall. In the 61-inch we were able to see details on the edge of the crack. The crater entirely filled the eyepiece and was blindingly bright even though it was half filled with shadow. The floor of the crater was not smooth as smaller telescopes show, but rather was undulating, cracked and broken. The whole scene looked exactly like the old Nasmyth & carpenter lithographs. What a thrill this was! We looked around.

The little craterlet in the wall of Torricelli was visible even in the rather high sun at that spot. In Messier we could see the crease along the floor and in Messier A we could easily see the ejecta blanked to one side.

At this point I realized that the phase was just right to make an observation of the "O'Neil Bridge" I had recently read about in a journal. So we swung over to M. Crisium, half in shadow and prominent. Proclus was bright and striations stetching from the floor to the top of the crater walls were seen.

A long ridge marked a serpentine illumination boundary through the center of the mare, very near the Luna 15 landing site. The spot where the "Bridge" was supposed to be was two ranges of mountains that almost touched. They were clear and unmistakable and the mountains were very craggy with many minor peaks and valleys. There was no impression of any sort of bridge, just normal mountain ranges and a pass between them and a few isolated peaks scattered about. In this telescope nothing was smooth, not even the floor of Crisium. I only wish I could have made a drawing of the region, but that would have taken all night with the amount of detail we were seeing!

Best regards,
Rik Hill
ALPO Solar Section coordinator

****

Frost on Mars revisted

Sirs:

In his article "Frost, Dunes on Mars, and Specular Reflections" (JALPO Vol. 44, No. 3) author Eric Douglass mischaracterizes the "flares" that we recorded at Edom Promintorium in June 2001 as being "of two types, a quicker five-second flash and a slower, gradually evolving brightening." The published accounts of our observations describe phenomena that persisted for tens of minutes, characterized by dramatic pulsations in brightness that were reminiscent of blowing on a glowing ember. These pulsations were typically of two to four seconds duration and were accompanied by discrete, localized flashes (usually at the northern end of Edom Promontorium) that lasted for mere fractions of a second.

Inside the ALPO
Member, section and activity news *(continued)*

Douglass further states: "The observers did note that there was gradual brightening of the Edom region across the several days of observation." This was emphatically not the case.

Douglass' explanation of the nature of Martian frosts and fogs is similarly flawed. He writes: "In temperate latitudes of Earth, most frost crystallizes directly from water vapor when the air is exposed to a cold surface. On Mars, rime frost may be more common. This type develops when water droplets (fog) are supercooled and, upon contacting a surface, freeze immediately." The existence of droplets of liquid water in Martian aerosols is not possible given the exceedingly low atmospheric pressures prevailing on the planet.

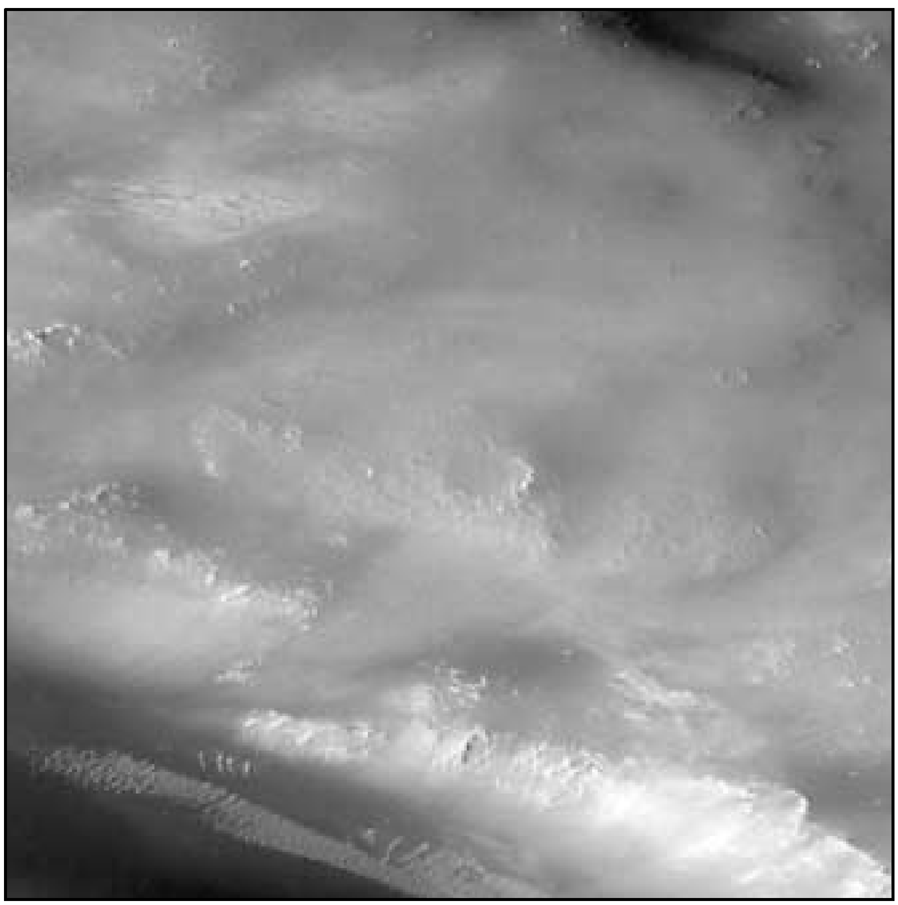
University of Nebraska astronomer Professor C. Martin Gaskell has argued that the 19-degree inclination on an east-west axis of the reflectors in Edom strongly favors a location on the surface, not a meteorological source as proposed by Douglass, while the comparative rarity of observations of Martian specular reflections militates against the "reflective rock surfaces" proposed by Douglass as yet another alternative:

I am particularly intrigued by the pulsations... If the pulsations in brightness occur on a timescale of around four seconds, this corresponds with motion of the Martian surface imparted by the planet's axial rotation of 200 meters, consistent with the size estimates derived from the brightness. What I would envisage then are patches of ice with typical spacings of a kilometer or two.

Since the Martian reflectors are inclined to the horizontal a fair bit, this strongly rules out clouds. It's got to be on the surface. The range of inclinations can be readily explained by a range of slopes on the surface. The rapidity of the fluctuations tells us that there are regions of the reflector with slightly different slopes. The size of region needed to explain the flashes of a few seconds duration is only a few times bigger than a football field. There are plenty of flat regions on this scale. I think the faces of dunes are an interesting possibility, although by no means the only one. These flashes are only seen when the weather is right, not every day, so they are fog or frost induced. It's not shiny rocks.

Here's my scenario for what happens: In the morning the Sun heats the ground and makes water evaporate. Martian air is always close to saturation and, unlike the Earth's, is significantly colder than the ground. Ice crystals therefore condense in the air above the ground, forming a fog… The ice crystals fall on the ground, creating a deposit of frost. Fog and frost must go hand in hand.

While Douglass admits that frost can form in the area where the flares appeared, he speculates "it likely sublimates during the day due to the equatorial location of Edom." But as Professor Gaskell explains:



High-resolution image of Edom taken in 1997 by the Mars Orbiter Camera (see text).

Ice crystals have a very high albedo, so they inhibit heating of the ground where they fall and they can stay there for quite a while. On Mars, unlike on the Earth, the surface temperature is ruled almost entirely by the amount of sunlight absorbed and by the emissivity of the surface, not by the atmosphere.

Jet Propulsion Laboratory planetary geologist Timothy Parker also favors the hypothesis of dunes as sources of specular reflections:

Many of the narrow-angle images of the terrain southwest of Schiaparelli show dune fields with crests oriented roughly north to south. The eastward-facing slopes could easily be on the order of 10 or 20 degrees, and might be acting as a field of reflectors.

One high-resolution image of Edom taken in 1997 by the Mars Orbiter Camera is particularly supportive of this notion (see page 10)

According to the Jet Propulsion Laboratory press release that accompanied the release of this image (which can be viewed online at http://photojournal.jpl.nasa.gov/catalog/PIA01026):

The small dunes moving from left to right (north to south) along the canyon floor [at bottom left] are apparently derived from bright deposits within Schiaparelli crater. They are brighter than most Martian dunes and may represent a unique composition. The shape of the dunes, and their relationships to one another, strongly suggest that these dunes have been active recently, although whether that means within the past year or the past century cannot be told from these images alone.

Despite compelling evidence of the presence of both frost and bright dunes at the site where the flares appeared, the question remains: "Why did Douglass' experiments fail to produce specular reflections?"

For a specular (from the Latin for "mirror," speculum) reflection to occur, the rays of light in the incident beam must be parallel, like the rays of sunlight that fall upon the surface of Mars. When parallel rays strike a smooth, planar surface, the reflected rays maintain their parallelism because the irregularities of a shiny surface are smaller than the wavelength of the incident radiation. Maintaining the parallelism of incident rays is the very essence of specular reflections.

Douglass fails to describe the light source that he employed. Given its close proximity to the soil samples within the confines of a small cardboard box, if it were a diffuse or Lambertian emitter (like an incandescent or fluorescent bulb) the result would hardly constitute a meaningful simulation. (The images accompanying the Douglass article strongly suggest that a diffuse or diverging light source was employed.) Moreover, any attempt to replicate Martian frosts by freezing an aerosol of water droplets at ambient terrestrial atmospheric pressure is highly questionable.

We believe that the hypothesis that the flares recorded at Edom Promontorium in June of 2001 were specular reflections from frost on the slopes of dunes remains a viable one.

Donald C. Parker
Thomas A. Dobbins
William P. Sheehan

****

(Eric Douglass replies)

(1) I regret any misrepresentation of these authors' observations; this was certainly not intentional. My information came from the paper Don Parker gave me at the ALPO meeting in 2001. This included the following statements: "These events occurred at sporadic intervals (typically 30 seconds), with recurring brightness maxima of approximately 2 to 3 second duration," and later: "The first was a series of short-lived (3 to 5 second) brightenings." In another place the paper stated: "From June 2 to June 6, Edom Promontorium appeared to grow brighter in its characteristic but mundane fashion as the rotation of Mars carried it towards the central meridian." This was attributed to De and Ds converging.

(2) I think this is a wonderful opportunity for readers to examine contradictory studies, and draw conclusions for themselves. Here one can evaluate the claims, limitations, and conclusions of each study.

(3) Did I make mistakes? Yes. For example, where I wrote about a water droplet fog (on Mars, given the atmospheric pressure, ice fogs occur). As to the comments about not replicating the Martian atmospheric pressure and sunlight: I noted this in my original paper (under "Discussion"). I am an amateur, and don't have the equipment available to create that environment. Does that mean that amateurs are excluded from trying to contribute to science? Or do we work with the equipment we do have available and make mention of our limitations?

(4) The tone of their response seems harsh. Yet my paper was no surprise. I sent one of the above authors a copy of it nearly a year ago, and his response was: "*WOW! Great job. I am leaving in a few hours to take a scope mounting to (deleted name) in Lake Placid. Will be back Friday and will study the paper and figures more diligently then. Looks very promising and would also explain why these "flashes" occur only in a few places at a narrow range of times. If due to frost, they would be common, not rare. Could you e-mail me your phone #? I might have to call you over the weekend if that's OK.*" Yet instead of continuing this dialogue, we receive the above paper. It is this kind of action and tone that discourages, instead of fosters, amateur participation in projects.

Respectfully submitted,
Eric Douglass

This month's cover

Located at 36°.0 N 39°.5 W (see Plate 9, from Rukl's *Atlas of the Moon*, right), Mons Gruithuisen Delta has a base of 20 km across. Its namesake, Franz von Paula Gruithuisen (1774-1852), was German physician-turned-astronomer who was among the most prolific of his age in terms of published output. He was a professor of astronomy at Munich from 1826, and he argued energetically in favor of advanced life on the Moon and inner planets. On the subject of a lunar civilization, he supported Schröter's similarly exuberant claims and wrote such papers as "Discovery of Many Distinct Traces of Lunar Inhabitants, Especially of One of Their Colossal Buildings" (1824), claiming that he had seen roads, cities, and a star-shaped "temple." Such extraordinary inferences, from what otherwise may have been sound telescopic observations, made him the object of ridicule by fellow astronomers, even those who appeared generally sympathetic to the idea of lunar life, such as Gauss, von Littrow, and Olbers. Gruithuisen's over-active imagination also led him to suggest that the "ashen light" of Venus was due to "festivals of fire given by the Venusians . . . celebrated either to correspond to changes in government or to religious periods."

(Text source: http://www.angelfire.com/on2/daviddarlin/Gruithuisen.htm; *Atlas of the Moon* map image used with permission.)

A Stereo JALPO?

I got my JALPO last Friday with the intention of reading it on Saturday, but the events of that day caused a delay until Tuesday.

If you look at the article of Plato's hook beginning on page 40, one can orient the page to look at the images in stereo, and pages 42 and 43 are easier to look at. The detail in the image stands out better than in the single image, and the shadows are more enhanced. This makes it all the easier to view these images.

Even the images of Venus are better viewed this way, and of course Mercury also. For this to happen, the images must be taken close together it time, a few minutes apart will do, and in some cases longer. Many images can be viewed this way, for instance Jupiter, (see Jupiter web site for images). Jupiter will show the curvature of its globe, and the satellites will stand out as in a 3D image. Saturn also can show interesting detail that you would not see in a single image.

This is quite interesting as I have been doing this kind of observing for many years and have enjoyed many views of images that are not just plain flat. I hope this will give greater enjoyment to you when looking at images this way.

Mike Mattei
mmattei@rcn.com

Ah, Shucks

Ken,

I'd just like to add my own "kudos" to all of the others you've received on Vol. 44 No. 4 of *The Strolling Astronomer.*

You've been doing an OUTSTANDING job as editor of the JALPO, and so have all the contributors. But you're the one who pulls it all together and gets it in print. And I think you do a really, really fantastic job. I know how much time and effort goes into it, too.

Keep up the good work, and thanks for your dedication.

Bill Mellberg

[The editor thanks you for those kind words, but also has to pass along his own thanks to the growing list of reviewers, proofreaders and contributing writers to the Journal who have helped it grow larger and better.]

Point of View
(continued from page 1)

Occasionally some of us publish articles in the popular press or papers in our Journal and professional journals as well, then gain apparent notoriety that can be pleasing to our egos. At times we even receive compensation for our efforts. We tend to forget the observers that make it possible for us to participate in such fanciful delights, so I wish to thank all the observers who participate in our observing programs and make it possible for us to get out the word for ALPO.

When we mention ALPO, we are actually speaking about the contributing observers and members who freely offer their time and effort for the ALPO team. Without you, we would only be a label on a can of dog food!

ALPO Announcement

A Proposed Project for 2003-2004: Photoelectric Photometry of Saturn's Rings

A team consisting of Walter Haas, Julius Benton, and Fred Pilcher of the ALPO have formed an observing project as a subset of the regular programs of the ALPO Saturn Section to do photoelectric photometry of Saturn's rings. This is a strategy to improve observations to detect and quantify the curious Bicolored Aspect of Saturn's Ring A pursuant to the article written by Thomas A. Dobbins, Alan Heath, and Valeri Dikarev entitled "Saturn's Colorful Mystery" in the January 2003 issue of *Sky & Telescope* magazine.

The ALPO Saturn Section project would monitor extremely small brightness fluctuations in different wavelengths at various position angles around Saturn's ring system. The technique suggested by Haas, Benton, and Pilcher would involve the use of old-style photoelectric photometers of the 1970's or early 1980's vintage, and an aperture of roughly 1.0 to 2.0 arcseconds. The technique would use the standard Johnson UBV filter set (or perhaps just B and V), perhaps supplemented with other standard filters such as the Kron R and G filters. Applied to Saturn's rings, this would admit the large amount of light required for very precise magnitude measurements. Observations at 10 to 15° intervals in position angle all the way around Ring A, calibrated with Ring B measurements, would be repeated at time intervals of 20 to 40 minutes on a single night. Such measurements should capture any progressive changes in the rings with the revolution of Saturn of conjectured underlying structures. Routine observations of this kind throughout several observing seasons (or apparitions) should provide quantitative information, currently lacking, which theorists need for model building.

The ALPO team is trying to locate observers who have older photoelectric photometers who would be interested in participating in this long term project

The greatest difficulty is that photoelectric photometers have largely been replaced by CCD photometers due to their relative ease of use, but the latter are also inherently less accurate. The ALPO team is trying to locate observers who have older photoelectric photometers who would be interested in participating in this long term project, slated to begin with the 2003-2004 apparition of Saturn (which begins soon after Saturn emerges from conjunction with the Sun on June 24, 2003). It is believed that there may also be professional and/or university observatories who possess top-of-the-line photoelectric photometers left over from the 1970'2 or 1980's that could be brought back into use.

More developments shall be forthcoming on this project, but observers who are adequately equipped are encouraged to join the team for the 2003-3004 apparition of Saturn. All inquiries should be addressed to the ALPO Saturn Section at the following address:

Julius L. Benton, Jr., Ph.D.
Coordinator - ALPO Saturn Section
c/o ASSOCIATES IN ASTRONOMY
305 Surrey Road, Wilmington Island
Savannah, GA 31410 USA
Telephone: 912-897-0951
Cellular: 912-661-3924

E-Mail: jlbaina@msn.com (All Routine E-Mail + Observations & Images)
E-Mail: jlbalpo@netscape.net (Back-Up E-Mail + Observations & Images)
E-Mail: jbenton55@comcast.net (Alternate E-Mail + Observations & Images)
Website: http://www.lpl.arizona.edu/alpo
eGroups: Saturn-ALPO@yahoogroups.com

ALPO Feature: The Sun

Techniques for Viewing Sunspot Umbrae with Isophotes

By Jamey Jenkins

Introduction

To an observer of the Sun the umbrae are the darker "cores" of sunspots. Close inspection of an umbra will reveal differences in color and density, often portrayed in a pattern that resembles a saddle shape. Some solar observers have reported colors that run the gamut from black through a deep reddish-brown. The stronger the magnetic field of the area, the darker the umbrae will be, this being an indicator of the relative photospheric temperature. That is, brighter regions equate to hotter regions.(1)

For the visual observer recognizing these delicate differences can be a challenge. Atmospheric turbulence and wide ranges in tonal gradation (between the umbra and the surrounding photosphere) make it difficult to catch more than a glimpse of what is happening here. A better method of studying the subtle density gradation within the umbral structure is a photographic technique which generates isophotal images.

"Isophotes" are lines or areas exhibiting a same or similar density.(2) Isophote charts may be grayscale or color diagrams that depict these regions in a manner that graphically illustrates the areas of various density levels.

Using this technique of solar study, the observer can expect to identify a number of interesting features of a sunspot group including the inner and outer bright rings, weak light bridges, and the core or point of minimum intensity within the umbra.

Contour Mapping

Although my experience with isophote mapping has been limited to photographs obtained from film, the newer digital cameras can surely be useful with this technique. A necessary precaution is the restriction of scattered light within the optical tube assembly. Much of this can be controlled with proper baffling and limiting the number of reflections in the optical path. The purist may wish to devise a small diaphragm to place at the prime focus of the telescope covering all but the sunspot's umbra and then to increase the exposure two, three, or fivefold to record deeper umbral detail.(3) I have found acceptable initial results by creating isophotes from my conventional high-resolution images obtained on Kodak's 2415 Technical Pan film.

Older darkroom techniques would have required one to spend hours creating masks and films that separated out the different density values from a negative. The common household personal computer has eliminated most of the work here and left us to point-and-click our way to producing the necessary density separated files.

A film image must first be digitized in order to be manipulated with a computer. The simplest method is to use a film scanner with a suitable bit depth. The Olympus ES-10 scanner produces a 24-bit 300-dpi scan which is acceptable for our task. Once the film is scanned, converted from RGB to grayscale, and cropped to eliminate all but the area of interest, it is saved in a TIFF format. This saved file is then opened in a software package called "NIH-Image."

NIH-Image is freeware, available for the Macintosh and PC platform. For a PC, it is called "Scion Image for Windows". *NIH-Image* can acquire, edit, enhance, analyze and animate images.(4) For information regarding the downloading of NIH-Image, Scion Image, and pertinent user manuals see this site on the internet: http://rsb.info.nih.gov/nih-image/.

One of the functions of the Image program allows the user to create a density slice of a photograph. A "LUT" (Look Up Table) tool is used to vary the upper and lower density limits being displayed and the location of the slice within the 256 levels of gray. When density slicing is enabled, slices are highlighted in red and the background pixels are left unchanged. On screen, I typically start with a medium slice of approximately 15-20 steps and move it in increments of 15-20 steps through the 256 level range, saving a screen shot of each position as the steps progress. These individual "frames" may be combined into an impressive animation later depicting the flow of density, which translates into brightness and temperature, from the coolest umbral regions to the warmest photospheric areas. To create a single isophote map however, one needs to combine or layer the multiple shots into a single frame. *Adobe Photoshop* permits this with simple copy-and-paste techniques; other software may allow the observer the same freedom.

Sample Observations

A pair of photos from the last activity maximum are good examples of what one may expect by using this technique to supplement their regular observations. AR8297 was captured on a day of fine seeing, 12 August, 1998, with a

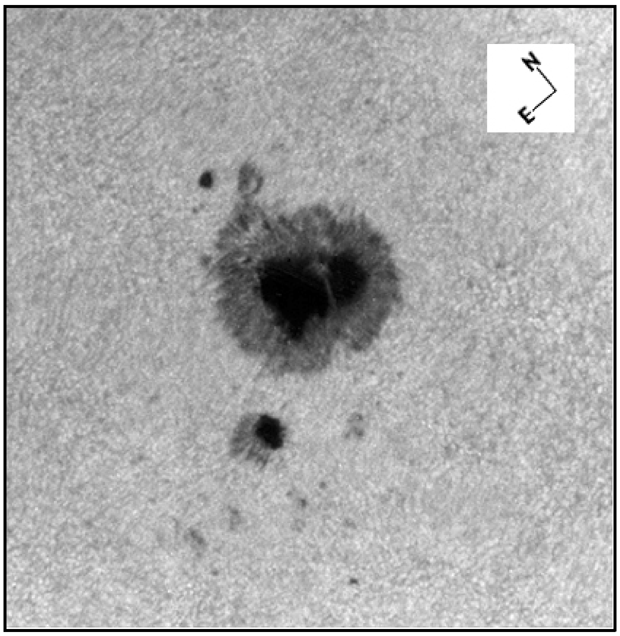


Figure 1: Conventional sunspot observation of AR8297 from 12 August 1998, 15:50 UT, as submitted to the ALPO Solar Section. Carrington Rotation 1939. Equipment: 125 mm refractor at f/64, #58 filter, image taken on Kodak 2415 Tech Pan film, seeing excellent, transparency, fair. Image by Jamey Jenkins.

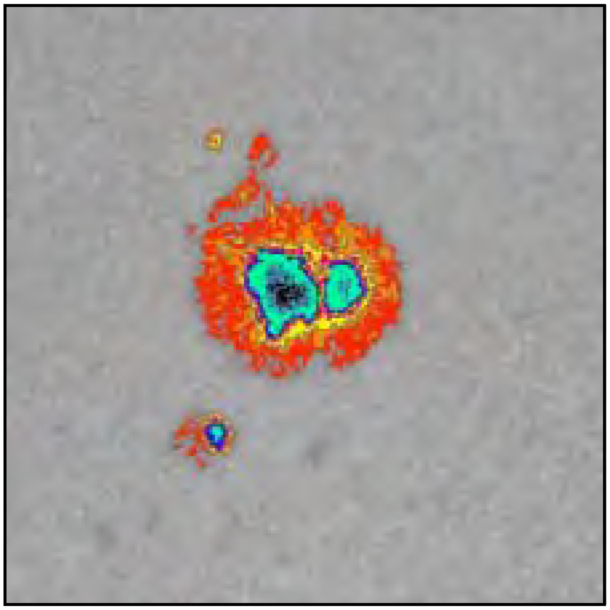


Figure 2: Isophotes of Figure 1 created using NIH-Image software and combined with Adobe Photoshop. Note darker core region at left, indicating a stronger magnetic field than core at right. Image by Jamey Jenkins.

125mm aperture refractor operating at f/64. A conventional photo or onscreen display fails to show the detail visible in the isophote image. The umbra has begun to divide with a clearly seen light bridge. The left half of the umbra is darker indicating a stronger magnetic field and cooler temperatures. The photo from 5 April, 2001 illustrates the spot group AR9415 as it came around the east limb of the sun.

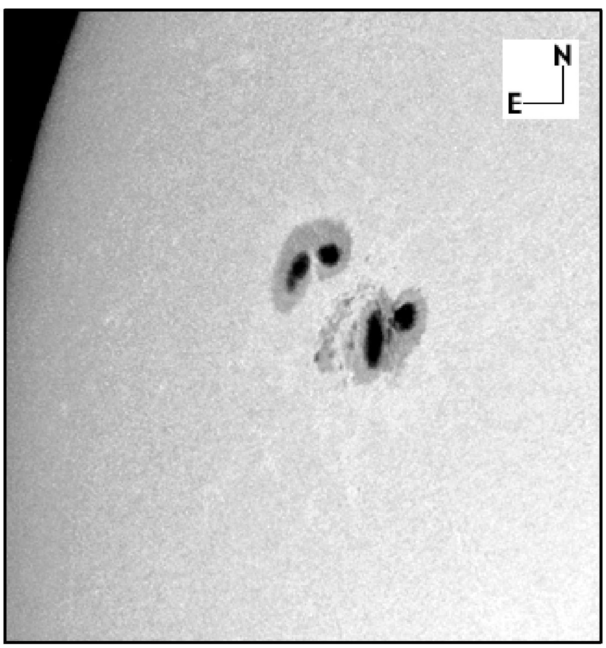


Figure 3: Conventional sunspot observation of AR9415 from 5 April 2001, 14:50 UT, as submitted to the ALPO Solar Section. Carrington Rotation 1974. Equipment: 125 mm refractor at f/64, #58 filter, image taken on Kodak 2415 Tech Pan film, seeing fair, transparency, fair. Image by Jamey Jenkins.

AR9415 was indeed a very rare bipolar group. Observations from the isophote image indicate the irregular transition of density as one transverses the umbrae. Also note that in this case the leading spot of both primary elements is found to have the greater density, stronger magnetic field and cooler temperatures.

One of the most interesting results of this type of work is the demonstration of the existence of a "core" in the umbra. The core is typically only a few arc seconds in diameter, with a temperature as much as 500 degrees less than that of the remaining umbra. As early as 1916, Father Stanislas Chevalier in China hinted at the existence of an umbral core and it is likely that several other earlier observers noticed this feature.(3)

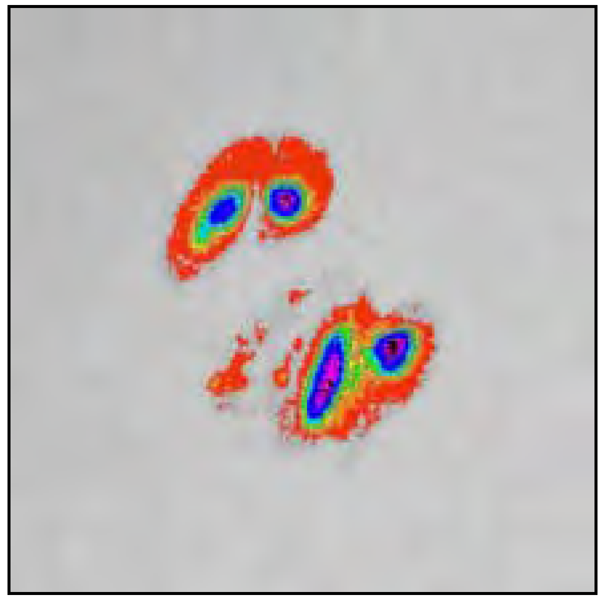


Figure 4: Isophotes of Figure 3 which show interesting areas of similar density and temperatures. Note that the western, or leading, spots both contain the larger amount of "core" material. Image by Jamey Jenkins.

Conclusion

Isophote construction is a powerful tool that can be used to illustrate features of a sunspot that one normally overlooks. The availability of the home computer and online software make this a tool the average solar observer can economically utilize and hardly afford not to. Even if no major discoveries are uncovered with this technique, one can easily come away with a greater understanding of the inner workings of the Sun and its attendant sunspots.

References

(1) Hilbrecht, Heinz (1995), "Solar Astronomy Handbook," pp.142-143.

(2) Hilbrecht, Heinz (1995), "Solar Astronomy Handbook," p. 97.

(3) Bray & Loughhead (1964), "Sunspots", pp. 128-132.

(4) http://rsb.info.nih.gov/nih-image/about.html

ALPO Feature:
A Decade of Mercury/Venus Transits

By: John E. Westfall,
Coordinator, Mercury/Venus Transit Section
Assistant Coordinator, Jupiter Section, Galilean Satellites
Member of the Board, ALPO

(Editor's Note: This paper was originally presented by Dr. Westfall at the meeting of the Assn. of Lunar & Planetary Observers in Salt Lake City in the summer of 2002. All tables and figures were provided by the author.)

Introduction

During the next ten years, we have the opportunity to see planets cross the face of the Sun on four separate occasions: A transit of Mercury in 2003, one of Venus in 2004, another transit of Mercury in 2006 and a second transit of Venus in 2012. So rapid a sequence of transits is unusual. But this decade is more than unusual; it one of the rare times that we can see transits of Venus. The two Venus transits will be the last we can see until the 2117/2125 pair and the first since the 1874/1882 pair. There is nobody alive now who has seen a transit of Venus, and (I am sorry to say) probably none of us will have a chance at the pair in the twenty-second century. With transits of Venus, you need to catch them when you can; there is no second chance.

Each of the two inferior planets crosses the Sun twice between 2003 and 2012, along the paths plotted in Figure 1. In all such transits, the planets cross the Sun from approximately celestial east to celestial west. How long they take to cross the Sun's disk varies, along with the apparent diameters of the Sun and the planet, as is shown in Table 1. Three of the transits take place in May and June, which favors observers in the Earth's northern hemisphere; the two transits of Venus are the first in June since the 1761/1769 pair. The 2006 Transit of Mercury, in November, is the only one of the four where observers south of the equator have the best view. The durations of all four transits are roughly the same; the major difference in the table is between the angular diameters of Mercury and Venus. With the proper filtration, one can see a transit of Venus with the naked eye but binoculars or a telescope are needed to see Mercury cross the Sun.

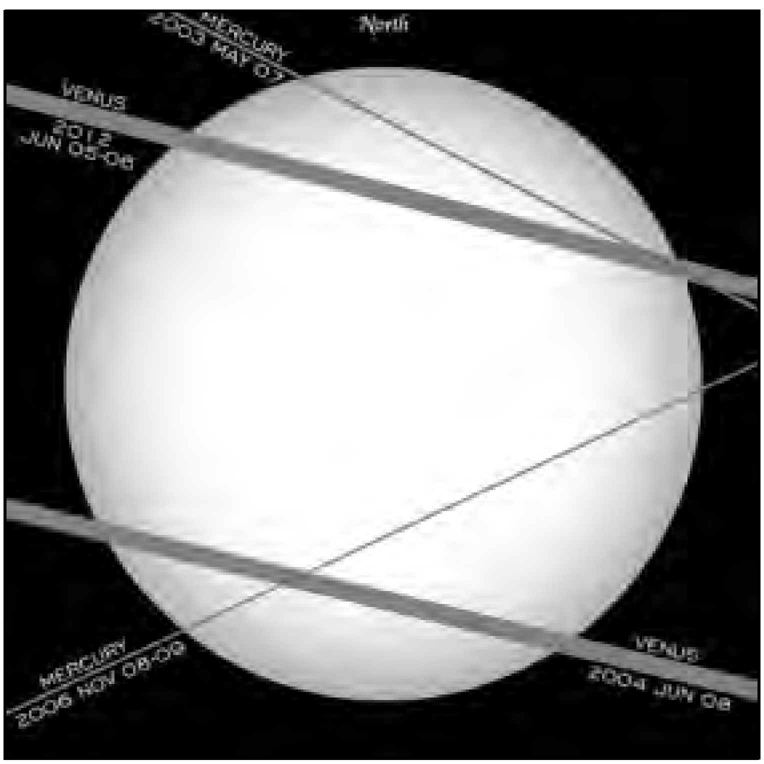


Figure 1. Geocentric paths of Mercury and Venus during transit, 2003 - 2012. Planets to scale; motion is from left to right (celestial east to west).

Since each transit lasts about one quarter of a day, about one quarter of the Earth can see the entire transit, and another half sees at least part, so roughly three-quarters of the Earth can see at least some of any single transit of the four. Figure 2 shows which of the four transits can be seen, at least in part, from different areas of North America. Some areas, like British Columbia, Mexico and the western United States, can see only two events; the 2006 transit of Mercury and the 2012 transit of Venus. The central United States and Canada can also see some of the 2004 transit of Venus. Best off are the eastern United States and Canada, as well as Alaska, where all four transits can be seen at least partially. (Naturally, all the above assumes clear skies!)

The sequence of events in a transit is fairly simple, as shown in Figure 3 (the planet is enlarged compared with the Sun). The entry of the planet on Sun' disk is called ingress, which starts with First Contact and ends with Second Contact. Egress describes the exit of the planet from the Sun's disk, starting with Third Contact and ending with Fourth

Table 1: The 2003 - 2012 Mercury / Venus Transits Compared
(Geocentric data from J. Meeus, *Transits)**

Date (UT)	Planet	Angular Diameter (arc-sec) Sun	Planet	Universal Times Begins	Ends	Transit Duration (hr)	Ingress or Egress Duration (m)
2003 MAY 07	Mercury	1902.1	12.0	05h 13m	10h 32m	5.3	4.5
2004 JUN 08	Venus	1890.1	58.2	05h 13m	11h 26m	6.2	19.4
2006 NOV 08-09	Mercury	1937.4	10.0	19h 12m	00h 10m*	5.0	1.9
2012 JUN 05-06	Venus	1891.4	58.3	22h 09m	04h 49m*	6.7	17.9

* Indicates the following UT day.

Contact. The most interesting optical phenomena associated with transits occur during ingress and egress. Fortunately, if a transit is visible at all for an observer, he or she should be able to see at least one of these phases.

Transit of Mercury, 2003

The Old World is the place to be on May 7, 2003, as shown in Figure 4. The Sun will be the highest in the Middle East and Central Asia, although the entire transit will be seen from almost all of Europe, Asia and Africa. Australia and other areas in the western Pacific will see the Sun set while the transit is still in progress; they will have watched the ingress phase, but not the egress. The opposite is true for transit-watchers in northeastern North America, eastern South America and western Africa, who will see the transit in progress at local sunrise and thus be able to watch egress, if not ingress.

In terms of densely settled areas in North America, Canadians observing from Ontario, Quebec, the Maritime Provinces and Newfoundland can watch transit egress. The same is true for Americans on the Atlantic Seaboard between South Carolina and Maine, along with some of the Midwest. However, as with all the maps shown in this paper, the farther a person is from the "Transit Not Visible" zone, the higher the Sun will be above their horizon.

There is one special circumstance for the 2003 transit of Mercury--its time of day is very similar to that of the 2004 transit of Venus. Thus in May, 2003, there is an opportunity to test observing sites and equipment 13 months before the big event in 2004.

Because the 2003 event is approaching rapidly, the Appendix of this paper provides local circumstance information for selected cities in the United States and other countries.

Transit of Venus, 2004

It's been 122 years since the last transit of Venus, so it would be unfortunate to miss this one. Thus, as Figure 5 shows, it is fortunate that most of the human race lives in areas that will be able to see at least part of the event. As with the 2003 transit of Mercury, those watching from Europe and most of Asia and Africa will see the entire event. Again, the Sun will be highest in the Middle East and Central Asia. Persons in east Asia and Australasia can watch ingress, while those in western Africa, most of South America, and

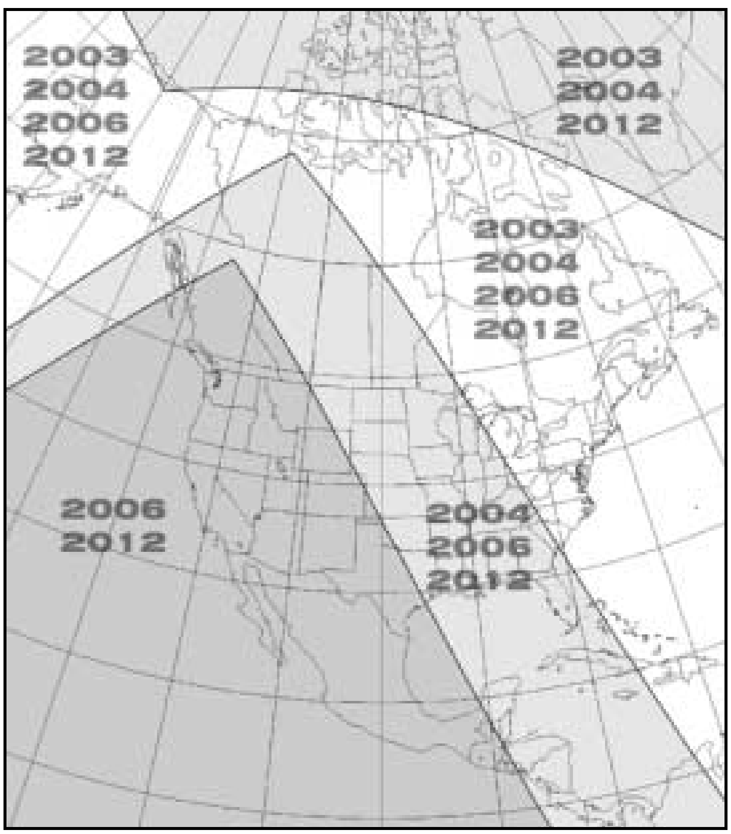


Figure 2. Transits visible from North America, 2003 - 2012.

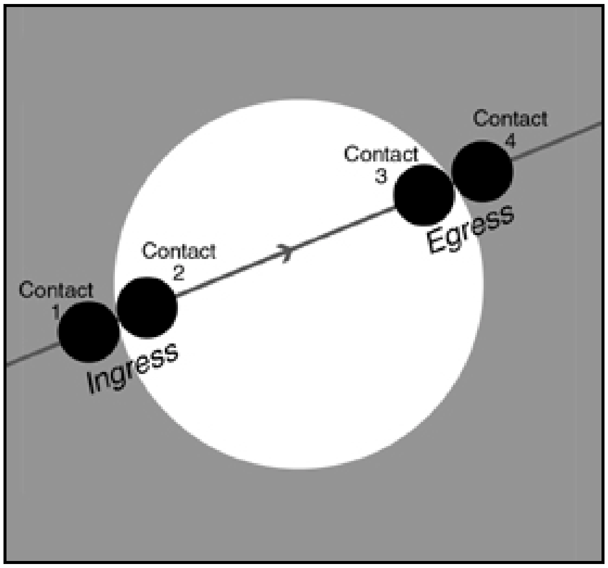


Figure 3. Sequence of transit events.

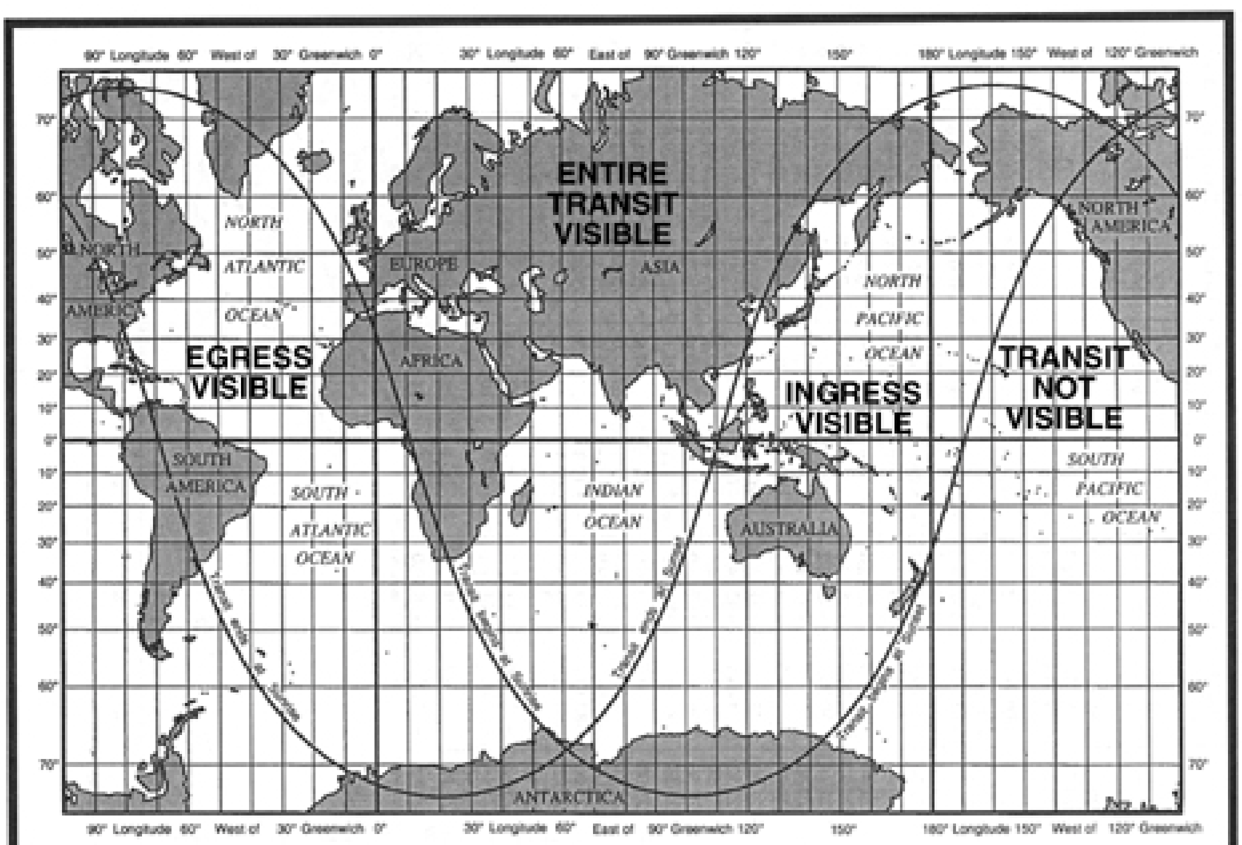
the central eastern United States and Canada will be able to observe egress. The only areas out of luck are Mexico, the western United States, and southwestern Canada.

Transit of Mercury, 2006

Finally we have an event that favors the New World. As shown in Figure 6, western North America, eastern Australia, New Zealand, and most of the Pacific Basin can catch the entire event. Eastern Asia and the remainder of Australia will miss ingress but will catch egress. On the other hand, central and eastern North America and South America will have to be content with watching ingress. In North America, the zone of complete visibility covers most of the Yukon and British Columbia in Canada; the Pacific Coast States and most of the Mountain States in the United States; and, in Mexico, the northwestern states. However, this is the one transit of the four that favors the southern hemisphere, and thus the only one not visible from the Arctic.

Transit of Venus, 2012

As with the Venus transit of 2004, this event is well-timed to maximize the number of people that will be able to watch at least some of it (see Figure 7). Eastern Asia, the western Pacific, northwestern North America, the Arctic, and most of Australasia will see all four contacts. The Sun will rise while the transit is in progress for the rest of Asia, almost all of Europe, western Australia, and most of Africa. On the other



From The Astronomical Almanac for the Year 2003.

Figure 4. Transit of Mercury, 2003 May 7.

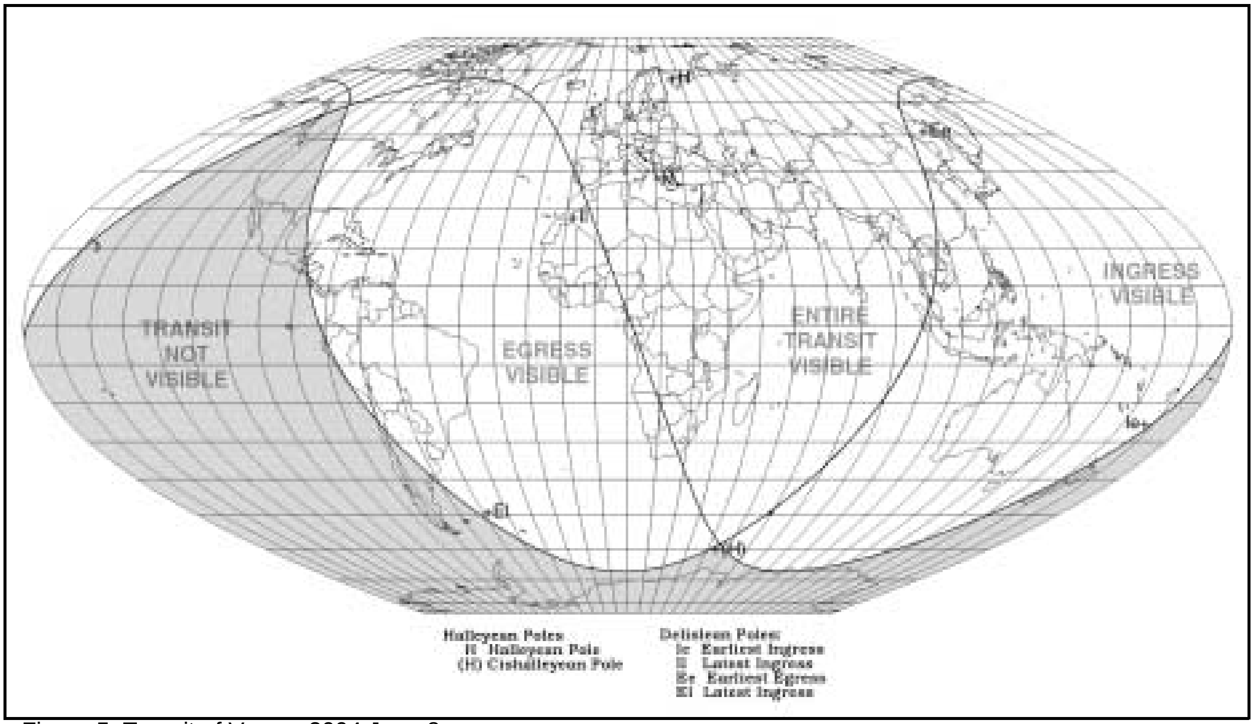


Figure 5. Transit of Venus, 2004 June 8.

hand, most of North America, northwestern South America, and southwesternmost Europe will see some of the transit, but their view will be terminated by sunset. All of Central America, the Caribbean, and the contiguous 48 States, along with most of Canada will be able to watch Venus's ingress, and typically 2-4 hours of the transit before the Sun sets. The Arctic, northwestern Canada, Alaska and Hawaii will be able to see the entire transit, however. The favorable coverage for North America is most fortunate because this is the last transit of Venus until the year 2117.

Preparing to Observe a Transit

The times given in Table 1 for the beginning and end of each transit are computed for an imaginary observer at the center of the Earth. For real observ-

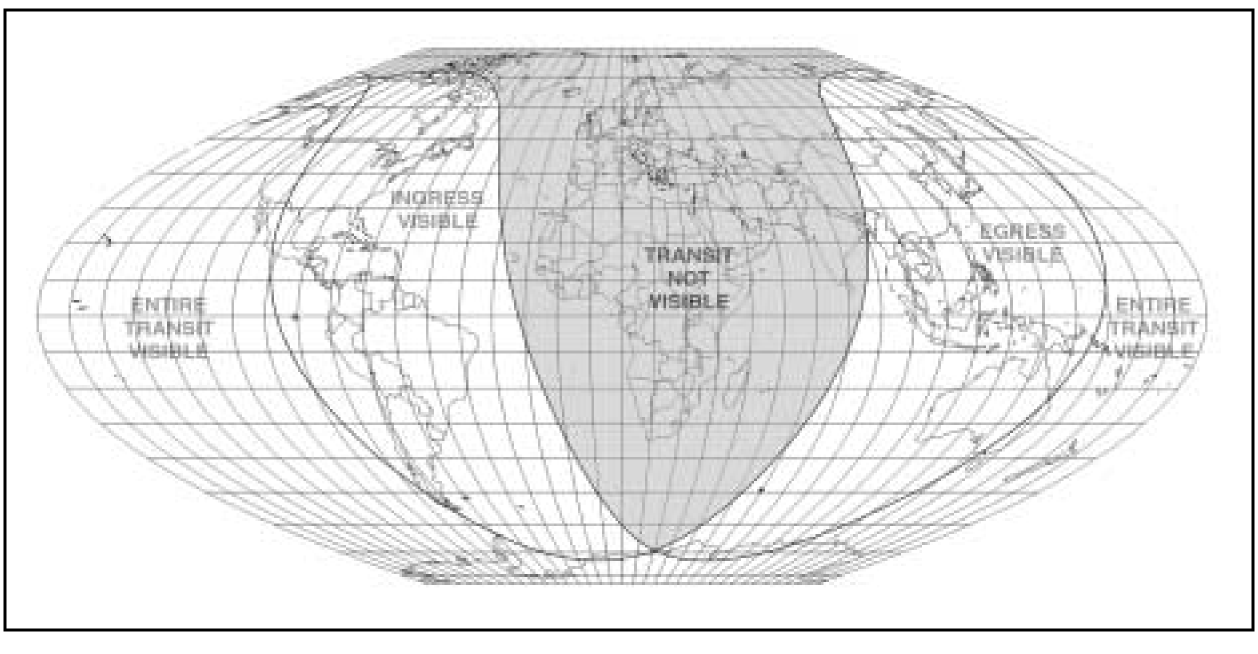


Figure 6. Transit of Mercury, 2006 November 8-9.

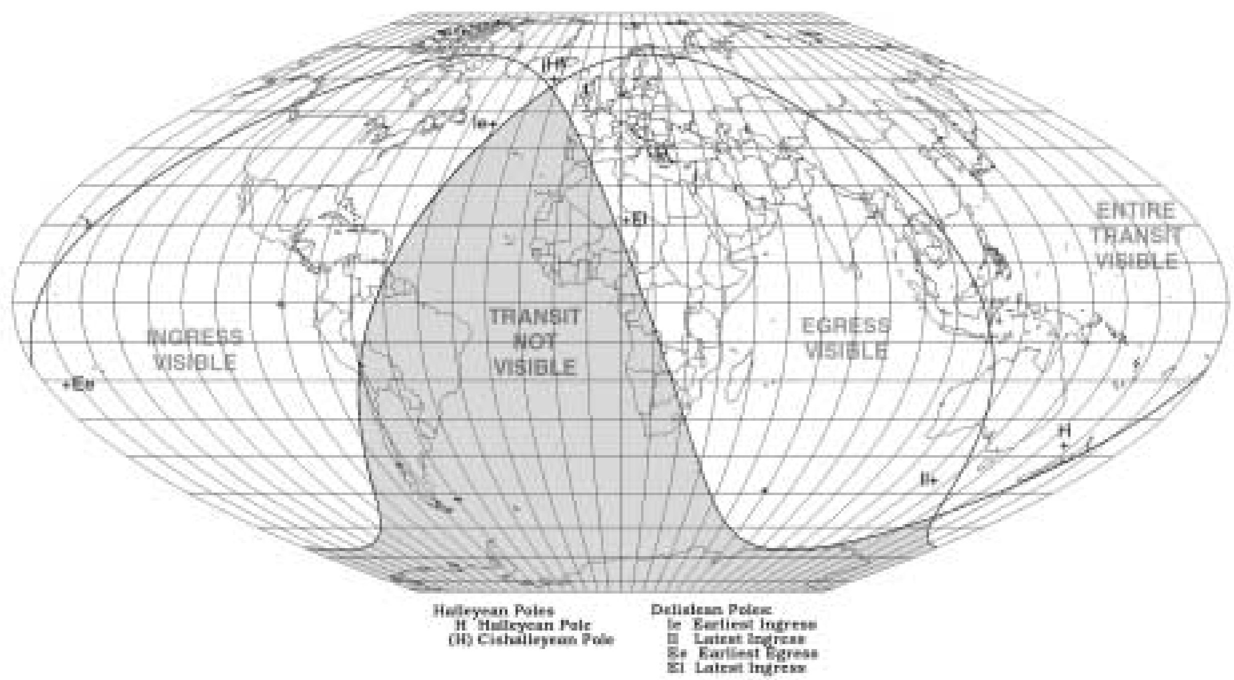


Figure 7. Transit of Venus, 2012 June 6.

ers, the times for the transits of Mercury vary from the geocentric by at most 2-3 minutes; they differ by up to 7 minutes for the transits of Venus. As the transits approach, *The Astronomical Almanac* and *The Strolling Astronomer* will give predictions for major cities in the areas of visibility of each transit; no doubt they will be given in other publications.

It is important to know where to look, as well as when. The apparent direction of a planet's motion relative to the Sun depends on several factors: whether you are in the northern or southern hemisphere, how far the Sun is from your meridian, whether you are looking with the naked eye or binoculars or with an inverting telescope, whether you are using a diagonal prism or not, and whether you are looking directly or using eyepiece projection. It is a very good idea, just before observing the transit, to determine the apparent direction of the Sun's diurnal motion, which will establish the direction of celestial west. First Contact is hard to catch unless you are looking at the right place on the Sun's limb.

As for equipment, instruments and filters suitable for observing a partial eclipse of the Sun are also appropriate for observing a planetary transit. You can always use eyepiece projection, but if you watch directly it is essential that you use a safe full-aperture filter in front of whatever optics you use: the objective, the telescope opening if a reflector, or your eyes. Safe filter types are either metal-on-glass or metal-on-mylar. For naked-eye viewing, Number 14 Welder's filter is also safe, but you can't see a transit of Mercury without using binoculars or a telescope; the planet's disk is just too small. On the other hand, there are numerous 19th-century reports of Venus being successfully viewed in transit with the unaided eye (just don't use 19th-century filters!).

To study the optical phenomena reported during transits, a telescope is essential. It need not be large, according to the latest information about successfully viewing a transit of Venus; the latest information, of course, dates from 1882! For viewing the nineteenth-century transits, small and medium-size refractors in the aperture range 2.4-8 inches were popular, with most observers using magnifications in the range 50-150X. This form of instrument is appropriate for the observing projects described below.

Purely visual observing of transits can give useful results, particularly if one makes careful notes, drawings, or both. If one wants a record of a transit, several media can be chosen from. One such is film photography, although a digital still camera might give images more suited for photometry. CCD imaging is particularly valuable for photometry. On the other hand, video taping makes a good record of any rapid changes in the appearance of the planet. Whatever the medium, it is important that all notes, drawings, photographs, or other images be timed with an accuracy of one second of time.

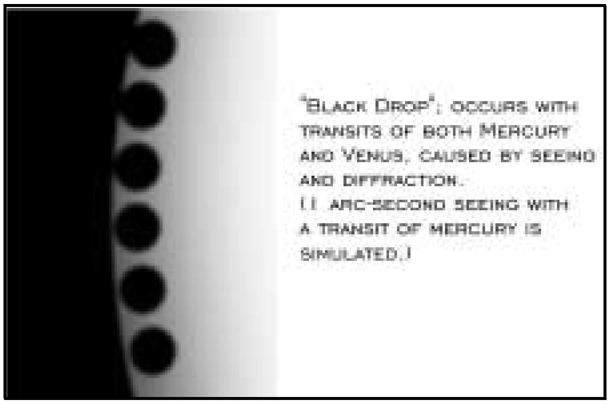


Figure 8. "Black Drop" visual and explanation.

Observing Projects

A transit is, of course, simply a very close inferior conjunction. Although care must be taken to avoid accidentally viewing the Sun, a challenging project would be to see how close before, or after, inferior conjunction Mercury or Venus is visible. With Venus there is the additional interest provided by light scattering in its upper atmosphere, which causes the cusps of its crescent to extend more than the 180 degrees one would expect had the planet no atmosphere. Indeed, at close conjunctions observers have sometimes noted, and also photographed, the entire night-hemisphere limb of Venus to be outlined by an arc of light. The arc of light is faint, and has been seen only without filters or with broad-band, relatively high-transmission filters. As far as this writer knows, the closest Venus has been to the Sun and remained visible is 1.8 degrees. Perhaps in 2004 or 2012 an observer with very clear skies, a red or infrared filter and perhaps a coronagraph may be able to beat this record.

As Mercury or Venus approaches First Contact, observers using hydrogen-alpha filters should be able to watch the planet silhouetted against the Sun's chromosphere. A similar view may be had after Fourth Contact. The duration of this appearance before ingress or after egress may be only a few minutes.

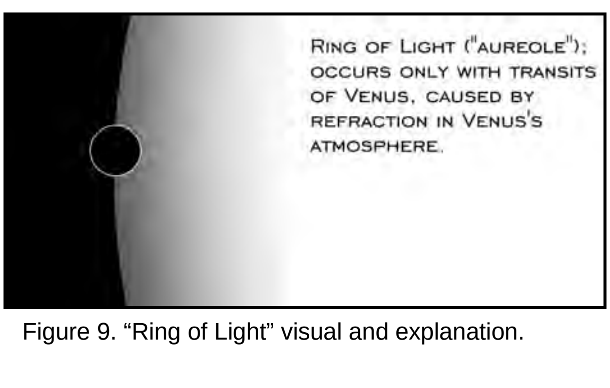


Figure 9. "Ring of Light" visual and explanation.

The optical phenomena during ingress and egress are particularly interesting, and have been reported differently by different observers. Getting the most attention is the "black drop" or "ligament," which in many reports connects the limbs of Venus and the Sun near Second and Third Contacts, as shown in Figure 8. This phenonemon has been seen for both Mercury and Venus, and thus has nothing to do with Venus's atmosphere; rather it is an illusion caused by "seeing" in our atmosphere, indistinctness of the solar limb, and by the limited resolution of even the best optics.

Some time between First and Second Contact, and between Third and Fourth, an aureole or "ring of light" often appears around Venus's limb (Figure 9). This ring of light is caused by refraction, rather than scattering, in the planet's upper atmosphere, and is far brighter than the scattered-light cusp extension mentioned before. The refraction ring can be safely viewed only by projection or, better, by viewing directly with one of the safe filters mentioned earlier. It would be very interesting to record just when this phenonemon appears or disappears, the angular extent of the light ring around the limb of Venus, whether the ring is uniform, and whether it can be seen against the solar disk itself. A suitably equipped observer might even attempt a spectrum of the light ring, which might give information on the composition of the planet's upper atmosphere.

Between Second and Third Contacts, Mercury and Venus are "safely" silhouetted against the Sun's photosphere. Nonetheless, unusual appearances have been reported even then. These reports included light or dark aureoles around the planet, or light spots or general illumination of the dark side of the planet itself. Almost certainly all these phenomena are illusory, but if due to telescopic optics or to our atmosphere, may still be photographed or otherwise recorded, which will help us to interpret the historical visual reports.

Communication

Whether handwritten notes, CCD images, or something in between, your observations won't advance science unless they are communicated. The ALPO Mercury/Venus Transit Section will be coordinating observing for all four of the approaching transits. Indeed, this paper marks the announcement of the 2003 transit of Mercury program, and its Appendix gives the visibility particulars for that event for major cities throughout its visibility zone. Future articles in *The Strolling Astronomer* will give further information as each transit approaches, and we look forward to hearing your questions and seeing your observations, ", which should be sent to the ALPO Mercury/Venus Transit Coordinator (PO Box 2447, Antioch, CA 94531-2447 USA; email: 74747.1102@compuserve.com)."

[Editor's Note: All ALPO members are also invited to post their findings to the ALPO listserv. Contact Ken Poshedly for details.]

Table of Local Circumstances for the Transit of Mercury, 2003 May 7

Computed by John E. Westfall, coordinator, ALPO Mercury/Venus Transit Section

NOTES:

Positions are N and E positive. Universal Times assume DT = +65 seconds;

A(S) = Solar altitude (center, unrefracted); data are not given for solar altitudes below -1°.0;

Least Distance = Time of minimum apparent distance between the centers of Mercury and the Sun.

Sun Prob. % = Percentage of measured sunlight hours to potential sunlight hours for the month of May.

	Sun	Position		Least Distance		Contact 1		Contact 2		Contact 3		Contact 4	
Place	**Prob. %**	**Lat. °**	**Long. °**	**UT 07h+ m**	**A(S) °**	**UT 05h + m**	**A(S) °**	**UT 05h+ m**	**A(S) °**	**UT 10h+ m**	**A(S) °**	**UT 10h+ m**	**A(S) °**
Geocentric	**--**			**52.3**		**12.9**		**17.3**		**27.2**		**31.7**	
United States													
Anchorage, AK	52	+61.17	-147.98	-----	-----	10.4	+5.2	14.8	+4.7	-----	-----	-----	-----
Fairbanks, AK	52	+64.82	-147.87	-----	-----	10.4	+6.7	14.8	+6.3	-----	-----	-----	-----
Kotzebue, AK	47	+66.87	-162.63	51.4	-0.4	10.4	+3.1	14.8	+12.6	-----	-----	-----	-----
Nome, AK	44	+64.50	-165.43	-----	-----	10.4	+13.7	14.9	+13.3	-----	-----	-----	-----
Yakutat, AK	13	+59.52	-139.67	-----	-----	10.4	+0.8	14.9	+0.3	-----	-----	-----	-----
Washington, DC	57	+38.85	-77.03	-----	-----	-----	-----	-----	-----	29.7	+3.9	34.1	+4.7
Boston, MA	58	+42.37	-71.02	-----	-----	-----	-----	-----	-----	29.7	+9.2	34.1	+10.0
Sault St. Marie, MI	55	+46.47	-84.37	-----	-----	-----	-----	-----	-----	29.6	+1.5	34.0	+2.2
Buffalo, NY	59	+42.93	-78.73	-----	-----	-----	-----	-----	-----	29.7	+4.0	34.1	+4.7
New York, NY	57	+40.77	-74.02	-----	-----	-----	-----	-----	-----	29.7	+6.7	34.1	+7.5
Asheville, NC	61	+35.60	-82.53	-----	-----	-----	-----	-----	-----	-----	-----	34.2	-0.5
Columbus, OH	60	+40.00	-83.88	-----	-----	-----	-----	-----	-----	29.7	-0.7	34.1	+0.1
Dayton, OH	60	+39.90	-84.22	-----	-----	-----	-----	-----	-----	29.7	-1.0	34.1	-0.2
Charleston, SC	69	-32.90	-80.03	-----	-----	-----	-----	-----	-----	29.8	-0.4	34.2	+0.5
San Juan, Puerto Rico	61	+18.43	-66.00	-----	-----	-----	-----	-----	-----	29.8	+7.3	34.3	+8.4
Canada													
Churchill, MB	32	+58.75	-94.07	-----	-----	-----	-----	-----	-----	29.2	+1.7	33.6	+2.2
Gander, NF	32	+48.95	-54.57	-----	-----	-----	-----	-----	-----	29.4	+21.5	33.9	+22.2
Goose, NF	36	+53.32	-60.42	-----	-----	-----	-----	-----	-----	29.4	+18.0	33.8	+18.6
Sachs Harbour, NWT	35	+71.95	-124.73	-----	-----	10.3	+3.9	14.7	+3.7	28.6	+1.5	33.0	+1.7
Halifax, NS	44	+44.65	-63.60	-----	-----	-----	-----	-----	-----	29.6	+14.9	34.0	+15.7
Sydney, NS	43	+46.17	-60.05	-----	-----	-----	-----	-----	-----	29.5	+17.6	34.0	+18.4
Resolute, NU	35	+74.72	-94.98	51.8	+2.7	10.4	+2.0	14.8	+1.9	28.7	+9.4	33.9	+9.7
Toronto, ON	48	+43.68	-79.63	-----	-----	-----	-----	-----	-----	29.6	+3.6	34.1	+4.4
Montreal, PQ	44	+45.47	-73.75	-----	-----	-----	-----	-----	-----	29.7	+7.6	34.1	+8.4
White Horse, YT	49	+60.72	-135.07	-----	-----	10.3	-0.4	14.8	-0.8	-----	-----	-----	-----
West Indies													
Kindley AFB, Bermuda	59	+33.37	-64.68	-----	-----	-----	-----	-----	-----	29.8	+12.1	34.2	+13.0
Willemstad, Curaçao	55	+12.18	-68.98	-----	-----	-----	-----	-----	-----	29.8	+2.9	34.3	+3.9
Santo Domingo, Dominican Republic	46	+18.47	-69.88	-----	-----	-----	-----	-----	-----	29.9	+3.8	34.3	+4.8
Fort-de-France, Martinique	62	+14.62	-61.07	-----	-----	-----	-----	-----	-----	29.5	+10.9	34.2	+12.0
South America													
Buenos Aires, Argentina	54	-34.58	-58.48	-----	-----	-----	-----	-----	-----	-----	-----	33.1	-1.0
Belém, Brazil	52	-1.47	-48.48	-----	-----	-----	-----	-----	-----	29.4	+18.4	33.8	+19.5
Rio de Janeiro, Brazil	56	-22.90	-46.65	-----	-----	-----	-----	-----	-----	28.8	+15.0	33.3	+15.9

Place	Sun	Position		Least Distance		Contact 1		Contact 2		Contact 3		Contact 4	
	Prob. %	Lat. °	Long. °	UT 07h+ m	A(S) °	UT 05h + m	A(S) °	UT 05h+ m	A(S) °	UT 10h+ m	A(S) °	UT 10h+ m	A(S) °
South America (continued)													
São Paulo, Brazil	50	-22.90	-43.17	-----	-----	-----	-----	-----	-----	28.8	+15.0	33.3	+15.9
Georgetown, Guiana	47	+6.82	-58.18	-----	-----	-----	-----	-----	-----	29.7	+11.6	34.1	+12.6
Asunción, Paraguay	--	-25.27	-57.63	-----	-----	-----	-----	-----	-----	29.0	+2.0	33.4	+2.9
Montevideo, Uruguay	61	-34.70	-56.20	-----	-----	-----	-----	-----	-----	28.6	-0.2	33.1	+0.7
Caracas, Venezuela	51	+10.50	-66.92	-----	-----	-----	-----	-----	-----	29.8	+4.3	34.2	+5.4
Europe													
Erivan, Armenia	63	+40.17	+44.50	51.8	+62.5	12.1	+36.0	16.5	+36.9	26.9	+59.8	31.4	+59.2
Vienna, Austria	50	+48.25	+16.37	52.2	+41.9	11.6	+15.7	16.0	+16.5	27.9	+58.2	32.3	+58.3
Brussels, Belgium	42	+50.80	+4.35	52.3	+33.7	11.4	+8.6	15.9	+9.3	28.3	+53.1	32.7	+53.5
Minsk, Belorussia	49	+53.87	+27.53	51.9	+44.6	11.5	+23.0	15.9	+23.6	27.7	+52.7	32.1	+52.6
Sofia, Bulgaria	50	+42.82	+23.38	52.2	+48.7	11.9	+20.1	16.3	+20.9	27.6	+63.9	32.0	+63.9
Prague, Czech Republic	49	+50.10	+14.28	52.2	+39.9	11.5	+14.6	16.0	+15.3	28.0	+56.1	32.4	+56.2
Copenhagen, Denmark	49	+55.63	+12.67	52.1	+36.6	11.3	+14.5	15.8	+15.1	28.1	+50.0	32.5	+50.6
Helsinki, Finland	51	+60.20	+24.97	51.9	+39.3	11.2	+21.2	15.7	+21.7	27.8	+46.4	32.3	+46.4
Marseilles, France	64	+43.45	+5.22	52.4	+36.1	11.7	+7.2	16.1	+7.9	28.2	+59.7	32.6	+60.1
Paris, France	46	+48.97	+2.45	52.3	+33.0	11.5	+6.9	15.9	+7.6	28.3	+54.1	32.7	+54.4
Berlin, Germany	49	+52.47	+13.40	52.1	+38.4	11.4	+14.4	15.9	+15.1	28.0	+53.6	32.4	+53.8
Munich, Germany	46	+48.13	+11.70	52.2	+39.1	11.6	+12.7	16.0	+13.4	28.0	+57.5	32.4	+57.7
Athens, Greece	63	+37.97	+23.72	52.2	+51.0	12.1	+20.0	16.5	+20.8	27.5	+68.8	31.9	+68.7
Budapest, Hungary	53	+47.52	+19.03	52.2	+43.8	11.7	+17.4	16.1	+18.2	27.8	+59.1	32.2	+59.2
Reykjavik, Iceland	32	+64.13	-21.93	52.2	+18.0	10.8	+1.6	15.3	+2.0	28.7	+34.1	33.1	+34.5
Dublin, Ireland	42	+53.43	-6.25	52.3	+26.8	11.2	+3.3	15.7	+4.0	28.5	+47.2	32.9	+47.7
Milan, Italy	48	+45.43	+9.28	52.3	+38.4	11.7	+10.5	16.1	+11.2	28.1	+59.4	32.5	+59.7
Rome, Italy	58	+41.80	+12.23	52.3	+41.4	11.8	+11.8	16.3	+12.6	28.0	+63.6	32.4	+63.8
Den Helder, Netherlands	46	+52.97	+4.75	52.2	+33.3	11.4	+9.4	15.8	+10.1	28.3	+51.3	32.7	+51.6
Oslo, Norway	44	+59.93	+10.73	52.0	+33.7	11.2	+14.1	15.6	+14.6	28.1	+46.0	32.5	+46.2
Warsaw, Poland	39	+52.18	+20.97	52.0	+42.5	11.5	+19.0	15.9	+19.7	27.8	+54.6	32.2	+54.6
Lisbon, Portugal	68	+38.77	-9.13	52.7	+25.7	-----	-----	-----	-----	28.6	+55.1	33.0	+55.8
Bucharest, Romania	53	+42.42	+26.10	52.1	+49.6	11.8	+22.2	16.3	+22.9	27.3	+62.2	32.0	+62.0
Astrakhan, Russia	65	+46.27	+48.03	51.7	+58.5	11.9	+37.2	16.3	+37.9	27.0	+53.6	31.4	+53.1
Irkutsk, Russia	49	+52.27	+104.35	51.1	+41.0	11.4	+54.3	15.9	+54.3	26.5	+18.1	30.9	+17.5
Moscow, Russia	48	+55.75	+37.57	51.8	+47.0	11.5	+28.4	15.9	+29.0	27.5	+49.3	31.9	+49.1
St. Petersburg, Russia	46	+59.97	+30.30	51.8	+41.3	11.3	+23.9	15.7	+24.4	27.7	+46.4	32.1	+46.3
Madrid, Spain	63	+40.40	-3.68	52.6	+29.9	11.7	-0.1	16.1	+0.7	28.4	+57.6	32.9	+58.2
Stockholm, Sweden	55	+59.35	+17.95	52.0	+37.1	11.2	+17.7	15.7	+18.2	28.0	+47.3	32.4	+47.4
Zurich, Switzerland	44	+47.38	+8.57	52.3	+37.3	11.6	+10.4	16.0	+11.2	28.1	+57.4	32.5	+57.7
Kiev, Ukraine	54	+50.40	+30.45	51.9	+48.3	11.6	+25.0	16.1	+25.7	27.6	+55.7	32.0	+55.5
Kew, United Kingdom	41	+51.47	-0.32	52.3	+30.7	11.4	+6.0	15.8	+6.7	28.4	+51.0	32.8	+51.4
Belgrade, Yugoslovia	52	+44.80	+20.47	52.2	+45.9	11.8	+18.2	16.2	+19.0	27.7	+61.9	32.2	+62.0
Southwest Asia													
Kabul, Afghanistan	72	+34.55	+69.20	51.5	+70.8	12.3	+56.4	16.8	+57.2	26.1	+44.9	30.6	+44.0
Nicosia, Cyprus	79	+35.15	+33.28	52.1	+59.1	12.3	+27.5	16.7	+28.4	27.2	+69.2	31.6	+68.7
Shiraz, Iran	79	+29.53	+52.63	51.8	+75.0	12.6	+44.0	17.0	+45.0	26.4	+59.7	30.9	+58.7
Tehran, Iran	61	+35.62	+51.67	51.8	+69.3	12.3	+42.3	16.7	+43.3	26.6	+57.9	31.0	+57.1
Baghdad, Iraq	70	+33.33	+44.40	51.9	+67.6	12.4	+36.7	16.8	+37.6	26.8	+64.2	31.2	+63.5
Jerusalem, Israel	81	+31.78	+35.22	52.1	+62.1	12.4	+29.0	16.9	+29.9	27.0	+71.0	31.5	+70.4
Amman, Jordan	81	+31.95	+35.95	52.1	+62.6	12.4	+29.6	16.8	+30.6	27.0	+70.5	31.4	+69.8

	Sun	Position		Least Distance		Contact 1		Contact 2		Contact 3		Contact 4	
Place	**Prob. %**	**Lat. °**	**Long. °**	**UT 07h+ m**	**A(S) °**	**UT 05h + m**	**A(S) °**	**UT 05h+ m**	**A(S) °**	**UT 10h+ m**	**A(S) °**	**UT 10h+ m**	**A(S) °**
Southwest Asia (continued)													
Shuwaikh, Kuwait	73	+29.33	+47.95	51.9	+72.5	12.6	+40.0	17.0	+41.0	26.6	+63.5	31.0	+62.6
Beirut, Lebanon	71	+33.82	+35.48	52.1	+61.3	12.3	+29.3	16.8	+30.2	27.1	+69.3	31.5	+68.7
Damascus, Syria	73	+33.48	+36.23	52.1	+62.0	12.4	+29.9	16.8	+30.8	27.0	+69.2	31.5	+68.5
Istanbul, Turkey	60	+40.97	-29.08	52.1	+53.3	12.0	+24.3	16.4	+25.1	27.4	+65.1	31.8	+64.9
Urfa, Turkey	76	+37.12	-38.77	52.0	+61.6	12.2	+31.9	16.6	+32.7	27.0	+65.0	31.5	+64.5
Sana, Yemen	69	+15.38	+44.18	52.1	+73.7	13.2	+35.7	17.6	+36.8	26.4	+69.2	30.8	+68.2
South and East Asia													
Rangoon, Burma	54	+16.77	+96.17	51.2	+56.7	12.9	+85.5	17.4	+86.5	25.2	+20.3	29.7	+19.2
Phom Penh, Cambodia	58	+11.55	+104.85	51.1	+47.6	13.1	+83.6	17.5	+82.9	25.0	+10.9	29.5	+9.8
Hong Kong, China	39	+22.30	+114.17	51.0	+40.2	12.5	+76.4	16.9	+75.5	25.3	+5.1	29.8	+4.1
Beijing, China	60	+39.95	+116.32	50.9	+37.4	11.8	+63.3	16.2	+62.8	26.0	+7.9	30.4	+7.1
Shanghai, China	39	+31.2	+121.43	50.9	+34.0	12.0	+66.5	16.5	+65.7	25.7	+1.5	30.2	+0.5
Urumchi, China	65	+43.78	+87.62	51.2	+55.0	11.9	+60.6	16.3	+60.9	26.2	+29.4	30.6	+28.6
Bombay, India	74	+18.90	+72.82	51.5	+78.8	13.0	+63.2	17.5	+64.3	25.6	+42.4	30.1	+41.1
Calcutta, India	63	+22.53	+88.33	51.2	+64.0	12.8	+76.8	17.2	+77.7	25.4	+28.5	29.9	+27.4
New Delhi, India	59	+28.58	+77.20	51.4	+71.2	12.6	+65.1	17.0	+66.0	25.8	+38.8	30.2	+37.8
Djkarta, Indonesia	60	-6.18	+106.83	51.3	+39.5	13.8	+66.3	18.3	+66.0	24.7	+4.1	29.2	+3.0
Osaka, Japan	48	+34.65	+135.53	50.9	+22.3	11.7	+54.5	16.2	+53.7	-----	-----	-----	-----
Tokyo, Japan	44	+35.68	+139.77	50.9	+19.0	11.6	+50.9	16.1	+50.1	-----	-----	-----	-----
Vientiane, Laos	54	+17.95	+102.57	51.1	+50.7	12.8	+88.0	17.3	+87.1	25.2	+14.6	29.7	+13.5
Kuala Lumpur, Malaysia	52	+3.12	+101.70	51.2	+48.1	13.5	+76.4	17.9	+76.3	24.9	+11.6	29.3	+10.6
Khatmandu, Nepal	42	+27.70	+85.33	51.3	+65.3	12.6	+71.8	17.0	+72.6	25.6	+31.6	30.1	+30.6
Wonsan, North Korea	53	+39.18	+127.43	50.9	+28.9	11.7	+58.0	16.1	+57.3	26.1	-0.4	-----	-----
Karachi, Pakistan	75	+24.92	+67.15	51.6	+80.1	12.8	+57.4	17.2	+58.4	25.9	+47.8	30.3	+46.8
Manilla, Philippines	56	+14.52	+121.00	51.2	+32.8	12.7	+70.6	17.2	+69.5	-----	-----	-----	-----
Singapore, Singapore	49	+1.35	+103.90	51.2	+45.4	13.5	+74.3	18.0	+74.1	24.8	+9.0	29.3	+8.0
Seoul, South Korea	60	+37.57	+126.97	50.9	+29.3	11.7	+59.2	16.2	+58.5	26.0	-0.7	-----	-----
Colombo, Sri Lanka	51	+6.90	+79.87	51.5	+69.3	13.5	+67.3	18.0	+68.3	25.2	+33.5	29.6	+32.4
Taipei, Taiwan	34	+25.03	+121.52	50.9	+33.7	12.3	+69.2	16.7	+68.2	25.5	-0.6	-----	-----
Bangkok, Thailand	59	+13.73	+100.50	51.1	+52.2	13.0	+87.0	17.5	+86.9	25.1	+15.5	29.6	+14.5
Saigon, Viet Nam	32	+10.82	+106.67	51.1	+45.7	13.1	+81.9	17.5	+81.1	25.0	+9.0	29.5	+7.9
Africa													
Algiers, Algeria	70	+36.72	+3.25	52.5	+35.6	11.9	+3.8	16.4	+4.6	28.2	+64.0	32.6	+64.6
Luanda, Angola	62	-8.85	+13.23	53.1	+36.4	13.9	-0.1	18.4	+1.0	27.2	+62.8	31.6	+63.2
Cotonou, Benin	55	+6.35	+2.38	53.1	+32.0	-----	-----	-----	-----	27.9	+68.0	32.3	+69.0
Ouagadougou, Burkina Faso	65	+12.35	-1.52	53.0	+29.7	-----	-----	-----	-----	28.1	+66.7	32.6	+67.8
Bujumbura, Burundi	53	-3.32	+29.32	52.7	+52.9	13.9	+16.8	18.3	+17.9	26.6	+68.8	31.1	+68.4
Yaounde, Cameroon	39	+3.87	+11.53	53.0	+39.9	13.4	+1.8	17.9	+2.9	27.5	+73.3	31.9	+74.0
Banguri, Central Africa	46	+4.38	+18.57	52.8	+46.7	13.5	+8.7	17.9	+9.8	27.2	+77.1	31.6	+77.3
Ndjemena, Chad	73	+12.13	+15.03	52.8	+45.4	13.1	+7.4	17.5	+8.4	27.6	+81.6	31.9	+82.5
Brazzaville, Congo	37	-4.25	+15.23	53.0	+40.2	13.8	+3.1	18.2	+4.2	27.2	+67.8	31.6	+68.2
Bata, Equatorial Guinea	50	+1.90	+9.80	53.0	+37.6	13.5	-0.4	17.9	+0.7	27.5	+70.7	31.9	+71.4
Addis Ababa, Ethiopia	61	+9.00	+38.73	52.3	+66.9	13.4	+29.2	17.9	+30.3	26.4	+72.4	30.9	+71.4
Libreville, Gabon	40	+0.45	+9.42	53.0	+36.8	-----	-----	18.0	-0.1	27.5	+69.4	31.9	+70.0
Cairo, Egypt	78	+30.13	+31.57	52.2	+59.6	12.5	+25.8	16.9	+26.7	27.1	+74.2	31.3	+73.6

	Sun	Position		Least Distance		Contact 1		Contact 2		Contact 3		Contact 4	
Place	Prob. %	Lat. °	Long. °	UT 07h+ m	A(S) °	UT 05h + m	A(S) °	UT 05h+ m	A(S) °	UT 10h+ m	A(S) °	UT 10h+ m	A(S) °
Africa (continued)													
Bathurst, Gambia	81	+13.35	-16.67	53.2	+15.5	-----	-----	-----	-----	28.7	+52.6	33.1	+53.6
Accra, Ghana	56	+5.60	-0.17	53.1	+29.3	-----	-----	-----	-----	28.0	+65.5	32.4	+66.4
Conacry, Guinea	41	+9.57	-13.62	53.3	+17.5	-----	-----	-----	-----	28.6	+54.6	33.0	+55.7
Bissau, Guinea-Bissau	67	+11.87	-15.58	53.2	+16.2	-----	-----	-----	-----	28.7	+53.3	33.1	+54.4
Abidjan, Ivory Coast	50	+5.25	-3.93	53.2	+25.6	-----	-----	-----	-----	28.1	+62.0	32.6	+63.0
Nairobi, Kenya	50	-1.30	+36.77	52.5	+60.0	13.9	+24.5	18.3	+25.5	26.3	+67.1	30.8	+66.4
Monovia, Liberia	40	+6.30	-10.80	53.3	+19.4	-----	-----	-----	-----	28.4	+56.2	32.8	+57.3
Tripoli, Libya	61	+32.68	+13.68	52.5	+44.6	12.2	+11.0	16.6	+12.0	27.8	+72.3	32.2	+72.7
Tananarive, Madagascar	66	-18.90	+47.53	52.5	+52.0	14.6	+26.9	19.0	+27.8	25.7	+46.8	30.2	+46.2
Lilongwe, Malawi	71	-13.97	+33.70	52.7	+49.2	14.3	+17.2	17.7	+18.2	26.3	+57.4	30.7	+57.0
Bamako, Mali	55	+12.63	-8.03	53.1	+23.5	-----	-----	-----	-----	28.4	+60.6	32.8	+61.7
Nouakshott, Mauretania	77	+18.10	-15.95	53.1	+17.3	-----	-----	-----	-----	28.7	+53.9	33.1	+54.9
Marrakech, Morocco	68	+31.62	-8.03	52.8	+26.3	-----	-----	-----	-----	28.6	+59.0	33.0	+59.9
Maputo, Mozam-bique	75	-25.97	+32.60	52.9	+39.2	14.7	+11.5	19.2	+12.4	26.2	+46.2	30.7	+45.9
Windhoek, Namibia	90	-22.57	+17.10	53.1	+31.9	14.5	-0.5	19.0	+0.5	26.8	+50.3	31.3	+50.5
Niamey, Niger	63	+13.48	+2.17	53.0	+33.4	-----	-----	-----	-----	28.0	+70.5	32.4	+71.5
Lagos, Nigeria	45	+6.58	+3.33	53.1	+32.9	-----	-----	-----	-----	27.9	+68.9	32.3	+69.9
Rubona, Rwanda	44	-2.48	+29.77	52.7	+53.7	13.9	+17.5	18.3	+18.5	26.6	+69.5	31.0	+69.1
Sâo Thomé, Sâo Thomé	42	+0.38	+6.72	53.1	+34.2	-----	-----	-----	-----	27.6	+67.6	32.1	+68.3
Dakar, Senegal	76	+14.73	-17.50	53.2	+15.1	-----	-----	-----	-----	28.8	+52.0	33.2	+53.1
Lungi, Sierra Leone	52	+8.62	-13.20	53.3	+17.7	-----	-----	-----	-----	28.5	+54.8	33.0	+55.8
Mogadiscio, Somalia	72	+2.03	+45.35	52.3	+68.7	13.8	+33.7	18.2	+34.7	26.1	+63.2	30.5	+62.3
Cape Town, South Africa	56	-33.93	+18.48	53.2	+25.2	-----	-----	-----	-----	26.6	+39.2	31.1	+39.2
Pretoria, South Africa	84	-25.75	+28.23	53.0	+36.9	14.7	+7.9	19.2	+8.9	26.4	+47.1	30.8	+47.0
Khartoum, Sudan	78	+15.60	+32.55	52.4	+62.6	13.1	+24.7	17.6	+25.8	26.8	+80.2	31.2	+79.2
Dar-Es-Salaam, Tanzania	61	-6.88	+39.20	52.5	+58.0	14.1	+24.9	18.6	+25.9	26.2	+61.2	30.6	+60.6
Lomé, Togo	51	+6.17	+1.25	53.1	+30.8	-----	-----	-----	-----	27.9	+67.0	32.4	+67.9
Entebbe, Uganda	51	+0.05	+32.45	52.6	+57.3	13.8	+20.8	18.2	+21.9	26.5	+70.6	31.0	+70.1
Kinshasa, Zaire	38	-4.38	+15.43	53.0	+40.4	13.8	+3.3	18.3	+4.3	27.2	+67.8	31.6	+68.1
Lusaka, Zambia	80	-15.42	+28.32	52.9	+44.5	14.3	+11.8	18.8	+12.8	26.5	+57.3	30.9	+57.1
Salisbury, Zimbabwe	76	-17.93	+31.10	52.8	+44.6	14.5	+13.4	18.9	+14.4	26.3	+54.3	30.8	+54.0
Oceania													
Alice Springs, Australia	75	-23.80	+133.88	51.5	+8.4	14.1	+38.1	18.6	+37.4	-----	-----	-----	-----
Darwin, Australia	82	-12.43	+130.87	51.3	+15.4	13.7	+48.3	18.2	+47.5	-----	-----	-----	-----
Melbourne, Australia	38	-37.82	+144.97	-----	-----	14.4	+21.4	18.9	+20.7	-----	-----	-----	-----
Perth, Australia	44	-31.95	+115.85	51.7	+18.5	14.6	+39.2	19.1	+38.8	-----	-----	-----	-----
Sydney, Australia	56	-33.87	+151.03	-----	-----	14.2	+20.3	18.7	+19.5	-----	-----	-----	-----
Suva, Fiji	45	-18.15	+178.45	-----	-----	13.2	+6.1	17.6	+5.1	-----	-----	-----	-----
Nouméa, New Caledonia	54	-22.27	+166.45	-----	-----	13.5	+14.8	18.0	+13.9	-----	-----	-----	-----
Port Morseby, New Guinea	62	-9.43	+147.22	51.3	+1.2	13.3	+37.2	17.8	+36.2	-----	-----	-----	-----
Auckland, New Zealand	44	-36.85	+174.77	-----	-----	14.0	+2.1	18.5	+1.3	-----	-----	-----	-----

ALPO Feature: The Moon
Domes in the Hortensius Region

By Raffaello Lena, Piergiovanni Salimbeni, Eric Douglass, Guido Santacana and Morio Higashida. Geologic Lunar Research Group (GLR)

Introduction

The crater Hortensius resides in the very rich Hortensius-Milichius-Tobias Mayer dome field of the Moon. Many observers have studied the dome field near crater Hortensius. North of Hortensius is a group of six domes called the "Schlumberger Domes" by Jim Phillips, former ALPO Lunar Dome Survey Recorder (1). This group is easily observed at a solar altitude of 4 to 5 degrees, and at least five of the domes show a summit craterlet (2). A sketch map of the region drawn by W.L. Rae in 1964 (Figure 1) shows the six domes to the north of Hortensius plus four more domes to the south. These latter four domes are the subject of this report. In Rae's drawing there are no details of the position or type of these domes. These four domes also appear in the *Geologic Atlas of the Moon* (3), but are not listed in the ALPO dome catalog.

Recently, this group of four domes has been observed by the GLR group. Observation of these domes requires very low solar altitude for maximum detail. In addition, a fifth feature has been observed in the area and is reported here.

Geology

The present domes are in the region of Oceanus Procellarum, just south of the outer wall of the Imbrium Basin . As it is not within a formal basin, we must first examine the likelihood of volcanic activity occurring here. Examination of this region with spacecraft reveals that this geographic area is of intermediate elevation and has an intermediate Bouguer gravity anomaly (4). While lava flows rarely occur in areas of great lunar height or low gravity anomalies, they frequently occur in the present context. Examination of the broader region, extending south from the wall of Imbrium through the Copernicus region, also reveals a wide variety of other volcanic products. So there are domes (especially those north of Hortensius, as well as those east and north of Milichius), the presence of extensive sheet (trap) lava flows, *mare ridges*, and sinuous rilles. From this material, it is clear that this region has been the source of volcanic activity, and is expected to have volcanic geology.

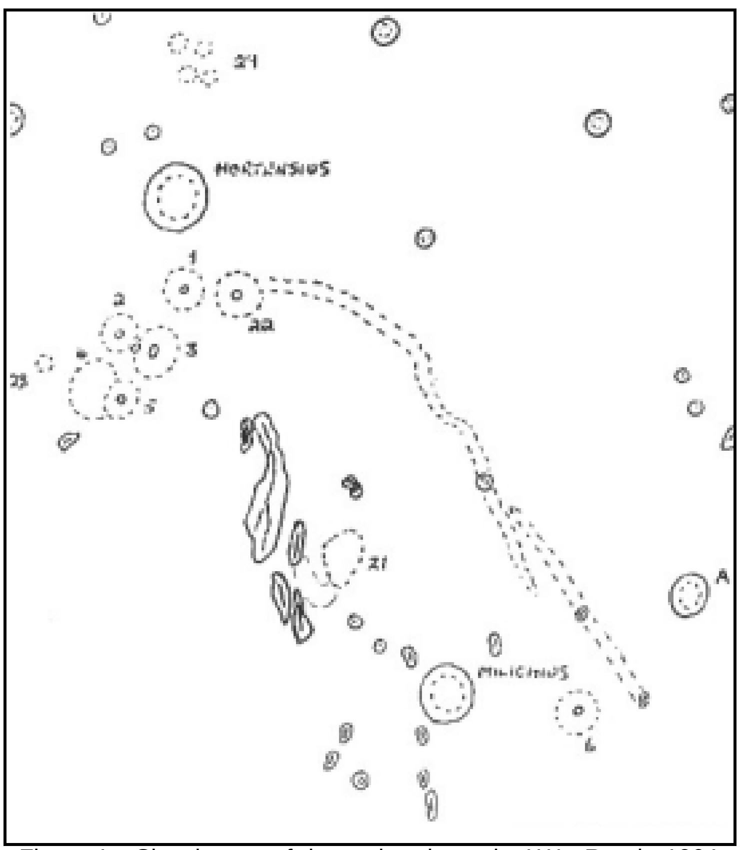


Figure 1 - Sketch map of the region drawn by W.L. Rae in 1964 and reported in reference (1). South is at the top and IAU east is at the left

The geologic history of the region began with the Imbrium impact 3.85 billion years ago. This impact created a multi-ring basin, with the outer ring occurring just north of the Copernicus area (though the Copernicus impact did not occur until much later). It also created deep fractures in the lunar crust.

Over the next few hundred million years, lava was created by radioactive heating of country rock in the upper mantle (5). These low-density melts oozed into the impact-created faults and flowed out into the basin. They were not confined to the basin, but poured through the low points in the basin walls and also tracked up faults created by smaller impacts nearby. It is tempting to suggest that the present volcanic structures formed from lavas that crossed the basin wall. However, domes from satellite vents rarely form this far from the main vent (see

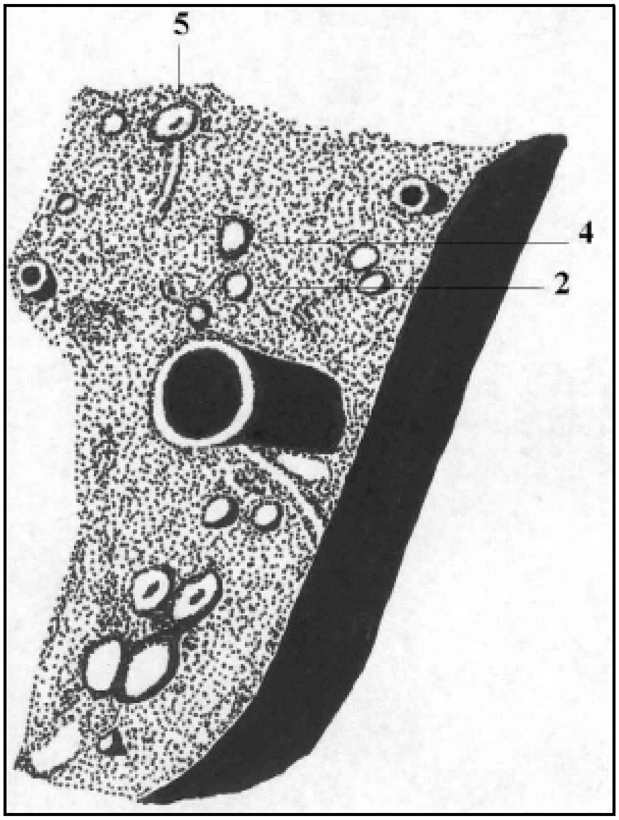


Figure 2 - Sketch map by Raffaello Lena. South is at the top and IAU east is at the left.

examples in reference 6). Further, while so-called "rootless cones" may occur at some distance from the vent, these are usually much smaller (7). Thus, the present volcanic products probably formed from lava tracking up faults just outside the basin proper.

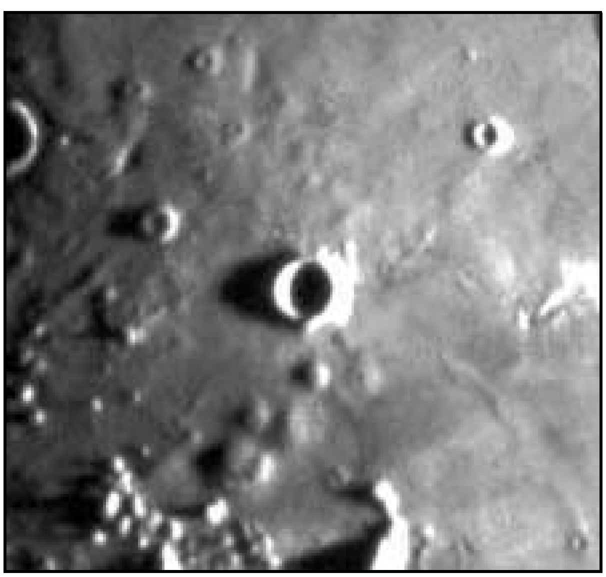


Figure 3 - Image by Morio Higashida. South is at the top and IAU east is at the left.

Eventually, the sheet flows gave way to lavas that were of higher viscosity. These formed small volcanoes, which on the Moon are called domes. The present domes are examples of these late lava flows.

At about this time, volcanism ceased in this region of the Moon. At a later time, this section was struck by the impact that produced the Copernicus crater (1 billion years of age). Although the ejecta from this impact covered all of the volcanic materials in this region, in some places one can still see the patterns of the darker *mare* lavas beneath. These lava fields can be seen both around the present domes and around the domes just north of Hortensius, suggesting that the objects under consideration are indeed volcanic domes.

Figure 4 - *The Photographic Lunar Atlas*, G. Kuiper. South is at the top and IAU east is at the left.

Observations

On August 28, 2001 at 22:00 UT (Colongitude 29.9°, solar altitude over Hortensius 2.12°) Raffaello Lena observed several domes-like features located to the south of the crater Hortensius (Figure 2). This observation was carried out under excellent seeing conditions (I Antoniadi Scale) using a 100mm f/15 refractor.

A CCD image of the region was obtained by Morio Higashida (Figure 3) using a Newton 20 cms f/8, on August 13 2001 at 19:04 UT (solar altitude over Hortensius of 3.06° and Colongitude 205.04°). The image details domes 1-4. *The Photographic Lunar Atlas* also reveals these five features (Fig. 4). This image was taken on August 30, 1956; 11:51 UT (solar altitude over Hortensius of 5.95° and Colongitude of 201.84°). The four domes are also seen in the geologic map of the Copernicus quadrangle (Figure 5). Domes 1-4 appear to be hemispherical, having a gentle slope, but are lacking in other surface features. Dome 5 has a more complex structure (best appreciated in Figure 4).

Table 1: Locations and Diameters of Domes 1 - 4

Feature	Longitude	Latitude	Diameter
1	-27.92	+5.60	5.0 Km
2	-28.10	+5.67	5.5 km
3	-27.87	+5.32	5.0 Km
4 (*)	-28.08	+5.37	5.0 km
5 (complex structure)	-27.72	+4.93	6.5 Km
(*) Head and Gifford reported a dome at -28.00 ° +5.50°			

Using available images, we were able both to measure the diameter of domes 1-4 and to document their position (Table 1). These 4 unlisted domes may be classified according to the Westfall classification scheme as DW/2a/5f/0 (9). The domes appear to require a solar altitude of 1.2° to 3.0 ° in order to be seen well. We were not able to evaluate the height of these domes.

Conclusion

This paper further clarifies the location and type of four domes to the south of Hortensius. A fifth feature (feature 5) is also identified, but further imagery is needed to confirm its real nature.

References

1. Phillips, Jim, M.D. “The New Lunar Dome Survey: The Hortensius-Millichius-Tobias Mayer Region,” *JALPO*, Vol. 33, 4-6, pp. 61-72, 1989
2. Jamieson H.D. “The Region South of Hortensius,” *The Moon*, 13, No. 2 (1965) pp. 32-34.
3. Schmitt, N, Trask, N. and Shoemaker, E. *Geologic Map of the Copernicus Quadrangle of the Moon, I-515*; 1967; U.S. Geologic Survey.
4. *Lunar Prospector Project, Planetary Data System (PDS)*, Geophysics Subnode; Washington Unviversity, St. Louis, MO.
5. Mursky, G. *Introduction to Planetary Volcanism. Upper Saddle River*: Prentice Hall; 1996; p. 172.
6. Davidson, J. and De Silva, S. “Composite Volcanoes” in the *Encyclopedia of Volcanoes*; ed. Sigurdsson, H. San Diego: Academic Press, 2000; p. 674.
7. Macdonald, G. *Volcanoes*. London: Prentice-Hall Inc.; 1972; p. 196.
8. Head and Gifford. *Moon and Planets*. Vol. 22, 1980; pp. 235-258.
9. Westfall, J. “A Generic Classification of Lunar Domes,” JALPO, Vol 18, Nos. 1-2, pp. 15-20, July 1964

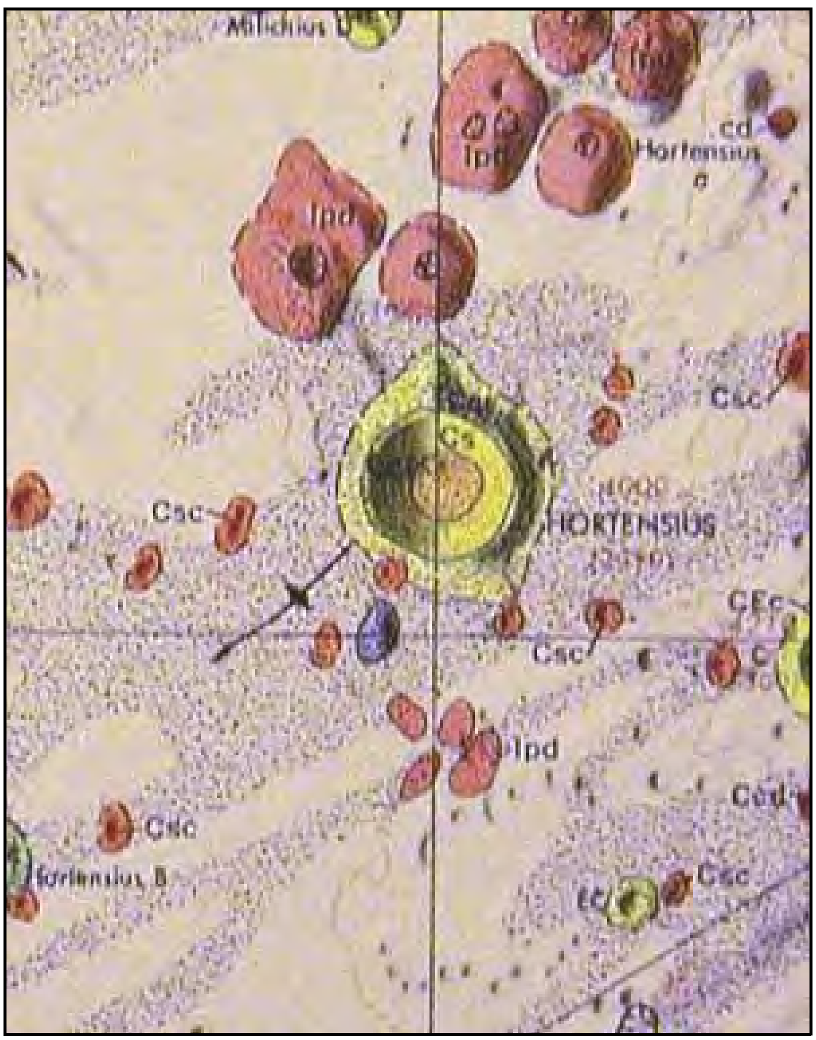


Figure 5 - The Hortensius region. In contrast to the other images of this article, north is at the top and IAU east is at the right. From ref. 3; U.S. Geologic Survey.

ALPO Feature: Mars

The Great 2003 Perihelic Apparition of Mars

By: Jeffrey D. Beish and Donald C. Parker, M.D. of the ALPO Mars Section
Edited by: Klaus Brasch

Abstract

Mars will approach closer to the Earth during the 2003 apparition than at any other time in over 59,000 years! Always an intriguing world, Mars offers both casual and serious observers many challenges and delights. It also provides astronomers a laboratory to study the atmosphere and surface of another planet, including the behavior of condensates and their effects on its atmosphere and surface. Mars is similar to Earth in that it has four seasons, exhibits global climates, changing weather patterns, annual thawing and growing of polar caps, storm clouds of water ice, howling dusty winds, and a variety of surface features that predictably change in color and size and appear to shift position over extended periods of time.

Introduction

Mars appears more Earth-like to us than most of the other planets because we can observe its surface, atmospheric clouds and hazes, and its brilliant white polar caps. The latter are composed of frozen CO_2 and underlying water ice, and wax and wane during the Martian year. These aspects, along with the changing seasons and the possibility of life, have made Mars one of the most studied planets in our solar system.

Mars offers both casual and serious observers many challenges and delights, as well as providing astronomers a laboratory to study another planet's atmosphere and surface. Some Martian features even appear to shift position around the surface over extended periods of time.

There are several cooperating international Mars observing programs under way to assist both professional and amateur astronomers. These include the *International Mars Patrol (I.M.P.)* coordinated by the Mars Section of the Association of Lunar and Planetary Observers (ALPO), the *International MarsWatch*, the Terrestrial Planets Section of *the British Astronomical Association (B.A.A.),* and the Mars Section of the *Oriental Astronomical Association (O.A.A.).*

The Opposition Cycle

As a general rule, an “apparition” begins when a planet emerges from the glare of the Sun shortly after ***conjunction.*** Early in an apparition, a superior planet such as Mars rises in the east or morning sky and sets with the rotation of the Earth in the western or evening sky. Practically speaking, however, quality telescopic observations are only possible once the apparent diameter of the Martian disk exceeds 6 arc-seconds. However, for those eager to begin observing at the earliest opportunity, it is probably safe to do so when Mars is at least 12 degrees east or west of the Sun. As a side note, we urge observers to use caution when observing an object too close to the Sun without proper filters. Accidentally catching the intense light from Sun in an unfiltered telescope **WILL** result in severe eye damage and possible blindness.

There is a rule of thumb to determine when Mars is at certain cardinal points in its orbit relative to the orbit of Earth. Mars is in conjunction when the Sun is between it and the Earth, and the planet will not appear in our morning sky until approximately 54 days later. Nearly 300 days after that, Mars begins retrogression, or retrograde motion against the background stars, when it appears to move backwards toward the west for a brief period during the apparition. In the 2003 AA, Mars will be in retrograde motion from August 4 to October 6.

Opposition occurs 390 days after conjunction, when Mars is on the opposite side of the Earth from the Sun. At that time, the two planets will lie nearly in a straight line with respect to the Sun, and about 33 days after that retrogression ends. It should also be noted that closest approach between Earth and Mars is not necessarily coincident with the time of opposition but varies by as much as two weeks.

Mars will remain visible for another approximately 300 days after opposition and then become lost in the glare of the Sun again as it approaches the next conjunction. The cycle is complete in 780 Earth days.

Another general rule for predicting oppositions of Mars is the following: the planet has an approximately 15.8-year periodic opposition cycle, which consists of three or four ***aphelic*** oppositions and three consecutive ***perihelic*** oppositions. Perihelic oppositions are also called “favorable” because the Earth and Mars come closest to each other on those occasions. We sometimes refer to this as the seven Martian **synodic** periods. This cycle is repeated

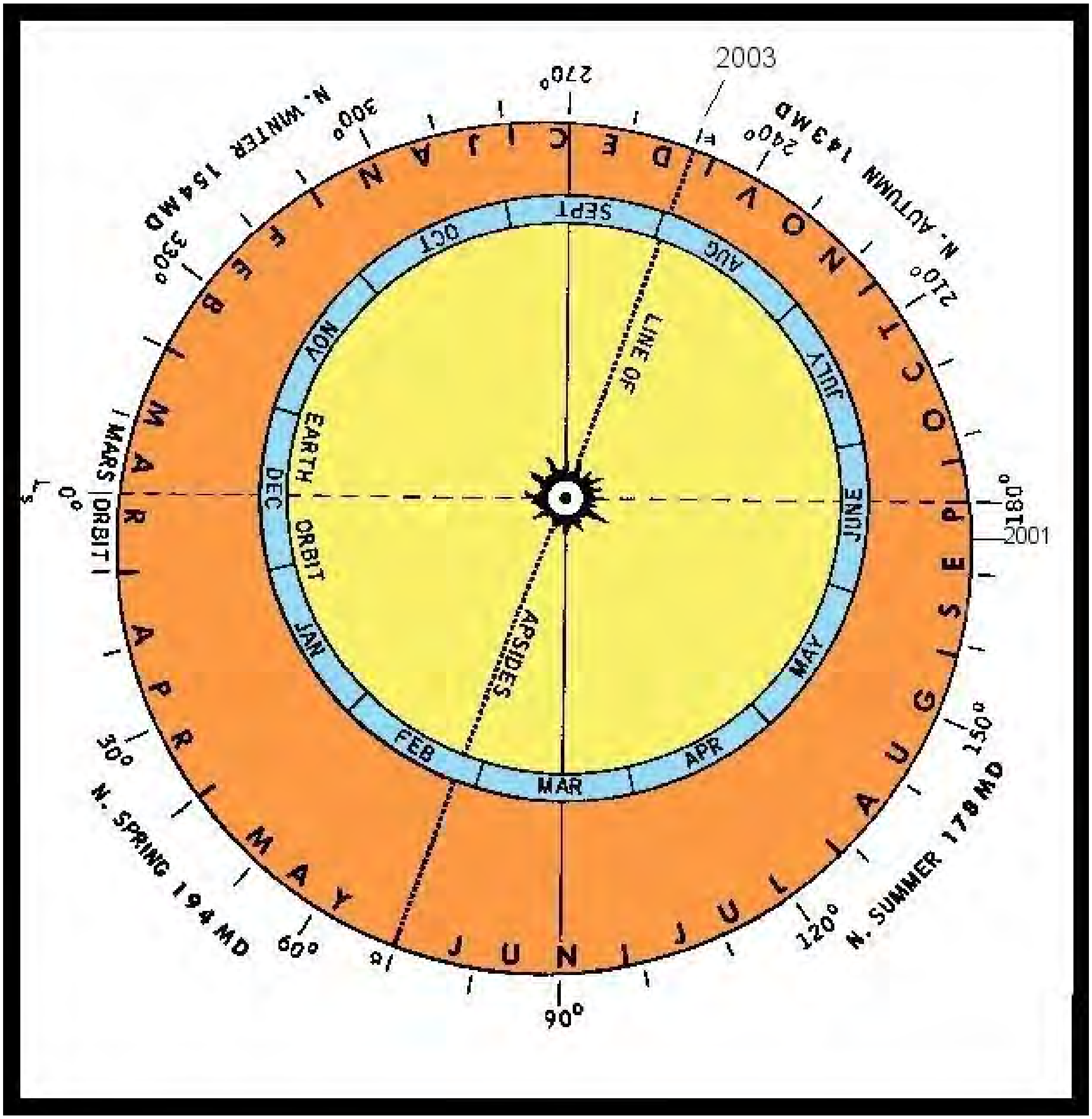


Figure 1. A Graphic Ephemeris for the 2003 Perihelic Apparition of Mars. Graph prepared by C.F. Capen.

every 79 years (+/- 4 to 5 days), and if one were to live long enough, one would see this cycle nearly replicated in 284 years.

2003 Apparition Characteristics

For nearly five weeks during 2003, from August 10th until September 14th, the Red Planet's apparent size will be greater than 23.8 arc-seconds, larger than it has been anytime in the past 15 years. Mars will be at a distance of 0.37271 astronomical units (AU), or 34,649,589 miles (55,756,622 km) from Earth at ***closest approach***. [NOTE: one (1) A.U. equals 92,955,621 miles or 149,597,870 km.]

The 2003 Mars apparition is considered ***perihelic*** because the orbital longitude at opposition will be at the perihelion longitude 250° Ls (Ls will be defined later.) Closest approach occurs on August 27, 2003 (248°.9 Ls) with an apparent planetary disk diameter of 25.11 arc-seconds. Opposition occurs the following day on August 28 (249°.5 Ls) with no appreciable difference in the apparent diameter. The observable disk diameter of Mars will be greater than 6 arc seconds starting Feb 25, 2003 and will not fall below this value until February 18, 2004. The geometry of the heliocentric aspects of Mars relative to the Earth is shown in Figure 1.

Although Mars' large apparent disk diameter permits unusually favorable observing in 2003, the planet will appear low in the sky for observers in the middle northern latitudes, being below the celestial equator for a good portion of the apparition. Good news for those observing from the Southern Hemisphere though — Mars will be seen high in their sky. The apparent declination of Mars begins at -17° in January 2003, and then continues southward to -23°.6 by mid-March, before climbing northward again. By mid-July, the declination of Mars will be -13°.0 with a slow decrease to -15°.7 by the opposition date (August 28, 2003). Mars will continue to decrease to -16°.5 (September 14, 2003) and then slowly climb northward until it reaches the celestial equator (0°) by mid-December, when the planet will still be a respectable 9.5 arc-seconds in apparent size.

Mars will exhibit a disk diameter greater than 10 arc seconds for a period of more than 7 months, from May 8 through December 12. During this time, useful film-based photography will be possible. Useful imaging by CCD and digital cameras, however, can begin earlier in April, when the disk diameter is 8 arc seconds or less. The geometry of the heliocentric aspects of Mars relative to Earth is shown in figures 3 and 4. Figure 5 provides information about several close apparitions, 1988, 2001 and 2003, for comparison.

The Ephemeris of Mars that lists the Sub-Earth Point or "De" is tabulated in the Mars Section of the ALPO's Internet Web Page located at

http://www.lpl.arizona.edu/~rhill/A.L.P.O./mars.html

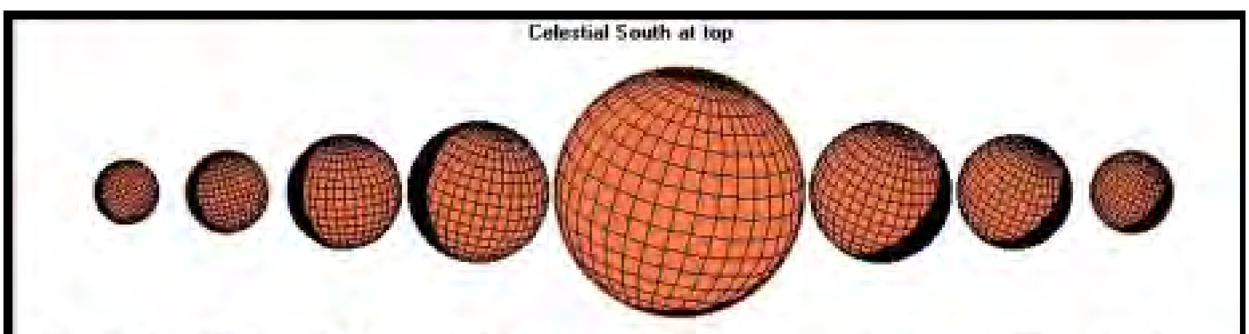
and published in the ALPO Mars Section newsletter, *The Martian Chronicle*. Look under the heading, "Ephemeris for Physical Observations - 2003," in the "Mars Observing Ephemeris for 2003." The sub-earth (De) and sub-solar (Ds) points are graphically represented in Figure 3.

Days and Seasons on Mars

The Martian solar day, or "sol", is about 40 minutes longer than a day on Earth. Consequently Mars only rotates through 350° of longitude in 24 hours. As a result, astronomers on Earth observing a particular Martian surface feature one night, will see that same feature positioned 10° further west on Mars (or closer to its morning limb) the next night at the same civil time.

Mars and Earth have four comparable seasons because their axes of rotation are both tilted at about the same angle to their respective orbital planes, 25°.2 for Mars and 23°.5 for Earth. In describing Martian seasons, scientists use the term "Ls" which stands for the Areocentric longitude of the Sun along Mars' ecliptic. The zero point, 0° Ls, is set at the Martian vernal equinox when the Sun, moving northward, appears to cross the celestial equator in Mars' sky. Thus, 90° Ls is the northern hemisphere summer solstice, 180° × the autumnal equinox, etc. The seasons are, of course, reversed for the southern hemisphere.

Since the Martian year is about 687 Earth days long — nearly twice as long as ours — the Martian seasons are similarly extended. While the Earth's seasons are nearly equal in duration, the Martian seasons can vary by as much as 52 days from each other due to that planet's greater orbital eccentricity (see Figure 1).



Date	27 Feb	10 Apr	08 May	29 Jun	27 Aug	23 Nov	12 Dec	08 Jan
Size	6.0"	8.0"	10.0"	12.0"	25.1"	12.0"	10.0"	8.0"
Ls	142.9°	165.8°	181.2°	193.3°	248.9°	303.5°	314.6°	329.8°
De	-1.0°	-11.9°	-17.1°	-19.6°	-18.4°	-25.0°	-25.7°	-24.7°
Ds	14.6°	5.9°	-0.5°	-5.5°	-23.0°	-20.5°	-17.4°	-12.2°
Dec	-23.3°	-22.4°	-19.6°	-16.9°	-15.6°	-6.2°	-1.5°	5.5°
A.U.	1.546	1.168	0.919	0.573	0.373	0.785	0.938	1.174

Figure 2. As it approaches Earth, Mars will swell from a small apparent disk of 6 arc-seconds in February 2003 to a maximum size on August 27, 2003, and then shrink as it moves away. June throughout December are the prime observing months.

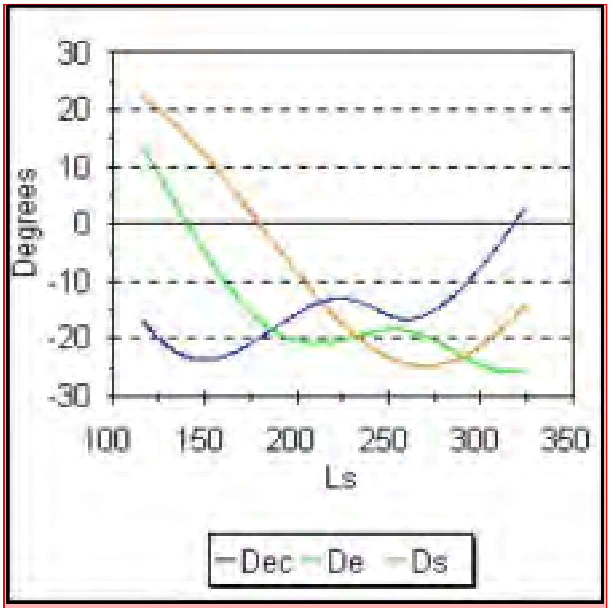


Figure 3. Graphic plot of Mars during the 2003 apparition from January 1, 2003 through December 31, 2003 (with color-coding for online viewing of the pdf version of this Journal). Plot illustrates the Declination (blue line; begins at approximately -16 degrees), the latitude of the sub-earth point (De) or the apparent tilt (green line; begins at approximately +14 degrees) in areocentric degrees, and the latitude of the sub-solar point (orange line; beginsa t approximately +23 degrees) in areocentric degrees. The areocentric longitude (Ls) of the Sun, shown along the bottom 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 250°when Mars is at perihelion, and 180° is northern autumn.

The axis of Mars does not point toward Polaris, our North Star, but is displaced about 40° towards Alpha Cygni. Because of this celestial displacement, the Martian seasons are 85° out of phase with respect to terrestrial seasons, or about one season earlier than ours. Consequently, when you observe Mars next spring and summer, it will be winter and spring, respectively, in the Martian southern hemisphere.

Making Observations of Mars

It is very important that each visual or photographic observation (including CCD images) be accompanied by a written data record made at the time of observation and/or imaging and not left to memory the following day. Whether or not the observations include visual drawings, it is recommended that the following data be recorded:

- Universal Date and time if known (state specific time system used if other than UT)
- Telescope and ocular power (magnification) or Barlow lens employed
- The astronomical seeing and sky transparency conditions
- Which filters – if any — were used
- A description of the Martian disk as observed through different color filters (again, if any were used)
- Orientation, usually with south at the top and Mars' preceding (evening) limb marked "P." This is most important when few surface landmarks are visible, as occurs with dust storms or observations made in violet light. It is also important for observers employing star diagonals, where the east-west image is reversed.

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

Anyone who observes 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)

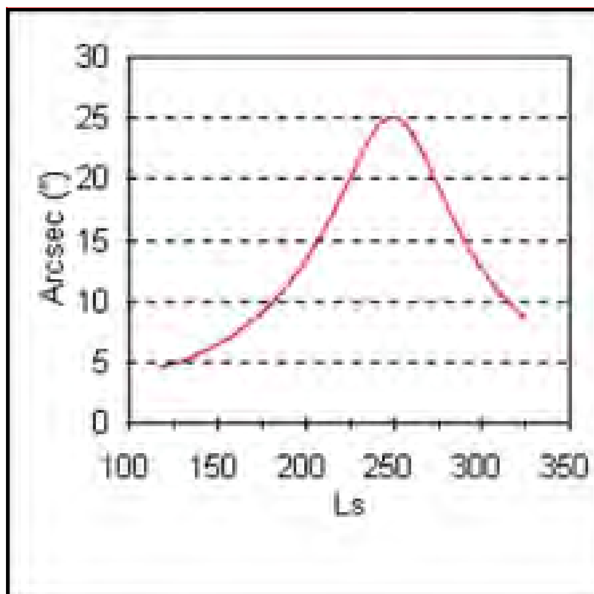


Figure 4. Graphic plot of Mars during the 2003 apparition from January 1, 2003 through December 31, 2003. Plot illustrates the apparent diameter of Mars in seconds of arc. The areocentric longitude (Ls) of the Sun, shown along the bottom edge of the graph defines the Martian seasonal date.

Table 1: Eastman Kodak Wratten Filters Used by ALPO Observers & Characteristics for Mars Observations

Eastman Kodak Wratten Filters	Characteristics for Mars Observations.
Yellow (W12, W15)	to brighten desert regions, darkens bluish and brownish features.
Orange (W21, W23A)	further 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, enhances fine surface details, dust clouds boundaries, and polar cap extremities.
Yellow-Green (W57)	darkens red and blue features, enhances frost patches, surface fogs, and polar projections.
Blue-Green (W64)	helps detect ice-fogs and polar hazes.
Blue (W80A, W38, W38A) and deep blue (W46, W47)	shows atmospheric clouds, discrete white clouds, and limb hazes, equatorial cloud bands, polar cloud hoods, and darkens reddish features. The W47 is the standard filter for detection and evaluation of the mysterious blue clearing.
Magenta (W30, W32)	enhances red and blue features and darkens green ones. Improves polar region features, some Martian clouds, and surface features.

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 as accurately on the disk as possible. 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.

Modern technology, like CCD and digital cameras, has greatly increased the efficiency even of small telescopes that in the past were considered less than optimal for serious planetary observing. In addition, image processing can often compensate for such factors as low contrast, poor color balance and even sharpness. Another plus is that because CCD and digital cameras can capture images much faster than conventional photography, atmospheric turbulence is less likely to spoil the results. It is important that serious imagers of Mars carefully calibrate their images by doing bias, flat fields, and dark frames. This way the images become quantitatively accurate for analysis and they will be much easier to process.

Recently many amateurs have been using web cams for imaging the planets. These inexpensive little devices do require a computer but are relatively easy to use and, with inexpensive (or even free!) software they can produce striking images of Mars. It is suggested that amateurs wishing to image Mars for the first time try using a web cam.

It is highly recommended that all astronomers, whether photographers, CCD or digital camera imagers, or visual observers, use at least a basic set of tricolor filters according to the following guide:

- Red or orange (W-25 or W-23A)
- Yellow-green (W57)
- Blue-green (W-64)
- Blue (W-38A or W-80A)
- Violet (W-47)

Observers with smaller telescopes (3- to 6-inch apertures) may find a yellow (W-15) useful and it may provide better performance than the deep red filter (See Table 1). Those employing larger instruments (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].

Those who use CCD cameras often employ filters designed for the spectral response of their cameras. If this is the case, it is necessary to provide information about what filters were used, so that those who receive the images will know the wavelengths involved. It is also suggested that, when using infrared or ultraviolet filters, the spectral range or the “bandwidth half-maximum” (BWHM) be provided. This information is usually readily available from the filter’s manufacturer.

The Mars observer will make his observations and studies more profitable if he familiarizes himself with a few other physical parameters:

- **De.** The axial tilt of Mars relative to Earth is defined by the declination of the planet Earth (De)

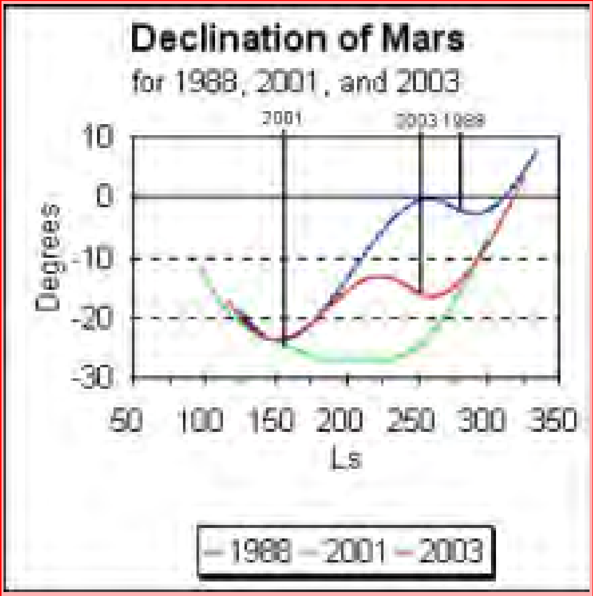


Figure 5. Graphic plot comparing the declination of Mars during the 1988, 2001, and 2003 apparitions. Dates from January through December of each year. The areocentric longitude (Ls) of the Sun, shown along the bottom edge of the graph, defines the Martian seasonal date. Oppositions years are shown at top of vertical lines. Opposition date 1988 (blue) Ls = 280°, for 2001 (green) Ls =177°,and 2003 (red) Ls = 250°. (Note: Plot lines are color-coded in pdf version of this Journal; year designations are provided at top of figure for paper version of this Journal.)

as seen from Mars. De is also equal to the areographic latitude of the center of the Martian disk, which is known as the sub-earth point. ("Areo-" is a prefix often employed when referring to Mars or "Ares.") The latitude is (+) if the north pole is tilted toward Earth and (-) 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 aspects and range of the axial tilt of the globe of Mars make it possible to observe the south polar region of Mars during the 2003 apparition.

- **The Martian Central Meridian (CM)**, an imaginary line passing through the planetary poles of rotation and bisecting the planetary disk, is used to define the areographic longitudes on the disk during an observing session. It is independent of any phase that may be present; though, if Mars presents a gibbous phase, then the CM will appear to be off center. The CM is the areographic longitude in degrees, as seen from Earth at a given Universal Time (U.T.). It can be calculated by adding 0.24°/min., or 14.6°/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 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 Earth-turned 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 west side, or morning limb. At opposition, there is no perceptible phase defect (See Figure 6).

Surface Features of Mars

The dark Martian surface markings, called "maria" or "albedo features," were once thought by some astronomers to be great lakes, oceans, or vegetation, but space probes in the 1970's revealed them to be vast expanses of rock and dust. Windstorms sometimes move the dust, resulting in both seasonal and long-term changes in these markings. These features seem to darken during early Martian spring in such a manner that a "wave of darkening" appears to sweep from the thawing polar cap towards the equator. This event, which occurs during each hemisphere's spring season, lent credence to the theory that the maria were composed of vegetation, which was replenished when water flowed from the melting polar cap towards the equator.

Now we know that this concept is false. In fact, C.F. Capen showed that the wave of darkening is in actuality a "wave of brightening" [*Michaux*, 1972, *Capen*, 1976, *Dobbins*, 1988]. The albedo features only appear to darken because the adjacent ochre desert areas have brightened during early spring. This has been confirmed by Viking Lander photos, which reveal a fresh, bright layer of dust appearing on the ground during early spring.

Light and dark surface features tend to change in albedo and color contrast diurnally and more slowly as the seasons change. Seasonal variations are usually predictable, but secular or long-period changes are unpredictable.

Seasonal Changes. Several regions that display seasonal changes are:

- Syrtis Major (300° W, 10° N)
- Pandorae Fretum (345° W, 25° S)
- Nilokeras-Lunae L. (60° W, 25° N)
- Candor-Tharsis (90° W, 10°N)
- Elysium-Trivium Charontis (210° W, 22° N)

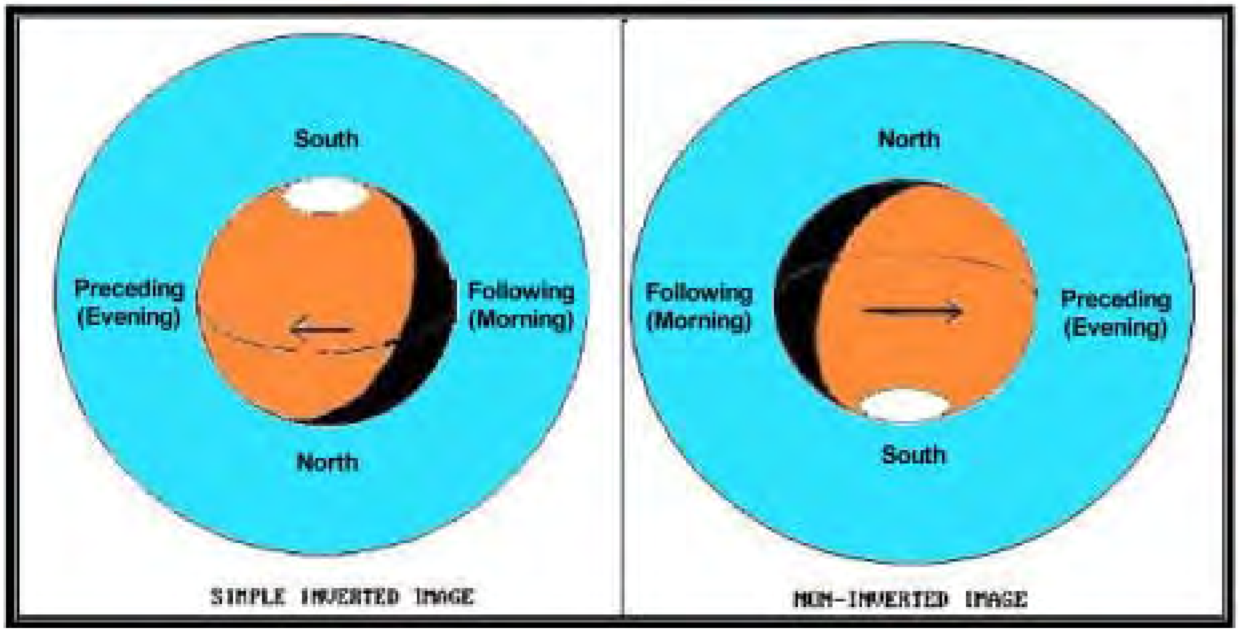


Figure 6. The Martian Disk and Useful terms. The orientation and nomenclature of the Martian globe as seen from Earth through an astronomical telescope. The figure indicates a simple inverted view of the disk of Mars, where south is at the top, bottom is north, the right side is terrestrial east or the 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.

- Mare Australe (90° W, 75° S)
- Aonius Sinus (105° W, 47° S).

Secular Changes. Areas that have undergone secular changes during the past two decades are:

- Nodus Laocoontis-Amenthes (245° W, 10° N)
- Nepenthes-Thoth (268° W, 08° N)
- Thoana Palus (256° W, 35° N)
- Moeris L. (270° W, 08° N)
- Antigones Fons-Astaboras complex (298° W, 22° N)
- Margaritifer S.-Hydaspis S. (30° W, 02° S)
- Solis Lacus (85° W, 28° S)
- Nilokeras-Lunae L. (60° W, 25° N)
- Acidalium Fons-Tempe C. (60° W, 58° N).

A few areas of particular interest will now be discussed.

Syrtis Major is the planet's most prominent dark area. Classical observations indicated seasonal variations in the breadth of this feature: maximum width occurring in northern mid summer (145° Ls), when its eastern edge expands eastward to about 275° W. longitude [*Dollfus*, 1961]. Minimum width classically occurs during early northern winter, just after perihelion (290° Ls) [*Antoniadi*, 1930, *Capen*, 1976]. However, recent observations by ALPO astronomers and the Hubble Space Telescope (HST) suggest that no such variations have occurred since 1990 [*Lee, et al.*, 1995.].

The Syrtis Major area has also undergone some rather dramatic long-term, or "secular," changes over the years. During recent apparitions it has become narrower and more blunted in appearance compared to the 1950's. After the 2002 dust storm this feature appeared thinner and more tapered to the north than it was before the storm [*McKim*, 2002]. Osiridis Promontorium became very dark in 1984, appearing as a dark bar jutting out into Libya from the northeast border of Syrtis Major. This feature was conspicuous in 1879, 1909, and during the 1940's and 1950's. The broad "canal," Nilosyrtis that curves northeast from the northern tip of Syrtis Major, was inconspicuous in 1984 [*Parker et al.*, 1999].

The Nepenthes-Thoth (268° W, 08° N) feature, lying to the west of the Elysium shield, so prominent in the 1940's, and 1950's, decreased in size in 1960 and began fading in 1971. It was virtually undetectable in 1984. Nodus Laocoontis (246°W, 25°N), first described by S. Kibe in 1935, had faded during the

1970's and was not seen during the 1983-1985 apparition.

Hellas. One of the most active areas on Mars is the Hellas Basin (292° W, 50° S), not only because of its dynamic meteorology but also for its never-ceasing albedo changes. Surface structure becomes apparent in this area when its darker center (Zea Lacus) seems to extend its arms or canals (Alpheus) to the north, and connect Mare Hadriacum (265° W, 40° S) and Yaonis Fretum (318° W, 43° S) eastward to the western edge of Peneus. As the Martian southern summer solstice approaches, the basin often becomes flooded with dust if a violent storm begins. Hellas was the initial site of the great planet-encircling dust storm of 2001 and is a region that bears careful scrutiny during the 2003 apparition, since Mars will then be in its "dusty season."

Hellas was also was involved in both the December 11, 1983, and the January 5, 1984, dust storms [*Beish et al.*, 1984]. As these apparitions progressed and southern hemisphere winter got underway, Hellas and the high basin Argyre (30°W, 50°S) appeared brilliant white on the southern limb. Both of these great basins are the water-ice reservoirs of the southern hemisphere and are often covered with frost or with low clouds. These features were often confused with the South Polar Cap (SPC) or its winter hood, owing to their foreshortened appearance due to the planet's axial tilt.

Solis Lacus is called the "Eye of Mars" because, with the surrounding light area called Thaumasia, it resembles the pupil of an eye. Centered at 90° W, 30° S, Solis Lacus is notorious for its variability. Small and relatively inconspicuous in 1971, it underwent a major dark secular change in 1973, perhaps as a result of the major dust storms occurring during those years [*Dobbins et al.*, 1988]. During the ensuing two decades it remained a large dark oval with a north-south orientation [*McKim*, 1992]. During the 1992-1993 apparition Solis Lacus was presented as a small, dark oval, but it enlarged and elongated in 1975 and has remained a large dark oval feature oriented slightly east-west until late 2001. At that time, after the massive dust storm had subsided, it appeared smaller than it had before the storm and the "canal" Nectar had all but disappeared [*McKim*, 2002].

Just west of Solis Lacus, another area that has undergone change is Daedalia-Claritas and Mare Sirenum. In 1973, the normally light region located between Sirenum M. and Solis Lacus, Daedalia-Claritas, underwent a dramatic darkening, which persisted through 1980. In 1984, this region had returned to its normal light intensity. However, during March and April 1984, ALPO observers reported that northeastern M. Sirenum had weakened considerably, possibly as a result of dust deposition from the storms sighted earlier in that region [*Capen*, 1986].

Early in 2001, after the dust had cleared from the 2001 storm, IMP observers reported a significant darkening in Daedalia-Claritas that extended eastward into Thaumasia near the site of the Phasis "canal." Both this region and nearby Solis Lacus bear careful watching in 2003.

Trivium-Cerberus (210° W, 22° N), lying on the southern rim of the Elysium shield, is another feature of great interest to professional Mars researchers. During the 1950s it was a classically dark feature 808 x 249 miles (1,300 x 400 km) in size, but it weakened somewhat in the 1960s. During the 1970s it varied in size and intensity from prominent to near invisibility. This area appears to have been covered over with dust during February and March of 1982 [*Parker et al.*, 1990]. A generally "washed out" appearance was reported during the remainder of that apparition and very low contrast has been observed ever since. Dust storms during 1983 and 1984 appeared to further lower the contrast of the Elysium and Trivium Charontis region [*Parker et al.*, 1999]. On May 14, 1984, ALPO observers reported that the Trivium Charontis-Cerberus was very difficult to see or missing from the face of Mars [*Beish*, 1984 and *Troiani*, 1996]. Except for a brief darkening in 1995 it has remained nearly invisible, appearing as two or three dots on a half-tone background [*Moersch et al.*, 1997. *Troiani et al.*, 1997].

In 1977 ALPO Mars observers reported a new dark area on the western side of the Elysium shield volcanoes [*Capen* and *Parker*,1980] Astronomers reported that the normally insignificant "canal" Hyblaeus (240°W, 30°N) had darkened and expanded westward into Aetheria. Termed the "Hyblaeus Extension" by Capen, this change has persisted to the present. Interestingly, 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 Solar System objects. On June 10, 1984 (162° Ls), ALPO observers photographed a further darkening in this region, located in Morpheos Lacus (228°W, 37°N). This darkening persisted into the 1980's & 1990's along with other changes near Elysium, notably the lightening of the wedge-shaped feature, Trivium Charontis. The entire region near the huge Elysium volcanoes appears to be in a state of flux and should be monitored often.

Cerberus III. A recent surface change is the appearance of a very conspicuous dark band across Hesperia. This has been named for the faint "canal" Cerberus III and was first detected in 1986 [*Beish et al.*, 1989].

In 1990, ALPO observers reported a bright streak running east-west from 160°W to 260°W at 50-60°N. At 220°W longitude, another streak extended at right angles southward from it into Elysium. These streaks, also observed in 1995 and 1997, appeared bright through all filters, and their nature is not known. This entire region bears careful scrutiny and will NOT be well placed for observation during the perihelic apparitions of the early 21st Century.

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 appear 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 made between 1965 and 1995 [*Beish*, 1999]. Statistical analysis indicates that discrete, water-ice crystal cloud activity and surface fog occurrences are significantly higher in the spring and summer of the Martian northern hemisphere than they are during the corresponding seasons in the southern hemisphere.

To participate in this important study, it is essential that ALPO astronomers employ blue (W-38A or W-80A) and violet (W-47) filters when making visual, photographic, CCD or digital camera observations of Martian clouds and other atmospheric phenomena.

Discrete clouds have been observed on Mars for over a century. In 1907, a remarkable, recurring W-shaped cloud formation was observed each late-spring afternoon in the Tharsis-Amazonis region [*Slipher*, 1962]. A decade later, C.F. Capen proposed that the W-clouds are orographic (mountain-generated), caused by the up-lifting of water vapor-laden atmosphere. [*Capen*, 1984 and *Capen, Parker & Beish*, 1986]. In 1971, the Mariner 9 spacecraft probe confirmed these observations, and showed that they were water clouds near the large volcanoes Olympus Mons (longitude 133° W, 18° N), Ascraeus Mons (104° W, 11° N), Pavonis Mons (112° W, 0° N), and Arsia Mons (120° W, 9° S). The W-clouds should be active during the 2003 apparition at least until opposition (250° Ls) and perhaps later in the apparition as well, during the southern hemisphere summer. Although often observed without filters, these clouds are best seen in blue or violet light when they are high in the Martian atmosphere, and in yellow or green light when they are at very low altitudes. Similar orographic clouds are also frequently observed over the Elysium Shield region.

In addition to such dramatic orographic clouds, Mars exhibits many localized, discrete clouds. These rotate with the planet and are most often seen in northern spring-summer over Libya, Chryse, and Hellas. One remarkable example of such 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 was 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 ("**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. When dust is present, these arcs are often conspicuous in orange light.

Morning clouds are bright, isolated patches of surface fog or frost near the morning limb. 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 best viewed with blue-green, blue, or violet filters. Occasionally, very low morning clouds can also be seen in green or yellow light.

Evening clouds have the same appearance as morning clouds but are usually larger and more numerous than the latter. 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 decrease rapidly in frequency after early summer, while limb hazes become more numerous and conspicuous throughout the northern summer.

Equatorial Cloud Bands (ECBs) appear as broad, diffuse hazy bands along the Martian equatorial zone and are difficult to observe with ground-based telescopes. CCD images and the HST have revealed that these clouds may be more common than 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 ECBs. ALPO astronomers are encouraged to watch for these elusive features during the 2003 apparition. Are they really more common, or could it be that our improved technologies merely allow us to detect them more easily?

ECBs are best observed visually through deep-blue (W47 and W47B) Wratten filters and may be photographed or imaged in blue or ultraviolet light.

New technologies, such as CCD cameras, sophisticated computer hardware and software, and large-aperture planetary telescopes have resulted in a virtual explosion in advancing the study of our Solar System. Never before, for example, have we been able to readily detect the delicate wispy Equatorial Cloud Bands on Mars as well as we can now with CCD imaging.

Dust storms. 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 the southern Martian summer, just after southern summer solstice, but a secondary peak has also been observed in early northern summer, around 105° Ls. Classically, the storms occurring during southern summer are larger and more dramatic, and can even grow rapidly to enshroud the whole planet. It should be remembered, however, that these global dust storms are quite rare – only ten have been reported since 1873, and all but two have occurred since 1956. Much more common are the "localized" dust events, 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:

Movement with obscuration of previously well-defined albedo features. Absence of this criterion disqualifies a candidate from inclusion under the dust clouds category.

Bright appearance of these phenomena in red light. 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 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. We vigorously discourage the use of the term "yellow clouds" to describe dust. If a suspect cloud is not bright in red light, it is not to be considered a dust cloud.

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

Blue Clearing, a little-understood phenomena, when 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 also in white light). The Wratten 47 filter or equivalent is the standard for analyzing 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 caps.

Recently, there has been renewed professional interest in blue clearing. We encourage ALPO Mars observers to watch for this phenomenon during the 2003 apparition.

References

Antoniadi, E. M. (1930). *The Planet Mars*. Chatham: W&J Mackay, Ltd. p. 110.

Beish, J.D., Parker, D.C., and Capen, C.F. (1984), "A Major Martian Dust Storm in 1984," *Journal of the Association of Lunar and Planetary Observers (JALPO)***,** Vol. 30, Nos. 9-10, August.

Beish, J.D. and Parker, D.C. (1988), "The 1983-85 Aphelic Apparition of Mars - Report I," *JALPO*, Vol. 32, Nos. 9-10, August.

Beish, J. D., DC Parker, and C.E. Hernandez (1989), "The Red Planet Show off," *Sky and Telescope Magazine*, Vol. 77, No. 1, January, pp.34.

Beish, J.D., and D.C. Parker (1990). "Meteorological Survey of Mars, 1968-1985," *Journal of Geophysical Research*, Vol. 95, B9, pp. 14567-14675. August 20.

Beish, J.D. (1999), "Meteorological Survey of Mars For Opposition Years 1965 – 1995," *The ALPO Computing Section Internet Web Page: The Digital Lens***,** November.

http://www.m2c3.com/A.L.P.O.cs/tdl1999/meterological110199/MOM.html

Capen, C. F. (1976). "Martian Albedo Feature Variations with Season: Data of 1971 and 1973." *Icarus*, Vol. 28, pp. 213-230.

Capen, C.F. (1976), "A Season for Viking," *JALPO*, Vol. 26, Nos. 3-4, August, pp. 41 - 46.

Capen, C.F., and Parker, D.C. (1980). "Observing Mars VIII — The 1979-80 Aphelic Apparition," *JALPO*, Vol. 28, Nos. 3-4, January 1980, pp.

Capen, C.F., and Parker, D.C. (1981). "What is New on Mars - Martian 1979-1980 Apparition Report II," *JALPO*, Vol. 29, Nos. 1-2, (July 1981, and Vol 29, Nos. 3-4.

Capen, C.F., Parker, D.C., and Beish, J.D. (1984). "Observing Mars XI - The 1984 Aphelic Apparition," *JALPO*, Vol. 30, Nos. 5-6.

Capen, C.F. (1984), "A Guide to Observing Mars – I," *JALPO*, Vol. 30, Nos. 7-8, (April 1984) and Vol 30, Nos. 9-10, August.

Capen, C.F., Parker, D.C., and Beish, J.D. (1986). "A Martian Observer's Menu for 1986," *JALPO*, Vol. 31, Nos. 9-10, July 1986, pp. 186 -188.

Dobbins, T.A., D.C. Parker, and C.F. Capen (1988). *Introduction to Observing and Photographing the Solar System*, Chapter 7.1.4, pp. 57. Willmann-Bell, Inc., Richmond.

Dollfus, A. (1961). "Visual and Photographic Studies of Planets at the Pic du Midi," in *The Solar System*. Vol III: Planets and Satellites, ed. G.P. Kuiper, University of Chicago Press, pp. 559-559.

Lee, S.W, M.J. Wolff, P.B. James, L.J. Martin, R.T. Clancy, and J.F. Bell III (1995). HST Observations of Time-Variable Albedo Features on Mars. *Workshop on Mars Telescopic Observations***,** *LPI Technical Report Number 95-04*, p. 19.

Martin, L. J. and R. W. Zurek (1993). "An Analysis of the History of Dust Activity on Mars." *Journal of Geophysical Research*, Vol. 98, no. E2, pp. 3221-3246.

McKim, R. (1992). "The Opposition of Mars 1990."." *Journal of the British Astronomical Association*, Vol. 102, no. 5, pp. 248-264.

McKim, R. (1996). "The dust storms of Mars**."** *Journal of the British Astronomical Association*, Vol. 106, no. 4, pp. 185-200.

McKim, R. (2002). "Mars in 2001: Second Interim Report." *Journal of the British Astronomical Association***,** Vol. 112, no. 3, pp. 119-121.

Michaux, C. M. and R.L. Newburn, Jr., (1972), *Mars Scientific Model*, JPL Document 606-1, March 1, Sections 4.2, "Seasonal Activity," pp. 27.

Moersch, J., J. Bell III, L. Carter, T. Hayward, P. Nicholson, S. Squyres, and J. Van Cleve (1997). "What Happened To Cerberus? Telescopically Observed Thermophysical Properties of the Martian Surface." *Mars Telescopic Observations Workshop II***,** *LPI Technical Report Number 97-03*, pp. 26-26.

Parker, D.C., J.D. Beish, and C.E. Hernandez (1990), "The 1983-85 Aphelic Apparition of Mars-Report II," *JALPO*, Vol. 34, No. 2, April, pp. 62-79.

Parker, D.C., J.D. Beish, D. M. Troiani, D. P. Joyce, and C. E. Hernandez (1999), "Telescopic Observations of Mars, 1996-1997: Results of the Marswatch Program," *ICARUS***,** Vol. 138, No. 1, March, pp. 3-7.

Slipher, E. C. (1962). *The Photographic Story of Mars*. Sky Publishing Corp. pp. 116-117.

Troiani, D. M., D. C. Parker, and C.E. Hernandez (1996), "The 1994-1995 Aphelic Apparition of Mars," *JALPO*, Vol. 39, No. 1, June, pp. 7-8.

Troiani, D. M., D. P. Joyce, D. C. Parker, C. E. Hernandez, and J. D. Beish (1997**).** *Mars Telescopic Observations Workshop II***,** *LPI Technical Report Number 97-03*, pp. 32-33.

Table 2: Calendar of Events for Mars in 2003-2004

DATE	PHYSICAL	REMARKS
2003 Feb 25	Ls 142.9° De -01.0° Ds 14.6° RA 17:38 Dec -23.3° A.Dia 6''	Apparition begins for observers using 4-inch to 8-inch apertures telescopes and up. Begin low-resolution CCD imaging. Views of surface details not well defined. Northern mid-summer (Southern hemisphere mid-winter). Use filters! Antarctic hazes, hood? Cloud activity? Northern clouds frequent. Syrtis Major broad. Are both polar hoods visible?
2003 Apr 09	Ls 165.2° De -11.7° Ds 6.1° RA 19:36 Dec –22.4° A.Dia 8''	Late southern hemisphere winter, SPH present and edge of NPH visible. Hellas frost covered? Are W-clouds present?
2003 May 06	Ls 180.1° De -16.8° Ds 0° RA 20:44 Dec -19.8° A.Dia 9.9''	Mars at 9.8'' apparent diameter. Mars at Southern Spring Equinox (Northern Autumn Equinox). South Polar Cap (SPC) maximum diameter, subtending ~65° ±12° width. North Polar Hood present. Frost covering Hellas? Hellas should begin to clear. Are W-clouds present? South cap emerges from darkness of Winter. SPH thinning and forms "Life Saver Effect."
2003 May 08	Ls 181.2° De -17.1° Ds -00.5° RA 20:49 Dec –19.6° A.Dia 10''	Quality photographs possible. Southern Spring Equinox. SPC clear of phase terminator, SPH thinning. . Begin low-resolution photography. South Polar Cap (SPC) maximum diameter, subtending ~65° latitude. North Polar hood present. SPH hood thinning.
2003 May 28	Ls 192.7° De -19.5° Ds -5.3° RA 21:34 Dec -17.1° A.Dia 12''	High-resolution CCD imaging and photography. Southern clouds frequent. SPH hood thinning. Eastern Syrtis Major fading and broadening? White areas brighter? Syrtis Major thinner and darker? Surface increasing in contrast. Hellas bright? Northern clouds frequent. Are both polar hoods visible? SPC should be free of its hood. Possible W-clouds in Tharsis-Amazonis. NPH bright. White areas brighter?
2003-Jun-09	Ls 200° De -20.3° Ds -08.2° RA 21:59 Dec -15.6° A.Dia 13.4''	Bright SPC (Width ~56° ±1°) projection Novissima Thyle 300° - 330° areographic longitude. Dark rift Rima Augusta connected from 60° to 270° longitude. Rima Australis visible in SPC (290°-350°W)? W-clouds possible. SPC bright projection Argenteus Mons (10° W - 20° W). SPC Dust clouds in Serpentis-Hellespontus, in Hellas or Noachis?
2003-Jun-26	Ls 210° De -20.7° Ds -12.1° RA 22:27 Dec -13.9° A.Dia 15.8''	Is the Rima Australis visible in SPC (290°-350°W)? SPC bright projection Argenteus Mons (10°-20°W). SPC Novissima Thyle (300°-330°W) projection present? Look for possible small dust clouds in Serpentis-Hellespontus.
2003 Jul 13	Ls 220° De -20.4° Ds -15.8° RA 22:48 Dec -13.1° A.Dia 18.8''	SPC Width ~53° ±1°. Bright SPC projection Novissima Thyle 300° - 330° areographic longitude. Dark rift Rima Augusta connected from 60° to 270° longitude. Rima Australis visible in SPC (290°-350°W)? W-clouds possible. SPC bright projection Argenteus Mons (10° W - 20° W). SPC Dust clouds in Serpentis-Hellespontus, in Hellas or Noachis?

Table 2: Calendar of Events for Mars in 2003-2004

DATE	PHYSICAL	REMARKS
2003 Jul 20	Ls 224.9° De -20.1° Ds -17.2° RA 22:53 Dec -13.0°	Mars at 20.1'' apparent diameter. SPC shrinking (Width ~53° ±1°). Syrtis Major darkens and continues to shrink. W-clouds possible. Surface details increasing in contrast. Hellas bright? SPC Novissima Thyle (300°-330°W) projection present? Dark rift Rima Augusta connected from 60° to 270° longitude. W-clouds possible. Dust clouds? Is the Rima Australis visible in SPC (290°-350°W)?
2003 Jul 28	Ls 230.0° De -19.7° Ds -18.7° RA 22:56 Dec -13.2° A.Dia 21.6''	Mars at 21.6'' apparent diameter. Rapid regression of SPC. (SPC Width ~35° ±1.5°). 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. Eastern Syrtis Major retreats. North Polar Hood prominent.
2003 Aug 27	Ls 248.9° De -18.4° Ds -23.0° RA 22:39 Dec -15.6 ° A.Dia 25.11''	Mars at Closest Approach and 25.11'' apparent diameter. 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.
2003 Aug 28	Ls 249.5° De -18.4° Ds -23.1° RA 22:38 Dec -15.7° A.Dia 25.1''	Mars at Opposition. Orographic clouds (W-Clouds) possible. Syrtis Major narrowing? Elysium and Arsia Mons bright?
2003 Aug 29	Ls 250.1° De -18.4° Ds -23.2° RA 22:37 Dec -15.8° A.Dia 25.1''	Mars at Perihelion. Late southern spring. SPC rapid retreat (Width ~34° ±0.8°). Orographic clouds present? Elysium and Arsia Mons bright? Frost in bright deserts? Novus Mons smaller. Hellas bright. White areas in bright areas? Watch for initial dust clouds in southern hemisphere over Serpentis-Hellespontus (Ls 250° - 270°).
2003 Sep 06	Ls 255.2° De -18.4° Ds -23.9° RA 22:29 Dec -16.3° A.Dia 24.7''	Mars at 24.7'' apparent diameter. SPC Width ~21.5° ±0.8. Watch out for major dust storms, first peak period for storms. 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?
2003 Sep 29	Ls 270° De -25.2° Ds -24.8° RA 22:16 Dec -15.8° A.Dia 21.1''	Southern Summer Solstice. SPC Width ~21° ±0.5°. Dust clouds in south? Atmosphere clearing of blue clouds? Decreased number of White clouds? White clouds rare. W-clouds present? White areas in deserts? Dust clouds in south? Watch for planetary system clouds bands. NPH extends 50°N?
2003 Oct 04	Ls 272.9° De -19.9° Ds -24.7 ° RA 22:16 Dec -15.3° A.Dia 20.1''	Mars at 20.1'' apparent diameter. Just past Southern Summer Solstice. W-clouds present? NPH extends 50°N? Decreased number of White clouds. Atmosphere clearing of blue clouds? White areas in deserts? Dust clouds in south?

Table 2: Calendar of Events for Mars in 2003-2004

DATE	PHYSICAL	REMARKS
2003 Nov 22	Ls 302.9° De -24.9° Ds -20.6 ° RA 23:12 Dec -06.4° A.Dia 12''	Orographics over the Tharsis volcanoes -- W-clouds present? SPC very small. Photography still possible. White areas? Look for orographics clouds (blue or violet filter). CCD and film imaging still possible.
2003 Dec 12	Ls 314.6° De -25.7° Ds -17.4° RA 23:51 Dec -01.5° A.Dia 10''	Quality CCD images still possible. Low-resolution photography still possible.
2003 Dec 13	Ls 315.2° De -25.7° Ds -17.2° RA 23:53 Dec -01.2° A.Dia 9.9''	Watch out for major dust storms. Is SPC remnant visible in mid-summer? Edom bright
2004 Jan 07	Ls 329.3° De -24.8° Ds -12.4° RA 00:46 Dec 5.3° A.Dia 8''	Hellas Ice-fog activity? NPC large hood present. W-Cloud?
2004 Feb 18	Ls 351.6° De -18.6° Ds -3.5° RA 02:26 Dec 15.4° A.Dia 6''	Apparition wanes for most observers. Begin low-resolution. Some CCD imaging still possible. Views of surface details not well defined. Large NPC hood present? Views of surface details still well defined. Some photography still possible. Discrete (white) clouds and white areas should be seen. NPC large hood (NPH) present. Syrtis Major begins to expand to its east.

ALPO Feature: Mars

Flashes on Mars Observed in 1937 And Some Random Remarks

By: Walter H. Haas, ALPO Director Emeritus

Abstract

The literature on Mars includes a very small number of reports of transient brilliant flares or intermittent series of flashing bright spots. These have been plausibly explained as specular reflections of the Sun from ice on the surface or sometimes crystals in clouds. Dobbins and Sheehan predicted that such events would occur in Edom Promontorium in early June, 2001; and a team of observers successfully confirmed them. The present paper describes similar, and almost unknown, observations of flashes in a different part of Mars in 1937. Speculations are offered about how well such events have been observed in the past.

Introduction

Among the multitude of Mars observers of the last century and a half, more or less, only a very few have occasionally reported small, temporary, rapidly variable brighter spots on the planet. These have varied in appearance from a transient brilliant spot fading out in some seconds to an intermittent series of tiny flashes over an interval of about an hour. Other brilliant flares have faded out in some minutes. The first known event of this kind was an observation on June 7, 1894 by Percival Lowell and W. H. Pickering of two "dazzling white specks" visible for a few moments in the South Polar Cap of Mars (1). These were the "Mountains of Mitchell", near Martian longitude 285 degrees and regularly visible at the right time during Martian southern spring as bright points detached from the shrinking south cap.The most recent observation must be that of a team of observers near Key West, FL on June 7 and 8, 2001 (2,3). They recorded a pulsating flare in Edom Promontorium for about an hour on June 7 and for two shorter intervals on June 8. The "flashes" were seen simultaneously in telescopes by many of the visual observers and were also recorded on videotapes by David Moore, who is carrying out an ongoing detailed analysis.

Dobbins and Sheehan have given us an excellent historical summary of known observations of these curious Martian flares (4). They propose as an explanation reflections of sunlight from ice on the surface of Mars or from crystals in clouds. The geometry needed for the reflected image of the Sun to reach the observer on the Earth is naturally very special, depending on the tilt of the axis of Mars toward the Earth and the Sun and the exact topography of the Martian surface or perhaps sometimes on the orientation of crystals in Martian clouds. They used their interpre-

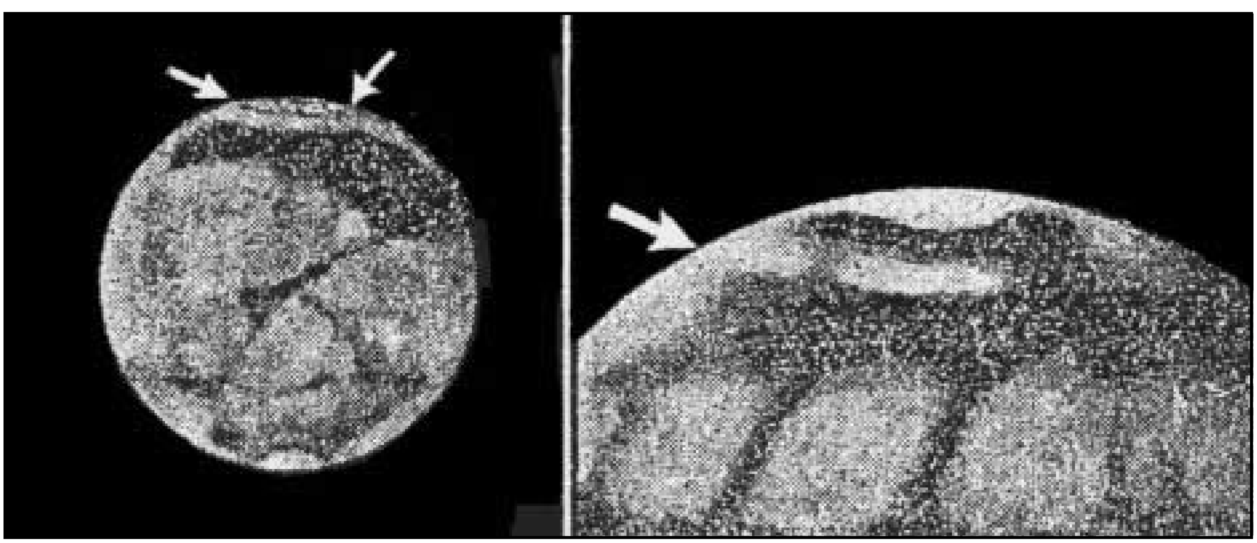


Figure 1. Drawings of Mars by Latimer J. Wilson with a 31-cm. reflector at 250X. Left drawing at 5 hrs., 30 mins., Universal Time, on May 30, 1937., CM = 203 degrees. The arrows indicate the location of the line of flashes. Right drawing shows same region of Mars at 2 hrs., 30 mins., UT, on September 15, 1924, CM = 205 degrees.

tation and known geometry at past observations of flashes to predict flashes in Edom in early June, 2001; and we must congratulate them on their success.

Observations by Latimer J. Wilson in 1937

Since known recorded flashes are so few, it appears very proper to review an overlooked observation by Latimer J. Wilson of Nashville, TN on May 30,1937(5,6). Indeed, are there others? Mr. Wilson was a leading amateur planetary observer of the 20th century and a pioneer in amateur lunar and planetary photography. He attempted to record the flashes which he saw on concurrent photographs. Unfortunately, the evidence of the latter is inconclusive. Wilson wrote in part:

"On May 30, 1937, during a part of the interval between 4 hrs., 35 mins. and 6 hrs., 0 mins., GCT [now Universal Time] while Mars was being observed through a 12-inch aluminized reflector, X250 diameters, and with unusually good seeing, a series of bright flashes was seen extending across the south polar cap about 1 arcsecond north of the southern rim of the disk. [Actually, no flashes were seen after 5 hrs., 40 mins., UT.] They were irregularly intermittent and were estimated to be about one [stellar] magnitude brighter than the rest of the cap. They were entirely unexpected and when attention was attracted to them, the greater part of the period [of observation] was given to concentrated study of the south polar regions.

"The short diameter [north-south breadth] of the cap on the central meridian measured from photos and drawings was 1.87 arcseconds, and about midway between the southern rim and northern edge of the light area, a narrow string of tiny bright spots was first noted. Some of these seemed to coalesce and swell into a brilliant light which passed, generally, across the cap in a direction contrary to that of the planet's rotation [thus from left to right in a simply inverted image of Mars with south at the top]. The flash first appeared white, then yellow, and quickly faded into the sharp whiteness of the line of tiny spots. The centers of origin of the flashes seemed to be in longitude about 190 and 212 degrees. The writer saw in all about eight of these sudden increases of light, and two other observers [with him] witnessed several".

We always desire confirmation of unusual visual observations. Mr. Wilson's Nashville neighbors, Mr. John H. De Witt, Jr. and his brother, saw no flashes but did think the south cap unusually white(6). Dr. E. C. Slipher at the Lowell Observatory was observing Mars with the 24-inch refractor while Wilson was seeing the flashes and did not record them, perhaps because of concentration on taking photographs and changing plates (5). I was observing Mars on May 30, 1937 but stopped at 2 hrs., 50 mins., UT and thus before the flashes started.

Physical data on Mars, partly supplied by Mr. Jeff Beish, for May 30, 1937, 4:35 to 5:40, UT, the interval during which flashes were seen, are as follows:

D, the angular diameter 18.4 arcseconds
Ls, the areocentric longitude 155.7 degrees \
(Thus the season on Mars was a little less than a month before the vernal equinox of the Southern Hemisphere.)

De, the tilt of the axis toward the Earth 13.0 degrees north
Ds, the tilt of the axis toward the Sun 8.4 degrees north
i, the phase-angle, or Sun-Mars-Earth angle 9.1 degrees
CM, the central meridian of longitude
at 4:35 189.4 degrees
at 5:40 205.2 degrees

Wilson added a few more details in correspondence(7). The flashes were not continuous, but intermittent; and a "line of keen whiteness" marked their position during most of the observing interval. The total flash effect persisted for about 3 or 4 seconds, sometimes longer.

Wilson went to considerable trouble to try to determine the latitude of the line of flashes, eventually making and measuring a large outline of Mars with the proper axial tilt (7). His result was about 55 degrees south latitude, thus at the north border of Thyle I and Thyle II. He noted:"The writer has suspected these regions to be plateaux separated from Electris and Eridania by a depression, Mare Chronium. Ice on steep slopes along a northern escarpment might flash sunlight if the angle between earth, sun, and Mars is just right. Cloudless sky in that region would be necessary".

Miscellaneous Remarks

Noting the brief duration of the flashes, we may do well to remember that the surface of Mars at the equator rotates through 1 km. in about 4 seconds of time, and in about 7 seconds at latitude 55 degrees. Noting also the similarity of the 1937 and the 2001 observations, we may wonder whether the Martian terrain is similar in Edom Promontorium and along the northern border of Thyle I and Thyle II.

How frequent are these flashes on Mars? Wilson stressed that he had never seen anything similar in his personal observations of Mars going back to 1909(6), and I have never remarked such an event in somewhat variable Mars studies begun in 1935.The flashes evidently require some extremely special geometry of the Earth-Mars-Sun system, as specular reflections of sunlight must. Wilson saw no flashes on May 26, 28, 29, and 31, when observing much the same longitudes on Mars, though the south cap looked unusually bright before May 30. Similarly the Key West observers obtained only negative results on June 2, 3, 4, 5, 6, and 9, 2001(3).

There are about 20 known reports of these Martian oddities in the literature(3). The most popular locales have been Edom and the general area of Solis Lacus-Tithonius Lacus. Certainly other observations may be unknown or now forgot, as Wilson's 1937 efforts have been. Indeed some of the reporting observers have been well aware of pitfalls which varying seeing or motes in the eye can cause before they decided to report the flares as genuine, like Tasaka in 1958 or Saheki in 1951(3). It may easily be that unknown other observers witnessing flares or flashes decided that they were seeing an illusion and hence reported nothing.

These old observations describe transient bright spots varying in brightness and lasting from a few seconds up to many minutes. The Key West 2001 observations and those by Wilson in 1937 are different in describing flashes over an interval of about an hour.

It appears very strange that the flashes of June 7 and 8 were apparently observed only by the Key West team. To be sure, the planet was at declination –26 degrees, making it low in the sky over most of the United States; and to be sure, there were cloudy skies on June 7 and 8 over much of the country. Still, the possible events, with an observing schedule, had been predicted in the widely read May, 2001 issue of *Sky & Telescope* (4); on June 13 Mars would be at its closest opposition since 1988; and June nights do bring comfortable observing.We would expect that a fair number of telescopes must have been pointed at Mars during the critical hours on June 7 and 8 – and we have no reports. For myself, I did not begin to look at Mars on June 7 until about 7:50, UT, when the flashes had stopped; and June 8 was completely cloudy. It would almost appear that our coverage of the Red Planet is rather superficial.

In August 2003 Mars will come closer to the Earth than it has for many centuries. Surely the possibility of these curious flashes should add interest to our future observations – and perhaps the unseasonal dust storms of 2001 will not repeat to hamper us. Some of the Key West team are already making plans for systematic watches of Edom when the geometry is proper in 2003. Please look for further information as plans develop and for helpful observing schedules.

References

1. Lowell, Percival. “Mars”. Third Edition, London, 1900. pp. 86 and 87.
2. Seronik, Gary. “Mars Flashes in Florida”. *Sky & Telescope* magazine. Vol. 102, No. 3, pg. 112.September, 2001.
3. Dobbins, T.; Sheehan,W.; Parker, D.; Moore,D; and D’ Auria,T. “The Martian Flares Mystery – Solved?” Unpublished paper read at the ALPO Convention at Frederick, MD, in July, 2001.
4. Dobbins, Thomas and Sheehan, William. “The Martian Flares Mystery”. *Sky & Telescope* magazine. Vol. 101, No. 5, pp. 115-123. May, 2001.
5. E. P. Martz, Jr. “Planetary Report No. 24, Mars, 1937, III”. *Amateur Astronomy* magazine. Vol. 3, No. 8, pp. 129-132,138. October, 1937.
6. Wilson, Latimer J. “Apparent Flashes Seen on Mars”. *Popular Astronomy* magazine, Vol. 45, No. 8, pp. 430-432. October, 1937.
7. Letters from Latimer J. Wilson to Walter H. Haas on June 4, July 21, September 14, and December 27, 1937.

It is a pleasure to acknowledge the assistance of Mr. J. O. Hughes of Las Cruces, New Mexico in the preparation of Figure 1 for publication in this journal.

ALPO Feature: Jupiter

The 1992-1993 Apparition of Jupiter

By Richard W. Schmude, Jr.,
Coordinator, Jupiter Section
Peer Review by John Westfall

Abstract

Drift rates are reported for 69 different features on Jupiter ranging in planetographic latitudes from 52°.3 S to 52°.8 N. From these drift rates, wind speeds for twenty Jovian currents were computed. A South Equatorial Belt revival began in early April at a System III longitude of 333° and spread in both the east and west directions. A "Little Red Spot" appeared in the South Tropical Zone in early March, 1993, and remained until at least late June. This spot had a color and shape similar to the Great Red Spot but its area was one-fifth that of the Great Red Spot.

Introduction

Three highlights of this apparition were the fading of the SEB [for Jovian nomenclature see Figure 7 on page 16] during 1992 (Olivarez, 1993a, 76), the revival of the SEB in early April of 1993 (*Sky & Telescope*, 1993a, 9; *Sky & Telescope*, 1993b, 78) and the appearance of the "Little Red Spot." Budine (1993, 15) and Olivarez (1993b, 44) have published preliminary reports of the 1992-93 apparition. A full report based largely on reports from American observers and the photographs made by Isao Miyazaki is given here. *Table 1* (page 1) lists the characteristics of Jupiter during 1993 while *Table 2* (page 2 and 3) lists the participating observers.

Disc Appearance

Figure 1 (page 4) shows photographs of Jupiter at several different longitudes and times while *Figures 2* and *3* (pp. 6, 8) show photographs and drawings of the South Equatorial Belt revival that began in early April. *Figures 4*, *5* and *6* (pp. 10, 12 and 14) plot drift rates of 60 different features. Nine additional features could not be graphed as their longitudes overlapped those of other features. The nomenclature used in this report is the same as that used in the 1991-92 Apparition report (Schmude, 2002) and is shown in Figure 7. "West" refers to the direction of increasing longitude. [Three longitude systems are used for Jupiter: "System I" (λ_I) applies to the EZ, south edge of the NEB, north edge of the SEB, and the south edge of the NTB. "System II" (λ_{II}) applies to the remainder of the disc. "System III" (λ_{III}) is the planet's underlying "radio" rotation period.]

Heath measured the light intensity of several Jovian features in both integrated light and through three different color filters. The light intensities were measured on the Standard ALPO Scale of 0 = black to 10 = white. Heath's mean light intensity values in integrated light were: NPR (7.0), NTZ (9.1), NTB (5.0), NTrZ (9.5), NEB (5.0), EZ (8.7), GRS (6.8), STrZ (9.6), STB (5.9) and SPR (7.0). Heath's values are in good agreement with observations made by others in 1993. The GRS was the reddest feature on the planet. The NEB, NPR, SPR, NTrZ and NTB were slightly red according to Heath's estimates, while the STrZ and EZ were both close to neutral in color. Heath reported that the revived SEB was darker in red than blue, which is consistent with a blue color for this feature. Olivarez also reported that the revived SEB had a blue color.

The planetographic (sometimes called "zenographic") latitudes of several Jovian belts were measured from high-resolution photographs. The formulae in Peek (1981, 49) were used in computing the latitude and the sub-Earth latitudes were taken from *The Astronomical Almanac* (1991, 1992); the resulting latitudes are listed in *Table 3* (page 5). Most features had latitudes similar to the previous apparition (Rogers and Foulkes, 1994, 168; Schmude, 2002); however one exception was the Equatorial Band, which was 3° farther north in 1992/93 than in 1991/92.

The writer measured the dimensions of several Jovian features from high-resolution photographs

Table 1: Characteristics of the 1992-93 Apparition of Jupiter*

First Conjunction with the Sun	1992 SEP 17 UT
Opposition Date	1993 MAR 30 UT
Second Conjunction with the Sun	1993 OCT 18 UT
Apparent equatorial diameter (opposition)	44.2 arc-seconds
Visual stellar magnitude (opposition)	-2.5
Planetographic declination of the Sun (opposition)	2°.8 S
Planetographic declination of Earth (opposition)	3°.2 S
Geocentric declination of Jupiter (opposition)	2°.4 S
* Data taken from *The Astronomical Almanac*	

Table 2: Persons Who Submitted Jupiter Data During the 1992-93 Apparition

Contributor	Location	Instrument*	Type of Data**
Adcock, Barry	View Bank, Australia	0.31-m RL	P
Aerts, Leo	Heist, Belgium	0.25-m & 0.31-m RR	TT
Barnett, John	Bon Air, VA	0.18-m RR	D
Benninghoven, Claus	Burlington, IA	0.30-m RR, 0.20-m RL	CCD, SS, TT, D, DN
Billiaert, Bruno	Hove, Belgium	0.25-m telescope	TT, D
Bosselaers, Marc	Berchem, Belgium	0.21-m & 0.41-m RL	TT, D
Boyar, Dan	Boynton Beach, FL	0.15-m & 0.25-m RL	D, DN
Buda, Stefan	A. S. V., Australia	0.08-m RR	TT
Budine, Phillip	Walton, NY	0.09-m MAK	SS, TT
Carlino, Lawrence	Lockport, NY	0.20-m RL	D, DN
Cauteren, P. Van	Aartselaar, Belgium	0.25-m RL	TT
Ciampi, A.	(Unknown)	0.23-m RL	D
Cross, Darrell	Birmingham, AL	0.20-m RL	D, DN
Cudnik, Brian	Flagstaff, AZ	0.15-m RR	D, DN
Cuppins, Wim.	Gruithode, Belgium	0.20-m RL	TT
Daerden, Frank	Genk, Belgium	0.25-m RL	TT
Dragesco, J.	(Unknown)	0.25-m telescope	P
Dymond, Garry	St. Johns, NF, Canada	0.20-m SC	D, TT
Everington, Sean	Vermont, Australia	0.13-m RL	TT
Fernandez, David	Barcelona, Spain	0.16-m RL	D, DN, TT
Goertz, Hans	Belgium	0.20-m RL	TT
Haas, Walter	Las Cruces, NM	0.20-m and 0.32-m RL	TT, SS, DN
Hays, Robert, Jr.	Worth, IL	0.15-m RL	D, DN, TT
Heath, Alan W.	Nottingham, England	0.32-m RL	DN, TT
Horst, Gross	Volkssternwarte Hagen, Germ.	0.25-m RL	TT
Johnson, Gus	Swanton, MD	0.08-m RR, 0.15-m & 0.51-m RL	D
Jones, James	(Unknown)	0.23-m RL	D
Joyce, Daniel P.	Chicago, IL	0.25-m RL	D
MacDougal, Craig	Tampa, FL	0.15-m RL	D, DN, TT
Mattei, Michael	Littleton, MA	0.15-m RL	D, SS, TT
Maxon, Paul	Phoenix, AZ	0.25-m Telescope	D
Miyazaki, Isao	Okinawa, Japan	0.40-m RL	CCD, P, SS, TT
Molenaire, B.	(Unknown)	0.23-m RL	D
Morrow, Mike J.	Ewa Beach, HI	0.46-m RL	D
Nelson, Peter	Ellinbank, Australia	0.32-m RL	TT
Newsom, John	Paragould, AK	0.15-m RR	D, TT
Niechoy, Detlev	Goettingen, Germany	0.20-m RL	D
Nowak, Gary	Essex Jct., VT	0.25-m RL	D, DN
Olivarez, Jose	Wichita, KS	0.20-m RR, 0.15-m & 0.32-m RL	D, DN, SS, TT
Parker, Donald	Coral Gables, FL	0.41-m RL	CCD
Plante, Phil	Poland, OH	0.15-m RL	D, DN, TT
Post, Cecil	Las Cruces, NM	0.20-m RL	D, DN
Riemis, Hugo	Berchem, Belgium	0.20-m RL	D, TT
Robinson, Robert	Morgantown, WV	0.25-m RL	D, DN, TT
Schmude, Richard, Jr.	College Station, TX	0.36-m SC	P
Siegel, Elisabeth	Malling, Denmark	0.20-m SC	D, DN, SS, TT
Swatek, John	Ewa Beach, HI	0.41-m RL	D, DN
Sweetman, Michael	Tucson, AZ	0.10-m RR	D, DN
Tatum, Randy	Richmond, VA	0.18-m RR	SS, TT
Titford, Bob	Essex, England	0.11-m RL	D, DN
Tomney, Jim	Towson, MD	0.15-m RL	D, DN, TT
Troiani, Daniel M.	Schaumburg, IL	0.44-m RL	D, DN, SS, TT
Vantomme, Jan	Ekeren, Belgium	0.30-m RL	TT
Verwichte, Erwin	Genk, Belgium	0.20-m RR	TT

Table 2: (continued)

Contributor	Location	Instrument*	Type of Data**
Ward, Don	Victoria, Australia	0.15-m RL	D
Weier, David, D.	Madison, WI	0.28-m RL	SS, TT
Whitbty, Samuel	Hopewell, VA	0.15-m RL, 0.18-m RR	D, DN, SS, TT

* MAK = Maksutov, RL = Reflector, RR = Refractor, SC = Schmidt-Cassegrain. Approximate English-unit equivalents of metric apertures are: 0.08 m = 3.1 in, 0.09 m = 3.5 in, 0.10 m = 3.9 in, 0.11 m = 4.3 in, 0.15-0.16 m = 6 in, 0.18 m = 7 in, 0.20-0.21 m = 8 in, 0.23 m = 9 in, 0.25 m = 10 in, 0.28 m = 11 in, 0.30-0.31 m = 12 in, 0.32 m = 12.5 in, 0.36 m = 14 in, 0.40-0.41 m = 16 in, 0.44 m = 17 in, 0.46 m = 18 in, 0.51 m = 20 in.

**CCD = CCD image, D = drawing, DN = descriptive notes, P = photograph, SS = strip sketch, TT = transit time.

and CCD images and the results are summarized in *Table 4* (page 7). Dimensions were computed in the same way as is described in Schmude (2002). The GRS had about the same area as in 1991/92. The mean aspect of the six SSTB white ovals was 0.88, which is close to the mean aspect of 0.90 for the 8 SSTB ovals in 1991/92 (Schmude, 2002). (The aspect equals the north-south dimension, as corrected for foreshortening, divided by the east-west dimension.) Rogers (1995, 225) plotted the lengths of Ovals FA, BC and DE from 1940 to 1990. Based on these data and the dimensions in Table 4, it is concluded that, since the early 1950s, Ovals BC and DE have been shrinking in linear dimensions at a rate of 3.2 percent per year whereas Oval FA has been shrinking at a rate of 3.3 percent per year.

Region I: Great Red Spot (GRS)

The GRS was first identified on 1992 NOV 29 and was followed until 1993 AUG 24. This feature was an orange-pink oval on a white background during most of the apparition. The SEB disturbance appeared to merge with the GRS in June 1993 but in July, the GRS could once again be distinguished from the SEB. At least the following half of the GRS remained darker than the STrZ on 1993 AUG 05 and 10; however, the GRS was not visible on an August 29 photograph. Benninghoven also reported that, on August 24, the northern half of the GRS was “light and diffuse” and that the GRS appeared to be displaced to the south. This fading of the GRS in late August is consistent with previous SEB revivals (Rogers, 1995, 171).

Based on visual reports and a series of color slides, it is concluded that the orange color of the GRS intensified in April 1993 and reached a peak toward the end of that month. The color intensity decreased during May and remained relatively low in June.

The GRS was slightly dark in red light on 1993 JAN 14, but became lighter in red light over the next two months. The GRS was as bright as the STrZ in red light between late March and at least early June. In visible light, a dark bar lay inside the GRS; this bar grew in size between January and March 1993 and it also became darker during this time. A similar dark bar had been visible during the first four months of 1992 (Schmude, 2002). This dark bar was very faint in red light.

A dark collar surrounded at least the southern half of the GRS throughout the first half of 1993. This collar was around 1,500 km wide and was best seen in integrated and green light. The GRS was completely surrounded by a dark collar on 1993 FEB 04, MAR 28, APR 16 and JUN 03, whereas the northern border of the GRS lacked the collar on 1993 JAN 14, MAY 17 and JUN 30.

A “Little Red Spot,” or LRS (D1,) formed at latitude 24°.2 S. This feature had a rotation period of 9h 55m 36s. The LRS had a color and shape that was similar to that of the GRS; however, the LRS was darker in red light than the GRS.

Region II: South Polar Region to the South Tropical Zone

The SPR was darker than the NPR between February and June, 1993 according to images and photographs. The northern limb had a sharper contrast with the dark sky background between February and April, 1993, but in May the contrast was about equal for the two Polar Regions. During June through August, the southern limb had the sharper contrast with the dark sky.

On a few occasions, two dark belt sections were photographed, which correspond to the S^4TB (SSSSTB) and S^5TB (SSSSSTB). There was at least one distinct bright oval (A1) at 52°.3 S, which is probably the same high-latitude oval shown in Figure 1-E at λ_{II} = 0°.

At least five bright ovals (B2-B4, B6 and B7) at a latitude of 42-43° S were all lying within the SSTB. Oval B5 at 41° S passed due south of Oval FA on about

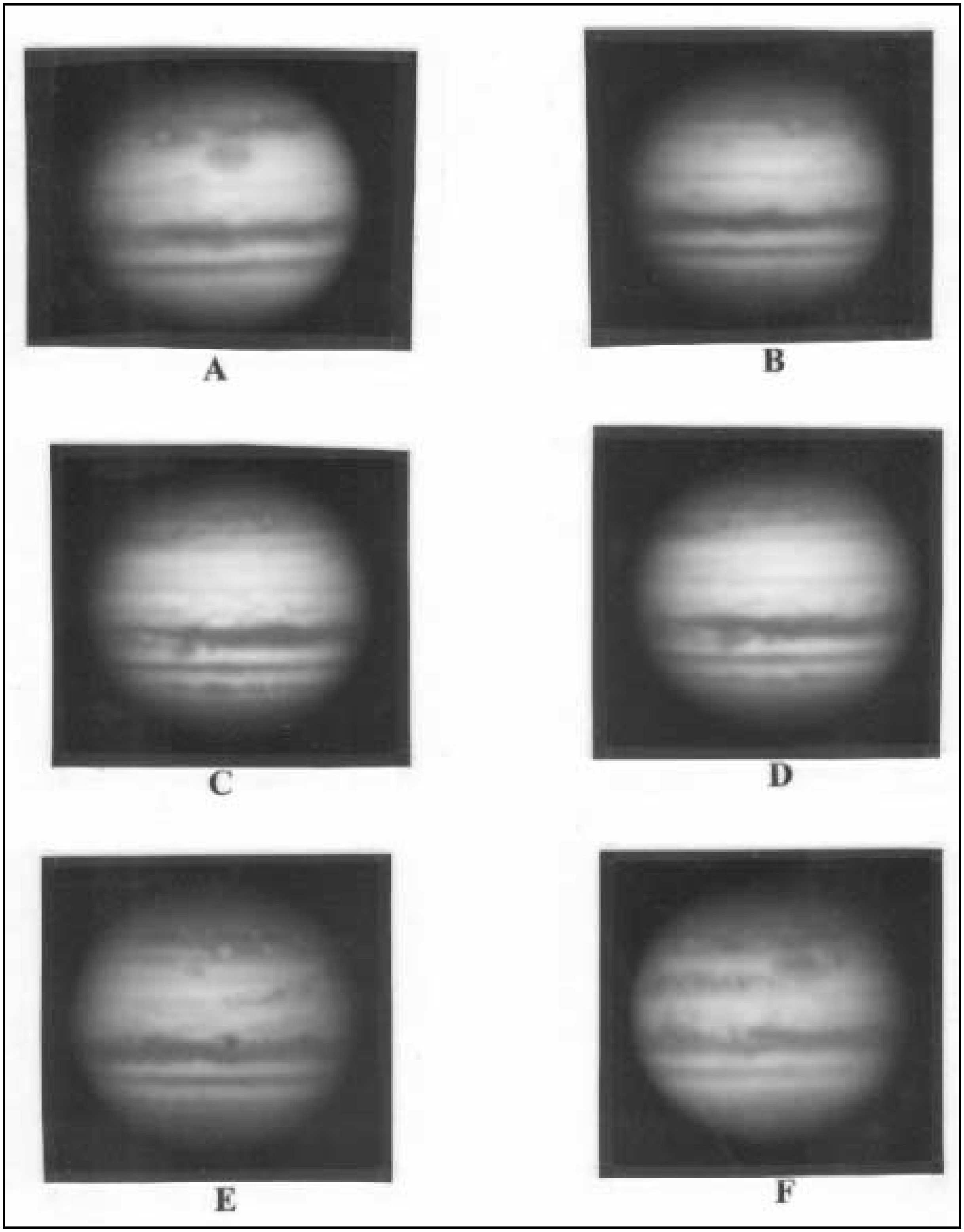


Figure 1: Photographs of Jupiter taken by Isao Miyazaki, using a 0.40-m reflector. All dates are in 1993 and all times are in Universal Time and are in parentheses. A: FEB 04, (20:07.5), λ_{I} = 260°, λ_{II} = 037°, λ_{III} = 328°; B: MAR 08 (14:58), λ_{I} = 88°, λ_{II} = 342°, λ_{III} = 282°; C: MAR 22 (14:40), λ_{I} = 130°, λ_{II} = 277°, λ_{III} = 220°; D: MAR 27 (13:46), λ_{I} = 167°, λ_{II} = 276°, λ_{III} = 221°; E: APR 15 (16:11), λ_{I} = 018°, λ_{II} = 341°, λ_{III} = 291°; F: MAY 17 (14:06), λ_{I} = 315°, λ_{II} = 036°, λ_{III} = 354°. South is at the top, the preceding limb is to the left and the direction of increasing longitude is to the right.

Table 3: Planetographic Latitudes of Belts on Jupiter During the 1992-93 Apparition

(The north and south edges of the belts are designated by a lower-case “n” or “s”; for example, the northern edge of the north equatorial belt is called “NEBn”. A lower-case “c” means “center”.)

Belt	Planetographic Latitude	Estimated Error
NNNNTBn	56° N	+/- 2°.0
NNNNTBs	53° N	+/- 2°.0
NNNTBn	46°.0 N	+/- 1°.0
NNNTBs	43°.6 N	+/- 1°.0
NNTBn	38°.7 N	+/- 1°.0
NNTBs	35°.0 N	+/- 1°.0
NTBn	28°.0 N	+/- 0°.5
NTBs	23°.8 N	+/- 0°.5
NEBn	17°.3 N (mean)	+/- 0°.5
NEBs	6°.3 N (mean)	+/- 0°.5
EBc	0°.2 N	+/- 1°.0
SEBn[a]	8°.7 S	+/- 0°.5
SEBs[a]	19°.9 S	+/- 1°.0
STBn	28°.0 S	+/- 1°.0
STBs	(Variable)	—
SSSSTBn	53° S	+/- 2°.0
SSSSTBs	57° S	+/- 2°.0
SSSSSTNn	62° S	+/- 2°.0
SSSSSTBs	66° S	+/- 2°.0
GRS	23°.0 S	+/- 0°.5

[a] Based on the faint belt components before the SEB revival.

1993 MAR 31, and there appears to have been no change in the drift rates of either oval.

Oval B2 passed due south of Ovals BC and DE on about 1993 APR 01 and MAY 11, respectively. There appears to have been no change on April 1; however beginning in mid-April, Oval B2 appears to have slowed down slightly; its longitudes were 2-3° west of its previous position. After mid-May, its longitudes were 2-3° east of the best-fit line in Figure 4 and so Oval DE may have changed the velocity of Oval B2. Ovals B2-B4, B6 and B7 had a mean rotation period of 9h 55m 05s, which is similar to that of the South Temperate Current rotation period in the previous apparition. Ovals B3 and B4 were preceded and followed, respectively, by a white section that resembled Ovals BC, DE and FA in the early 1940s (Haas, 1953, 5).

Oval FA was surrounded by a dark streak during 1993 but the dark streak was much smaller than what it was in early 1992. In a drawing by Olivarez on 1993 JUL 31, Oval FA was almost due south of the GRS. Ovals BC and DE passed the GRS on about 1992 NOV 23 and 1993 JAN 17. The drift rate of Oval DE did not change much as it passed the GRS. There were no data on the passage of BC and the GRS.

Region III: South Equatorial Belt

Whitby made several drawings of Jupiter in mid-July 1992 (in the immediately previous apparition), which show a very faint southern component of the SEB. The northern component of the SEB in these drawings was distinct. Jupiter reached conjunction with the Sun two months after Whitby’s last drawing. Benninghoven and Whitby both observed Jupiter in late October, 1992, and their drawings show the SEB as a thin line, which is undoubtedly just the northern component of the SEB. Whitby noted on 1992 OCT 27: “a definite SEBn was seen...” Based on these observations, it appears that the SEB was in the process of fading during most of 1992. The author considers this fading to have been gradual.

During early 1993, the southern component of the SEB was very faint but it was usually visible in high-resolution photographs. The northern component of the SEB was always visible but it was lighter than the Polar Regions. The northern component was darkest in blue light and lightest in red light. On 1993 APR 04 Robinson drew a dusky dark spot in the SEB near (λ_{II} = 030°, λ_{III} = 336°); this spot appears to be the first hint of the SEB disturbance; see Figure 7.

The darkening of the SEB is referred to as the “SEB disturbance” or the “SEB revival”. The SEB revival started out as a dark spot (S7) near Robinson’s April 4 spot. A bright oval appears next to the dark spot on an April 13 photograph. The longitude of S7 was followed from April 6 to 16 and an approximate rotation period of 9h 54m 34s was computed from the longitudes in *Table 5* (page 9). Feature S6 was a white oval near the center of the SEB revival and its longitudes are listed in Table 5.

Features S9 and S10 were the trailing and leading edges of the SEB revival, respectively. Their longitudes are listed in Table 5 and their drift rates are listed in *Table 6* (page 11) with respect to the System

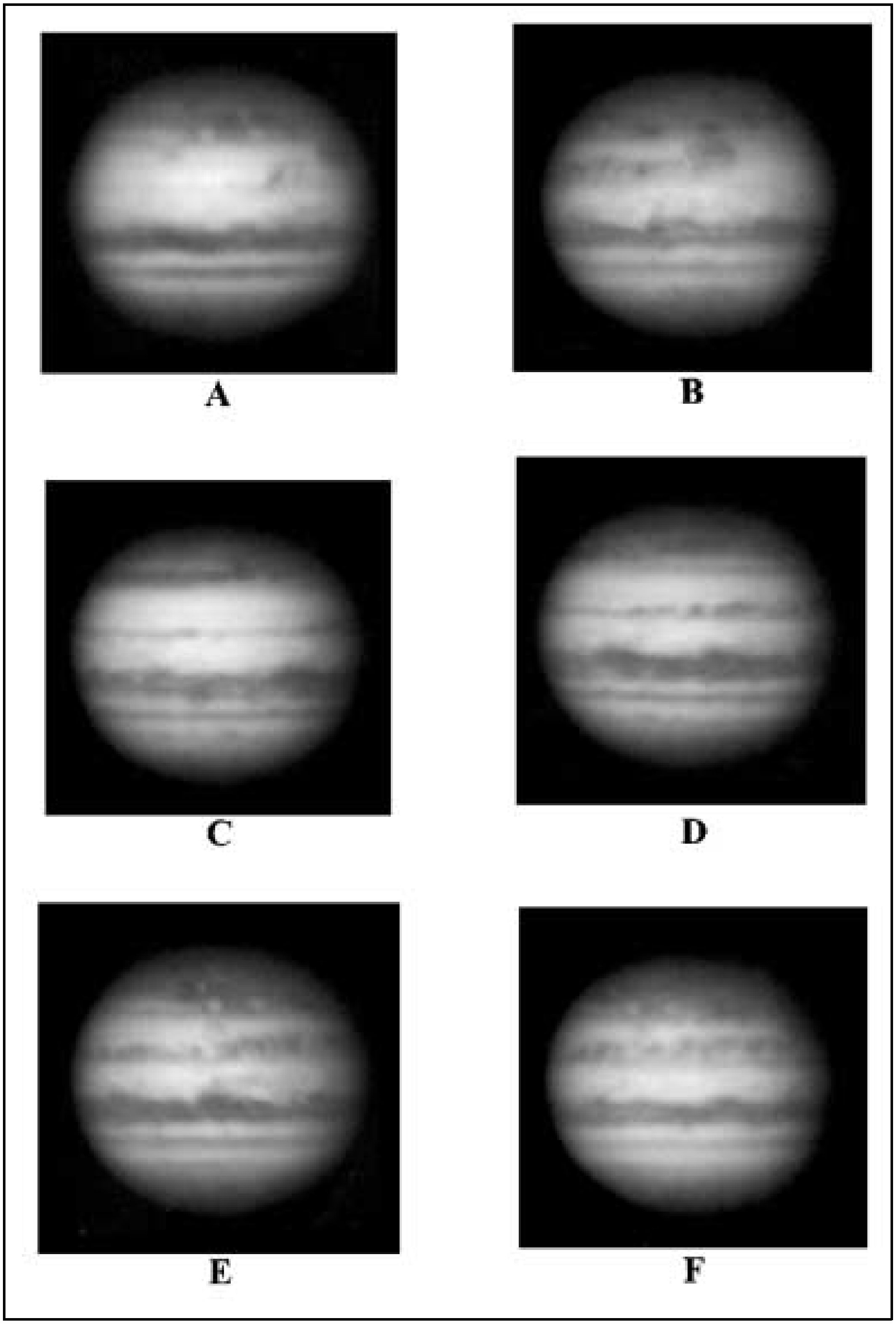


Figure 2: Photographs of the South Equatorial Belt revival taken by Isao Miyazaki, using a 0.40-m reflector. All dates are in 1993 and all times are in UT and are in parentheses. A: APR 13 (14:50.5), λ_I = 013°, λ_{II} = 352°, λ_{III} = 301°; B: MAY 12 (15:03) λ_I = 281°, λ_{II} = 039°, λ_{III} = 355°; C: MAY 19 (11:11), λ_I = 164°, λ_{II} = 230°, λ_{III} = 189°; D: MAY 19 (12:44) λ_I = 221°, λ_{II} = 286°, λ_{III} = 245°; E: MAY 19 (14:11) λ_I = 274°, λ_{II} = 339°, λ_{III} = 298°; F: JUN 03 (12:09) λ_I = 047°, λ_{II} = 358°, λ_{III} = 321°. South is at the top, the preceding limb is to the left and the direction of increasing longitude is to the right.

Table 4: Dimensions of White Ovals and the SEBz Dark Spot During the 1992-93 Apparition of Jupiter

(The aspect is the north-south dimension corrected for foreshortening, divided by the east-west dimension. All areas were computed by assuming an elliptical shape for each feature. All east-west and north-south dimensions have uncertainties of 1,000 km except for the GRS and the Little Red Spot, which have uncertainties of 500 km.)

	Dimension (km)			Area
Feature	East-West	North-South	Aspect	(10^6 km^2)
GRS	23,000	13,500	0.59	244+/-10
Little Red Spot	11,400	5300	0.46	47+/-5
Oval FA	8100	6200	0.77	39+/-8
Oval BC	9200	7400	0.81	54+/-9
Oval DE	9000	7000	0.78	50+/-9
B2	5800	5300	0.90	24+/-6
B3	6200	5400	0.88	26+/-6
B4	5600	4600	0.81	20+/-6
B5	6300	5500	0.88	27+/-7
B6	4400	4700	1.06	16+/-5
B7	5000	3900	0.76	15+/-5
A1	4300	4700	1.10	16+/-5

II longitude. Since the source of the SEB revival (S7) moved with respect to the System II longitude, the relative drift rates of S9 and S10 compared to S7 are different from those listed in Table 6.

Region IV: Equatorial Zone

The Equatorial Zone (EZ) is well illustrated in Figures 1-2. The EZ was the fourth brightest area on Jupiter according to Heath. There were nine large festoons (N21, N23-26, N29-31) along the NEBs that projected into the EZ. The mean rotation rate of these festoons was 9h 50m 31s, which is close to the mean festoon rotation rate in 1991-92.

The Equatorial Band was faint in 1993 and appeared to have moved northward by about 3° since the previous apparition. One dark spot near the center of the EZ (E3) was followed for 19 days in March 1993; its longitudes are listed in *Table 5* (page 13), and its rotational period was 9h 51m 41s. This period is too slow for the normal EZ current and instead it appears to be the “slow drift in the equatorial current” described by Rogers (1995, pp. 146-147). Feature E3 is at λ_I = 112° in Figure 1-C.

Features E5 and E6 are the preceding and following ends of a dark spot in the EZ. The longitudes of E5 and E6 are listed in Table 5.

Region V: North Equatorial Belt

The NEB had several low southward projections (bumps) on its southern edge; a good example is near the central meridian in Figure 1-A. The mean drift rate of these features was 9h 55m 38s, which is close to the 1991-92 value of 9h 55m 39s.

White spots and rifts often developed in the NEB during 1993; however, these features changed rapidly. Longitudes for three spots (N1, N21 and N22) were tracked for at least a few days and two of these features (N21 and N22) are plotted in Figure 6. Longitudes for feature N1 are listed in Table 5; N1 is centered at λ_{II} = 251° in Figure 1-C.

Region VI: North Tropical Zone to the North Polar Region

The NTB was relatively calm during the current apparition. There were a few short-lived low projections on this belt but only one of them (F5) could be followed for more than a couple of days. This feature followed the fast-moving North Temperate Current C and had a rotation period of 9h 49m 10s. Feature F5 is at λ_I = 190° in Figure 2-C. The longitudes of F5 are listed in Table 5.

Dark spots (G1, G3 and G4; see *Table 8*, page 15) were seen in the NNTB. Features G3 and G4 correspond to the preceding and following edges of a dark bar that can be seen centered at λ_{II} = 050° in Figure 1-F. Feature G1 is shown as a dark bar with two low northward projections at λ_{II} = 340° in Figure 1-B. The mean rotational speed for G1, G3 and G4 was 9h 55m 47s, which is slightly longer than other values measured over the last century (Rogers, 1995, 88-89; Peek, 1981, 77).

One dark spot (H1) was seen in the N^3TB and two faint, bright ovals I3 and I4 were seen at a planetographic latitude of 52°.4 N. Features I3 and I4 are faintly visible at λ_{II} = 310° and 330°, respectively, in Figure 2-E. The rotation rate of H1 was 9h 55m 16s, which is close to the N^3TC (NNNTC) values summarized by Rogers (1995, 90). Based on the latitudes of features I3 and I4, both were within the N^4TC (NNNNTC). The mean rotation period of I3 and I4 was 9h 55m 48s, which is similar to historical values for the N^4TC (Rogers, 1995, 90).

Satellites

Westfall (1998) has summarized the visual Galilean Satellite eclipse timings for the 1992-93 Apparition. Also, Mallama (2000, 350) has summarized 17 photoelectric eclipse timings for the Galilean Satellites made during the 1992-93 Apparition.

Wind Speeds and Drift Rates

Tables 6-8 (pp. 11, 13 and 15) summarize the drift rates for 69 different features. The majority of the longitudes in Fig-

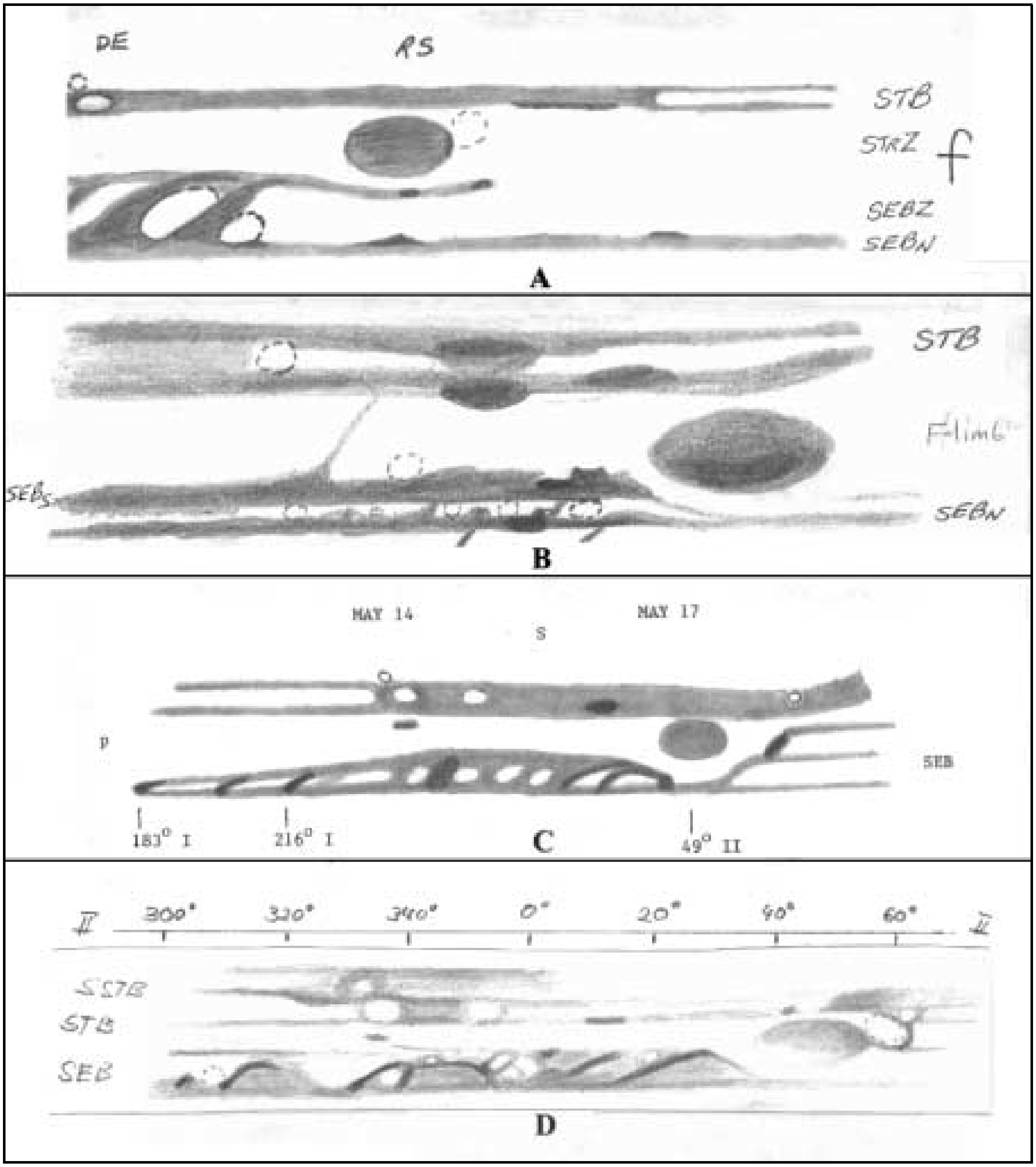


Figure 3: Strip maps of the South Equatorial Belt revival. All dates are in 1993 and all times are in UT and are in parentheses. A: APR 29 (00:00 - 00:40) by Phil Budine; B: MAY 10 (02:51 - 03:12) by Daniel Troiani; C: MAY 14 & 17 by Jose Olivarez; D: MAY 17 by Claus Benninghoven. South is at the top, the preceding limb is to the left and the direction of increasing longitude is to the right.

ures 4-6 were measured from images and photographs with a device described by Rogers (1995, 391). Longitudes were also obtained from central meridian transit times and strip maps. In a few cases, estimated longitudes (shown as lines in Figures 4-6) were measured from disc drawings.

García-Melendo and Sánchez-Levega (2001, 318-319) point out that changes not related to Jovian currents can influence wind measurements. These changes were kept in mind as the author made his longitude measurements.

In the professional literature, System III longitudes are almost exclusively used. System III longitudes are based on a radio-frequency rotational period of 9h 55m 29.68s, which is also believed to be the rotational period of Jupiter's interior. The "wind speeds" of various features are the relative velocities with respect to the System III longitude. The wind speeds and corresponding uncertainties were computed in the same way as in the previous apparition (Schmude, 2002).

Wind speeds of various Jovian currents are summarized in *Table 9* (page 16). There is an overall good agreement between the results in Table 9 and those for the previous apparition (Rogers and Foulkes, 1994; Schmude, 2002).

Acknowledgements

The author would like to thank John McAnally for his assistance in obtaining the files needed to write this report. The author is also grateful to the people, listed in Table 2, who submitted Jupiter observations.

References

Budine, P. W. (1993) "Jupiter's 1993 SEB Disturbance." *Proceedings of the 43rd ALPO Conference* (J. Westfall - editor), Las Cruces, NM, August 4-7, 1993, pp. 15-30.

García-Melendo, E. and Sánchez-Levega, A. (2001) "A Study of the Stability of Jovian Zonal Winds from HST Images: 1995-2000." *Icarus*, Vol. 152, pp. 316-330.

Haas, W. H. (1953) "Some Long-Enduring Features in the South Temperate Zone of Jupiter." *The Griffith Observer*, Vol. 17, No. 1 (Jan.), pp. 2-9.

Mallama, A.; Collins, D. F.; Nelson, P.; Park, J. and Krobusek, B. A. (2000) "Precise Timings of Galilean Satellites Eclipses and Assessment of the E5 Ephemeris." *Icarus*, Vol. 147, pp. 348-352.

Olivarez, J. (1993a) "Jovian Belt Fades Again." *Sky & Telescope* magazine, Vol. 85, No. 4 (April), p. 76.

________. (1993b) "Highlights of the 1992-1993 Apparition of Jupiter." *Proceedings of the 43rd ALPO Conference* (J. Westfall - editor), Las Cruces, NM, August 4-7, 1993, pp. 44-46.

Peek, B. M. (1981) *The Planet Jupiter*, revised edition, London: Faber and Faber, Ltd.

Rogers, J. H. (1995) *The Giant Planet Jupiter*, Cambridge, UK: Cambridge University Press.

Rogers, J. H. and Foulkes, M. (1994) "Jupiter in 1991-92." *Journal of the BAA*, Vol. 104, No. 4 (Aug.), pp. 167-178.

Schmude, R. W. Jr. (2002) "The 1991-92 Apparition of Jupiter." *JALPO*, Vol. 44, pp. 22-40.

Sky & Telescope magazine (1993a) Vol. 86, No. 1 (July), p. 9.

Sky & Telescope magazine (1993b) Vol. 86, No. 1 (July), p. 78.

U.S. Naval Observatory (1991). *The Astronomical Almanac for the Year 1992*. U. S. Govt. Printing Office, Washington, DC.

________ (1992). *The Astronomical Almanac* for the Year 1993. U. S. Govt. Printing Office, Washington, DC.

Westfall, J. E. (1998) "Galilean Satellite Eclipse Timings: The 1992/93 Apparition." *JALPO*, Vol. 40, pp. 14-25 (January).

Table 5: Longitudes of Jovian Features in the 1992-93 Apparition That Were Not Plotted in Figures 4-6

(Longitudes with a "~" sign were taken from disc drawings and were not used in the evaluation of drift rates. All dates are in 1993.)

	System I Longitudes
Feature E3:	MAR 08.6 (087°), MAR 22.6 (112°), MAR 24.6 (115°), MAR 27.5 (120°)
Feature E5:	APR 13.6 (293°), APR 15.6 (294° twice), APR 17.6 (292°,293°), APR 22.5 (286°), MAY 13.4 (292°), MAY 15.1 (287°, 288°)
Feature E6:	APR 15.5 (269°), APR 17.6 (272°), APR 22.5 (270°), MAY 10.1 (270°), MAY 13.4 (265°), MAY 15.1 (268°, 269°), MAY 17.5 (268°), MAY 19.6 (269°), MAY 24.5 (270°)
Feature S6:	MAY 08.0 (197°), MAY 15.1 (216°), MAY 17.5 (225°), MAY 19.5 (228°)
Feature F5:	MAY 14.2 (197°, 200°), MAY 16.6 (202°), MAY 19.5 (186°, 193°), MAY 23.6 (181°)
	System II Longitudes
Feature S7:	APR 06.3 (026°), APR 07.9 (022°), APR 09.1 (017°), APR 10.3 (015°), APR 13.6 (013°), APR 15.7 (008°), APR 16.6 (008°)
Feature N1:	MAR 22.6 (250°, 252°), MAR 24.6 (242°), MAR 26.2 (238°), MAR 27.5 (242°), MAR 27.6 (247°)
Feature S9:	APR 13.6 (029°), APR 15.7 (035°), APR 16.6 (035°), APR 19.1 (~042°), APR 26.1 (~053°), APR 29.0 (066°)
Feature S10:	APR 13.6 (006° or 366°), APR 15.7 (344°), APR 20.6 (317°)

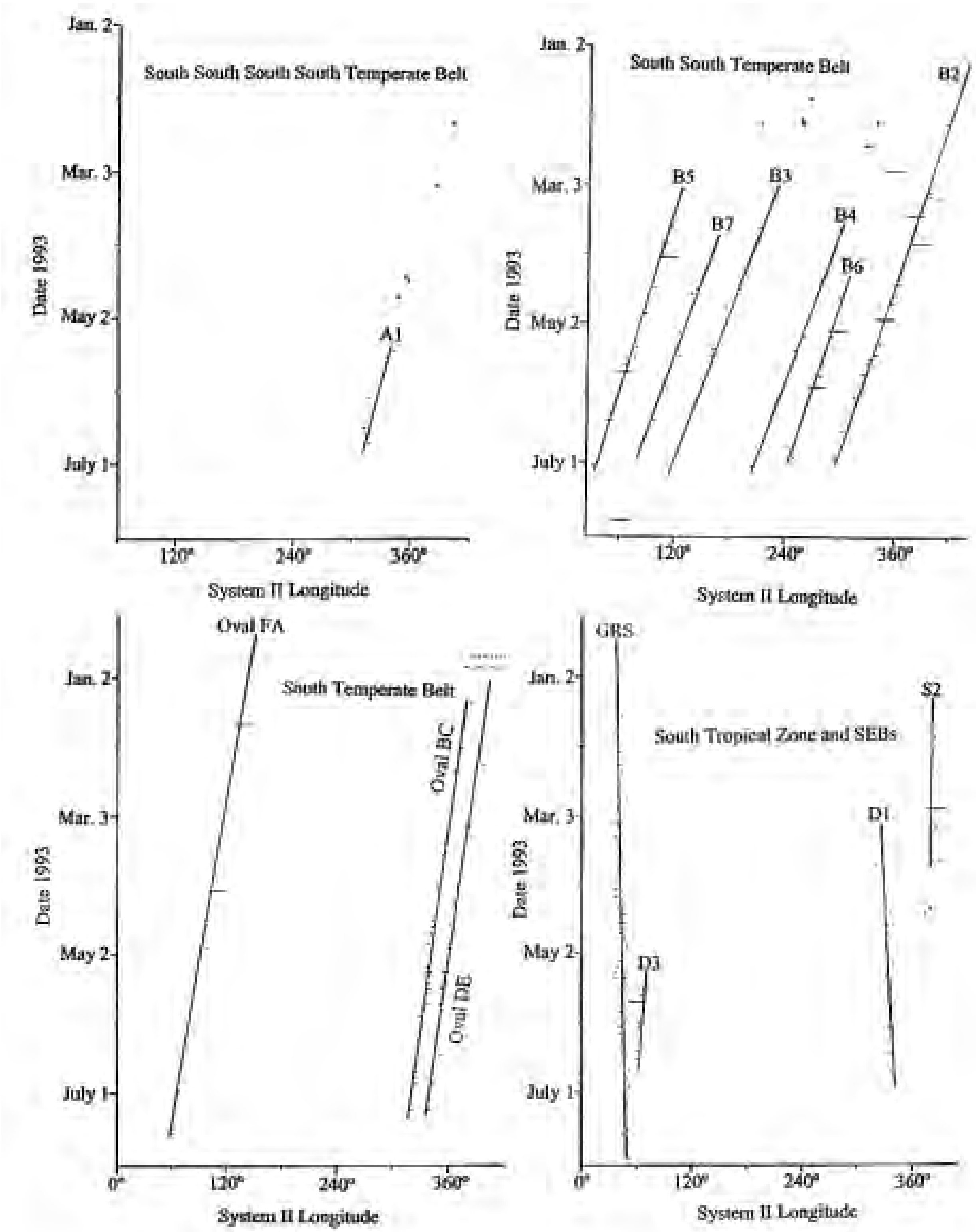


Figure 4: Drift Rates for features between the South Pole and the southern edge of the South Equatorial Belt. Crosses are points that are not included in the linear fit but are believed to be points of the feature that they are lined up with; a solid line is a confirmed position for the feature on a drawing whereas a dashed line is a negative observation of the feature on a drawing.

Table 6: Drift Rates of Features Between the South Pole and the Central Portion of the SEB, 1992-93 Apparition of Jupiter

Feature	Number of Points	Time Interval (1992/93)	Planetographic Latitude	Drift Rate (degrees/30 d) (System II)	Rotation Rate
South South South South Temperate Belt					
A1	8	MAY 15 - JUN 22	52°.3 S	-19.1	9h 55m 15s
South South Temperate Belt					
B2	46	JAN 06 - JUL 09	41°.9 S	-25.3	9h 55m 06s
B3	34	MAR 07 - JUL 05	42°.5 S	-27.8	9h 55m 03s
B4	20	MAR 22 - JUL 03	42°.8 S	-27.8	9h 55m 03s
B6	11	APR 13 - JUN 30	42°.5 S	-24.6	9h 55m 07s
B7	19	MAR 26 - JUN 30	42°.5 S	-26.9	9h 55m 04s
Mean			**42°.4°S**	**-26.5**	**9h 55m 05s**
South Temperate Zone					
B5	35	MAR 06 - JUL 02	41°.0 S	-22.7	9h 55m 10s
South Temperate Belt					
Oval FA	48	DEC 16 - JUL 19	34°.7 S	-12.8	9h 55m 23s
Oval BC	52	JAN 14 - JUL 09	34°.0 S	-10.3	9h 55m 27s
Oval DE	51	JAN 06 - JUL 09	34°.1 S	-10.9	9h 55m 26s
Mean			**34°.3 S**	**-11.3**	**9h 55m 25s**
South Tropical Zone					
D1 (LRS)	28	MAR 08 - JUN 27	24°.2 S	-3.6	9h 55m 36s
D3	16	MAY 13 - JUN 16	25°.5 S	-6.4	9h 55m 32s
GRS	139	NOV 29 - AUG 05	23°.0 S	+1.4	9h 55m 43s
South Equatorial Belt (south edge)					
S2	13	JAN 14 - MAR 23	15°.7 S	-1.4	9h 55m 39s
South Equatorial Belt Revival (southern portion)					
S9	4	APR 13 - APR 29	20°.9 S	+72.0[a]	9h 57m 20s
(central portion)					
S3	7	MAY 08 - MAY 19	11°.5 S	-137.8[b]	9h 52m 33s
S4	6	MAY 08 - MAY 19	11°.5 S	-147.9[b]	9h 52m 19s
S6	5	MAY 08 - MAY 19	12°.9 S	-145.5	9h 52m 23s
S7	7	APR 06 - APR 16	14°.4 S	-49.0	9h 54m 34s
(northern portion)					
S10	3	APR 03 - APR 20	9°.8 S	-202.1[a]	9h 51m 06s

[a] The drift rates of S9 and S10 with respect to S7 are +121°.0 and -153.1° respectively.

[b] Plotted in Figure 5; System I drift rates are: S3 = +91.1 and S4 = +81.0 degrees/30 days.

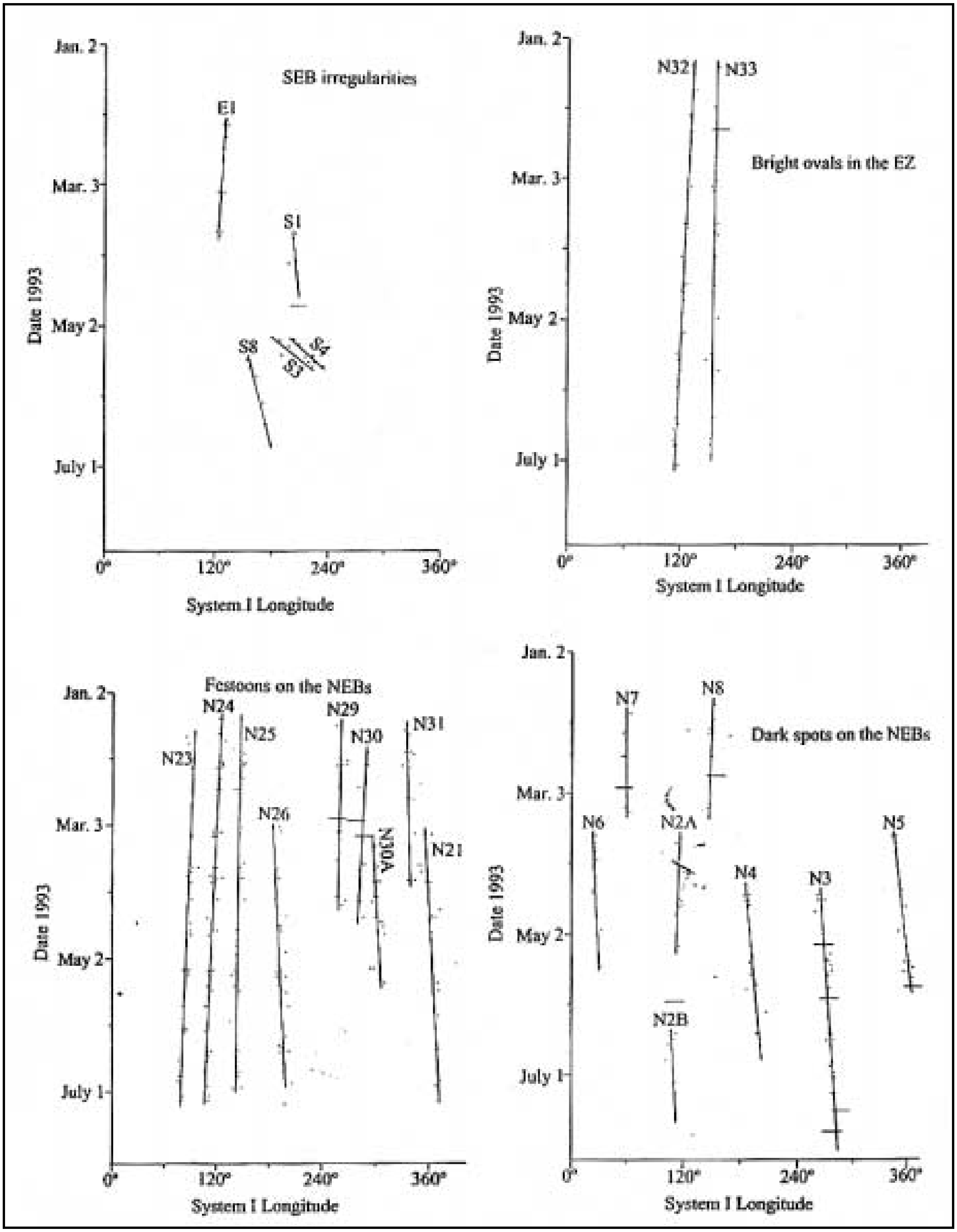


Figure 5: Drift Rates for Features between the central portion of the SEB and the northern edge of the NEB. Symbols are the same as in Figure 4.

Table 7: Drift Rates of Features in the Great Equatorial Current (Northern Portion of the SEB to the Southern Portion of the NEB), and the North Temperate Belt Fast Current, 1992-93 Apparition of Jupiter

Feature	Number of Points	Time Interval (1992/93)	Planetographic Latitude	Drift Rate (degrees/30 d) (System I)	Rotation Rate
South Equatorial Belt (central portion of northern component)					
S8	10	MAY 16 - JUN 22	10° S	+19.5	9h 50m 56s
South Equatorial Belt (northern edge)					
S1	4	MAR 23 - APR 17	8.7° S	+7.1	9h 50m 40s
Equatorial Zone (central portion)					
E1	13	FEB 03 - MAR 24	0°	-3.1	9h 50m 26s
E5	12	APR 13 - MAY 19	0°	-1.9	9h 50m 27s
E6	10	APR 15 - MAY 24	0°	-1.6	9h 50m 28s
Mean			**0°**	**-2.2**	**9h 50m 27s**
Equatorial Zone (central portion - slow current; see Rogers, 1995, p. 147)					
E3	4	MAR 08 - MAR 27	0°	+52.6	9h 51m 41s
North Equatorial Belt (festoons along the southern edges)					
N21	21	MAR 07 - JUL 05	—	+3.9	9h 50m 35s
N23	38	JAN 22 - JUL 05	—	-2.8	9h 50m 26s
N24	51	JAN 14 - JUL 05	—	-3.4	9h 50m 26s
N25	44	JAN 14 - JUN 29	—	-1.2	9h 50m 28s
N26	27	FEB 03 - JUL 06	—	+3.5	9h 50m 35s
N29	23	JAN 17 - APR 08	—	-1.1	9h 50m 29s
N30	16	JAN 29 - APR 13	—	-3.4	9h 50m 26s
N30A	20	MAR 12 - MAY 12	—	+4.4	9h 50m 36s
N31	15	JAN 17 - MAR 28	—	+3.0	9h 50m 34s
Mean				**+0.3**	**9h 50m 31s**
North Equatorial Belt (dents and bright ovals along the southern edges)					
N2A	13	MAR 22 - MAY 09	—	-2.1	9h 50m 27s
N2B	8	JUN 13 - JUL 19	—	+3.6	9h 50m 35s
N3	22	APR 15 - AUG 01	—	+5.2	9h 50m 37s
N4	20	APR 15 - JUN 22	—	+6.5	9h 50m 39s
N5	15	MAR 21 - MAY 20	—	+8.9	9h 50m 42s
N6	14	MAR 21 - MAY 16	—	+3.6	9h 50m 35s
N7	10	JAN 28 - MAR 11	—	+1.3	9h 50m 32s
N8	13	JAN 24 - MAR 11	—	-2.0	9h 50m 27s
N32	32	JAN 14 - JUL 05	—	-3.4	9h 50m 25s
N33	20	JAN 14 - JUN 29	—	-1.0	9h 50m 29s
Mean				**+2.1**	**9h 50m 33s**
North Temperate Belt (southern edge)					
F5	6	MAY 14 - MAY 23	23°.8 N	-59.4	9h 49m 10s

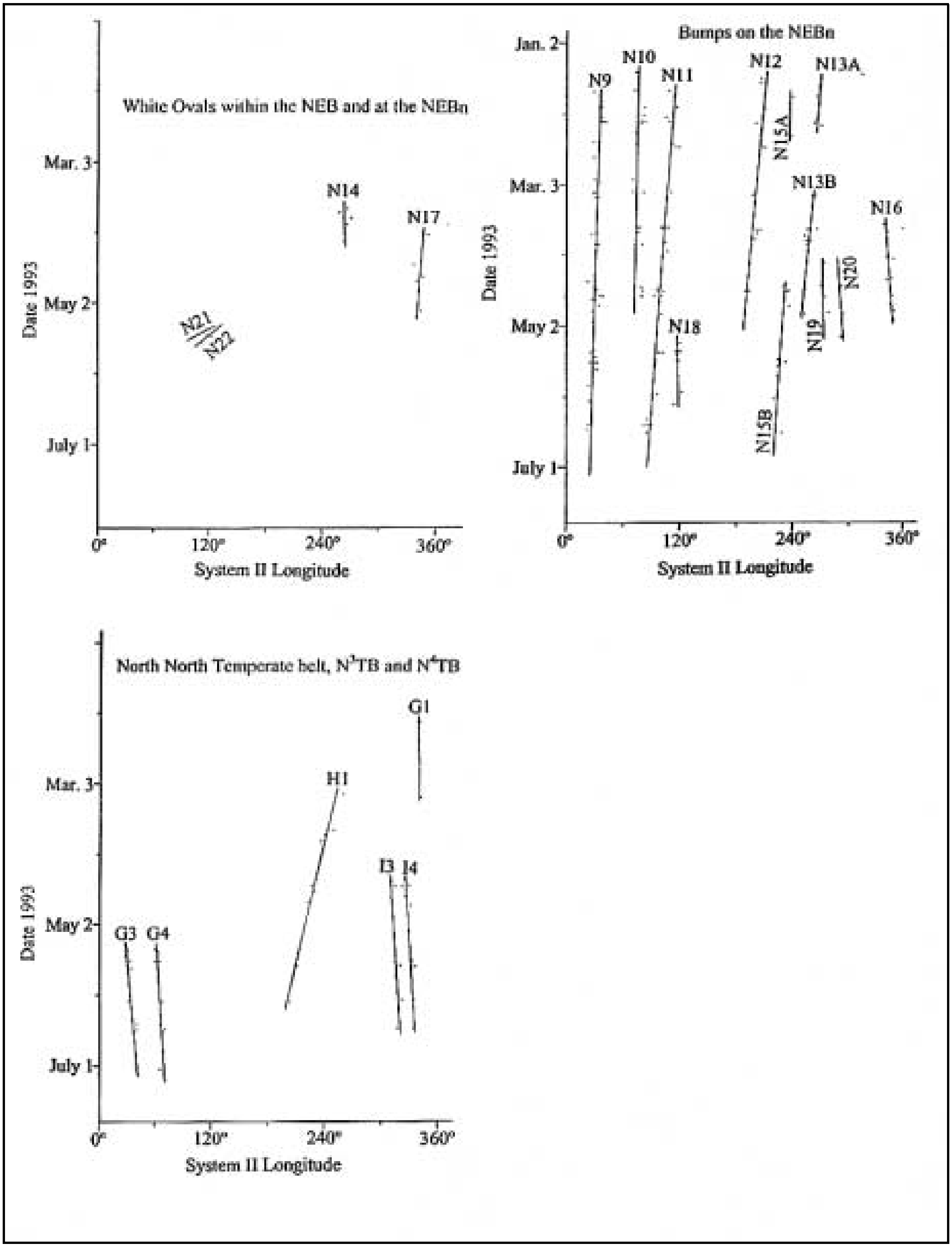


Figure 6: Drift rates for features between the central portion of the NEB and the North Pole. Symbols are the same as in Figure 4.

Table 8: Drift Rates of Features Between the Central Portion of the NEB and the North Pole, 1992-93 Apparition of Jupiter

Feature	Number of Points	Time Interval (1992/93	Planetographic Latitude	Drift Rate (degrees/30 d) (System II)	Rotation Rate
North Equatorial Belt (central portion)					
N1	6	MAR 22 - MAR 27	12°.5 N	-56.2	9h 54m 24s
N21	5	MAY 13 - MAY 16	12°.3 N	-145.7	9h 52m 22s
N22	7	MAY 13 - MAY 18	13°.9 N	-79.9	9h 53m 52s
North Equatorial Belt (bulges in the northern portion)					
N9	55	JAN 22 - JUL 02	—	-2.0	9h 55m 38s
N10	26	JAN 06 - APR 19	—	-1.1	9h 55m 39s
N11	35	JAN 22 - JUN 28	—	-5.7	9h 55m 33s
N12	22	JAN 17 - MAY 02	—	-6.5	9h 55m 32s
N13A	6	JAN 17 - FEB 05	—	-5.4	9h 55m 33s
N13B	16	MAR 07 - APR 27	—	-6.1	9h 55m 32s
N14	8	MAR 22 - APR 05	—	+2.6	9h 55m 44s
N15A	4	JAN 25 - FEB 10	—	-0.8	9h 55m 40s
N15B	14	APR 15 - JUN 24	—	-5.3	9h 55m 34s
N16	12	MAR 20 - APR 30	—	+5.5	9h 55m 48s
N17	5	APR 03 - MAY 06	—	-5.9	9h 55m 33s
N18	9	MAY 09 - MAY 30	—	+1.2	9h 55m 42s
N19	7	APR 06 - MAY 07	—	+1.3	9h 55m 42s
N20	7	APR 06 - MAY 07	—	+5.4	9h 55m 48s
Mean				**-1.6**	**9h 55m 38s**
North North Temperate Belt					
G1	4	FEB 04 - MAR 08	39°.2 N	+1.5	9h 55m 43s
G3	13	MAY 12 - JUL 02	37°.6 N	+7.3	9h 55m 51s
G4	16	MAY 12 - JUL 05	37°.6 N	+4.3	9h 55m 47s
Mean			**38°.1 N**	**+4.3**	**9h 55m 47s**
North North North Temperate Belt					
H1	10	MAR 07 - JUN 04	45°.7 N	-18.0	9h 55m 16s
North North North North Temperate Belt					
I3	9	APR 13 - JUN 15	52°.8 N	+5.1	9h 55m 48s
I4	10	APR 13 - JUN 15	52°.0 N	+5.0	9h 55m 48s
Mean			**52°.4**	**+5.1**	**9h 55m 48s**

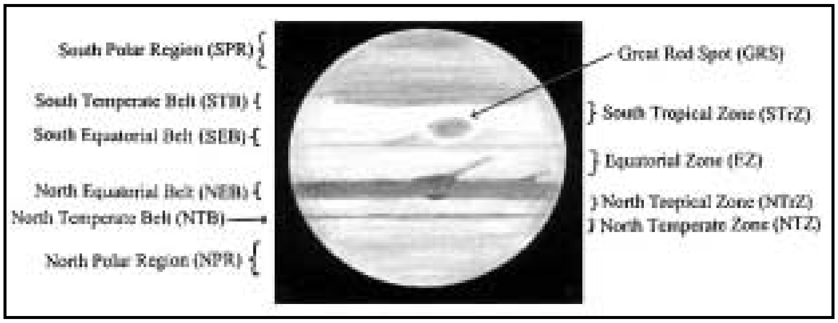


Figure 7: A disc drawing of Jupiter made by Robert Robinson on 1993 APR 04 (03:44 UT), with a 0.25-m Reflector (λ_I = 344°, λ_{II} = 036°, λ_{III} = 342°). This drawing shows a dark spot, which may have been a precursor to the SEB revival. Selected Jovian nomenclature is also given in this figure.

Table 9: Average Drift Rates, Rotation Periods and Wind Speeds for Several Currents on Jupiter, 1992-93 Apparition

Current	Feature(s)	Drift Rate[c] (deg./30 day) Sys. I	Sys. II	Sys. III	Rotation Period	Wind Speed (m/s) System III [a]
SSSS Temp. Current	A1	+209.8	-19.1	-11.1	9h 55m 15s	-3.4+/-0.6
SS Temp. Current	B2-B4, B6, B7	+202.4	-26.5	-18.5	9h 55m 05s	-6.8+/-0.3
S Temp. Current	Ovals FA, BC, DE	+217.5	-11.3	-3.4	9h 55m 25s	-1.4+/-0.3
S Temp. Current	B5	+206.2	-22.7	-14.7	9h 55m 10s	-5.5+/-0.4
S Trop. Current	D1, D3	+223.9	-5.0	+3.0	9h 55m 34s	+1.3+/-0.4
S Trop. Current	Great Red Spot	+230.3	+1.4	+9.4	9h 55m 43s	+4.2+/-0.2
SEBs Current	S2	+227.5	-1.4	+6.6	9h 55m 39s	+3.1+/-0.5
SEB Revival						
Southern Branch	S9	+300.9	+72.0	+80.0	9h 57m 20s	+36.2+/-0.9[a]
Central Branch	S7	+179.9	-49.0	-41.0	9h 54m 34s	+19.2+/-0.9
Northern Branch	S10	+26.8	-202.1	-194.1	9h 51m 06s	+92.1+/-0.9[a]
SEBn Current	S1	+7.1	-221.8	-213.8	9h 50m 40s	-101.8+/-1.0
SEBn Comp. Current	S8	+19.5	-209.4	-201.4	9h 50m 56s	-95.5+/-0.5
Equatorial Current[b]	E1, E5, E6	-2.2	-231.1	-223.1	9h 50m 27s	-107.3+/-0.3
Equatorial Current[c]	E3	+52.6	-176.3	-168.3	9h 51m 41s	-80.9+/-1.0
N Eq. Current	N2A-N8, N21, N23-N26, N29-N33	+1.52	-227.7	-219.7	9h 50m 32s	-105.1+/-0.5
N Eq. Current Cent.	N1, N21, N22	d				
N Trop. Current	N9-N20	+227.3	-1.6	+6.4	9h 55m 38s	+3.0+/-0.6
N Temp. Current "C"	F5	-59.4	-288.3	-280.3	9h 49m 10s	-124.6+/-0.9
NN Temp. Current	G1, G3, G4	+233.2	+4.3	+12.3	9h 55m 47s	+4.8+/-0.6
NNN Temp. Current	H1	+210.9	-18.0	-10.0	9h 55m 16s	-3.5+/-0.5
NNNN Temp. Current	I3,I4	+234	+5.1	+13.1	9h 55m 48s	+4.0+/-0.3

[a] Winds are with respect to System III and not the moving S7 spot.
[b] Central portion of the Equatorial Zone.
[c] Slow drift in the Equatorial Current; see Rogers, 1995, p. 147.
[d] The computed wind speed range is -22.6 to -64.7 m/s

ALPO Feature: Saturn

Photoelectric Photometry of Saturn in 2000-2001

By: John E. Westfall,
Coordinator, Mercury/Venus Transit Section
Assistant Coordinator, Jupiter Section, Galilean Satellites
Member of the Board, ALPO

Abstract

V-band photoelectric photometry of the Saturn System (Globe plus Rings) was conducted on eight nights during the 2000-2001 Apparition, with B, R, and I measures on one night. 37 Tau was the comparison star and 74 Tau the check star. The normalized V(1,0) system magnitude, extrapolated to zero phase angle, was -8.766, with a phase coefficient of +0.026+/-.002 magnitudes/degree. Saturn's color indices were measured as (B - V) = +1.025+/-.010, (V - R) = +0.709+/-.006, and (V - I) = +0.939+/-.006.

Photometry of the bright planets is undertaken surprisingly infrequently, even though all of them but Mercury have atmospheres and thus can undergo brightness changes in addition to those expected from changing Earth-Sun-planet geometry. In addition, the magnitudes of the naked-eye planets can be measured with a high signal:noise ratio even with a small telescope.

The photometry described here was conducted during Saturn's 2000/2001 Apparition, with opposition to the Sun on 2000 NOV 19 and quadrature (maximum phase angle of 6°.2) on 2001 FEB 13. The writer measured the planet's magnitude on eight nights, using a 12.7-cm (5-in.) f/10 Schmidt-Cassegrain (Celestron-5) telescope and an Optec SSP-3 photoelectric photometer with a 1-mm (162 arc-sec) aperture and Johnson B, V, R and I Filters. The observing site was Antioch, California, 85 meters above mean sea level.

Table 1: Extinction and Filter Coefficients used for Saturn Photometry, 2000/2001

Filter	Coefficient: Extinction (mag./air mass)	Coefficient: Filter (mag./Δ[B - V])
B	-0.404 ± 0.027	+0.061 ± 0.030
V	-0.247 ± 0.013	-0.029 ± 0.009
R	-0.189 ± 0.005	-0.107 ± 0.010
I	-0.137 ± 0.014	-0.129 ± 0.017

Table 2: Comparison and Check Stars Used for Saturn Photometry, 2000/2001

	Comparison	Check
Star	**37 Tau**	**74 Tau**
V	+4.36	+3.53
(B - V)	+1.07	+1.01
(V - R)	+0.80	+0.73
(V - I)	+1.33	+1.23

Sources:
(1) Iriarte, Braulio; Johnson, Harold H., Mitchell, Richard I. and Wisniewski, Wieslaw K. 1965. "Five-Color Photometry of Bright Stars." *Sky & Telescope* magazine, 30 (1): 21-31. (2) United States Naval Observatory 1999. *The Astronomical Almanac for the Year 2000* (AA2000), pp. H6, H7, H32.

Table 1 (page 1) gives the extinction and filter coefficients for the writer's site and instruments, as determined on eight nights in August, 2000, by measures of the five stars Beta and Eta Oph, Sigma Sag, and Alpha and Gamma Aqu. *Table 2* (page 1) describes the comparison and check stars used for the Saturn measurements themselves.

The measurements of Saturn's magnitude are summarized in *Table 3* (page 2). Multiple measurements using 1-second integration times were made on each date; one set of from 10-13 readings for each of four bands on 2000 NOV 08, and three sets of 9-14 readings on the remaining dates.

Some items in Table 3 need to be described:

1. Saturn's distance from the Earth and the Sun varied throughout the apparition, and the normalized magnitudes in Table 3 adjust for this effect by reducing the observed magnitude to that one would see if Saturn were simultaneously one astronomical unit distant from both the Earth and the Sun.

2. The phase angle is the angle between the Earth and the Sun as seen from Saturn.

3. The saturnicentric latitude of the Earth (ring tilt) is used to estimate the contribution made by the rings to that of Saturn's entire system, so that the magnitude of the globe alone can be estimated in the final column (using formula (6) on p. 283 of Kuiper, Gerard P. and Middlehurst, Barbara M., eds. 1961. *Planets and Satellites*. Chicago: University of Chicago Press).

Besides the stated "±" uncertainties (standard errors) in Table 3, the accuracy of the measures is also expressed by the estimated magnitude of the check star, as computed from that of the comparison, which was:

$$V = +3.542 \pm 0.007 \ (s = \pm 0.018)$$

Table 3: Photoelectric Photometric Measures of Saturn, 2000/2001

UT Date	Band	Measured	Normalized	Phase Angle	Earth's Saturncentric Latitude (B)	Magnitude Adjustment for Rings	Adjusted Magnitude of Globe
2000 NOV				°	°		
08.352	B	+0.781±.009	-8.565±.009	1.332	-23.754	+0.844	-7.721±.009
	V	-0.244±.005	-9.590±.005				-8.746±.005
	R	-0.953±.004	-10.299±.004				-9.455±.004
	I	-1.183±.003	-10.529±.003				-9.685±.003
2000 DEC							
18.210	V	-0.140±.003	-9.523±.003	3.219	-23.219	+0.831	-8.692±.003
2001 JAN							
03.125	V	-0.043±.005	-9.469±.005	4.626	-23.103	+0.828	-8.641±.005
04.165	V	-0.037±.004	-9.466±.004	4.703	-23.099	+0.828	-8.638±.004
16.133	V	+0.019±.006	-9.471±.006	5.469	-23.079	+0.827	-8.644±.006
28.236	V	+0.061±.007	-9.456±.007	5.976	-23.121	+0.828	-8.628±.007
2001 FEB							
01.184	V	+0.094±.003	-9.438±.003	6.082	-23.148	+0.829	-8.609±.003
05.153	V	+0.103±.002	-9.445±.002	6.159	-23.182	+0.829	-8.616±.002

The measured color indices of the comparison star differed by at most 0.01 magnitude from those given in AA2000.

Table 4 (page 2) gives the color indices of Saturn, as determined on 2000 NOV 08, and for comparison that for (B - V) as given in *AA2000*.

Finally, the V-magnitudes were compared with the phase angles in order to measure the value of the phase coefficient of Saturn's globe, as shown in the scattergram in *Figure 1* (page 2). The value of the phase coefficient was found to be +0.026 ± 0.002 magnitudes/degree (the effect statistically significant at the 0.01-percent level), with the normalized V-magnitude at 0° phase angle equal to -8.766. This differs noticeably from the value of -8.88 given on p. E88 of *AA2000* (and later years).

In terms of the combined globe-plus-ring magnitude, the writer's normalized, zero-phase angle estimate was -9.620, with a phase-angle coefficient of +0.029+/-.003 magnitudes/degree. During the same apparition, independent measures by Richard W. Schmude, Jr., gave corresponding values of -9.69+/-.02 and +0.036+/-.006 magnitudes per degree, respectively. (R.W. Schmude, Jr., 2001, "Wideband Photoelectric Magnitude Measurements of Saturn in 2000." *Georgia Journal of Science*, Vol. 59, No. 3: pp. 123-127.)

Table 4: Color Indices of Saturn

Index	Measured by Author	*Astronomical Almanac, 2000*
(B - V)	+1.025±.010	+1.04
(V - R)	+0.709±.006	-----
(V - I)	+0.939±.006	-----

The photometric behavior of Saturn is necessarily complex, given the effect of the shadow of the rings on the globe, the shadow of the globe on the rings, and the blocking of the rings and globe by each other. To the writer's knowledge, no complete model exists for the brightness of Saturn's combined globe and ring system. He recommends continued photoelectric photometry of the ringed planet, over not only the maximum possible range of phase angle, but also over the entire range of changing ring inclination, even though this will involve many apparitions.

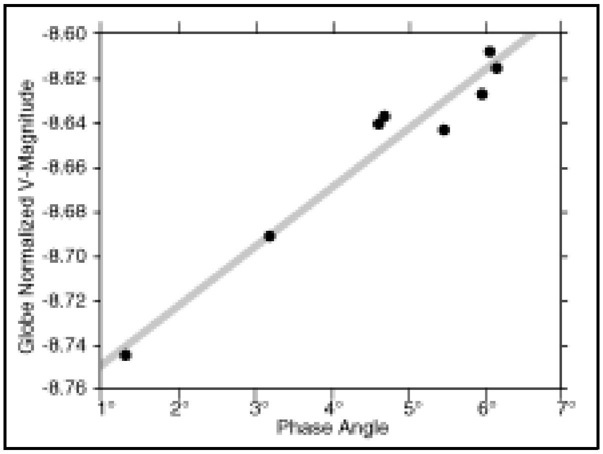


Figure 1. Normalized V-band magnitude of Saturn's globe as a function of phase angle during the 2000-2001 apparition; the measured magnitude of the Saturnian System has been adjusted for the estimated effect of the rings.

ALPO Feature: Saturn

ALPO Observations of Saturn During the 2000-2001 Apparition

By: Julius L. Benton, Jr., Coordinator, ALPO Saturn Section

Abstract

During the 2000-2001 Apparition of Saturn 170 excellent visual, photographic, and CCD observations were contributed by 23 individuals residing in the United Kingdom, France, Germany, Italy, Spain, Japan, Mexico, Puerto Rico, and the United States. The observations spanned the time period from 2000 Jun 29 through 2001 Apr 14, and instruments used to record these data ranged in aperture from 10.2 cm (4.0in.) up to 65.0 cm (25.6in.). Saturn observers reported occasional dusky festoons and other ill-defined dark spots among the belts and zones of Saturn's Southern Hemisphere during the apparition, and diffuse, short-lived white spots were intermittently suspected in the South Tropical Zone (STrZ) and Southern Equatorial Zone (EZs). Due to the transient nature of these phenomena, recurring central meridian (CM) transit timings were not recorded. The inclination of the ring system to Earth, **B**, reached a maximum negative value of -24°.440 on 2001 Apr 14, and consequently, observers enjoyed very good views of Saturn's Southern Hemisphere and the South face of the Rings during the apparition. Accompanying the report are references, drawings, photographs, CCD images, graphs, and tables.

Introduction

The analysis that follows was based on 170 visual observations, photographs, and CCD images contributed by ALPO observers from 2000 Jun 29 through 2001 Apr 14, hereinafter referred to as the 2000-2001 Apparition of Saturn or "observing season." Accompanying this discussion are drawings, photographs, and CCD images, and all times and dates mentioned in this report are in Universal Time (UT).

Table 1 (page 1) provides geocentric data in Universal Time (UT) for the 2000-2001 Apparition of Saturn. During the observing season, the numerical value of **B**, or the Saturnicentric latitude of the Earth referred to the ring plane (positive when north), ranged between the extremes of -23°.078 (2001 Jan 15) and -24°.440 (2001 Apr 14). The value of **B'**, the Saturnicentric latitude of the Sun, ranged from -22°.600 (2000 Jun 29) to -24°.885 (2001 Apr 14).

Table 2 (page 2) lists the 23 individuals who provided a total of 170 observations to the ALPO Saturn Section for the 2000-2001 Apparition, with their observing sites, number of dates of observations, and descriptions of their telescopes.

Figure 1 (page 3) is a histogram giving the distribution of observations by month, showing that the data were spread somewhat evenly from 2000 August through 2001 March, with a sharp decline in the number of observations on either side of this period of generally consistent observation. In many prior apparitions, there was a greater tendency for observers to study Saturn during the months including, and immediately surrounding, the date of opposition, but the results in 2000-2001 suggest that more individuals are apparently keeping Saturn under surveillance from near the time the planet first emerges in the eastern sky before dawn until it approaches conjunction with the Sun. Of the submitted observations, 51.8 percent were made before opposition, 1.2 percent on the date of opposition (2000 Nov 19), and 47.1 percent thereafter.

Figure 2 (page 4) shows the ALPO Saturn Section observer base (total of 23) for 2000-2001, including the international distribution of the 170 observations that were contributed. During the apparition, the United States accounted for slightly more than half

Table 1: Geocentric Phenomena in Universal Time (UT) for the 2000-2001 Apparition of Saturn

Conjunction	2000	May	10d	20h	UT
Opposition		Nov	19	13	
Conjunction	2001	May	25	13	

Opposition Data:

Constellation		Taurus
Declination		+17°.35
Visual Magnitude		-0.40
B		-23°.59
B'		-23°.83
Globe Diameter		
	Equatorial	20".43
	Polar	18".75
Ring Axes		
	Major	46".37
	Minor	18".55

Table 2: Contributing ALPO Observers, 2000-2001 Apparition of Saturn

Observer and Observing Site	Number of Observations	Telescope(s) Used
Akutsu, Tomito; Hoshi-no-mura, Japan	1	31.8-cm (12.5-in.) NEW
	1	65.0-cm (25.6-in.) CAS
Benton, Julius L.; Wilmington Island, GA	37	15.2-cm (6.0-in.) REF
Berg, Ray; Crown Point, IN	2	20.3-cm (8.0-in.) SCT
Boisclair, Norman J.; South Glens Falls, NY	1	20.3-cm (8.0-in.) NEW
Boylar, Dan; Boynton Beach, FL	1	15.2-cm (6.0-in.) REF
	1	25.4-cm (10.0-in.) NEW
Crandall, Ed; Winston-Salem, NC	6	25.4-cm (10.0-in.) NEW
Cudnik, Brian; Houston, TX	12	25.4-cm (10.0-in.) NEW
	2	31.8-cm (12.5-in.) NEW
	2	35.6-cm (14.0-in.) SCT
Dal Prete, Ivano; Pescantina, Italy	1	15.2-cm (6.0-in.) REF
	10	20.3-cm (8.0-in.) NEW
del Valle, Daniel; San Juan, Puerto Rico	15	20.3-cm (8.0-in.) SCT
	18	20.3-cm (8.0-in.) NEW
Frassati, Mario; Crescentino (VC), Italy	1	20.3-cm (8.0-in.) SCT
Haas, Walter H.; Las Cruces, NM	11	20.3-cm (8.0-in.) NEW
	11	31.8-cm (12.5-in.) NEW
Melillo, Frank J.; Holtsville, NY	3	20.3-cm (8.0-in.) SCT
Niechoy, Detlev; Göttingen, Germany	7	20.3-cm (8.0-in.) SCT
Olivarez, Jose; Oakland, CA	1	50.8-cm (20.0-in.) REF
Parker, Donald C.; Coral Gables, FL	1	40.6-cm (16.0-in.) SCT
Peach, Damian; Norfolk, UK	5	30.5-cm (12.0-in.) NEW
Plante, Phil; Braceville, OH	3	15.2-cm (6.0-in.) NEW
	6	20.3-cm (8.0-in.) SCT
Post, Cecil; Las Cruces, NM	1	30.5-cm (12.0-in.) NEW
Roel, Eric; Valle de Bravo, Mexico	2	24.5-cm (10.0-in.) MAK
Schmude, Richard W.; Barnesville, GA	4	10.2-cm (4.0-in.) NEW
Teichert, Gerard; Hattstatt, France	2	28.0-cm (11.0-in.) SCT
Tobal, Tofol; Barcelona, Spain	1	10.2-cm (4.0-in.) REF
Viladrich, Christian; Paris, France	1	20.3-cm (8.0-in.) MAK
Total Number of Observations	**170**	
Total Number of Observers	**23**	

* CAS = Cassegrain, MAK = Maksutov, NEW = Newtonian, REF = Refractor, SCT = Schmidt-Cassegrain

(56.5 percent) of participating observers and nearly two-thirds (61.8 percent) of the contributed observations. With 43.5 percent of the ALPO Saturn observers residing in the United Kingdom, France, Germany, Italy, Spain, Japan, Mexico, and Puerto Rico, whose total contributions accounted for 38.2 percent of all the observations, it is evident that international cooperation in our programs continued satisfactorily during the 2000-2001 observing season.

Figure 3 (page 4) depicts the number of observations by instrument type, where it can be seen that 72.9 percent of the 170 total observations in 2000-2001 were made with telescopes of classical design (refractors, cassegrains, and Newtonians). Such instruments, when properly collimated, usually produce superior resolution and image contrast, and they are many times the telescopes of choice for detailed studies of the Moon and planets. Telescopes with apertures of 15.2 cm (6.0 in.) or larger accounted for 97.1 percent of the observations submitted during the 2000-2001 Apparition. We remind our readers, however, that smaller apertures of good quality in the range of 7.5 cm (3.0 in.) to 12.8 cm (5.0 in.) are still quite useful for observing the planet Saturn.

The writer is sincerely grateful to all of the individuals listed in Table 2 who contributed their observational

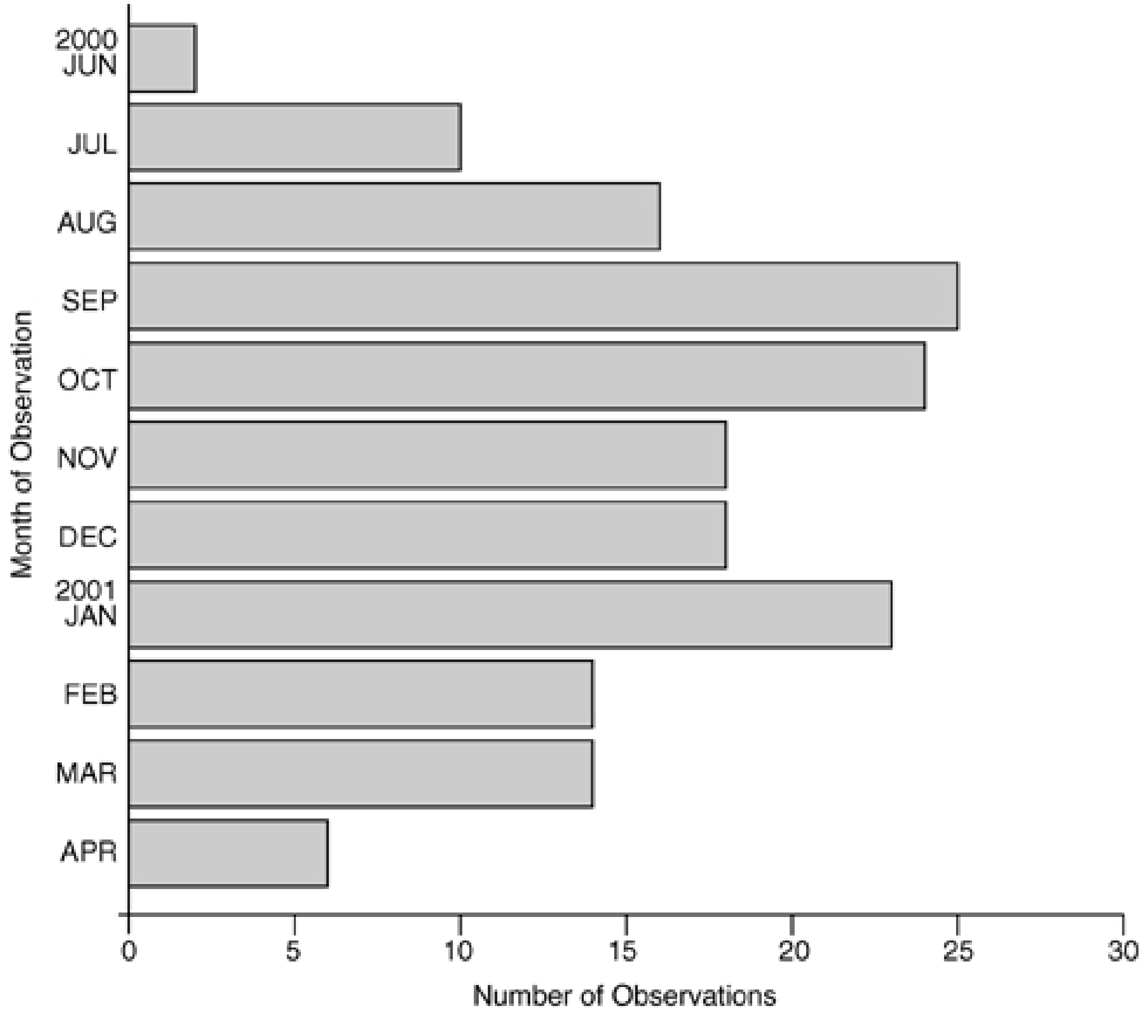


Figure 1. Distribution of observations by month, 2000-2001 Apparition of Saturn.

reports to the ALPO Saturn Section in 2000-2001. Observers everywhere who desire to undertake systematic studies of Saturn using visual methods (drawings and intensity estimates), photography, and electronic techniques employing CCDs and video cameras, are heartily encouraged to join us in the future as we attempt to maintain an international, comprehensive surveillance of the planet. Readers should understand that the ALPO Saturn Section considers all methods of recording observations mentioned above as vital to the success of our programs, whether one's particular preference might be simply drawing Saturn at the eyepiece, making visual numerical relative intensity estimates, doing photography, or pursuing CCD imaging and videography. Novice observers are also urged to contribute their work, and the ALPO Training Program and Saturn Section will always be pleased to offer assistance in getting started.

The Globe of Saturn

The excellent collection of 170 observations sent to the ALPO Saturn Section during 2000-2001 by the 23 observers listed in Table 2 were used to prepare this apparition report. Unless the identity of individuals is considered pertinent to the discussion, names have been omitted in the interest of brevity. However, contributors are mentioned in the captions of the selected illustrations accompanying this report. Drawings, photographs, CCD images, tables, and graphs are included with this summary so that readers can refer to them as they study the text. Readers should be aware that features on the Globe of Saturn are described in south-to-north order and can be identified by looking at the nomenclature diagram shown in *Figure 4* (page 5). If no reference is given to a particular global feature in our south-to-north discussion, these areas were not reported by observers during the 2000-2001 Apparition.

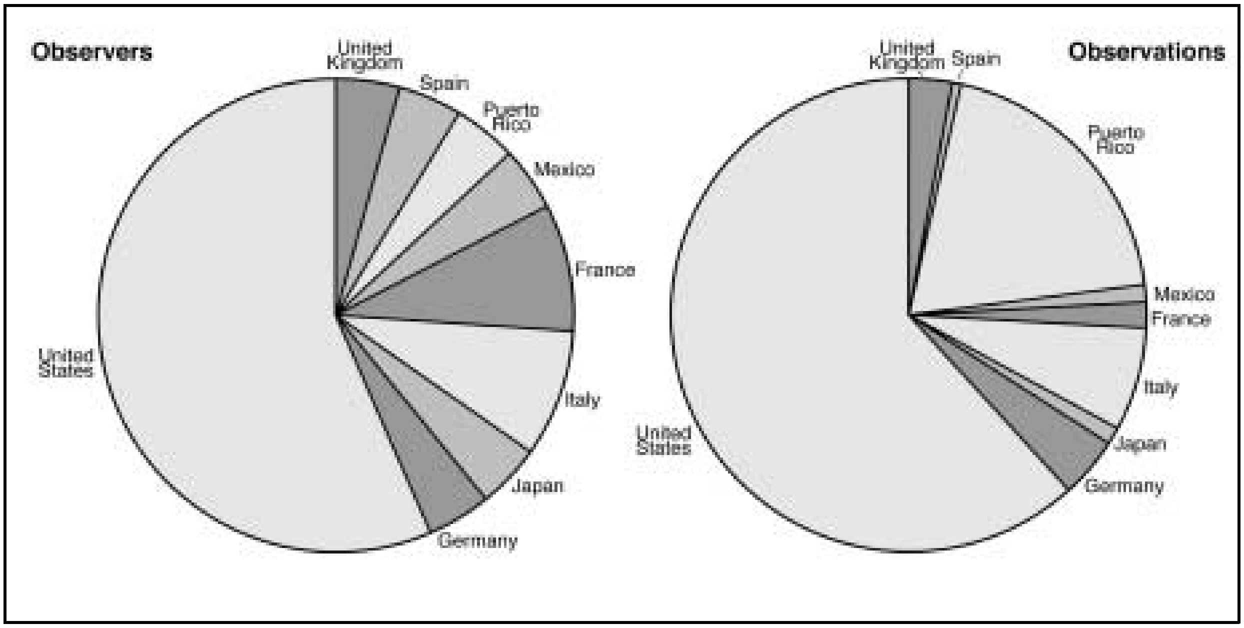


Figure 2. Distribution of observers and observations by nation of residence, 2000-2001 Apparition of Saturn.

In preparing apparition reports, it has been customary for the ALPO Saturn Section to compare data for global atmospheric features between successive observing seasons. This practice continues with this report to assist the reader in understanding the significance of very subtle, but nevertheless recognizable, variations that may be occurring seasonally on Saturn.

Observational data indicate that some of the intensity variations noted in Saturnian belts and zones (see *Table 3*, page 6) may be simply a consequence of the constantly varying inclination of the planet's rotational axis relative to the Earth and Sun. Using photoelectric photometry, observers have also recorded delicate oscillations of about 0.10 in the visual magnitude of Saturn in recent years, beyond effects attributable to Saturn's varying ring inclination and distance from the Sun and Earth. Of course, transient and long-enduring atmospheric features occurring in Saturn's belts and zones must also play a role in perceived brightness fluctuations. Routine photoelectric photometry of Saturn, in conjunction with visual numerical relative intensity estimates, remains a very worthwhile project for observers to pursue (see the article on photoelectric photometry of Saturn immediately following this report).

The intensity scale employed is the ALPO Standard Numerical Relative Intensity Scale, where 0.0 signifies a total black condition and 10.0 denotes maximum brightness. This scale is normalized by setting the outer third of Ring B at a standard brightness of 8.0. The arithmetic sign of an intensity change is found by subtracting a feature's 1999-2000 intensity from its 2000-2001 value. Variations of only 0.10 mean intensity points are not significant, and a perceived intensity fluctuation is not considered really noteworthy unless it is more than about three times its standard error.

Latitudes of Global Features

Observers employed the very convenient visual technique devised by Haas almost four decades ago to perform eyepiece estimates of Saturnian global latitudes during 2000-2001. To use the method, observers simply make estimates of the fraction of the polar semidiameter of the planet's Globe that is subtended on the central meridian (CM) between the limb and the feature whose latitude is desired. This process is

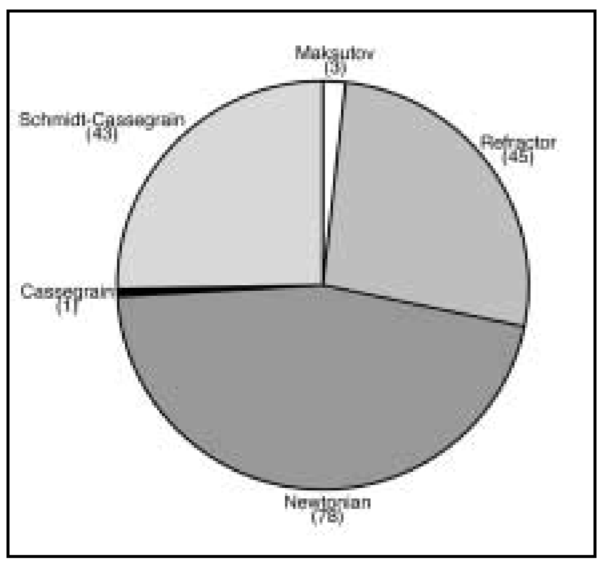


Figure 3. Distribution of observations by instrument type, 2000-2001 Apparition of Saturn.

easy to use and produces data that compare very well with latitudes derived from drawings, images, or measured with a bifilar micrometer. After quantitative reduction, latitudes of Saturn's global features during 2000-2001 are listed in *Table 4* (page 7). One must exercise caution, however, in placing too much confidence in data generated by only a couple of observers. However, Haas, the author, and several other individuals have been using this visual technique for many years with what appears to be reliable results. More observers are encouraged to try this very simple procedure, even if a bi-filar micrometer is available. Comparison of latitude data generated by more than one method is always useful. A detailed description of Haas' visual technique can be found in *The Saturn Handbook* available from the author in printed or *.pdf format. It is worth noting that, as a control on the accuracy of the visual method, observers should include in their estimates the positions on the CM of the projected ring edges and the shadow of the Rings. The actual latitudes can then be computed from the known values of **B** and **B'** and the dimensions of the Rings, but this test cannot be readily applied when **B** and **B'** are near their maximum attained numerical values. In describing each feature on Saturn's Globe, gleanings from latitude data are incorporated into the text where appropriate.

Southern Regions of the Globe

During 2000-2001, the maximum value of B approached -24°, affording observers excellent views of Saturn's Southern Hemisphere. As one might expect, most of the Northern Hemisphere of the planet was obscured by the Rings as they crossed in front of the Globe. From the observational data for 2000-2001, the Southern Hemisphere of Saturn displayed essentially the same mean numerical relative intensity as in the immediately preceding apparition. There were a few moments during the 2000-2001 observing season when observers suspected dark features in the Southern Hemisphere of Saturn (usually in association with the SEB), but these features did not persist long enough to be recovered after a small number of rotations of the planet. Very diffuse and ill-defined white spots were also periodically suspected (mainly in mid-September 2000) in the Equatorial Zone (EZs) and South Tropical Zone (STrZ) during 2000-2001, but confirming reports were lacking. So, like the rare wispy festoons suspected in the SEB, the subtle white spot phenomena on Saturn were short-lived and afforded no good opportunities for timing of recurring CM transits.

South Polar Region (SPR)

The dark yellowish-grey SPR was typically uniform in appearance during 2000-2001, with no apparent

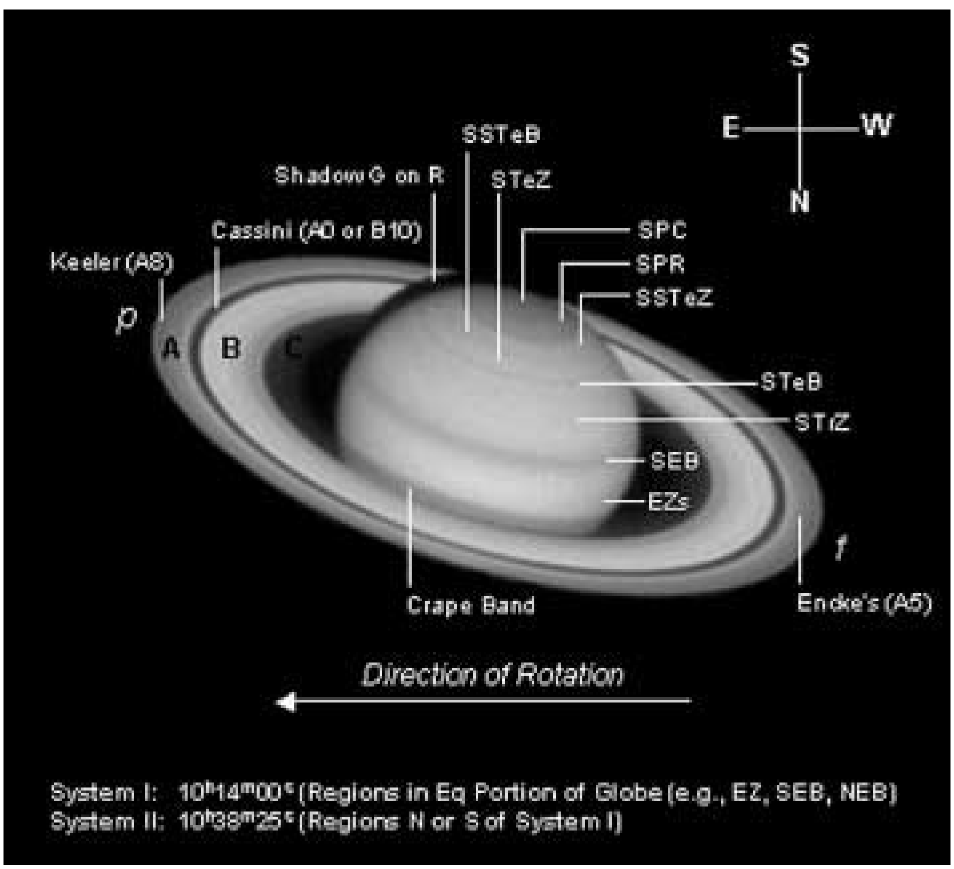


Figure 4: General Nomenclature of Features of Saturn:
B = Belt
C = Cap
G = Globe
R = Region or Ring,
Z = Zone
N = North
S = South
f = following
p = preceding
E = Equatorial
P = Polar
Te = Temperate
Tr = Tropical

A, B and C (Crepe) are Ring designations, while Cassini (A0 or B10), Encke's (A5) and Keeler (A8) refer to Ring divisions (intensity minima).

Table 3: Visual Numerical Relative Intensity Estimates and Colors for the 2000-2001 Apparition of Saturn

2000-2001 Relative Intensities

Globe/Ring Feature	Number of Estimates	Mean and Standard Error	Change Since 1999-2000	"Mean" Derived Color in 2000-2001
Zone:				
SPC	13	5.35±0.03	+0.18	Light Grey
SPR	31	4.91±0.07	+0.21	Dark Yellowish-Grey
SSTeZ	2	6.75±0.15	—-	Pale Yellowish-White
STeZ	18	5.75±0.11	+0.25	Yellowish-White
STrZ	25	5.84±0.11	-0.69	Yellowish-White
SEBZ	5	5.16±0.19	+0.06	Dull Yellowish-Grey
EZs	57	7.79±0.18	+0.89	Bright Yellowish-White
Globe S of SEB	21	4.90±0.05	-0.12	Dull Yellowish-Grey
Belts:				
SPB	19	3.73±0.02	-0.06	Dark Grey
SSTeB	1	5.00 ——-	———	Light Grey
STeB	9	5.03±0.17	-0.97	Light Yellowish-Grey
SEB (entire)	27	3.96±0.13	+0.21	Greyish-Brown
SEBs	24	3.46±0.06	-0.17	Dark Grey
SEBn	24	2.94±0.10	-0.12	Very Dark Grey
EB	15	4.83±0.22	+0.86	Light Grey
Ring:				
A (entire)	53	6.92±0.05	+0.02	Pale Yellowish-White
Ring A (outer 1/2)	7	6.83±0.04	-0.09	Pale Yellowish-White
Ring A (inner 1/2)	7	6.56±0.03	-0.23	Pale Yellowish-White
A8	1	0.40 ——-	———	Dark Greyish-Black
A5	34	1.80±0.22	-2.03	Very Dark Grey
A0 or B10	51	1.15±0.11	+0.27	Greyish-Black
B (outer 1/3)	STANDARD	8.00 ——-	———	Brilliant White
B (inner 2/3	25	7.26±0.02	+0.02	Bright Yellowish-White
B1	6	3.52±0.16	-0.23	Dark Grey
B2	3	3.83±0.10	-0.01	Dark Grey
C (ansae)	55	1.76±0.15	+1.13	Greyish-Black
Crape Band	21	2.16±0.02	-0.07	Very Dark Grey
Sh G on R	49	0.47±0.06	+0.33	Dark Greyish-Black
Sh R on G	11	0.68±0.10	-0.41	Dark Greyish-Black
TWS	12	8.18±0.14	+0.44	Brilliant White

Notes: For nomenclature see text and Figure 4. A letter with a digit (e.g., A0 or B10) refers to a location in the ring specified in terms of units of tenths of the distance from the inner edge to the outer edge. Visual numerical relative intensity estimates (visual surface photometry) are based upon the ALPO Intensity Scale, where 0.0 denotes complete black (shadow) and 10.0 refers to the most brilliant condition (very brightest Solar System objects). The adopted scale for Saturn uses a reference standard of 8.00 for the outer third of Ring B, which appears to remain stable in intensity for most ring inclinations. All other features on the Globe or in the Rings are compared systematically using this scale, described in The Saturn Handbook, which is issued by the ALPO Saturn Section. The "Change Since 1999-00" is in the same sense of the 1999-2000 value subtracted from the 2000-2001 value, "+" denoting an increase in brightness and "-" indicating a decrease (darkening). When the apparent change is less than about 3 times the standard error it is probably not statistically significant.

Table 4: Saturnian Belt Latitudes in the 2000-2001 Apparition

Saturnian Belt	Number of Estimates	Form of Latitude					
		Eccentric (Mean)		Planetocentric		Planetographic	
N edge SPB	12	-85.50±0.58	(-4.14)	-84.97±0.65	(-4.63)	-85.98±0.52	(-3.71)
S edge SEB	22	-34.19±0.27	(-2.34)	-31.24±0.26	(-2.22)	-37.26±0.28	(-2.43)
N edge SEB	22	-27.84±0.18	(-2.74)	-25.25±0.17	(-2.56)	-30.01±0.19	(-2.33)
Center EB	14	-15.55±1.28	(+5.18)	-13.98±1.16	(+4.70)	-17.26±1.41	(+5.71)

Notes: For nomenclature see Figure 4. Latitudes are calculated using the appropriate geocentric tilt, B, for each date of observation, with the standard error also shown. Planetocentric latitude is the angle between the equator and the feature as seen from the center of the planet. Planetographic latitude is the angle between the surface normal and the equatorial plane. Eccentric, or "Mean," latitude is the arc-tangent of the geometric mean of the tangents of the other two latitudes. The change shown in parentheses is the result of subtracting the 1999-2000 latitude value from the 2000-2001 latitude value.

activity, and had nearly the same mean intensity as in 1999-2000. Several observers called attention to a light greyish South Polar Cap (SPC) that appeared a little brighter than the surrounding SPR, and it reportedly displayed virtually the same mean intensity also as during the 1999-2000 Apparition. The dark greyish South Polar Belt (SPB) encircling the SPR, complete from limb to limb, was reported fairly often during 2000-2001, and it maintained the same mean intensity since the previous observing season.

South South Temperate Zone (SSTeZ)

The SSTeZ was reported only twice during the 2000-2001 Apparition, pale yellowish-white in hue. According to those who saw the feature, it was second only to the EZs in mean intensity. The SSTeZ displayed no discrete atmospheric phenomena during the observing season. The SSTeZ was not reported in 1999-2000, so no comparisons could be made between apparitions.

South South Temperate Belt (SSTeB)

There was only one report of the light grey SSTeB during 2000-2001, describing it as a narrow, continuous feature running across the Globe from one limb to the other. As with the SSTeZ, the SSTeB was not seen in 1999-2000, so no assessment could be made of intensity change. Also, based on only one sighting of this feature, the apparently equal brightnesses of the SSTeB and STeB in 2000-2001 may be only coincidental.

South Temperate Zone (STeZ)

The yellowish-white STeZ was detected slightly more frequently by observers in 2000-2001 than in 1999-2000, and some individuals even reported that this zone had become slightly more prominent (although a change of +0.25 mean intensity points is hardly significant). In overall intensity, the STeZ in 2000-2001 ranked as the fourth brightest zone in the Southern Hemisphere of Saturn, behind the EZs, SSTeZ, and STrZ. However, the difference between the STrZ and STeZ was very subtle at best. The STeZ maintained steady intensity throughout the 2000-2001 Apparition with no obvious activity associated with it.

South Temperate Belt (STeB)

The light yellowish-grey STeB was reported on rare occasions during the 2000-2001 Apparition. According to observers who detected it, the SteB was slightly darker by -0.97 mean intensity points than in 1999-2000. The STeB showed no activity as it ran uninterrupted across Saturn's Globe.

South Tropical Zone (STrZ)

The yellowish-white STrZ was frequently seen throughout 2000-2001. According to most descriptive reports, the STrZ took on a slightly more dusky appearance than in the preceding apparition (based on mean intensity data; however, a difference of -0.69 is not particularly noteworthy). Other than the EZs and the seldom-seen SSTeZ, the STrZ was the brightest zone in the Southern Hemisphere of Saturn, but again, the STrZ was about the same overall brightness as the STeZ in 2000-2001. On 2000 Sep 13d 06h 48m UT, Parker thought he may have imaged a very small white spot in the STrZ at 291° (System III) using a 40.6-cm (16.0-in) Newtonian and CCD camera in good seeing from South Florida (Figure 7, page 10), but there were no confirming reports of this feature from other observers. Aside from this solitary report of activity in the STrZ, the zone remained uniform in intensity and devoid of activity throughout the observing season.

South Equatorial Belt (SEB)

The SEB was reported about as frequently in 2000-2001 as an undifferentiated greyish-brown feature as it was seen divided into distinct SEBn and SEBs components (where **n** refers to the North Component and s to the South Component). The SEB (as well as the SEBn and SEBs) maintained essentially the same mean intensity in 2000-2001 as in 1999-2000. A well-defined intervening and dull yellowish-grey South Equatorial Belt Zone (SEBZ) was referred to in only five observations during 2000-2001, undergoing no real change in mean intensity since 1999-2000. As a whole, the SEB was second only to the SPB in being the darkest belt on Saturn during the 2000-2001 Apparition, but the very dark grey SEBn and dark grey SEBs (at mean intensity values of 3.46 and 2.94, respectively) were the most conspicuous belts of all in the Southern Hemisphere of the planet. The SEBn was always described by observers as slightly darker than the contiguous SEBs in 2000-2001.

There were a few reports in early 2001 January of small, ill-defined dark spots within the SEB, as well as somewhat dispersed dusky projections emanating from the northern edge of the SEBn into the bordering EZs. These features did not persist long enough to be recovered in subsequent rotations for good CM transit timings.

Equatorial Zone (EZ)

The southern half of the bright yellowish-white Equatorial Zone (EZs) was the region of the EZ seen between where the Rings cross the Globe of the planet and the SEB in 2000-2001 (the EZn was not visible during the apparition). The mean intensity of the EZs was somewhat brighter than in 1999-2000, and this zone was constantly the brightest zone on Saturn during the 2000-2001 observing season and slightly brighter than the inner third of Ring B in mean intensity. At numerous times during the 2000-2001 Apparition, observers suspected diffuse bright mottling in the EZs, but none of these poorly-defined features endured long enough for CM transit timings.

Several observers sighted a narrow, continuous light greyish Equatorial Band (EB) in 2000-2001 extending across Saturn's Globe. Mean intensity data in 2000-2001 hinted that the EB was perhaps slightly brighter than in 1999-2000, but again, a mean change of +0.89 since the previous apparition is not considered statistically significant.

Northern Portions of the Globe

Owing to the -24° tilt of Saturn's Rings in 2000-2001, and thus an improved visibility of the Southern Hemisphere of the planet, essentially none of the Northern Hemisphere could be viewed to advantage.

Shadow Features

Shadow of the Globe on the Rings (Sh G on R)

The Sh G on R was seen by observers as a geometrically regular dark greyish-black feature on either side of opposition during 2000-2001. Any perceived departure

Table 5: Observations of the Bicolored Aspect of Saturn's Rings During the 2000-2001 Apparition

Observer	UT Date and Time		Telescope Type and Aperture	X	S	Tr	Filter Bl	Filter IL	Filter Rd
Crandall	2000 Dec 24	03:05-03:35	NEW 25.4 cm (10.0in.)	220	3.5	4.0	=	=	E
del Valle	2000 Dec 24	00:36-00:45	SCT 20.3 cm (8.0in.)	339	8.0	3.0	E	=	=
Haas	2001 Feb 04	02:12-04:04	NEW 20.3 cm (8.0in.)	231	3.0	3.0	W	=	=
Haas	2001 Feb 05	03:17-04:10	NEW 20.3 cm (8.0in.)	231	3.5	3.5	W	=	=
Haas	2001 Feb 19	04:46-05:16	NEW 20.3 cm (8.0in.)	231	2.0	3.0	W	=	=
Crandall	2001 Feb 20	01:30-01:49	NEW 25.4 cm (10.0in.)	220	5.0	4.0	W	=	=
Haas	2001 Mar 16	01:55-02:31	NEW 20.3 cm (8.0in.)	231	4.0	3.0	W	=	=
Haas	2001 Mar 22	02:53-03:17	NEW 20.3 cm (8.0in.)	203	3.0	3.5	W	=	=
Haas	2001 Mar 17	02:05-02:20	NEW 31.8 cm. (12.5 in.)	202	2.0	3.5	E	=	=

Notes: **NEW** = Newtonian, **SCT** = Schmidt-Cassegrain, **X** = magnification. Seeing (**S**) is in the 0-10 ALPO Scale, and Transparency (**Tr**) is the limiting visual magnitude in the vicinity of Saturn. Under "Filter," **Bl** refers to the blue W47, W38 or W80A Filters, **IL** to integrated light (no filter), and **Rd** to the red W25 or W23A Filters. "E" means the east ansa was brighter than the west, "W" that the west ansa was the brighter, and "=" means that the two ansae were equally bright. East and west directions are in the IAU sense.

General Comments for Figures 5-16. The 12 CCD images and drawings that follow are all oriented with celestial south at the top and celestial west at the left (unless otherwise stated), which is the normal inverted view when observing objects near the meridian with an astronomical telescope in the Earth's Northern Hemisphere. Seeing (S) was reported on, or has been converted to, the standard ALPO scale, ranging from 0.0 for the worst possible condition to 10.0 for perfect seeing. Transparency (T) is the limiting naked-eye stellar magnitude in the vicinity of Saturn. Consult *The Saturn Handbook* for central meridian and other information; see the ALPO Resources section for ordering information.

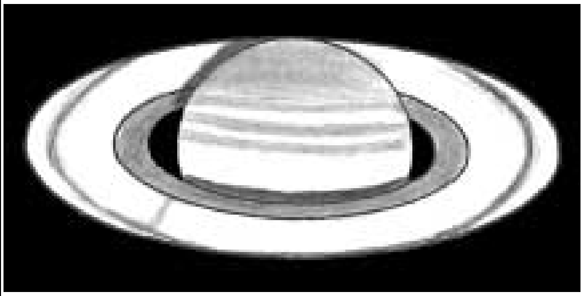


Figure 5: 2000 JUN 29, 09:15-09:45 UT. D. del Valle. 20-cm (8-in.) Newtonian, 200X & 266X; W23A (light red), 38A (blue) and 58 (green) Filters. S = 6, twilight. CM I = 002°.5 - 020°.1. B = -23°.7, B' = -22°.6. Globe = 16".8 X 15".4, Rings = 38".2 X 15".3. Note spoke-like feature on Ring B (lower left).

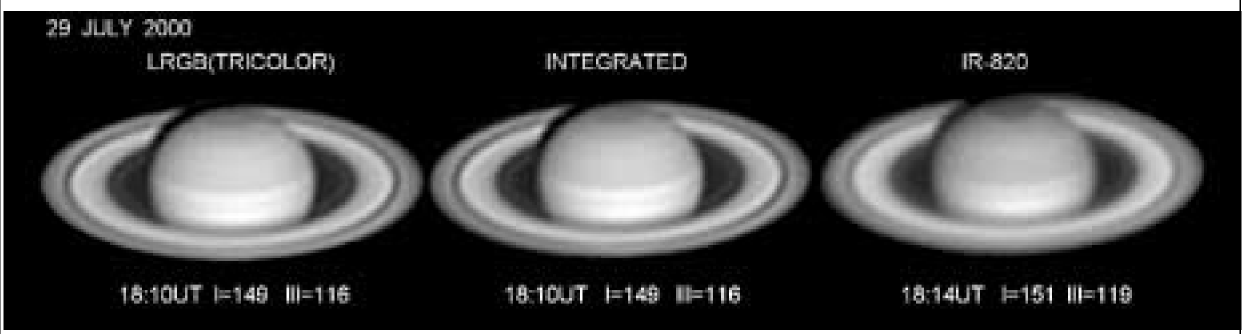


Figure 6: 2000 JUL 29, 18:10-18:14 UT. T. Akutsu. 32-cm (12.5-in.) Newtonian, Teleris CCD camera. CM I = 149-151°, CM III = 116°-119°. B = -24°.1, B' = -22°.9. Globe = 17".5 X 16".1, Rings = 39".8 X 16".3.

from a true black (0.0) intensity was a consequence of less-than-favorable seeing conditions or scattered light.

Shadow of the Rings on the Globe (Sh R on G)

Observers in 2000-2001 reported this shadow as a dark greyish-black feature south of the Rings where they passed in front of the Globe. Reported variations from an intrinsic black (0.0) condition were due to the same causes noted for the Sh G on R.

Saturn's Ring System

The following portion of the 2000-2001 Apparition report pertains to studies of Saturn's ring system, including a continuing comparative analysis of mean intensity data that has been traditional in many previous observing seasons. Views of the southern face of the Rings were increasingly favorable during 2000-2001 as the tilt of the Rings to the Earth (**B**) increased to nearly -24°.

Ring A

Ring A as a whole was pale yellowish-white during all of 2000-2001 with no real change in mean intensity since 1999-2000. On several dates during the apparition, observers referred to pale yellowish-white outer and inner halves of Ring A, with both halves very similar in overall intensity. The dark greyish Encke's Division (A5) was visible frequently at the ring ansae, and Keeler's Division (A8) was imaged at the ansae by Damian Peach in the United Kingdom on 2000 Oct 13d 01h 24m - 29m UT using a 30.5-cm (12.0-in) Schmidt-Cassegrain and CCD camera (Figure 9, page 11). No other intensity minima in Ring A were reported in 2000-2001.

Ring B

The outer third of Ring B is the standard of reference for the ALPO Saturn Visual Numerical Relative Intensity Scale, with an assigned value of 8.00. For the entire 2000-2001 Apparition, this region of Ring B was brilliant white, maintained its seemingly stable intensity, and was always the brightest feature on Saturn's Globe or in the ring system, with the possible exception of the illusory Terby White Spot (TWS). The inner two-thirds of Ring B, which was described as bright yellowish-white in color and uniform in intensity, was basically the same mean intensity in 2000-2001 as in 1999-2000. Daniel del Valle in Puerto Rico reported spoke-like features in Ring B near the East ansa on 2000 Jun 29d 09h 15m - 45m UT and again on 2001 Jan 10d 22h 07m - 22m UT using a 20.3-cm (8.0-in.) Newtonian, remarking that these features were particularly prominent in W38A (blue) and W58 (green) Filters under excellent seeing conditions. Likewise, using a 20.3-cm (8.0-in.) Newtonian at 250X and a yellow filter in good seeing, Ivano Dal Prete in Italy suspected wispy radial spokes at both ansae in Ring B on 2000 Oct 22d 02h 25m - 03h 40m UT. No images received by the ALPO Saturn Section

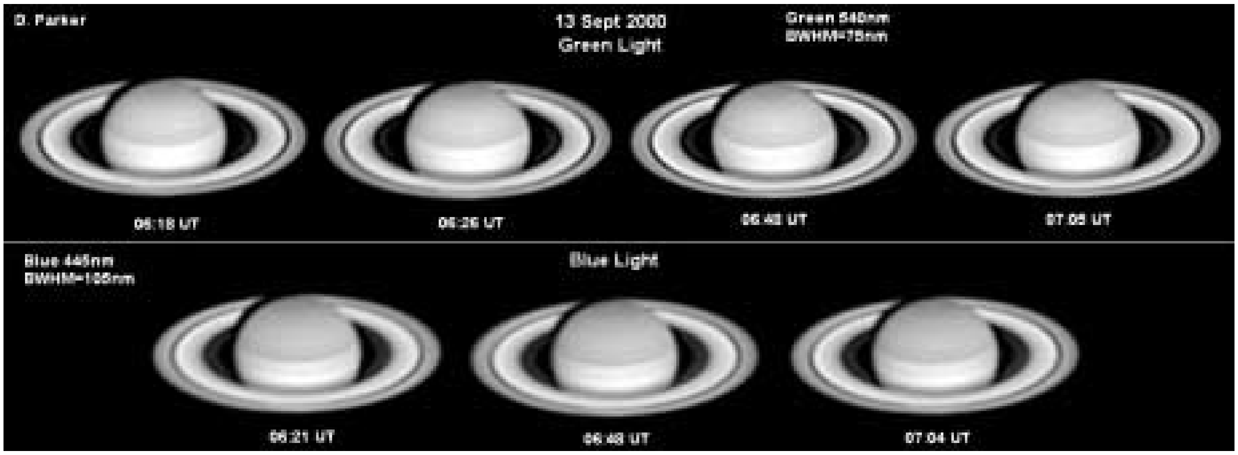


Figure 7: 2000 SEP 13, 06:13-07:06 UT. D. Parker. 40.6-cm (16.0-in.) Newtonian, CCD camera. B = -24°.3, B’ = -23°.3. Globe = 19”.0 X 17”.5, Rings = 43”.1 X 17”.8.

Figure 8: 2000 OCT 09, 02:05 UT. D. Peach. 30.5-cm (12.0-in.) Schmidt-Cassegrain, CCD image, Integrated light + RGB filters. S = 4.0 - 7.0 (variable), T = +5.0. CM I = 222°.1, CM II = 005°.7. B = -24°.1, B’ = -23°.5. Globe = 19”.8 X 18”.2, Rings = 45”.0 X 18”.4.

showed any hint of these radial spoke features in Ring B. Observers also suspected dark grey intensity minima at B1 and B2 during 2000-2001.

Cassini’s Division (A0 or B10)

Cassini’s division (A0 or B10), many times seen encircling the entire ring system with larger instruments in favorable seeing, was greyish-black in hue and visible by observers at both ansae during most of 2000-2001. For Earth-based visual observations, any divergence from a totally black intensity for Cassini’s Division would likely be due to scattered light, poor seeing, inadequate aperture, and other external factors, despite the fact that Voyager results do show some material within Cassini’s Division. (Morrison 1982: 176). Also, the visibility of main ring divisions and other intensity minima was improved in 2000-2001 because of the greater inclination of the Rings, where the numerical value of **B** averaged about -24°.0 during the apparition as opposed to -20°.0 in 1999-2000. The mean intensity of Cassini’s Division did not vary appreciably since the preceding apparition.

Ring C

The greyish-black Ring C was regularly reported at the ansae throughout 2000-2001, and observers noted that Ring C appeared somewhat lighter in intensity than in 1999-2000 (mean intensity difference of +1.13). Where Ring C crossed Saturn’s Globe (a feature referred to as the “Crepe Band”), the very dark grey “band” was uniform in intensity and as a whole unchanged in brightness and appearance since 1999-2000. When **B** and **B**' are both negative and **B** is numerically larger, the Sun is farther north of the rings than the Earth so that shadows are cast to the south. This condition existed during the 2000-2001 apparition prior to 2000 Nov 08. The Crape Band is also located south of the projected Rings A and B. If **B** is numerically smaller than **B'**, the shadow falls north of the projected rings, and off the globe in 2000-20001, which took place in the observing season after 2000 Nov 08. When the shadow of Ring A, Ring B, and Ring C’s projection are superimposed, it is difficult to distinguish them from one another in ordinary apertures and seeing conditions, and the shadow of Ring C is an added complication.

Terby White Spot (TWS)

The TWS is a sometimes striking brightening of the Rings immediately adjacent to the Sh G on R. On several occasions in 2000-2001 observers noticed a brilliant TWS (intensity of 8.18), but it is almost certainly a spurious contrast phenomenon and not an intrinsic feature in Saturn’s Rings. It is still meaningful, however, to attempt to determine what correlation may exist between the visual numerical relative intensity of the TWS and the changing tilt of the ring system, including its brightness and visibility with variable-density polarizers, color filters, photographs, and CCD or digital camera images.

Bicolored Aspect of the Rings

The bicolored aspect is an observed variation in color between the east and west ansae (IAU system) when systematically compared with alternating W47 (Wratten 47), W38, or W80A (all blue filters) and W25 or W23A (red filters). The circumstances of observations when a bicolored aspect of the ring ansae was noted in 2000-2001 are listed in *Table 5* (page 8). Readers should be aware that the directions in Table 5 refer to Saturnian or IAU directions, where west is to the right in a normally-inverted telescope image (observer located in the Northern Hemisphere of the Earth) which has south at the top.

The ALPO Saturn Section has established a simultaneous observing schedule to help observers monitor the planet on the same date and at the same time. The greater the number of people participating in this effort, making concurrent independent visual estimates with color filters, along with CCD imaging and photography at corresponding wavelengths, the greater the chances of shedding some new light on this intriguing and poorly-understood phenomenon.

A recent published article by T. A. Dobbins and others discusses this curious aspect , some professional obser-

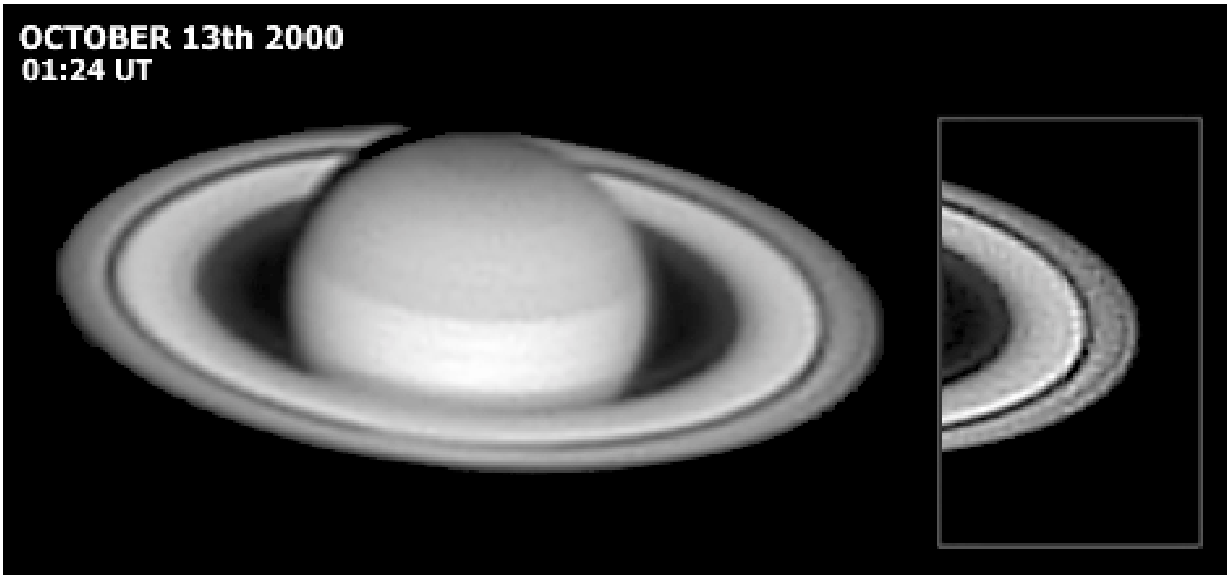


Figure 9: 2000 OCT 13, 01:24 UT. D. Peach. 30.5-cm (12.0-in.) Schmidt-Cassegrain, CCD image, Integrated light + RGB filters. S = 8.0 - 10.0 (variable), T = +1.5 - +5.0 (variable in fog). CM I = 334°.6, CM II = 351°.0. B = -24°.1, B' = -23°.5. Globe = 19".9 X 18".3, Rings = 45".2 X 18".5. Note Keeler's Division near ansae of Ring A, enhanced in inset to the right.

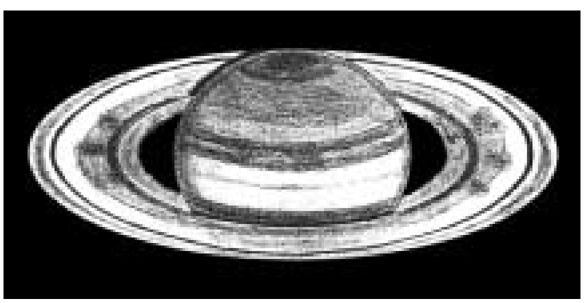


Figure 10: 2000 OCT 22, 03:00 UT. I. Dal Prete. 20-cm (8-in.) Newtonian, 250X; yellow filter. Seeing very good. B = -24°.0, B' = -23°.6. Globe = 20".1 X 18".5, Rings = 45".7 X 18".6. Note possible spoke-like features on inner portion of Ring B.

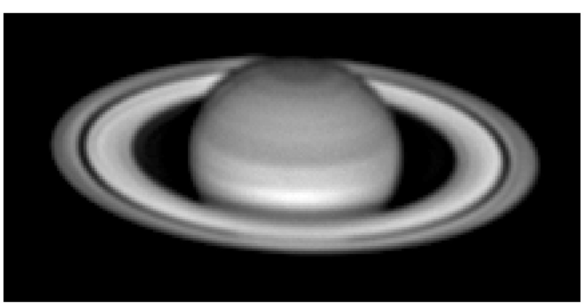


Figure 11: 2000 NOV 11, 00:57-01:04 UT. C. Viladrich. 20.3-cm (8.0-in.) Maksutov, f/10, Kaf 1600 Film, integrated light. CM I = 329°.8, CM II = 128°.6, CM III =043°.3. B = -23°.7, B' = -23°.8. Globe = 20".4 X 18".7, Rings = 46".3 X 18".6.

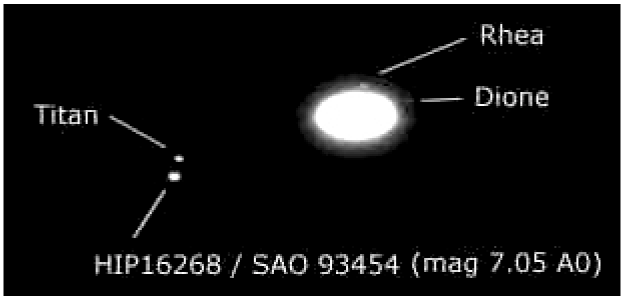


Figure 12: 2001 JAN 08, 22:17:15 UT. T. Tobal. 10.2-cm (4.0-in.) refractor, f/10, CCD SX camera, 10-second exposure. Saturn (overexposed) with satellites Dione, Rhea and Titan; the latter passing near the 7.05-magnitude star SAO 93454. B = -23°.1, B' = -24°.2. Globe = 19".4 X 17".8, Rings = 44".3 X 17".4.

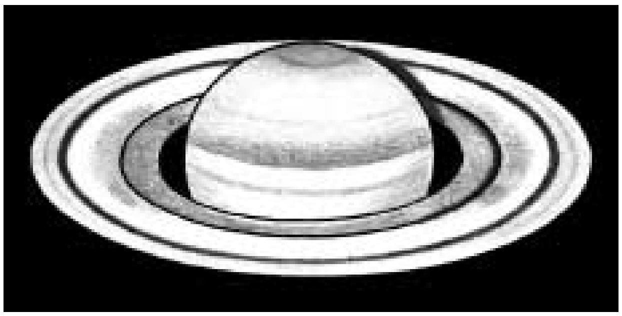


Figure 13: 2001 JAN 18, 01:30 - 02:00 UT. I. D. Boyar. 15-cm (6-in.) refractor, 183X & 254X. S = 7 - 8, Transparency = +4. B = -23°.1, B' = -24°.3. Globe = 19".2 X 17".6, Rings = 43".7 X 17".1. Original drawing reversed (due to use of a star diagonal); rectified in this reproduction.

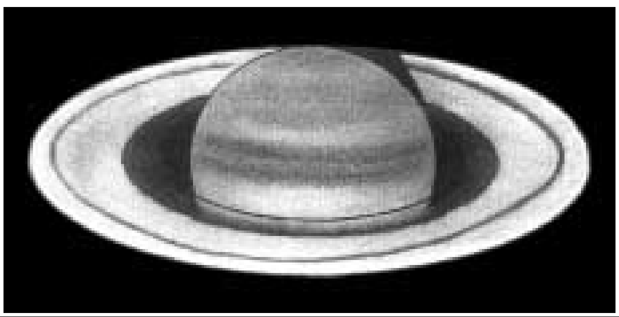


Figure 14: 2001 FEB 27, 01:15 - 01:30 UT. P. Plante. 20-cm (8-in.) Schmidt-Cassegrain, 250X, integrated light. S = 5.0, Transparency = +3.0 (haze). CM I = 079°.6 - 088°.4, CM II = 351°.1 - 359°.6, CM III = 134°.9 - 143°.4. B = -23°.5, B' = -24°.6. Globe = 17".9 X 16".4, Rings = 40".6 X 16".2.

vations poorly known to amateurs , and possible interpretations.

The Satellites of Saturn

Observers in 2000-2001 did not submit systematic visual estimates of Saturn's satellites employing suggested methods described in *The Saturn Handbook*, but Tobal submitted an interesting CCD image of Saturn's satellites Titan, Rhea, and Dione (with a comparison star) on 2001 Jan 08d 22h 17m UT using a 10.2-cm (4.0-in.) refractor (Figure 12, page 12). Photoelectric photometry and systematic visual magnitude estimates of Saturn's satellites is strongly encouraged in future apparitions.

Since the beginning of the 1999-2000 Apparition, the ALPO Saturn Section has solicited regular spectroscopy of Titan as a new professional-amateur cooperative project. Although Titan has been sporadically monitored by large Earth-based instruments and the Hubble Space Telescope, a definite need exists for good systematic observations with instrumentation available to amateurs. Titan is a very dynamic satellite that exhibits transient as well as long-term variations for variety reasons. From 3000Å to 6000Å Titan's color is dominated by reddish methane haze in its atmosphere, while longward of 6000Å, increasingly deeper methane absorption bands occur in its spectrum. Between these methane bands are "windows" to Titan's lower atmosphere and surface, so daily monitoring in these "windows" using photometers or spectrophotometers is useful for cloud and surface studies. Long-term studies from apparition to apparition can also shed light on Titan's seasonal variations. Melillo was the first ALPO observer to try his hand at rudimentary spectroscopy of Titan during 1999-2000, and during the 2000-2001 Apparition he continued to experiment with imaging Titan with a methane-absorption filter. We wish to expand these studies in subsequent apparitions and involve considerably more people in the effort. Therefore, we urge suitably-equipped observers to participate in this very interesting project. More details on this endeavor can be found on the Saturn page of the ALPO website at http://www.lpl.arizona.edu/alpo/ .

Simultaneous Observations

Simultaneous observations, or studies of Saturn by individuals working independently of one another at the same time and on the same date, afford good opportunities for verification of ill-defined or controversial Saturnian phenomena. The ALPO Saturn Section has organized a simultaneous observing team so that several individuals in reasonable proximity of one another can maximize the chances of viewing Saturn at the same time using similar equipment and methods. Joint efforts like this significantly reinforce the level of confidence in the data submitted for each apparition. Several simultaneous, or near-simultaneous, observations of Saturn were submitted during 2000-2001, but as in the 1999-2000 Apparition, the occurrence of such observations

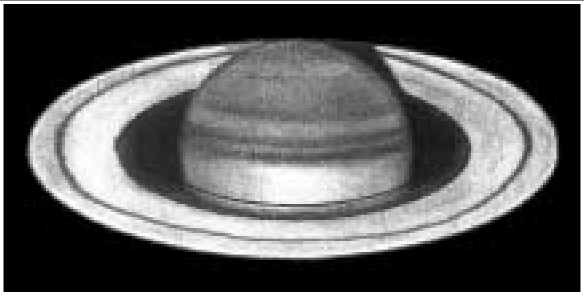


Figure 15: 2001 MAR 11, 01:10 - 01:20 UT. P. Plante. 20-cm (8-in.) Schmidt-Cassegrain, 154X. S = 5, Transparency = +4.0. CM I = 126°.5 - 132°.4, CM II = 010°.5 - 016°.1, CM III = 139°.9 - 145°.6. B = -23°.7, B' = -24°.7. Globe = 17".5 X 16".1, Rings = 39".8 X 16".0.

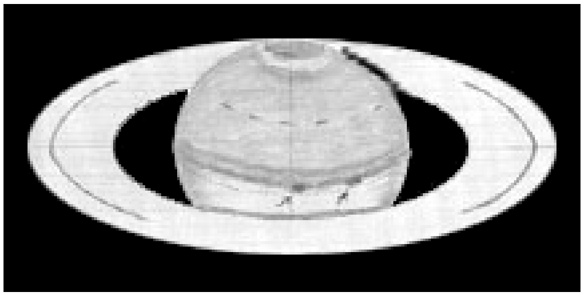


Figure 16: 2001 MAR 27, 18:58 UT. G. Teichert. 28.0-cm (11.0-in.) Schmidt-Cassegrain. CM I = 219°.3, CM II = 282°.0. B = -24°.0, B' = -24°.8. Globe = 17".1 X 15".7, Rings = 38".9 X 15".8.

was mostly fortuitous. Although it is important that more experienced observers participate in this effort, newcomers to observing Saturn are always welcome to get involved. Readers are urged to inquire about how to join the simultaneous observing team in future observing seasons.

Conclusions

Saturn's atmosphere appeared relatively quiescent during the 2000-2001 Apparition, as was the situation in the two immediately preceding observing seasons. In summary, reported activity on Saturn in 2000-2001 took the form of ill-defined dusky festoons in the SEB and vague whitish areas in the EZs and STrZ of the Globe, none of which reappeared following some rotations of the planet. Aside from the often-seen Cassini (A0 or B10) and Encke (A5) divisions, one observer imaged Keeler's gap (A8), a few spotted B1 and B2 intensity minima, while a couple of individuals remarked that dusky ring spokes were possibly evident from time to time during the apparition.

The author expresses his gratitude to the observers mentioned in this report who faithfully submitted visual drawings, photographs, CCD images, and descriptive reports in 2000-2001. Dedicated, systematic observational work in support of our programs helps amateur and professional astronomers alike gain a better understanding of Saturn and its always strikingly beautiful ring system.

Interested observers everywhere are cordially invited to join us in our pursuits in future apparitions of Saturn, and the ALPO Saturn Section is always eager to offer guidance for beginning, as well as advanced, observers. It should be mentioned that a very meaningful resource for learning how to observe and record data on the Moon and planets is the ALPO Training Program, and we encourage participation in this valuable educational experience.

References

Alexander, A.F. O'D. 1962. *The Planet Saturn*. London: Faber and Faber.

Benton, J.L., Jr. 1996. *Visual Observations of the Planet Saturn: Theory and Methods (The Saturn Handbook)*. Savannah, GA: Review Publishing Company (8th Revised Edition; now available also in *.pdf format).

________. 1999a. "The 1995-96 Apparition of Saturn and Edgewise Presentation of the Rings: Visual and Other Observations." JALPO, 41, 1: 1-23.

________. 1999b. "Observations of Saturn During the 1996-97 Apparition." JALPO, 42, 1: 1-12.

________. 2000. "Observations of Saturn During the 1997-98 Apparition." JALPO, 42, 3: 106-117.

________. 2001. "Observations of Saturn During the 1998-99 Apparition." JALPO, 43, 4: 31-43.

________. 2002. "Observations of Saturn During the 1999-2000 Apparition." JALPO, 44, 1: 15-27.

Dobbins, T.A., Heath, A., and Dikarev, V.,"Saturn's Colorful Mystery", *Sky & Telescope* magazine, Vol. 105, No.1, Jan., 2003, pp.106-111.

Morrison, D. 1982. *Voyages to Saturn*. NASA SP-451. Washington: National Aeronautics and Space Administration.

United States Naval Observatory. *The Astronomical Almanac*. Washington: U.S. Government Printing Office. (Annual Publication; the 2000 and 2001 editions, which were published in 1999 and 2000, respectively, were used for this report).

ALPO Resources

People, publications, etc. to help our members

Board of Directors

- Executive Director (Chair); Donald C. Parker, 12911 Lerida Street, Coral Gables, FL 33156
- Associate Director; Richard W. Schmude, Jr., 109 Tyus St., Barnesville, GA 30204
- Founder/Director Emeritus; Walter H. Haas, 2225 Thomas Drive, Las Cruces, NM 88001
- Member of the Board; Julius L. Benton, Jr., Associates in Astronomy, 305 Surrey Road, Savannah, GA 31410
- Member of the Board; Richard Hill, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721
- Member of the Board; Ken Poshedly, 1741 Bruckner Ct., Snellville, GA 30078-2784
- Member of the Board, Secretary; Elizabeth W. Westfall, P.O. Box 2447, Antioch, CA 94531-2447
- Member of the Board; John E. Westfall, P.O. Box 2447, Antioch, CA 94531-2447
- Membership Secretary/Treasurer; Matthew Will, P.O. Box 13456, Springfield, IL 62791-3456

Publications Staff

- Acting Publisher; Ken Poshedly. Send ALL papers and articles to 1741 Bruckner Ct, Snellville, GA 30078-2784; e-mail poshedly@bellsouth.net

Science Editors

- Dr. Klaus R Brasch, Executive Director, Office of Technology Transfer & Professor of Biology, California State University, San Bernardino, 5500 University Parkway, San Bernardino, CA 92407
- Acting Editor; Dr. Richard K Ulrich, Professor, Dept. Of Chemical Engineering, 3202 Bell Engineering Center, University of Arkansas, Fayetteville, AR 72701
- John E Westfall, P.O. Box 2447 Antioch, CA 94531-2447

General Editors

- Acting Editor (General Materials); Robert A Garfinkle, F.R.A.S., 32924 Monrovia St., Union City, CA 94587-5433
- Magazine Markup and Assembly; Ken Poshedly, 1741 Bruckner Ct, Snellville, GA 30078-2784
- Acting Editor (General Materials); Roger J Venable, MD, 3405 Woodstone Pl., Augusta, GA 30909-1844

Book Review Editor

- Jose Olivarez, 4705 SE 14th St., Ocala, FL 34471

Graphics (Acting)

- John Sanford, P.O. Box 1000, Springville, CA 93265-1000

Staff Writers (Acting)

- Eric Douglass, 10326 Tarieton Dr., Mechanicsville, VA 23116-5835
- James S Lamm, 9211 13th Avenue Circle NW, Bradenton, FL 34209
- Richard J Wessling, 5429 Overlook Dr., Milford, OH 45150-9651

Translators (Acting)

- French Language Submissions; Richard J McKim, Cherry Tree Cottage, 16 Upper Main Street, Upper Benefield, Peterborough Pe8 5an, United Kingdom
- Spanish Language Submissions; Guido E Santacana, Nuevo Laredo 1678, Venus Gardens, Rio Piedras, PR 00926

Lunar and Planetary Training Program

- Coordinator; Timothy J. Robertson, 2010 Hillgate Way #L, Simi Valley, CA 93065

Solar Section

- Coordinator, *Website, SolNet, Rotation Report,* handbook; Richard Hill, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721
- Assistant Coordinator, Correspondence and New Observers; Gordon W. Garcia, 340 Illinois Boulevard, Hoffman Estates, IL 60194-3319
- Assistant Coordinator; Brad Timerson (use e-mail for correspondence, see Internet directory)

Mercury Section

- Acting Coordinator; Frank J. Melillo, 14 Glen-Hollow Dr., E-#16, Holtsville, NY 11742

Venus Section

- Coordinator: Julius L. Benton, Jr., Associates in Astronomy, 305 Surrey Road, Savannah, GA 31410

Mercury/Venus Transit Section

- Coordinator; John E. Westfall, P.O. Box 2447, Antioch, CA 94531-2447

Lunar Section

- Coordinator, *Selected Areas Program;* Julius L. Benton, Jr., Associates in Astronomy, 305 Surrey Road, Savannah, GA 31410
- Coordinator, *Lunar Meteoritic Impacts Search*; Brian Cudnik, 11851 Leaf Oak Drive, Houston, TX 77065
- Acting Coordinator, *Lunar Transient Phenomena*; Anthony Cook, School of Computer Science and Information Technology, University of Nottingham, Jubilee Campus, Wollaton Rd., Nottingham NG8 1BB, United Kingdom

ALPO Resources (continued)

- Assistant Coordinator, *Lunar Transient Phenomena*; David O. Darling, 416 West Wilson St., Sun Prairie, WI 53590-2114
- Coordinator, *Lunar Topographical Studies*; Marvin W. Huddleston, 2621 Spiceberry Lane, Mesquite, TX 75149

Mars Section

- Coordinator, *all observations, U.S. correspondence;* Daniel M. Troiani, P.O. Box 1134 Melrose Park, IL 60161-1134
- Assistant Coordinator; CCD Imaging, “Mars Project”; Donald C. Parker, 12911 Lerida Street, Coral Gables, FL 33156
- Assistant Coordinator; Daniel Joyce, 6203 N. Keeler Avenue, Chicago, IL 60648-5109
- Assistant Coordinator; Jeff D. Beish, 842 Virginia Ave., Lake Placid, FL 33852

Minor Planets Section

- Coordinator; Frederick Pilcher, Illinois College, Jacksonville, IL 62650.
- Assistant Coordinator; Lawrence S. Garrett, 206 River Road, Fairfax, VT 05454
- Assistant Coordinator; Richard Kowalski, 7630 Conrad Street, Zephyrhills, FL 33544-2729
- Scientific Advisor; Steve Larson, Lunar & Planetary Lab, University of Arizona, Tuscon, AZ 85721

Jupiter Section

- Coordinator, Richard W. Schmude Jr., 109 Tyus St., Barnesville, GA 30204
- Assistant Coordinator, Scientific Advisor; Sanjay Limaye, University of Wisconsin, Space Science and Engineering Center, Atmospheric Oceanic and Space Science Bldg. 1017, 1225 W. Dayton St., Madison, WI 53706
- Assistant Coordinator, Transit Timings; John McAnally, 2124 Wooded Acres, Waco, TX 76710
- Assistant Coordinator, Newsletter; Craig MacDougal, 821 Settlers Road, Tampa, FL 33613
- Assistant Coordinator, Galilean Satellites; John E. Westfall, P.O. Box 2447, Antioch, CA 94531-2447
- Acting Assistant Coordinator; Ed Grafton, 15411 Greenleaf Lane, Houston, TX 77062
- Acting Assistant Coordinator; Dr. P. Clay Sherrod, Arkansas Sky Observatory, Conway Offices, 794 Drake Drive, Conway, AR 72034
- Scientific Advisor, Prof. A. Sanchez-Lavega, Dpto. Fisica Aplicada I, E.T.S. Ingenieros, Alda. Urquijo s/n, 48013 Bilbao, Spain

Saturn Section

- Coordinator, Julius L. Benton, Jr., Associates in Astronomy, 305 Surrey Road, Savannah, GA 31410

Remote Planets Section

- Coordinator; Richard W. Schmude, Jr., 109 Tyus St., Barnesville, GA 30204

Comets Section

- Acting Coordinator; Gary Kronk, 132 Jessica Drive, Saint Jacob, IL 62281-1246

Meteors Section

- Coordinator; Robert D. Lunsford, 161 Vance Street, Chula Vista, CA 91910
- Acting Assistant Coordinator; Robin Gray, P.O. Box 547, Winnemuca, NV 89446

Meteorites Section

- Coordinator; Dolores Hill, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721

Computing Section

- Coordinator; Mike W. McClure, 170 Prestwick Ct., Bowling Green, KY 42103

Youth Section

- Acting Coordinator; Timothy J. Robertson, 2010 Hillgate Way #L, Simi Valley, CA 93065

Historical Section

- Coordinator; Richard Baum, 25 Whitchurch Rd., Chester, CH3 5QA, United Kingdom
- Acting Assistant Coordinator; Thomas A. Dobbins, 305 Northern Spy Circle, Howard, OH 43028

Instruments Section

- Coordinator; R.B. Minton, 568 N. 1st St., Raton, NM 87740
- Assistant Coordinator; Richard J Wessling, 5429 Overlook Dr., Milford, OH 45150-9651

Website

- Webmaster; Richard Hill, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721
- Assistant Webmaster; Jonathan D. Slaton, 2445 Seiler Rd., Alton, IL 62002

Eclipse Section

- Coordinator; Michael D. Reynolds, Chabot Observatory and Science Center, 10000 Skyline Boulevard, Oakland, CA 94619

ALPO Publications:

The Monograph Series

ALPO monographs are publications that we believe will appeal to our members, but which are too lengthy for publication in *The Strolling Astronomer*. They should be ordered from *The Strolling Astronomer* science editor (P.O. Box 2447, Antioch, CA 94531-2447 U.S.A.) for the

ALPO Resources (continued)

ALPO Staff E-mail Directory

Beish, J.D. .... dustymars@tnni.net
Benton. J.L. (routine e-mail + observations & images)
.... jlbaina@msn.com
Benton, J.L. (back-up e-mail + observations & images)
.... jlbalpo@netscape.net
Benton, J.L. (alternate e-mail + observations & images)
.... jbenton55@comcast.net
Brasch, K.R. .... kbrasch@csusb.edu
Baum, R. .... richardbaum@julianbaum.co.uk
Cook, A .... acc@css.nott.ac.uk
Cudnik, B. .... xflare@earthlink.net
Darling, D.O. .... DOD121252@aol.com
Dobbins, Tom .... kmdobbins@coshocton.com
Douglass, E. .... ejdftd@mindspring.com
Garcia, G.W. .... gordg@megsinet.net
Garfinkle, R.A. .... ragarf@earthlink.net
Garrett, L.S. .... lgasteroid@earthlink.net
Grafton, E. .... egrafton@ghg.net
Haas, W.H. .... haasw@zianet.com
Hill, D .... dhill@lpl.arizona.edu
Hill, R. .... rhill@lpl.arizona.edu
Huddleston, M.W .... Kc51e:@hotmail.com
Joyce, D. .... djoyce@triton.cc.il.us
Kowalski, R. .... bitnik@bitnik.com
Kronk, G .... kronk@amsmeteors.org
Lamm, J.S. .... jlspacerox@aol.com
Limaye, S. .... sanjayl@ssec.wisc.edu
Lunsford, R.D. .... lunro.imo.usa@cox.net
MacDougal, C. .... macdouc@prodigy.net
McAnally, J. .... CPAJohnM@aol.com
McClure, M.W. .... mike.mcclure@kctcs.net
McKim, R.J. .... rmckim5374@aol.com
Melillo, F. .... FrankJ12@aol.com
Olivarez, J. .... olivarezhsd@earthlink.net
Parker, D.C. .... park3232@bellsouth.net
Pilcher, F. .... pilcher@hilltop.ic.edu
Poshedly, K. .... poshedly@bellsouth.net
Reynolds, M. .... MReynolds@ChabotSpace.org
Robertson, T.J. .... cometman@cometman.net
Sanford, J. .... starhome@springvillewireless.com
Santacana, G.E. .... laffitte@prtc.net
Schmude, R.W. .... schmude@gdn.edu
Sherrod, C. .... drclay@arksky.org
Slaton, J.D. .... jd@justfurfun.org
Timerson, B. .... bwtimer@eznet.net
Troiani, D.M. .... dantroiani@earthlink.net
Ulrich, R.K. .... rulrich@uark.edu
Venable, R.J. .... rjvmd@knology.net
Wessling, R.J. .... pinesop@aol.com
Westfall, E.W. .... ewestfall5@attbi.com
Westfall, J.E. .... 73737.1102@compuserve.com
Will, M. .... will008@attglobal.net

prices indicated, which include postage. Checks should be in U.S. funds, payable to "ALPO".

- **Monograph Number 1.** *Proceedings of the 43rd Convention of the Association of Lunar and Planetary Observers. Las Cruces, New Mexico, August 4-7, 1993.77* pages. Price: $12 for the United States, Canada, and Mexico; $16 elsewhere.
- **Monograph Number 2**. *Proceedings of the 44th Convention of the Association of Lunar and Planetary Observers. Greenville, South Carolina, June 15-18, 1994.52* pages. Price: *$7.50* for the United States, Canada, and Mexico; $11 elsewhere.
- **Monograph Number 3**. *H.P Wilkins 300-inch Moon Map.* 3rd Edition (1951), reduced to 50 inches diameter; 25 sections, 4 special charts; also 14 selected areas at 219 inches to the lunar diameter. Price: $28 for the United States, Canada, and Mexico; $40 elsewhere.
- **Monograph Number 4.** *Proceedings of the 45th Convention of the Association of Lunar and Planetary Observers. Wichita, Kansas, August 1-5, 1995.127* pages. Price: $17 for the United States, Canada, and Mexico; $26 elsewhere.
- **Monograph Number *5.*** *Astronomical and Physical Observations of the Axis of Rotation and the Topography of the Planet Mars. First Memoir; 1877-1878.* By Giovanni Virginio Schiaparelli, translated by William Sheehan. 59 pages. Price: $10 for the United States, Canada, and Mexico; $15 elsewhere.
- **Monograph Number *6.*** *Proceedings of the 47th Convention of the Association of Lunar and Planetary Observers, Tucson, Arizona, October 19-21, 1996.20* pages. Price $3 for the United States, Canada, and Mexico; $4 elsewhere.
- **Monograph Number 7.** *Proceedings of the 48th Convention of the Association of Lunar and Planetary Observers. Las Cruces, New Mexico, June 25-29, 1997.76* pages. Price: $12 for the United States, Canada, and Mexico; $16 elsewhere.
- **Monograph Number 8**. *Proceedings of the 49th Convention of the Association of Lunar and Planetary Observers. Atlanta, Georgia, July 9-11,1998.122* pages. Price: $17 for the United States, Canada, and Mexico; $26 elsewhere.
- **Monograph Number 9**. *Does Anything Ever Happen on the Moon?* By Walter H. Haas. Reprint of 1942 article. 54 pages. Price: $6 for the United States, Canada, and Mexico; $8 elsewhere.
- **Monograph Number 10.** *Observing and Understanding Uranus, Neptune and Pluto*. By Richard W. Schmude, Jr. 31 pages. Price: $4 for the United States, Canada, and Mexico; $5 elsewhere.

ALPO Observing Section Publications

Order the following directly from the appropriate ALPO section coordinators; use the address in the listings pages which appeared earlier in this booklet unless another address is given.

ALPO Resources (continued)

- **Lunar and Planetary Training Program (Robertson):** *The Novice Observers Handbook* $15. An introductory text to the training program. Includes directions for recording lunar and planetary observations, useful exercises for determining observational parameters, and observing forms. To order, send check or money order payable to "Timothy J. Robertson."
- **Lunar (Benton):** (1) *The ALPO Lunar Section's Selected Areas Program (*$17.50). Includes a full set of observing forms for the assigned or chosen lunar area or feature, together with a copy of the *Lunar Selected Areas Program Manual.* (2) *Observing Forms Packet,* $10. Includes observing forms to replace those provided in the observing kit described above. Specify *Lunar Form*s. (See note for Venus.)
- **Lunar (Jamieson):** *Lunar Observer's Tool Kit*, price $50, is a computer program designed to aid lunar observers at all levels to plan, make, and record their observations. This popular program was first written in 1985 for the Commodore 64 and ported to DOS around 1990. Those familiar with the old DOS version will find most of the same tools in this new Windows version, plus many new ones. A complete list of these tools includes Dome Table View and Maintenance, Dome Observation Scheduling, Archiving Your Dome Observations, Lunar Feature Table View and Maintenance, Schedule General Lunar Observations, Lunar Heights and Depths, Solar Altitude and Azimuth, Lunar Ephemeris, Lunar Longitude and Latitude to Xi and Eta, Lunar Xi and Eta to Longitude and Latitude, Lunar Atlas Referencing, JALPO and Selenology Bibliography, Minimum System Requirements, Lunar and Planetary Links, and Lunar Observer's ToolKit Help and Library. Some of the program's options include predicting when a lunar feature will be illuminated in a certain way, what features from a collection of features will be under a given range of illumination, physical ephemeris information, mountain height computation, coordinate conversion, and browsing of the software's included database of over 6,000 lunar features. Contact hjamieso@midsouth.rr.com; web site at http://members.telocity.com/hjamieson/TKWebPage.htm#Jamieson's
- **Venus (Benton):** (1) *The ALPO Venus Observing Kit,* $17.50. Includes introductory description of ALPO Venus observing programs for beginners, a full set of observing forms, and a copy of *The Venus Handbook.* (2) *Observing Forms Packet,* $10. Includes observing forms to replace those provided in the observing kit described above. Specify *Venus Forms.* To order either numbers (1) or (2), send a check or money order payable to "Julius L. Benton, Jr." All foreign orders should include $5 additional for postage and handling; p/h included in price for domestic orders. Shipment will be made in two to three weeks under normal circumstances. NOTE: Observers who wish to make copies of the observing forms may instead send a SASE for a copy of forms available for each program. Authorization to duplicate forms is given only for the purpose of recording and submitting observations to the ALPO Venus, Saturn, or lunar SAP sections. Observers should make copies using high-quality paper.
- **Mars (Troiani):** (1) *Martian Chronicle;* published approximately monthly during each apparition; send 8 to 10 SASEs; (2) *Observing Forms;* send SASE to obtain one form for you to copy; otherwise send $3.60 to obtain 25 copies (make checks payable to “Dan Troiani").
- **Mars:** *ALPO Mars Observers Handbook,* send check or money order for $10 per book (postage and handling included) to Astronomical League Book Service, c/o Paul Castle, 2535 45th St., Rock Island, IL 61201.
- **Jupiter:** (1) *Jupiter Observer’s Startup Ki*t, $3 from the Jupiter Section Coordinator. (2) *Jupite*r, ALPO section newsletter, available online via the ALPO website or via snail-mail; send SASE to the Jupiter Section Coordinator; (3) To join the ALPO Jupiter Section e-mail network, *J-Ne*t, send an e-mail message to the Jupiter Section Coordinator. (4) *Timing the Eclipses of Jupiter’s Galilean Satellites* observing kit and report form; send SASE with 55 cents in postage stamps to John Westfall.
- **Saturn (Benton):** (1) The *ALPO Saturn Observing Ki*t, $20; includes introductory description of Saturn observing programs for beginners, a full set of observing forms, and a copy of *The Saturn Handboo*k. (2) *Saturn Observing Forms Packe*t, $10; includes observing forms to replace those provided in the observing kit described above. Specify *Saturn Forms.* To order, see note for *Venus Forms*.
- **Meteors:** (1) Pamphlet, *The ALPO Guide to Watching Meteors,* send check or money order for $4 per book (postage and handling included) to Astronomical League Book Service, c/o Paul Castle, 2535 45th St., Rock Island, IL 61201. (2) *The ALPO Meteors Section Newslette*r, free (except postage), published quarterly (March, June, September, and December). Send check or money order for first class postage to cover desired number of issues to Robert D. Lunsford, 161 Vance St., Chula Vista, CA 91910.
- **Minor Planets (Derald D. Nye):** *The Minor Planets Bulleti*n, published quarterly $14 per year in the U.S., Mexico and Canada, $19 per year elsewhere (air mail only). Send check or money order payable to “Minor Planets Bulletin” to 10385 East Observatory Dr., Corona de Tucson, AZ 8564I-2309.
- **Computing Section (McClure):** Online newsletter, *The Digital Lens,* available via the World Wide Web and e-mail. To subscribe or make contributions, contact Mike McClure

Other ALPO Publications

Checks must be in U.S. funds, payable to an American bank with bank routing number.

ALPO Resources (continued)

- ***An Introductory Bibliography for Solar System Observers.*** **Free** for a stamped, self-addressed envelope. A 4-page list of books and magazines about Solar System bodies and how to observe them. The current edition was updated in October, 1998. Order from: ALPO Membership Secretary.
- *ALPO* ***Membership Directory.*** $5 in North America; $6 elsewhere. Latest updated list of members on 3.5-in. MS-DOS diskette; either DBASE or ASCII format. Make payment to "ALPO" Also available via e-mail as portable document format (pdf) file to requester's e-mail address. Provided at the discretion of the Membership Secretary. Order from Matthew Will, ALPO membership secretary/treasurer.
- **Back issues** of *The* ***Strolling Astronomer (JALPO).*** Many of the back issues listed below are almost out of stock, and it is impossible to guarantee that they will remain available. Issues will be sold on a first-come, first-served basis. In this list, volume numbers are in italics, issue numbers are in plain type, and years are given in parentheses. The price is $4 for each back issue; the current issue, the last one published, is $5. We are always glad to be able to furnish old issues to interested persons and can arrange discounts on orders of more than $30. Order directly from and make payment to "Walter H. Haas"(see address under "Board of Directors," page 56):

  $4 each:
  Vol. 7 (1953); 3 and 10
  Vol. 8 (1954); 7-8
  Vol. 11 (1957); 11-12
  Vol. 21 (1968-69); 3-4 and 7-8
  Vol. 23 (1971-72); 7-8 and 9-10
  Vol. 24 (1972-74); 7 and 8
  Vol. 25 (1974-76); 1-2, 3-4, and 11-12
  Vol. 26 (1976-77); 3-4 and 11-12
  Vol. 27 (1977-79); 3-4 and 7-8
  Vol. 31 (1985-86); 9-10
  Vol. 32 (1987-88); 11-12
  Vol. 33 (1989); 7-9
  Vol. 34 (1990); 2 and 4
  Vol. 37 (1993-94); 1
  Vol. 38 (1994-96); 1 and 3
  Vol. 39 (1996-97); 1, 3 and 4
  Vol. 40 (1998); 2
  Vol. 41 (1999); 4
  Vol. 42 (2000); 1, 2, 3 and 4
  Vol. 43 (2001); 1, 2, 3 and 4
  Vol. 44 (2002); 1, 2, 3 and 4

  $5 each
  Vol. 45 (2003); 1 (current issue)

Membership in the ALPO

The ***Association of Lunar and Planetary Observers*** **(ALPO)** was founded by Walter H. Haas in 1947, and incorporated in 1990 as a medium for advancing and conducting astronomical work by both professional and amateur astronomers who share an interest in Solar System observations. We welcome and provide services for all levels of astronomers: For the novice, the **ALPO** is a place to learn and to enhance and practice techniques. For the advanced amateur, it is a place where one's work will count. For the professional, it is a resource where group studies or systematic observing patrols are necessary.

Our Association is an international group of students of the Sun, Moon, planets, asteroids, meteors, and comets. Our goals are to stimulate, coordinate, and generally promote the study of these bodies using methods and instruments that are available within the communities of both amateur and professional astronomers. We hold a conference each summer, usually in conjunction with other astronomical groups.

Membership dues include a subscription to this Journal and option to participate on the ALPO-Member-Discussion e-mail listserv. Membership dues are:

$US100 – Sponsor member level, 4 issues of the digital and paper Journal, all countries
$US50 – Sustaining Member level, 4 issues of the digital and paper Journal, all countries
$US46 – 8 issues of the paper Journal only, USA, Mexico and Canada
$US26 – 4 issues of the paper Journal only, USA, Mexico and Canada
$US60 – 8 issues of the paper Journal only, all other countries
$US33 – 4 issues of the paper Journal only, all other countries
$US19 – 8 issues of the digital Journal only, all countries, e-mail address required
$US11 – 4 issues of the digital Journal only, all countries, e-mail address required

There is a 20-percent surcharge on all memberships obtained through subscription agencies or which require an invoice. Make payment by check or money order, payable (through a U.S. bank and encoded with U.S. standard banking numbers) to **"ALPO".**