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Journal of the Association of Lunar & Planetary Observers

The Strolling Astronomer

Volume 44, Number 2, Spring 2002

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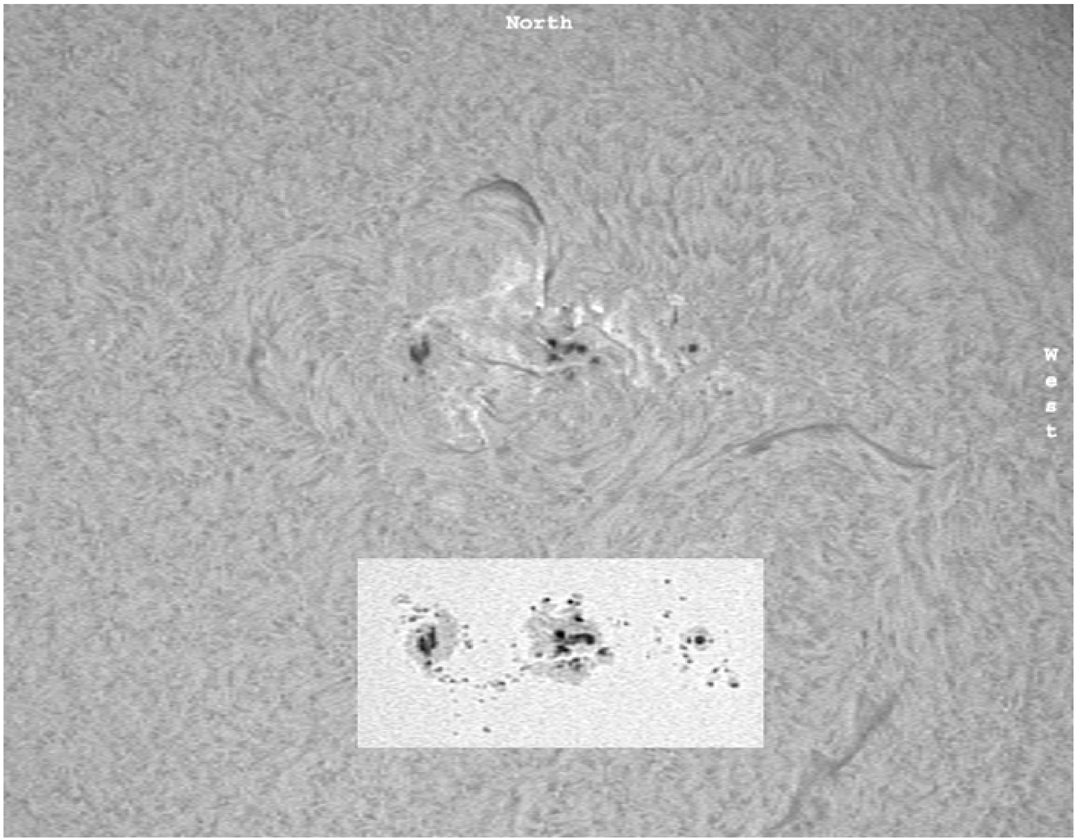
Inside . . .

Spectacular storm on the Sun

Solar active region AR0030 imaged on 17 July 2002 both in H-alpha and white light by ALPO member Frank Schiralli of Northport, NY. Details on page 1.



Also ..a report CCD photometry of Galilean satellites, a report on the 1991-92 Jupiter Apparition, a look at oblique impacts on the lunar surface, a report from the ALPO membership secretary and much, much more

Journal of the Association of Lunar & Planetary Observers,

The Strolling Astronomer

Volume 44, No. 2, Spring 2002
This issue published in July 2002 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.

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

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The ALPO Pages:
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Association of Lunar and Planetary Observers (ALPO)

Board of Directors

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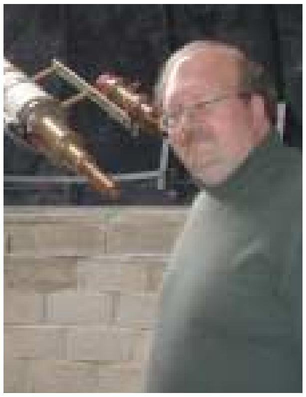
(Full listing in *ALPO Resources* at end of this issue)
Lunar and Planetary Training Program: Coordinator; Timothy J. Robertson
Solar Section: Coordinator, *Website, SolNet, Rotation Report,* handbook; Richard Hill
Mercury Section: Acting Coordinator; Frank Melillo
Venus Section: Coordinator; Julius 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: Acting 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 (provisional): Acting Coordinator; Dolores Hill
Computing Section: Coordinator; Mike W. McClure
Youth Section: Acting Coordinator; Timothy J. Robertson
Historical Section: Coordinator; Richard Baum
Instruments Section: Acting Coordinator; R.B. Minton
Eclipse Section (provisional): Acting Coordinator; Michael D. Reynolds
Webmaster: Coordinator; Richard Hill

Point of View
Why I am a member of the ALPO

By Richard Jakiel, new member



Many readers may be familiar with my "deep-sky" writings in *Astronomy* and *Sky & Telescope* magazines over the past 10 years but I originally began as a "shallow sky" observer.

In 1977 after months of scrimping and saving, I acquired an 8-inch f/7 Cave OTA on a massive home-built mount. I then constructed a small observatory in my parents' backyard located in upstate New York (45 miles SW of Buffalo).

Until I moved to Atlanta, Ga, in 1987, I observed a wide selection of objects including double stars, deep-sky and the planets. I was particularly fond of observing and sketching Mars and Jupiter - and kept a notebook containing dozens of black & white and colored drawings. However, shortly after I had moved to the deep south, my car was broken into and the backpack containing all of my notes, camera equipment and eyepieces was stolen. It was a heartbreaking and irreplaceable loss. I had to start all over again and learned a valuable lesson about living in the big city.

After several years using the Atlanta Astronomy Club's observatory site in Villa Rica, Ga, I had filled a couple large sketchbooks with both deep-sky and solar system drawings. At the 1992 Winter Star Party in Flrida, I showed ALPO member Don Parker my Mars drawings of the last couple apparitions. He asked me if I would consider sending those (and other) sketches to ALPO. Unfortunately, I didn't -- procrastination got the better of me -- but I did think about becoming a member.

What really got my attention was the 1994 collision of Shoemaker-Levy 9 with Jupiter. I followed the evolution of the impact spots for weeks with my 13.1-inch Coulter and a smaller 6-inch f/5 Parks. The sheer magnitude of the event finally got me to send my money in, where I've been a member even since.

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.

No More LTP, Please

To the editor:

I was dismayed to see two articles discussing Lunar Transient Phenomena (LTP) in Volume 44, Issue 1 (Winter 2002) of the JALPO.

While Lunar Meteoritic Impacts are a valid area of research, "classical" LTP such as mists, fogs, color changes and volcanic activity have been thoroughly discredited. Interested readers should see the 1999 *Sky & Telescope* magazine article "The LTP Myth: A Brief for the Prosecution" by William Sheehan and Thomas Dobbins. This article cites the many flaws in the methodology and selection of events for LTP catalogs.

My own 1998 article in Volume 40, Issue 3 issue of the JALPO describes the many physical and geological problems with "classical" LTP. Any member wishing a copy of that article need only send an e-mail to me at fhasmith@crocker.com.

My article discussed the implausibility of LTP. Since the ALPO is supposed to be an amateur organization devoted to science, let me make a stronger statement. There is no science in "classical" LTP observations. I don't believe that anyone has seen a valid "classical" LTP. Ever.

While I do not intend to disparage anyone's views, LTP "research" belongs in someone's web page. Not in the pages of JALPO.

Sincerely,

Frank Smith
(fhasmith@crocker.com)

Cover Photo Notes

Dramatic photo of AR0030 on solar surface taken 17 July 2002, 13:03:00 UT by A.L.P.O. member Frank Schiralli, Jr. of Northport, NY; observing location 40° 54' 27" North, 73° 19' 21" West, altitude 15 meters above mean sea level

Says Mr. Schiralli: "I (imaged AR0030) in both H-a and white light. For expediency sake, I placed the cropped white light image inside of and adjacent to its H-a counterpart...makes for easy comparison(s)."

Equipment:
40mm Coronado Solar Max
94mm Brandon refractor @ F/28.8
Starlight Xpress MX916 in hi-resolution, fast mode
0.001 second exposure; FOV (full size image 46.8 x 36 arc-minutes)

Seeing: 8/10
Transparency: Good
Wind: Zero

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.

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Speaking of address changes, ALPO Meteors Section Coordinator Robert D. Lunsford has changed e-mail addresses. The new one is:

lunro.imo.usa@cox.net

Call for Papers

ALCon 2002, this year's National Convention of the Astronomical League, will be held Wednesday through Saturday, July 31 - August 3, at the University of Utah in Salt Lake City, NV.

The Assn. of Lunar & Planetary Observers traditionally plays an important and active role in this event. At ALCon, ALPO members present their own research papers on lunar and planetary studies, plus this is the place where the ALPO board holds its annual meeting.

For more information on ALPO presentations, contact ALPO Executive Director Julius Benton, c/o Associates in Astronomy, 305 Surrey Road, Savannah, GA 31410; or e-mail jlbaina@msn.com

For more information about ALCon 2002 itself, either write to: ALCon 2002 P.O. Box 9574, Salt Lake City, UT 84109-9574, or visit the website at:

<http://www.alcon2002.org/index1.html>

Observing Section Reports

Meteors Section

By Robert Lunsford, Coordinator

The ALPO Meteors Section continues to collect reports of fireballs and visual activity and forward them to the International Meteor Organization. The Meteors Section Newsletter is still being published on a quarterly basis providing articles on past displays, future prospects and a list of reports received by the coordinator. The past quarter has been the "off season" for meteor activity. Combine that with the cold temperatures encountered in most locations and the number of reports received by the coordinator has been light.

Solar Section

By Rik Hill, Coordinator, Solar Section

With the sun just past maximum for Solar Cycle 23, the state of the ALPO Solar Section is very good indeed! We have never had more data coming in, of more varied types and never had more enthusiasm among our observers.

Since there is no particular "membership" to the Section and since we accept observations from members and non members alike, there is no way to accurately know how many observers consider themselves members at any given moment and are contributing data. Those data consists of whole disk white light drawings, photographs in white light, H-alpha and calcium (H&K line), video (in the same various wavelengths) and CCD. Typically we can receive from 2 to 12 observations per day. We virtually never have days without observations submitted and changes to the Solar Section webpages are almost daily now. For example, in the month of April we received 149 digital images and around 40 drawings and photographs. In May this number was a bit less but we are still getting some observations from that month.

The digital data are posted on a sub-page of the Solar Section pages at:

http://www.lpl.arizona.edu/~rhill/alpo/solstuff/recobs.html

and each contribution by each member is recognized in the Rotation Report (published irregularly due to staffing shortage), the newsletter of the Solar Section, published on the website.

Gordon Garcia is doing a superb job of taking care of solar observer training and correspondence. He addresses these issues frequently, on various email list groups and in personal communications. You can contact him at gordg@megsinet.net .

Our email list, SolNet, founded in 1995, hosted by Yahoo and moderated by Jeff Medkeff, continues to be a premier communication avenue for the ALPO solar observers with 124 listed members. You can join by going to:

http://www.yahoogroups.com

or by sending an empty email to:

solnet-subscribe@yahoogroups.com

It may take a couple days for Jeff to get you on the list if he is out of town so please be patient. The Section still seeks help in writing our various reports. If you have writing skills, some knowledge of solar astronomy and an interest in contributing your talents, go to:

http://www.lpl.arizona.edu/~rhill/alpo/solstuff/help.html

The outlook for the next year is very good. We expect a substantial amount of solar activity that should maintain our current levels of data submission.

Venus Section

By Julius Benton, Coordinator

The 2002 Eastern (Evening) Apparition of Venus is currently underway. Venus will reach Greatest Elongation East (46°) on 2002 Aug 22, with Greatest Brilliancy taking place on 2002 Sep 26 (mv = -4.6), and Inferior Conjunction will not occur until 2002 Oct 31. There is plenty of opportunity, therefore, for systematic observations of Venus in 2002, and observers are encouraged to get underway with their studies of the planet.

Observations from the 2001-2002 Western (Morning) Apparition are still being received, and observers are encouraged to send their observations to the A.L.P.O. Venus Section if they have not done so already. Work on the 2001-2002 report will begin shortly.

Observing forms and instructions for carrying out studies of Venus can be obtained from the A.L.P.O. Venus Section. The Venus Handbook provides details concerning all aspects of visual observations of Venus, and it will soon be available in *.pdf format for the same price as the printed version ($18.00).

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

- Visual observation and categorization of atmospheric details in dark, twilight, and daylight skies.
- Drawings of atmospheric phenomena.
- Observation of cusps, cusp-caps, and cusp-bands, including defining the morphology and degree of extension of cusps.
- Observation of dark hemisphere phenomena, including monitoring visibility of the Ashen Light.
- Observation of terminator geometry (monitoring any irregularities).

- Studies of Schröter's phase phenomenon.
- Visual photometry and colorimetry of atmospheric features and phenomena.
- Routine photography (including UV photography), CCD imaging, photoelectric photometry, and videography of Venus.
- Observation of rare transits of Venus across the Sun.
- Simultaneous observations of Venus.

Individuals interested in participating in the programs of the A.L.P.O. Venus Section are cordially invited to contact Dr. Julius L. Benton, Jr., Coordinator, A.L.P.O. Venus Section

Lunar Section: Lunar Topographical Studies

By William Dembowski

In addition to accepting and cataloging general observations of the Moon, the Lunar Topographical Studies Section regularly issues "Lunar Challenges". These encourage observers to sketch or image specific features; usually those which have reputations of being unique and/or elusive.

Challenges in the past have included O'Neill's Bridge and Plato's Hook, and the current Lunar Challenge is for "Gruithuisen's Lunar City". This feature, first reported by Baron Franz von Paula Guithuisen in 1824 was offered as proof that intelligent life existed on the Moon. Although located near the center of the lunar disk it can be a difficult feature to record.

Observations should be sent to the section coordinator (Bill Dembowski; see ALPO Resources section for e-mail and regular-mail addresses).

Sketch of "Gruithuisen's Lunar City" about 1824 at left, general location of the site. Sketch and photo provided by Bill Dembowski.

Lunar Selected Areas Program (SAP)

ByJulius Benton

The lunar features that observers are monitoring as the *official* lunar formations that are being monitored as part of the SAP are:

SAL Feature	Selenographic Longitude	Selenographic Latitude
Alphonsus	40°W	13°S
Aristarchus	47°W	23°N
Atlas	43°E	46°N
Copernicus	20°W	9°N
Plato	9°W	51°N
Theophilus	26°E	11°S
Tycho	11°W	42°S
NOTE: The nearby *Herodotus* is also considered a part of the Aristarchus program with its environs.		

All of the areas listed above were chosen because they are relatively easy to find, convenient to observe, and have historically shown numerous instances of suspected anomalies. Complete outline charts and observing forms are available from the A.L.P.O. Lunar Section for each of the features noted.

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

Thus, observations of the Moon that are specific to the Lunar Selected Areas Program may be summarized as:

- Visual photometry of specific lunar features, defining their normal albedo profiles throughout a lunation as a function of changing solar illumination.
- Visual photometry of specific lunar features, monitoring variations from their normal albedo that are not simply a result of changing solar illumination.
- Drawings of specific lunar features throughout a lunation and from lunation-to-lunation in conjunction with visual photometry.

- Routine photography, CCD imaging, photoelectric photometry, and videography of specific lunar features to supplement visual photometry programs throughout a lunation and from lunation-to-lunation.

- Comparative analysis of lunar features and albedo pofiles.

NOTE: Now included as part of the Selected Areas Program is the Bright and Banded Craters Program and the Dark-Haloed Craters Program. Further information on these programs is available upon request.

Complete details on our observing programs can be found in the ***A.L.P.O. Lunar Selected Areas Handbook***. Individuals interested in participating in the A.L.P.O. Lunar Selected Areas Program should contact: Dr. Julius L. Benton, Jr., Coordinator, A.L.P.O. Lunar Section, Selected Areas Program

Lunar Transient Phenomena

By David O. Darling

I have made contact with the principal investigator for the Smart-1 mission to conduct ground based observations for lunar transient phenomena during the mission. This mission is being conducted by the European Space Agency. I have also had a response from the POC for the Lunar-A mission and he has given me a name and address of the principal investigator for the Japanese Moon mission. I have combined forces with Dr. Anthony Cook the BAA lunar transient phenomena recorder and he will be sending a letter to the Japanese POC for the mission.

Mars Section

By Daniel M. Troiani, Coordinator

Reflecting on the past ten years

Hard to believe it's ten years since Hurricane Andrew struck South Florida, creating havoc with Mars Coordinators Don Parker and Jeff Beish. It was the following month that I took over the operation of the Mars Section. Thereafter, the experiences have been exhilarating and very fulfilling - I love it! One highlight has to be the 1997 Mars Workshop in Tucson where Don and I presented papers on the Section to several dozen professionals, who were obviously impressed. Another was the response, from all over the globe, that my Mars maps have received; they have been published in four countries now and downloaded innumerable times over the net. Even NASA has asked permission for its use in their publications. Together with others on the Section staff, it was a privilege to author an article on Martian meteorology which was published in Icarus. And it will be twenty-five blissful years since I have been submitting to the Section when next year's apparition commences.

Last Call for 1999-2000-2001 Apparition Reports

Please send in any late observations of this apparition as soon as possibe. I'm in the process of finishing its corresponding map and would like to include everyone's observations. Jeff is currently working on the final apparition report, quite an effort when considering there are over 1,300 observations so far. A special thanks is to be accorded Jeff, and also to Dan Joyce, for the outstanding job on the recorded amount of newsletters this time; 28 in all! Most have been authored by Jeff and include informative articles on how to observe Mars. All are located on the Mars Section web page:

http://groups.yahoo.com/group/Mars-ALPO/ or

http://groups.yahoo.com/group/MarsALPO/files/Martian%20Chronicles/

The 1998-1999 Apparition Report and Observations Archives

This report is now in the final stages of production and will be completed soon. Almost all sketches and prints have been scanned into a computer (therefore it will be helpful if any delayed images can be sent to us soon). We plan to place all images, articles, maps, etc. from this apparition on CD-ROM and it will be available to all observers.

Media Frenzy

There's been considerable excitement in the major media recently about the apparent abundance of subsurface frozen water on Mars, even a suggestion that the findings, no pun intended, may just be the tip of the iceberg. The impetus to explore Mars for water resources can be traced to the total input of the space science community which has detected, then published, the evidence that water was there to be found, and the amateur contribution over the years toward that end has been second to none. Very determined efforts at the focuser by unpaid observers, perhaps especially those in the Mars Section, have yielded a substantial data base of meteorological and geological information that could well be the major reason that funding has been forthcoming for space agency missions to explore the Red Planet. The presence of water has always been implicit, and maybe explicit, in the observations; and it's nice to know that they have been thought of as reliable. Now they have been effectively confirmed!

The Big One!!! The 2003 Apparition of Mars

A very fine, detailed article on this apparition (as a "2003 Pre-Apparition Report") has been posted by Jeff and is available at the Section website:

http://groups.yahoo.com/group/Mars-ALPO/files/Mars_2003/

The undersigned has an article, not as detailed, "An Observer's Guide to Mars", along with the Mars map available for downloading at the Sky & Telescope website:

http://skyand telescope.com/observing/objects/planets/article_374_1.asp

Furthermore, I'm in the process of production on a variety of globe scales illustrating the anticipated Martian landscape for 2003. They will be at the Mars Section site in the near future. We at the Section are preparing and looking forward to the next great apparition of the Red Planet!

Minor Planets Section

By Frederick Pilcher, Coordinator

As reported in the Minor Planet Bulletin 28-3 through 29-2, there have been several significant developments, primarily in asteroid photometry, in the past year. The CAPS (Center for Asteroid Physical Studies) website http://www.MinorPlanetObserver.com/caps/default.htm has been established with much educational information on asteroid CCD photometry. M. L., D. R., S. M., and T. M. Bisque have won the Prof. R. P. Binzel "Automated Lightcurve Prize" by producing a totally automated asteroid lightcurve: Press a key in early evening, sleep all night, and have the lightcurve appear on your screen in the morning.

Collaboration by observers at widely different longitudes is filling gaps in lightcurves made at a single site. The Magnitude Alert Program has published revised absolute magnitudes H for 23 asteroids, and is continuing to distribute e-mail Alerts for asteroids with discrepant magnitudes. Lightcurves of a total of 55 different asteroids, most of them new or with previously published ambiguities, have been published.

Jupiter Section

By Richard Schmude, Coordinator

The 2001-2002 Jupiter apparition is drawing to a close. Jupiter will reach conjunction in July and will then appear in the morning sky during the second half of this year. The coordinator would like to remind everyone to keep observing Jupiter as its visibility permits. The coordinator hopes to begin writing the 2001-2002 Jupiter apparition report shortly. The main highlight of the 2001-02 apparition was the passage of the Great Red spot and a huge storm in the STB. This event along with many other observations will be summarized in the 2001-2002 Jupiter apparition report.

Alerts and the Jupiter Section

By John W. McAnally, Assistant Coordinator, Transit Timings

From time to time, the Jupiter Section has found it advantageous to issue observing alerts. In recent years, alerts have been issued judiciously and sparingly, and only when events, or the anticipation of events, have been such that widespread, intense observations have been thought critical. Since 1997, these alerts have most often been issued by the Assistant Coordinator for Transit Timings. The Assistant Coordinator has usually been in the position to note trends and changes in drift rates, trends toward the conjunction and merging of objects, or peculiar or unusual behavior of objects with regard to position on the planet. Changes in morphology are also of particular interest. Such was the case for recent alerts.

With the advent of the Jupiter Net on the yahoogroups network, the need to issue alerts to the Section's regular contributors is not as urgent as it once was. Members of the group communicate among themselves on a regular basis and are usually very current on events. However, from time to time, events warrant an attempt to contact observers outside the group and particularly, within the professional community.

Recently, the anticipated conjunction of the south temperate oval BA with the GRS was such an event. As BA arrived at the longitude of the following edge of the GRS, it took on a somewhat compressed appearance. As bright material preceding BA began to be compressed or, piled up, between the GRS and BA, the south temperate oval began to take on the appearance of being split. Although not actually split, the oval did change shape. Concerned that this might be the beginning of the oval's disruption, an alert was issued through Sky and Telescope magazine's astro-alert service with a copy being sent to the normal Jupiter Net members. Although board member Donald Parker had previously encouraged the use of Sky & Telescopes' astro-alert service, the Section had never used it.

This first-time use by the Jupiter Section of the astro-alert service on 2002 January 14 had very positive results. We received e-mail messages from several amateur astronomers for the first time. Several of these are accomplished observers and CCD imagers, and the section received a large number of CCD images that we otherwise would not have received. Many were casual observers with questions about transit timing and how to begin doing serious work. We received our first ever e-mail from Ireland from an amateur who was very interested in trying to visually observe the BA/GRS conjunction. We were also contacted by a professional astronomer who was very interested in any CCD images in methane obtained by any of our observers. This request was passed on to Jupiter Net members who had methane imaging capability, heightening their awareness of the special need for these images. We find our observers have a greater sense of satisfaction and are inspired when they know the professional community needs and appreciates their work. We had an opportunity to discuss this BA/GRS conjunction with a professional astronomer by telephone.

On 2002 January 26, another astro-alert was issued, with a copy to the Jupiter Net, to announce that a consensus was forming among certain professional and amateur astronomers that BA would survive; but that observations were still encouraged with all urgency since Jupiter has surprised us in the past. Again, a series of e-mail messages was received by the Jupiter Section. A personal note: a friend of my son's, both of whom live in Atlanta, is on the list of subscribers to receive these astro-alerts. However, he is not a member of ALPO and is not on our Jupiter Net. Realizing he recognized my name, the friend mentioned this to my son. My son was amazed that his friend was somehow in the information loop. The point is, we never know whom we will touch with our work. We want to use every reasonable means to reach the observers who are so important to us. I must believe we have been effective. If the preceding discussion is an indication, our communications are in much better shape than they were in 1997, and we are grateful. In the past couple of months, the ALPO Jupiter section has been favorably presented in *Sky & Telescope* magazine and in *Mercury,* a publication of the Astronomical Society of the Pacific. The editors of *Sky & Telescope* had contacted us for some quotes and the author of the *Mercury* article had contacted us for an interview. We appreciate their attention and favorable coverage.

To all of our Jupiter observers, we appreciate your efforts. Keep up the good work.

Mutual Events of the Galilean Satellites

By John Westfall, Assistant Jupiter Coordinator, Galilean Satellites

Every six years the Earth and the Sun pass through the orbital planes of Jupiter's four Galilean satellites, creating a series of events where these moons occult and eclipse each other. These events are fascinating to watch; in addition, electronic observations of them give accurate positions of the satellites, allowing their orbital parameters to be updated. Dr. Jean-Eudes Arlot of the French Bureau des Longitudes is coordinating an observing campaign for the 2002-2003 mutual events, and welcomes reduced event timngs and photometry using either video, photoelectric photometers, or CCD images. Full details about his "PHEMU03" program, including an event schedule, are given on his website: http://www.bdl.fr/Phemu03/phemu03_eng.html . Note that the first event of this series occurs on October 3, 2002, and the series ends on September 22, 2003.

Saturn Section

By Julius Benton, Coordinator

Saturn is no just past conjunction with the Sun (conjunction occured on 2002 Jun 09). Observers are encouraged to submit their drawings, images, and other observations of the now-past apparition to the A.L.P.O. Saturn Section as soon as possible for inclusion the 2001-2002 apparition report.

The 2002-2003 will get underway when Saturn has emerged from the glare of the Sun in July, so observers are encouraged to begin preparations for the next apparition right away. Observing forms and instructions for carrying out studies of Saturn and its satellites can be obtained from the A.L.P.O. Saturn Section. The Saturn Handbook provides details concerning all aspects of visual observations of Saturn, and it is now available in *.pdf format for the same price as the printed version ($20.00).

Observations of Saturn's globe, rings, and satellites are organized into the following routine programs:

- Visual numerical relative intensity estimates of belts, zones, and ring components.

- Full-disc drawings and sectional sketches of global and ring phenomena (the Saturn Section furnishes templates with the correct global oblateness and ring geometry to facilitate drawing). All drawings submitted for publication must be originals, not photocopies.

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

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

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

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

- Observational monitoring of the bicolored aspect of the rings of Saturn.
- Observations of stellar occultations by Saturn's rings.
- Specialized observations of Saturn during edgewise ring presentations in addition to routine studies.
- Visual observations and magnitude estimates of the satellites of Saturn.
- Routine photography, CCD imaging, imaging using digital cameras, photoelectric photometry, and videography of Saturn and its ring system.
- Simultaneous observations of Saturn by different observers.

Individuals interested in participating in the A.L.P.O. Saturn programs should contact Dr. Julius L. Benton, Jr., Coordinator, A.L.P.O. Saturn Section

Remote Planets Section

By RichardSchmude, Coordinator

The 2001 remote planets report will appear in the next issue the ALPO Journal. At least two people have begun making magnitude measurements of the remote planets in 2002. Uranus and Neptune will be visible at around 5 a.m. in July and Pluto will be visible for most of the night during June.

About 25 copies of *The Remote Planets Review* were mailed out in May. This publication has finder charts for Uranus and Neptune and it also includes reviews of discoveries made by professional astronomers related to the remote planets. If anybody wants a copy of *The Remote Planets Review*, please contact Richard Schmude, Jr. at: Schmude@falcon.gdn.peachnet.edu

Interest Section Reports

ALPO Website

By Rik Hill

The A.L.P.O. website: our welcome mat to the world. Currently the A.L.P.O. website contains over 80 Mb of information and observations on everything in the solar system. Here you will find observation forms, information on making various observations and new reports on the latest finds and observations by ALPO members. It is a good resource for teachers and astronomy clubs as well as an introduction to the organization itself. On the front page you will not only find the display of the correct Universal Time from the U.S. Naval Observatory but there are a number of tools linked there that will help you plan your observing and aid with identification of objects and features. There is also the “Tons-O-Clubs” page, with the names and URLs for hundreds of astronomical clubs, societies, associations and organizations from around the world, that is constantly growing. If you would like to have a club added to the listing, just contact the website manager at: rhill@lpl.arizona.edu .

Computing Section

By Michael (Mike) McClure
Coordinator

(From an online posting) I've discontinued the newsletter, at least for now. Instead I'm going to create a reference-resource-tutorial page on the website to link (in an organized way) all the articles and resources accumulated in the newsletter. I was not getting any new articles or submissions for the newsletter, so it seemed like the interest was dying out.

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Wes Erickson announces that his Lunar Co-Longitude program has been relocated to:

http://ourworld.compuserve.com/homepages/twesley/tw03001.htm

Wes can reached at mwm@m2c3.com

Instruments Section

By Dick Wessling
Assistant Coordinator

Activity in the instruments section continues at a nice pace and has been exclusively in the form of email questions. The subject matter varies but one of the most popular subjects is about wavefront deformation in reflectors and what is required for good lunar and planetary performance. This involves an optical discussion and is a complex issue including f/no, tube currents and alignment. Other inquiries are about portable refractors, achromatic vs, apochromatic, as related to resolution and color. Portability is a big concern these days concerning telescope purchases, which leads members to the expensive high quality refractor, but there seems to be some lack of understanding when it comes to color, and some commercial advertisements seem to mislead.

I am open to members’ suggestions concerning articles about instruments, but the subject of color in refractors may be a good subject. There has been very little discussion about photography with the telescope, which is surprising to me these days of planetary alignments and conjunctions. Again, the ongoing reflector quality discussion, instrument portability and color in refractors are the hot topics.

ALPO Feature: A Report from the A.L.P.O. Membership Secretary

By Matthew Will

As Membership Secretary, there are some frequently asked questions regarding membership status that I answer on an individual basis that I would like to share with the membership at large:

Question: If my membership is for one year why am I getting a renewal notice six months after I renewed?

Answer: Traditionally, a one-year membership equates to four issues of the *Journal*. Currently, the *Journal* has been produced at an accelerated pace, with issues being distributed every two months or so. A quarterly schedule will resume as the backlog of material for publishing is reduced.

Question: What was that funny number doing above my address on the envelope that the Journal was sent in last time?

Answer: That "number" was just some coding for the edification of the printing company and wasn't intended to be a part of the address on the envelope when it was sent out. I have a coding system for the printing company to alert them as to which members need to receive which type of renewal notices.

Question: How do I know when my membership expires?

Answer: There are several ways. First of all, you'll know when you get the first renewal notice. The first renewal notice is inserted with the last issue of your membership. A second renewal notice accompanies another issue, which is sent out on the assumption that you intend to renew and is considered the first issue of your renewal. If the second renewal notice is not answered, then a third "last call" renewal is sent first class mail before that lapsed member is dropped. When a member renews, the Membership Secretary replies with an acknowledgment letter. That letter has the issue volume and number for which your renewed membership expires. Also, the accompanying A.L.P.O. membership card also has the expiration issue's volume number and issue number printed on the card. I will be working with the printer to see if this volume number and issue number can be printed on the mailing label as well, for the convenience of our members.

Membership Statistics

As of May 29, 2002 there are 398 members in the Association of Lunar and Planetary Observers. 147 of you have been with the A.L.P.O. for 12 years or more. Below is a break down of membership interest in the various subjects and topics related to lunar and planetary astronomy. The subject of interest is followed by the number of members interested in that particular Solar System object or phenomenon.

INTEREST	NO. OF MEMBERS
Sun	136
Mercury	57
Venus	85
Moon	230
Mars	201
Jupiter	238
Saturn	185
Uranus	65
Neptune	55
Pluto	38
Asteroids	100
Comets	141
Meteors	93
Instruments	116
Photography	129
CCD Imaging	41
Radio Astronomy	29
Astronomical Software	76
Astronomical History	90
Tutoring	30

The A.L.P.O. wishes to thank the following members listed below for voluntarily paying higher dues. The extra income helps in maintaining the quality of the *Journal* while helping to keep the overall cost of the *Journal* in check. Thank you! As of May 29, 2002:

Table 1: Sponsoring Members

Name	City	State/ Province/ Country
Julius L. Benton, Jr	Savannah	GA
Leland A. Dolan	Houston	TX
Geoff Gaherty	Toronto	Ontario, Canada
Robert A. Garfinkle, F.R.A.S.	Union City	CA
Phillip R. Glaser	La Jolla	CA
Donald Parker	Coral Gables	FL
James Phillips	Charleston	SC
Gerald Watson	Cary	NC
Christopher Will	Springfield	IL
Matthew Will	Springfield	IL
Thomas R. Williams	Houston	TX

Table 2: Sustaining Members

Name	City	State/ Province /Country
Paul H Bock Jr	Hamilton	VA
Raffaello Braga	Corsico (Mi)	Italy
Klaus R Brasch	Highland	CA
Phillip W Budine	Binghamton	NY
Hank Bulger	Grants	NM
Thomas F Davis	Fairfield	CT
William Dembowski	Windber	PA
Thomas Wesley Erickson	San Luis Rey	CA
Richard R Fink	Brick	NJ
Gordon W Garcia	Hoffman Estates	IL
Robin Gray	Winnemucca	NV
Robert H Hays	Worth	IL
Daniel Del Valle Hernandez	Aguadilla	PR
Mike Hood	Kathleen	GA
George Kidwell	Waco	TX
Jim Lamm	Bradenton	FL
David J Lehman	Fresno	CA
Robert D Lunsford	Chula Vista	CA
Michael Mattei	Littleton	MA
Donald E Neiman	Dallastown	PA
Dr William P Pala	Centreville	VA
Capt. Syd Palmer	Nanaimo	British Columbia, Canada
Dr. A K Parizek	Phoenix	AZ
Timothy J Robertson	Simi Valley	CA
Francisco J Roldan	La Crosse	WI
Takeshi Sato	Hatsukaichi City	Hiroshima-Pref., Japan
Mark L Schmidt	Racine	WI
Lee M Smojver	Tukwila	WA
Roger J Venable	Augusta	GA
Elizabeth W Westfall	Antioch	CA

The A.L.P.O. would like to wish a warm welcome to those who recently became members. Below are those who have joined from July 1, 2001 through May 29, 2002: where they live and their interest in lunar and planetary astronomy. The legend for the interest code is located below the name listings.

Table 3: New Members

Member	City	State/ Province/ Country	Interests	Member	City	State/ Province/ Country	Interests
Aubudon Louisiana	New Orleans	LA		Susannah Lazar	Baton Rouge	LA	
J. S. Alagia	Paradise Valley	AZ		Roger Lee	Akron	OH	
Edward R Blankenship	Stafford	VA	03456	Anthony Mallama	Bowie	MD	
Mary L Bousquet	West Kingston	RI		Joseph C Mancilla	Las Cruces	NM	
Steven Brisbey	Coral Springs	FL		Steve Mc Kay	Richmond	VA	
Jack Carpenter	Alameda	CA	0245CR	John Milne	Scotia	NY	
Roy D Mc Cale, Jr	Warren	OH		Patrick F Moynihan	Dorchester	MA	
Charles L Calia	Ridgefield	CT		Robert Otto	Amherst	NH	02345678 ACMPS
Dr Anthony C Cook	Washington	DC	1234MD	Albert A. Nofi	Ukiah	CA	
Raymond B De Puy	Kerhonkson	NY	03P	Peter F Pastore	Massapequa	NY	
Sterling Eddings Jr	Chicago	IL		Robert E Patow	Plymouth	MI	
Sheldon Faworski	Elizabeth	IL		R Brad Perry	Yorktown	VA	456789 ACDIM
Mark Fisher	Macquarie Fields, NSW	Australia		Ebony Martha Pollard	Guilford	CT	
Donald R Franck	Livingston	TX		Rod Pommier, MD	Portland	OR	012345678
Charles Galdies	Naxxar	Malta		Eugene R Roeschlein	Indianapolis	IN	
Ed Grafton	Houston	TX	45678D	Douglas Schmude	Vancouver	WA	
James Harvey	Pompano Beach	FL		Ronald Sidell	San Carlos	CA	
Deborah Hines	Broadview	IL		Ray Shapp	Watchung	NJ	
Michael Jacob	Marlton	NJ		David R Torres	San Jose	CA	3DPT
Don C Jardine	Pleasant Plains	IL		Bob Vickers	Huntingdon	TN	
Jane & Morris Jones	San Rafael	CA		Samuel R Whitby	Hopewell	VA	
					Springfield	IL	
					Stockton	CA	3ASID
Richard C S Kinne	Ithaca	NY		John Winners	Harrisburg	PA	
Raymond P Kuntz							
Walter J Kupson							
Christopher Layser							

Table 4: Interest Codes

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

ALPO Feature: The Moon

Oblique Impacts

By Eric Douglass

Abstract

Craters, the end product of the impacting process, are the features we most commonly associate with the lunar surface. The majority are roughly circular, like Copernicus (Figure 1). However, various shapes exist, including a class of oblong craters. While oblong craters may have a variety of causes, the cause we will explore here is that of oblique impacts.

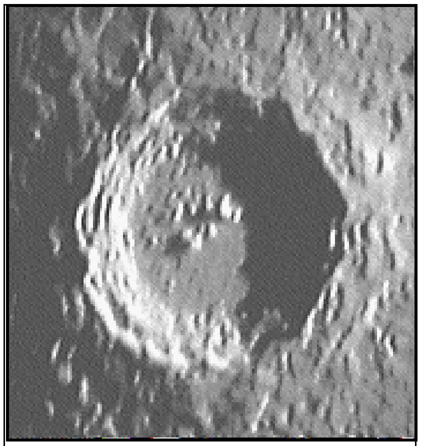

Figure 1. Copernicus. Video image by Eric Douglass

When a *bolide* (the formal name for an impacting body) strikes the lunar surface, it transfers its kinetic energy into a shock wave that travels both rearward into the impactor and forward into the lunar surface. This wave compresses the target material with a pressure of several million atmospheres, causing the target rocks to vaporize.

As the shock wave propagates in a hemispheric pattern, its pressure dissipates, so that the rocks it encounters undergo progressively less energetic transitions -- rather than vaporize, they melt, form glasses, and farther from the impact they simply fracture. While the rock is undergoing these transitions, much of it is being ejected from the surface via a rarefaction wave. The ejection creates the initial crater, called a *transient crater*, and the ejected materials produce the *ejecta* that we see around the crater. Since the shock wave is hemispheric, craters are expected to assume a circular shape, with an ejecta pattern that is equally distributed in all directions. However, all is not well in paradise, for certain craters do not conform to this pattern, but instead have elliptical shapes and asymmetrical ejecta patterns.

Therefore, scientists went "back to the drawing board" to model these unusual patterns, and performed experiments with high speed impacts. By firing small projectiles at speeds ranging from three to seven kilometers per second, they showed that impacts below 10 degrees (depending on the kind of target materials) produce elongated craters (Melosh, 1989, p81).

Figure 2. Messier on the right (lunar east), and Messier A on the left, in Mare Fecunditatis. Kuiper, et. al. *Consolidated Lunar Atlas, Digital Edition*. Eric Douglass, editor.

Using a special imaging technique called "3D Particle Velocimetry," they showed that the ejecta produced in these oblique impacts is not symmetrical. Below 30 degrees, it is lacking in the rearward direction and is concentrated in the forward and side directions

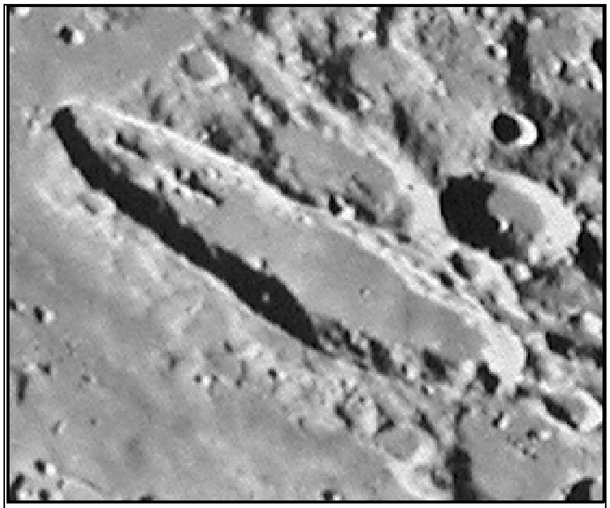

Figure 3. Schiller, near the moon's southwest limb. Kuiper, et. al. *Consolidated Lunar Atlas, Digital Edition*. Eric Douglass, editor.

Figure 4. Delmotte, north of Mare Criseum. Bowker, et. al. *Lunar Orbiter Photographic Atlas of the Moon*.

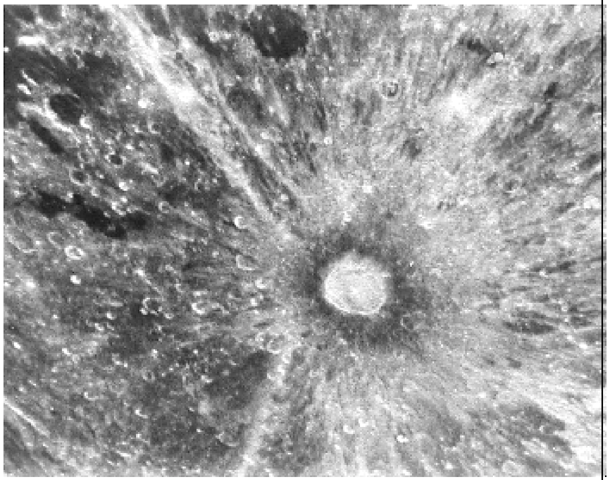

Figure 5. Tycho. Kuiper, et. al. *Consolidated Lunar Atlas, Digital Edition*. Eric Douglass, editor.

(Anderson, et. al., 2000). At more extreme angles — less than 5 degrees to the surface — ejecta is concentrated sideways in what is often called a “butterfly pattern.” From these experiments, we can say with confidence that impacts that occur at low angles produce oblong craters with asymmetrical ejecta blankets.

Now, let's have a look at these patterns on the Moon. Some familiar craters are clearly oblong, such as Messier (Figure 2) and Schiller (Figure 3). Other oblong craters are unfamiliar and may require considerable searching, such as Delmotte (Figure 4).

Asymmetrical ejecta patterns are also found. Herrick classifies these into three types (Herrick, 2001). The first has ejecta concentrated in the downrange direction, but it still surrounds the crater. An example of this type is Tycho (Figure 5), where the western direction from the crater is decidedly lacking in long, bright rays but near the western rim the ejecta forms a continuous blanket. Herrick's second type also has ejecta concentrated downrange, but with *no* uprange ejecta. An examples of this type is Proclus (Figure 6). The third pattern is the butterfly shape, indicating an angle of impact of less than 5 degrees. An example of this is Messier (Figure 2).

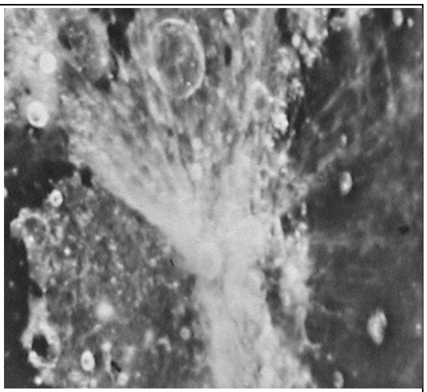

Figure 6. Proclus, near the western rim of Mare Criseum. Kuiper, et. al. *Consolidated Lunar Atlas*, Digital Edition. Eric Douglass, editor.

Figure 7. Aristoteles, in eastern Mare Frigoris. Video image by Eric Douglass.

Figure 8. The same crater seen in Figure 7. Whitaker, et. al. *Rectified Lunar Atlas*.

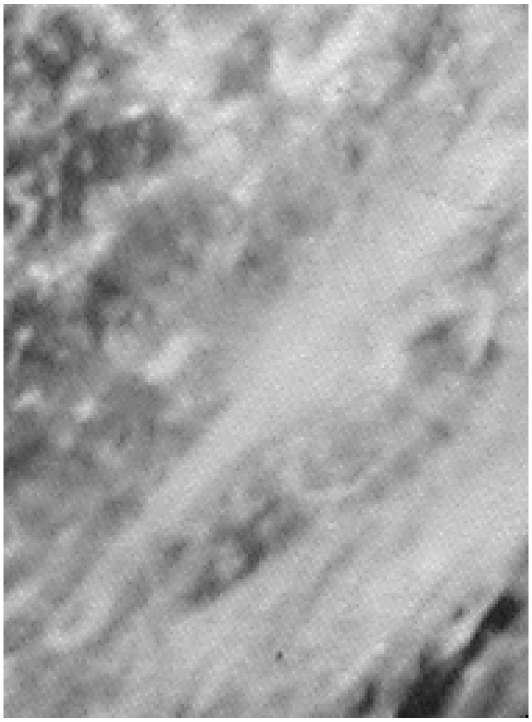

Figure 9. Stevinus is the prominent crater to the lower right of center. The ejecta is centered on small, bright Stevinus A to its northwest, in the center of the image. Kuiper, et. al. *Consolidated Lunar Atlas, Digital Edition*. Eric Douglass, editor.

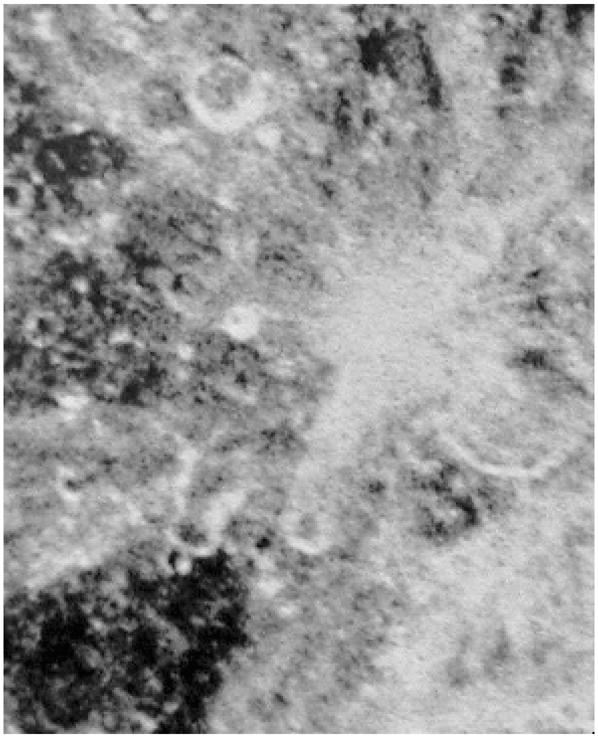

Figure 10. Stevinus is the large crater at the right. Hidden in the bright ejecta, Stevinus A is at the apex of the angle in the ejecta, near the center of the image. Whitaker, et. al. *Rectified Lunar Atlas*.

Craters and ejecta resulting from oblique impacts are fun to hunt down. You can search best for the ejecta patterns when the moon is near full phase, but the craters are seen best when illuminated obliquely. The main pitfall to avoid is the spherical effect: objects near the limb appear foreshortened, making circular craters appear elliptical. Crater Aristoteles appears elliptical (Figure 7), but when foreshortening is taken into account, the shape is found to be circular (Figure 8). In contrast, the oblong telescopic appearance of crater Delmotte might be assumed to be due only to spherical foreshortening, but this Lunar Orbiter image (Figure 4) shows it to be truly oblong! This effect also distorts our perception of ejecta patterns. The appearance of Stevinus A's ejecta (Figure 9) changes considerably when the image is corrected for spherical foreshortening (Figure 10). In the former image, the ejecta appears oblong, but in the latter, it is generally symmetrical with a forbidden zone to the west -- marking the direction from which the bolide came, and indicating an angle of impact of less than 30 degrees to the surface. Thus, when examining craters near the limb, it is helpful to consult an atlas which has taken this foreshortening into account. The *Rectified Lunar Atlas* is best, though the atlas by Firsoff may be of some help.

A second pitfall involves other misleading lunar formations, such as two impacts that occur so near each other that they appear as a single oblong crater. An example of this is Messier A (Figure 2), which is actually two craters from different periods. This kind of error is easily rectified by examining the feature in an atlas of high resolution.

Otherwise, happy hunting!

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ALPO Feature: Jupiter

CCD Photometry of Galilean Satellites

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Bruce Krobusek (Farmington Observatory, Farmington NY)
Donald F. Collins (Warren Wilson College, Asheville NC)
Peter Nelson and James Park (Ellinbank Observatory, Ellinbank, Australia)

Abstract

Timings of Galilean satellite eclipses obtained since 1990 using CCD cameras agree very closely with recent eclipse predictions derived from Galileo spacecraft data. A comparison of CCD results with ALPO visual timings shows a consistent bias and considerable scatter among individual visual timings. However, the yearly averages of visual observations are consistent with CCD results, provided that the visual data are corrected for telescope aperture. CCD photometry has also led to the following new findings: (1) there are variations of eclipse times with respect to the E2 satellite ephemeris on time scales as short as weeks; (2) Jupiter's polar haze extends several hundred kilometers above its cloud tops; and (3) the collision of Comet SL-9 with Jupiter in 1994 injected extremely high altitude dust into the planet's atmosphere.

Background

Over the long history of observation of the Galilean satellites visual eclipse data have accounted for most of the timings. Visual data correspond to the moment when the last noticeable light disappears during ingress of a satellite into Jupiter's shadow or when the light is first noticed during egress. Such timings have traditionally been the basis for computing orbits for the satellites, and the string of observations is almost continuous from the seventeenth century after Galileo discovered them. Many data points were obtained during a program of visual photometry at Harvard College Observatory from 1878 through 1903 (Sampson, 1909), and the ALPO program (Westfall, 2000, and references therein) has added thousands since 1975.

Attempts to improve upon the accuracy of visual timings by using photoelectric photometry met with only limited success, due to scattered light from Jupiter. CCD technology overcame this problem since the background light could be isolated and removed from the images. The first CCD timings of Galilean satellite eclipses were reported by Mallama (1992a). Figure 1a (page 16) shows an example of the light curve of an eclipse disappearance. These often contain 100 or more data points and the photometric quality is typically very good. We use another satellite in the same field of view for the brightness reference, and carefully extract photometric information from the CCD images while allowing for scattered background light.

In order to derive an eclipse time from an observation, the observed light curve is fitted to a model light curve. The model is generated on a computer based upon satellite factors (its diameter, surface markings, limb darkening, and motion), jovian factors (the planet's radius, atmospheric refraction, and extinction due to haze) and geometrical factors (the Sun-satellite-Earth angle and the distance from the satellite to Jupiter). Two papers by Mallama (1991, 1992b) give more detailed information about the satellite, jovian and geometric parameters. The model light curve corresponding to the observations in Figure 1a is shown in Figure 1b (page 16). Once the observed and model light curves have been generated they are fitted together by least-squares statistics, as shown in Figure 1c (page 16). This fitting gives the exact time when the center of the satellite was lined up with the limb of Jupiter and the Sun, which should correspond to the mid-eclipse time given in satellite eclipse ephemerides. A complete listing of the CCD results is hosted by the American Meteor Society at http://www.amsmeteors.org/mallama/galilean/.

Accuracy of the CCD Timings

In order to assess the accuracy of the CCD eclipse timings, we compared them to predictions from a very high quality JPL [Jet Propulsion Laboratory] ephemeris. The orbits for this ephemeris were derived from satellite positions observed by the Galileo spacecraft and from other precise data obtained in recent years. In Figure 2a (page 17) we have plotted the difference between our timings for Europa and the predictions of the JUP147 ephemeris (Jacobson et al., in press) as a function of time from 1990 until 1999. These differences are often referred to as observed-minus-calculated, or "O - C", residuals as indicated on the graph. The root-mean-square (rms) of the (O - C) values is only ± 2.6 seconds, and indicates that the CCD timings are very accurate. A similar comparison gives an rms difference of ± 1.9 seconds for Io and ± 8.3 seconds for Ganymede. There are very few data points for Callisto and the results are inconclusive, as Callisto undergoes eclipses only for three-year periods separated by three-year

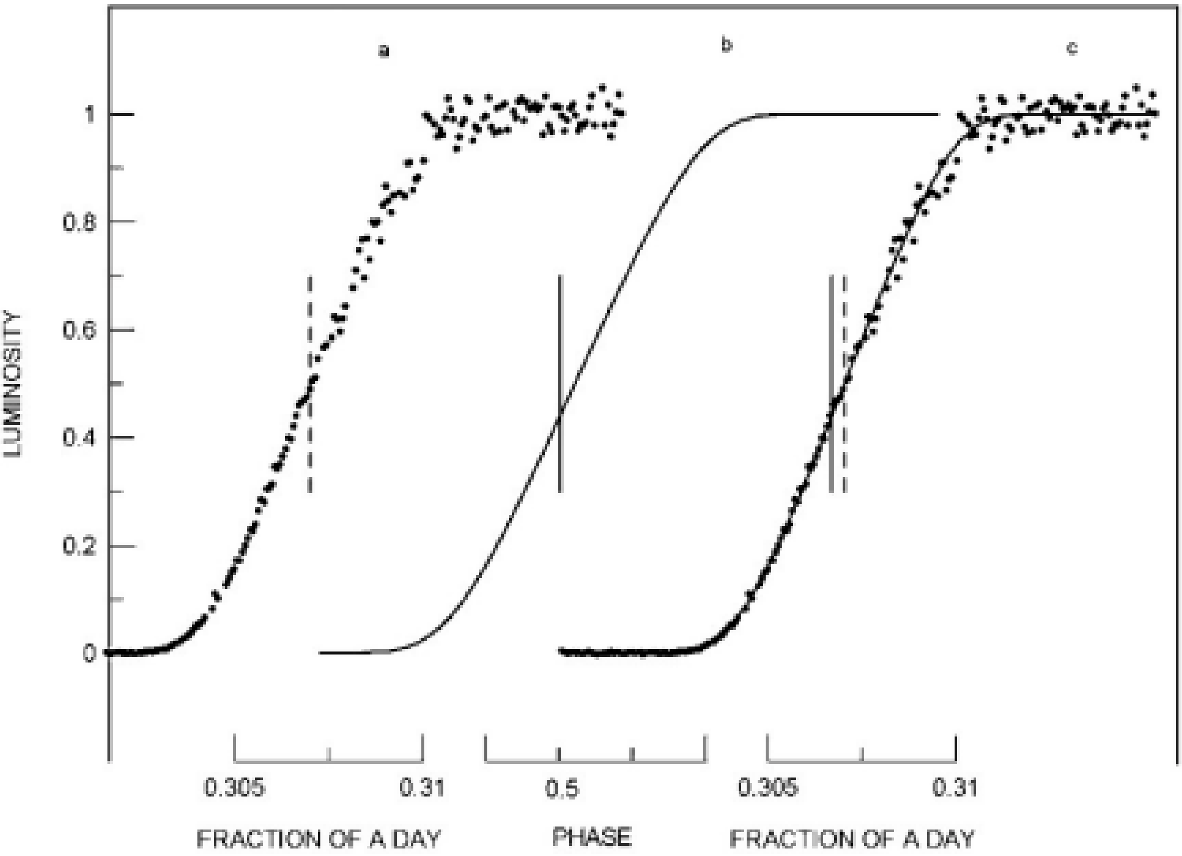

Figure 1. A CCD eclipse timing. (a) The observed light curve of a reappearance of Ganymede was observed on 18 Oct 2001 by Bruce Krobusek with an 8-in Schmidt-Cassegrain telescope and PC Lynxx camera. The dashed vertical line corresponds to the time of observed half-luminosity. (b) A model light curve for the eclipse is generated based upon factors relating to the satellite, Jupiter and their geometry with the Sun and Earth. There is no absolute time in the model, but the phase of mid-eclipse is shown by the solid vertical line. (c) The model is fitted to the data and indicates the observed time of mid-eclipse. Notice that mid-eclipse occurred prior to half-luminosity. During pre-opposition reappearances like this one, the satellite limb that catches the first ray of sunlight is on the far hemisphere as seen from the Earth. Thus the eclipse is more advanced in geometrical phase than it is photometrically.

gaps. Converting from seconds to kilometers of travel along the satellite orbits, the rms differences are: Io, ±33 km; Europa, ±36 km, and Ganymede, ±90 km. Overall, the CCD eclipse timing accuracy appears to be of the order of a few seconds of time or several tens of kilometers along the orbit track.

An older ephemeris denoted “E2” by Lieske (1980) has served as the basis of comparison with ALPO visual data for many years. Since it dates from before the Galileo spacecraft era, E2 does not have the benefit of those observations and other recent data. Figure 2b (page 17) shows a comparison between the same CCD timings and E2. The ±16.4 second rms residual of the CCD timings of Europa versus E2 is much larger, and indicates the inaccuracy of that ephemeris. Furthermore, there is a strong trend in the residuals, which appears to indicate that the error had grown to 30 seconds or more (several hundred kilometers) by the late 1990s.

The more recent “E5” ephemeris by Lieske (1998) also appears to have similar limitations as shown by the trend in Figure 2c (page 17), and by the ±18.6 seconds rms for Europa, which is worse than that for E2. In addition to lacking some recent data, the “E” series ephemerides are also handicapped relative to the “JUP” series because they are analytical models as opposed to dynamical models. In other words the “E” series do not compute physical gravitational forces, but rather rely on orbit perturbation theory.

Comparison of Individual Visual Timings to CCD Results for Io

Having established the high accuracy of CCD observations, it is now possible to assess the quality of visual timings. Following the ALPO tradition, we have used E2 as the basis for the comparisons. While we demonstrated in the last section that E2 is not the most accurate ephemeris, there are two compelling reasons to employ it here. One is that all of the visual timing results published in the J.A.L.P.O. are given in

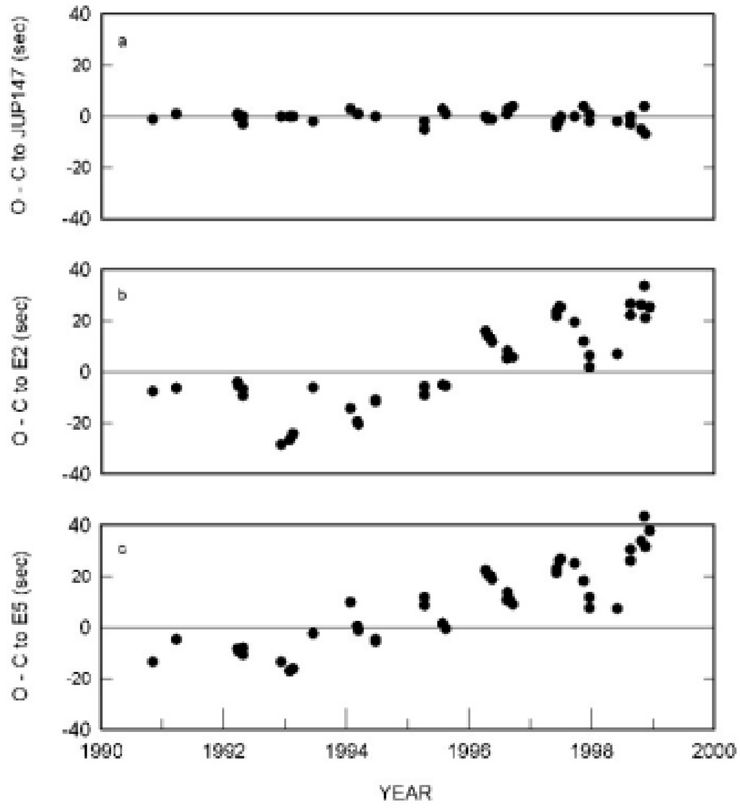

Figure 2. CCD timings of Europa compared with the following ephemerides: (a) JUP147, (b) E2, and (c) E5. The JUP147 ephemeris fits the data much better than the other two. Notice the large positive slope after 1993 for E2 and E5.

terms of (O - C)-values, where "C" is E2. The other is that E2 provides reasonably accurate predictions for the satellite Io, whose data we analyze first. We chose to use data on Io from the 1993/94 Jupiter Apparition, where ample CCD and visual observations are available. Prior to 1992 there are too few CCD timings, and after 1995 the ALPO results are not yet available at the time of this writing.

Visual eclipse timings require a correction before they can be useful. This is because the moment that the first or last speck of light was recorded corresponds to the time when the satellite's limb, rather than its center, was aligned with Jupiter's limb and the Sun's limb. Thus a correction corresponding to the time required for the satellite to travel by a distance equal to its own radius has to be subtracted for disappearances and added for reappearances. [This correction was determined by Westfall by correcting for an "aperture effect" because actual observers, and actual instruments, require that a satellite must be partly illuminated in order to be visible.] The (O - C)-values for visual data listed by Westfall (1999), when corrected for the "aperture effect", required correction by 110 seconds or 111 seconds depending on the eclipse latitude.

The comparison of these corrected visual (O - C)-values and those of CCD timings is shown in Figure 3 (page 17). There is much more scatter (rms of differences from the mean value) in the visual timings than in the CCD results. For the disappearance the visual (O - C) standard deviation is ±25.6 seconds as

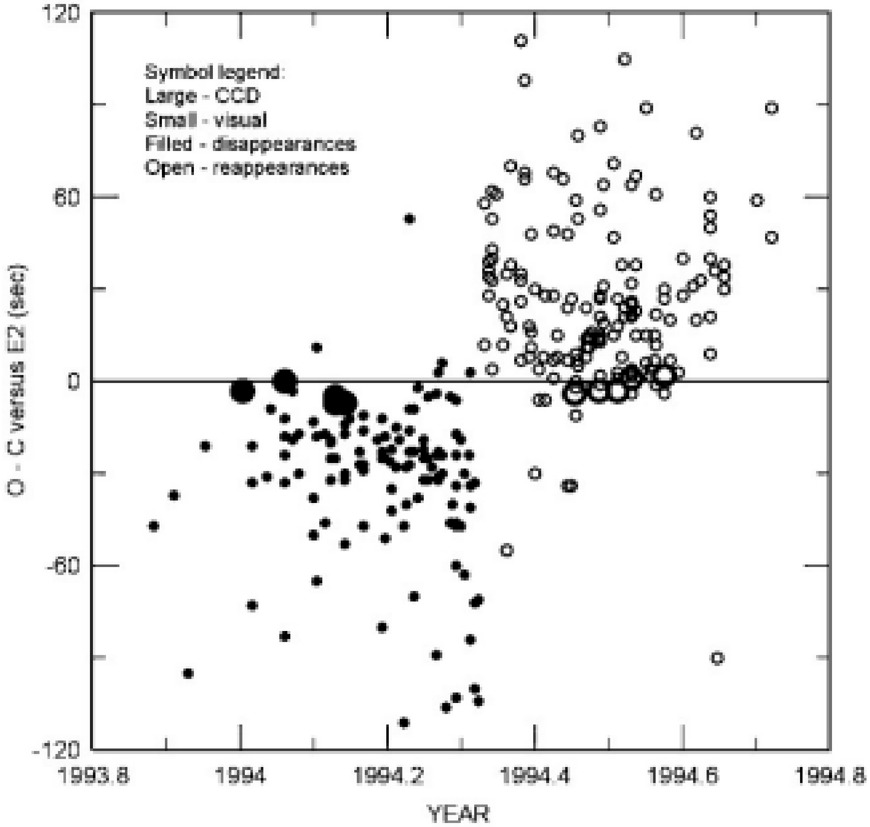

Figure 3. CCD and visual times for Io compared to the E2 ephemeris for the 1993/94 observing season. The visual timings are much more scattered than the CCD results and are biased in time. Some outlying visual data points are beyond the y-axis limits of the graph.

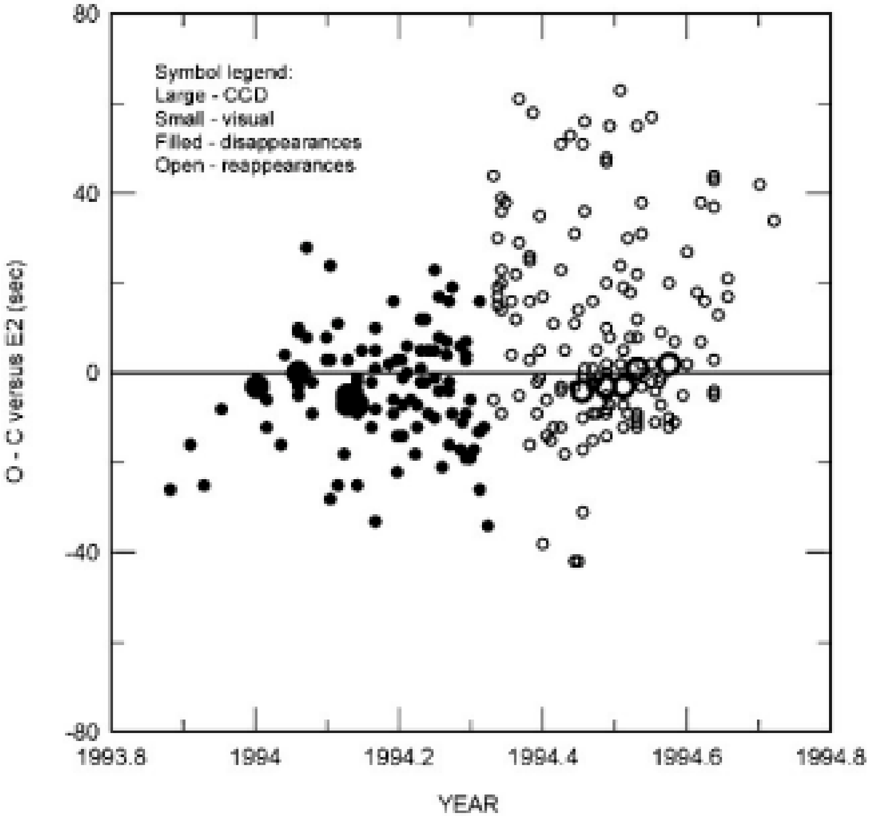

Figure 4. The visual results agree more closely with CCD observations after they are corrected for the aperture effect and about 10 percent of the outlying data points are removed.

compared to ±2.6 for CCD timings, while for reappearances the visual scatter was ±40.5 seconds and that for CCD results was ±2.4 seconds.

Note that the visually timed eclipse disappearances were usually early while the reappearances were late. This is due to observers losing sight of the satellite before it has been totally eclipsed, or failing to see it at the moment that the limb begins to reappear from shadow. The effect is normally more pronounced for observers using small telescopes, and is referred to as the 'aperture effect' below. The average (O - C) for a CCD disappearance was -4.4 seconds while that for a visual disappearance was -32.3 seconds. The average (O - C) for a CCD reappearance was -1.4 seconds and the average for a visual one was +32.1 seconds. Thus the differences between visual and CCD results were typically half a minute.

Westfall devised an ingenious method to correct for the aperture effect which makes visual timings correspond more closely to those that would be produced by a telescope with infinite light-gathering power. The method involves plotting (O - C)-values versus the inverse of the telescope aperture, as shown in Figure 2 of Westfall (1999). A straight line is fitted to the residuals and evaluated where inverse aperture is zero (and aperture itself is infinite). We followed this procedure and found the same linear solution as Westfall for the visual disappearance and reappearance (O - C)-values. Westfall also threw out 29 of the 281 timings due to their poor fit to his linear correction function, and we removed the same data points for our analysis.

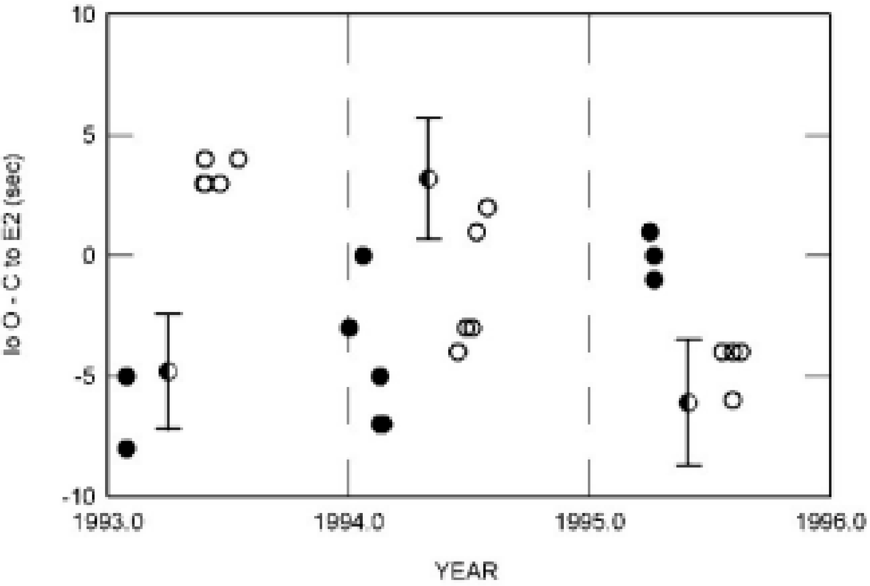

Figure 5. The averaged seasonal (O - C)-values for visual observations of Io are shown with their reported error bars. The agreement with CCD data (no error bars) is reasonably close. The dashed vertical lines separate the different apparitions of Jupiter. Thus the visual observation averages correspond to the CCD results immediately on either side of them. The open and filled symbols for CCD results have the same meaning as in Figures 3 and 4.

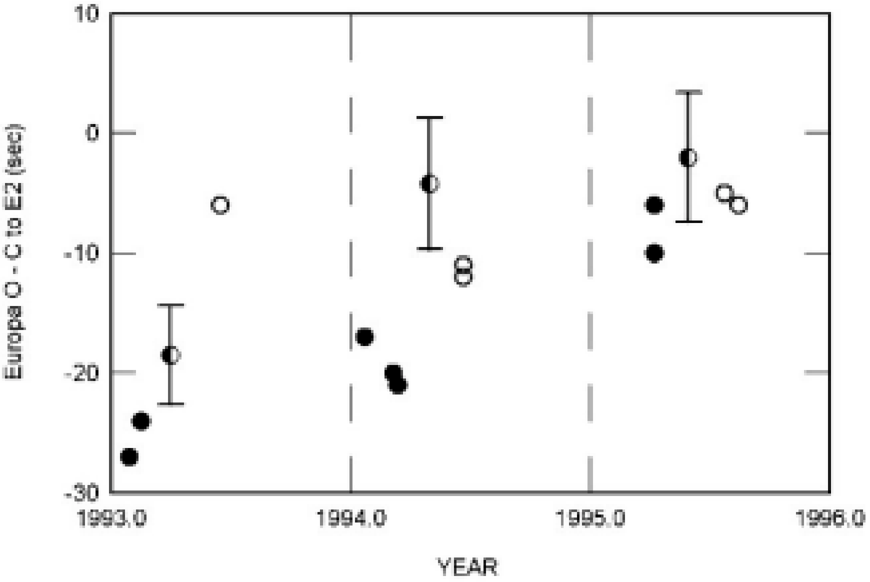

Figure 6. Same as Figure 5 but for the satellite Europa.

We then corrected all the remaining visual data for the aperture effect and plotted the (O - C)-values in Figure 4 (page 18). The rms scatter among the visual timings is now considerably reduced. For the disappearance data it decreases from ±25.6 seconds before the aperture correction to ±12.3 afterward. The corresponding scatter values for visual reappearances was ±40.5 and ±21.9 seconds. The average residuals for visual and CCD timings are also in better agreement, especially for disappearances. For CCD disappearances the average (O - C) was -4.4 seconds, while that for visual timings was -3.8. For CCD reappearances the average was -1.4 seconds, and for visual it was +10.3.

Comparison of Averaged Results Over Several Apparitions

As noted above, the three observing seasons from 1992/93 through 1994/95 provide the best means of comparison of the averaged results over several apparitions of Jupiter. The (O - C)-values for those apparitions of Io, Europa and Ganymede are shown in Figures 5, 6 and 7 (page 18 and page 19), respectively. Since a single CCD timing appears to give an accurate (O - C) we have plotted each of those timings, while only the average of the visual (O - C)-values for each apparition is plotted, based on the results given by Westfall.

The averaged (O - C)-values of the visual timings are within approximately 2 standard deviations of the mean of the CCD results for all nine of the comparisons, which indicates reasonably good consistency. Notice especially how both techniques captured the increasing (O - C) for Europa during the three-apparition time span. On the other hand, CCD data on Io revealed simultaneously increasing (O - C)-values for disappearances and decreasing (O - C)-values for reappearances, while the averaging of visual data masked this effect.

Other Significant Findings

One surprising result from CCD timings was the presence of large (O - C) variations with respect to the E2 ephemeris over relatively short periods of time. Figure 8 (page 20) shows an example where the trend for Ganymede during the 2000/2001 season is on the order of one second per week. Another example is the behavior of Europa with respect to E5 as shown in Figure 9 (page 20), which has a slope of similar magnitude. Figures 5 and 6 also show that Io and Europa may have a disappearance (O - C) before opposition that is substantially different from the reappearance (O - C) after opposition.

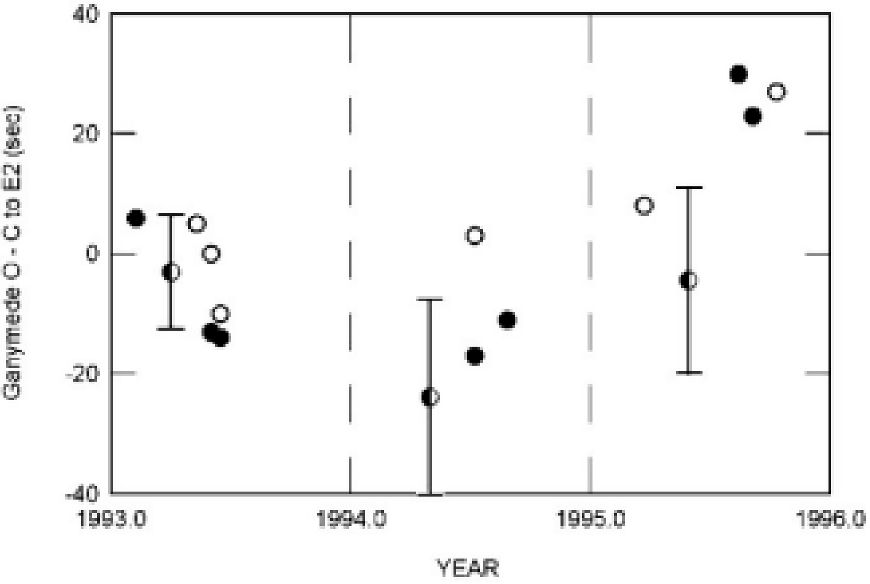

Figure 7. Same as for Figure 5 but for Ganymede.

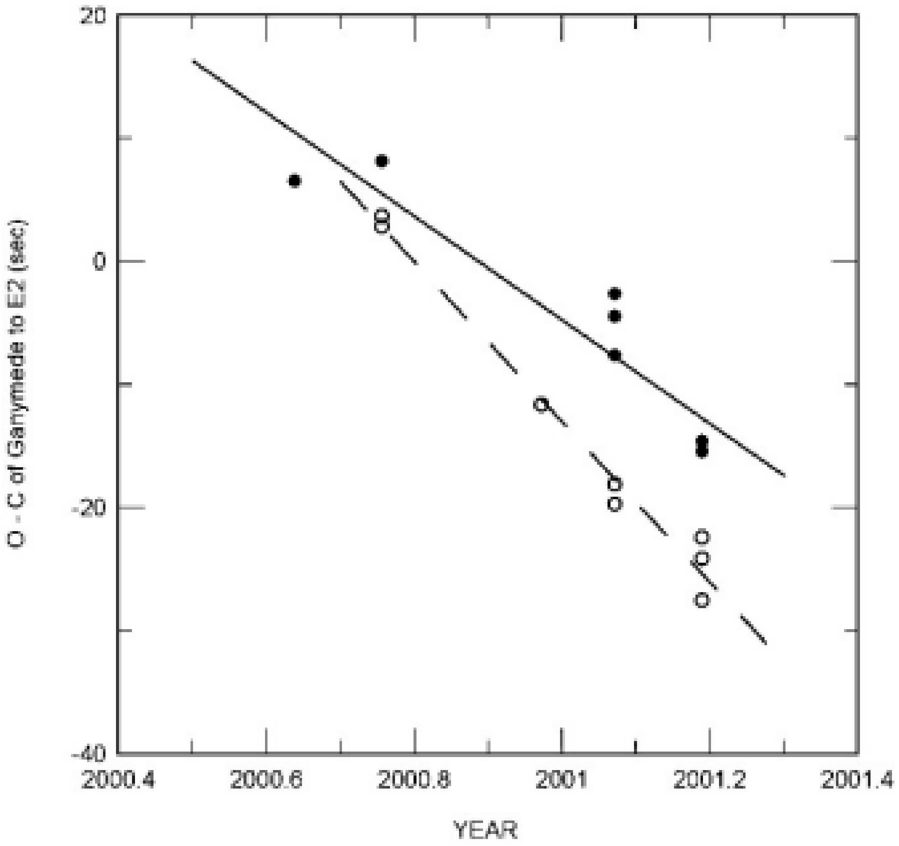

Figure 8. The (O - C)-values of Ganymede relative to E2 during Jupiter's apparition of 2000/2001. The negative trend is approximately one second of (O - C) per week of elapsed time for eclipse disappearances or reappearances.

While these phenomena themselves are conspicuous, their interpretation is not exactly clear. The (O - C)-values for the Galilean satellites are more complex than those of two-body systems, such as eclipsing binary stars, where there is usually just a starting epoch and an orbital period. In that case, (O - C) changes sometimes correspond with real accelerations. The short-term satellite (O - C) variations, on the other hand, probably do not indicate a real speeding up or slowing down of the bodies. Missing or erroneous terms in the perturbation theory of the analytical ephemerides are a more likely explanation. Such (O - C) variations are not seen when observations are compared to the dynamical JUP ephemeris.

Another interesting finding occurred on 1992 DEC 06, when Mallama and D. S. Caprette observed that a partial eclipse of Callisto by Jupiter's south pole was deeper than expected. Observations from two separate observatories were made by Mallama and by Krobusek (Mallama et al. 2000) at another partial eclipse on 1998 DEC 10. The results of the 1998 eclipse, by Jupiter's north

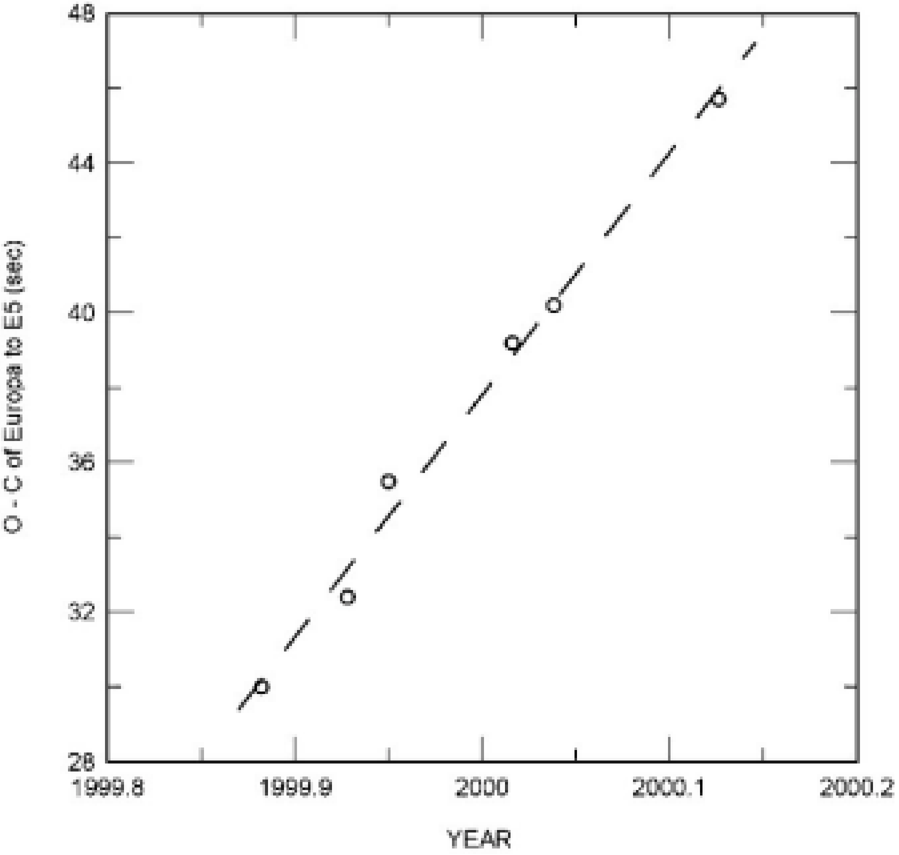

Figure 9. The (O - C)-values of Europa relative to E5 in 1999/ 2000. These eclipse reappearances become later at a rate of about one second for each week of elapsed time over the course of the observing season.

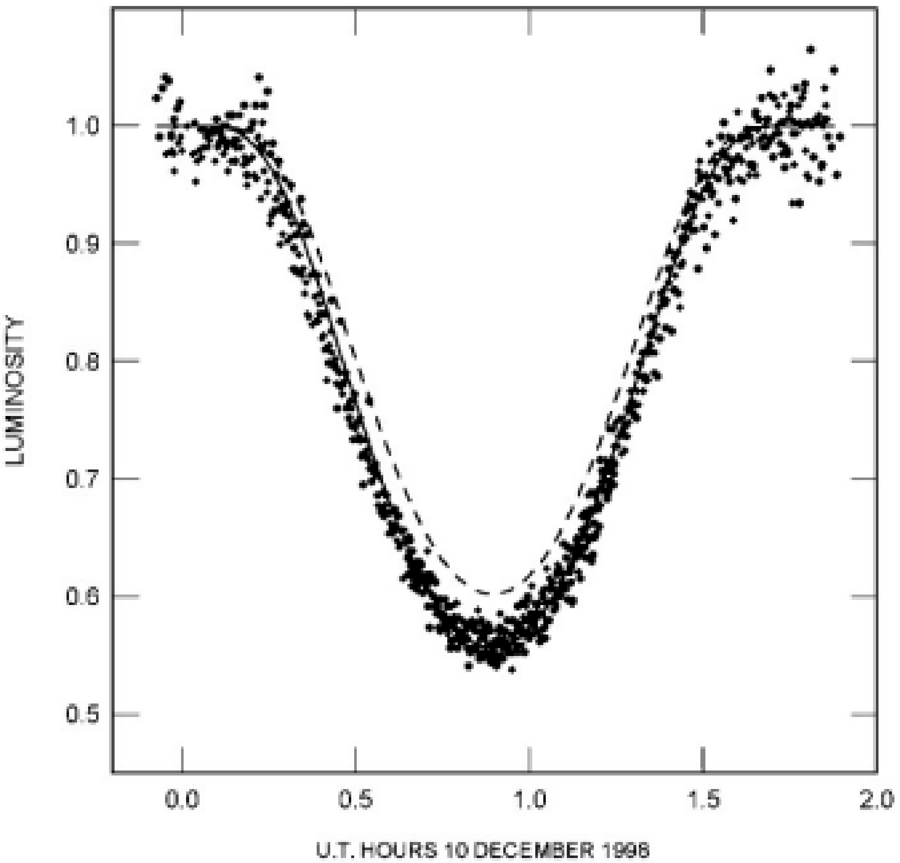

Figure 10. The eclipse observations obtained by Mallama (circles) and Krobusek (diamonds) agree quite well. However they indicate a deeper eclipse than the regular model light curve (dashed line). A model having increased attenuation at high altitudes (solid line) fits the data much more closely. The added extinction is attributed to Jupiter's polar haze.

pole, shown in Figure 10 (page 21), confirmed the greater extent of Jupiter's shadow than expected. The constraints of gravitational theory make it unlikely that Jupiter has a larger polar diameter than previously thought. The probable explanation for these anomalously deep eclipses is that the planet's polar haze is contributing extra absorption and effectively enlarging its shadow in the polar regions. This is a significant finding because other methods of investigation do not clearly indicate the height of the polar haze. However, eclipse observations are very sensitive indicators and our data gave a fairly reliable altitude of 300 km above the conventional cloud tops.

Finally, we found unusual eclipses immediately following the collision of Comet Shoemaker-Levy 9 with Jupiter in 1994. In this case, there were three eclipses whose (O - C) residuals disagreed widely with those obtained prior to the collision and with some other eclipses shortly following the collision. The (O - C) differences were too large and too sudden to attribute to ephemeris error. An investigation of the geometry of these anomalous eclipses showed that each of them occurred at a point on Jupiter's limb where sunlight on its way to the satellite passed through the locality of a dark spot imparted by a fragment of SL-9 (Mallama et al. 1995). Comparison of the eclipse light curves with model light curves that had been augmented with high-altitude attenuation showed that the observed anomalies were probably due to fallout particles from the cometary explosions at extremely high altitudes. Once again, these findings could only be obtained from eclipse observations.

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ALPO Feature:
The 1991-92 Apparition of Jupiter

By Richard W. Schmude, Jr., Acting Coordinator, ALPO Jupiter Section

Editor's Note: While this report covers a Jovian apparition of 10 years past, it was only prepared by Richard Schmude upon taking office as the newest coordinator of this section within the past year. He is also preparing reports for subsequent apparitions, and those also will appear in these pages. The ALPO is indebted to Dr. Schmude for his enthusiasm and dedication in preparing reports on data that is still hopefully pertinent for current and future studies

Abstract

During 1991-92 three major events occurred on Jupiter: (1) the interaction between, and probable merging of, two white oval storms at a planetographic latitude of 42°.2S, (2) the interaction of the Great Red Spot with a small dark spot within the South Equatorial Belt, and (3) the interaction of two dark spots lying on the south edge of the North Temperate Belt. All three events are described in this report along with the drift rates of several Jovian currents. Detailed descriptions of the Great Red Spot and festoons are also presented together with the shapes and sizes of several Jovian features.

Introduction

One highlight of the 1991-92 Apparition was the fly-by of the Ulysses probe past Jupiter in February, 1992 (Hanlon, 2001, p. 18). This probe gathered data on the Jovian magnetic field. The Hubble Space Telescope (HST) also took valuable pictures of Jupiter during 1992 (Cole, 1992). The HST has since been used to study the longitude drift rates of Jovian features over the planetographic latitude range 68°S to 77°N (Garcia-Melendo and Sanchez-Lavega, 2001, pp. 324-326). [Planetographic latitude refers to the angle between the surface normal and the Jovian equator; this distinction is necessary because of the planet's ellipsoidal shape.] Samuel Whitby discovered the eruption of dark spots along the south edge of the north temperate belt on 1991 OCT 10; soon afterwards, these features were photographed from Earth and imaged by the HST (Garcia-Melendo *et al*. 2000, p. 514). Donald Parker made many high-resolution CCD images of Jupiter during 1991-92. Preliminary accounts of the 1991-92 Jupiter Apparition are given elsewhere (Olivarez, Budine and Miyazaki, 1992a, 1992b; Olivarez, 1992). Rogers and Foulkes (1994) have also published a report for this apparition based largely on British observations. A full report based on American and overseas observations for this apparition is presented here. The characteristics of Jupiter during the 1991-92 Apparition are listed in *Table 1* (page 22) while the participating observers and their locations are listed in *Table 2* (page 23).

Disc Appearance

The overall aspect of Jupiter is shown in *Figures 1 and 2* (pp. 24 and 25). Figure 1 is a map of Jupiter made by Isao Miyazaki on 1992 FEB 26-27. Figure 2 is a selection of drawings made by several individuals throughout the apparition.

The nomenclature used in this report is shown in part A of Figure 2. Essentially the North Equatorial Belt is called the NEB and the Great Red Spot is called the GRS. The north and south edges of the belts and zones are designated by a lower-case **n** or **s** after the feature name. As an example, the south edge of the north temperate belt is called the NTBs. The SEB was broken into three components during 1991-92, consisting of a bright area lying between two darker belts. The darker belts are called the north and south components of the SEB while the brighter portion is called the SEB Zone. The SEBn refers to the northern edge of the SEB and the SEBs refers to the southern edge of the SEB.

Table 1: Characteristics of the 1991-92 Apparition of Jupiter

First Conjunction with the Sun	1991 AUG 17 UT
Opposition Date	1992 FEB 29 UT
Second Conjunction with the Sun	1992 SEP 17 UT
Apparent equatorial diameter (opposition)	44.6 arc-seconds
Visual stellar magnitude (opposition)	-2.5
Planetographic declination of the Sun (opposition)	1°.4 S
Planetographic declination of Earth (opposition)	1°.7 S
Geocentric declination of Jupiter (opposition)	9°.2 N

Table 2: Persons Who Submitted Jupiter Data During the 1991-92 Apparition.

Contributor*	Location	Instrument**	Type of Data***
Adcock, Barry	View Bank, Australia	0.31-m RL	P
Aerts, Leo	Heist, Belgium	0.15-m RR	TT
Benninghoven, Claus	Burlington, IA, USA	0.30-m RR, 0.20-m RL	D, SS, TT, CCD
Biesmans, Marc	Essen, Belgium	0.20-m RR	TT, CCD
Bosselaers, Marc	Berchem, Belgium	0.23-m RL	TT
Budine, Phillip	Walton, NY, USA	0.10-m RR, 0.20-m RL	D, SS, TT
Carlino, Lawrence	Lockport, NY	0.15-m RR	D
Cuppins, Wim.	Gruithode, Belgium	0.20-m RL	TT
Daerden, Frank	Genk, Belgium	0.12-m RL, 0.20-m RL	TT
Fimmers, Bert	Houthalen, Belgium	0.22-m RR	TT
Haas, Walter	Las Cruces, NM, USA	0.32-m RL, 0.20-m RL	TT, SS
Hays, Robert, Jr.	Worth, IL, USA	0.15-m RL	TT
Heath, Alan	Nottingham, England	0.32-m RL	TT, SS
MacDougal, Craig	Tampa, FL, USA	0.15-m RL	D, DN, TT
Miyazaki, Isao	Okinawa, Japan	0.40-m RL	TT, SS, P
Nelson, P.	Ellinbank, Australia	0.32-m RL	TT
Nowak, Gary	Vermont, USA	0.25-m Tri-Sch	D (Ganymede)
Olivarez, Jose	Wichita, KS, USA	0.20-m RL	D, TT
Parker, Donald	Coral Gables, FL	0.41-m RL	CCD
Plante, Phil	Poland, OH	0.20-m SC	D, TT
Richards, Tom	Eltham, Australia	0.25-m RL	TT
Robinson, Robert	Morgantown, WV, USA	0.25-m RL	TT
Schmude, Richard	Los Alamos, NM, USA	0.25-m RL	PP
Siegel, Elisabeth	Malling, Denmark	0.20-m RL	TT
Tatum, Randy	Richmond, VA, USA	0.18-m RR	TT, SS
Vandenbruaene, Hendrik	Beernem, Belgium	0.30-m RL, 0.25-m RL	TT
Vandenbulche, G.	Oostdvinkerre, Belgium	0.28-m RL	TT
Vanderzeuit, Antoine	Lokeren, Belgium	0.13-m RR	TT
Verwichte, Erwin	Genk, Belgium	0.20-m RR	TT
Whitbty, Samuel	Hopewell, VA, USA	0.15-m RL	TT, D, SS, DN

*Michael Morrow and Dieter Niechoy also made contributions, but we have no further data regarding them.

**RL = Reflector (type unspecified), RR = Refractor, SC = Schmidt-Cassgrain, Tri-Sch = Tri-Schiefspiegler. Approximate English-unit equivalents of metric apertures are: 0.10 m = 4 in.; 0.12 & 0.13m = 5 in.; 0.15 m = 6 in.; 0.18 m = 7 in.; 0.20 m = 8 in.; 0.22 & 0.23 m = 9 in.; 0.25 m = 10 in.; 0.30 & 0.31 m = 12 in.; 0.32 m = 13 in.; 0.40 & 0.41 m = 16 in.

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

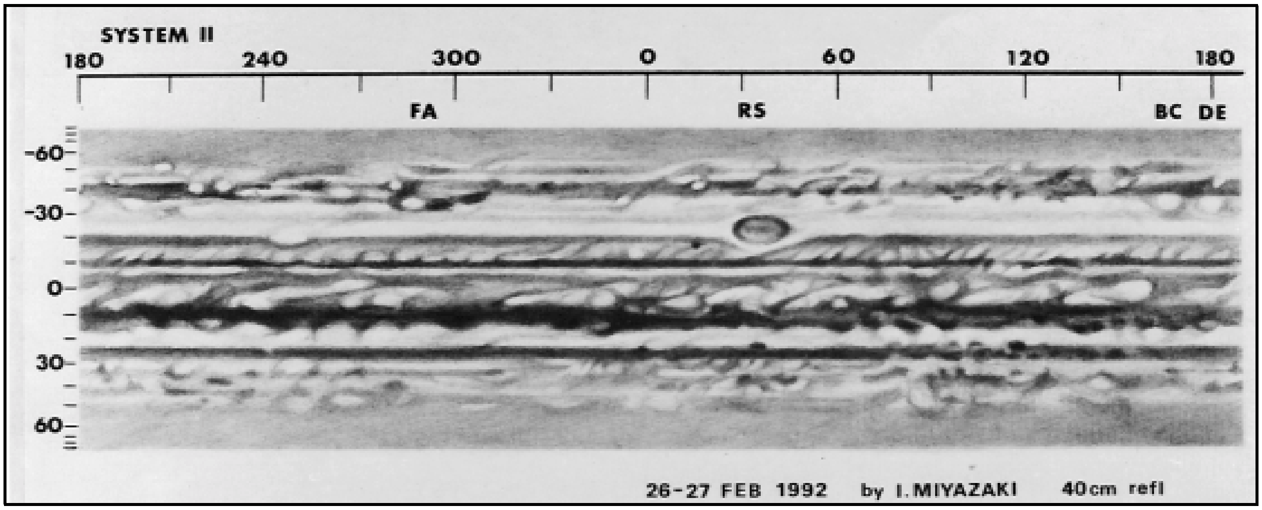

Figure 1: Strip map of Jupiter drawn by Isao Miyazaki on 1992 FEB 26-27, with a 0.4-m reflector. Cylindrical equal-area projection; south at top.

"West" will refer to the direction of increasing longitude. There are three systems of longitude in common use for Jupiter and all three are used in this report. The longitude will be designated by the Greek letter lambda, λ, followed by a Roman numeral indicating the longitude system. As an example, λII = 045° refers to a System II longitude of 045°. All wind speeds in this paper are based on System III longitude. The method for computing wind speeds is presented later.

The planetographic (sometimes called zenographic) latitudes of several Jovian belts were measured from CCD (charge-coupled device) images made by Parker, and the results are summarized in *Table 3* (page 26). The method outlined in Peek (1981) was used in determining the latitudes. The planetographic latitudes of the Earth used in the calculations were taken from *The Astronomical Almanac* (1990, 1991). The latitudes of the NEB, SEB, NTBs, NNTBn and SSTBn are in agreement with the 1990-91 values (Rogers, 1992, p. 325). Belts were centered at 49°.4 S and 42°.2 N and are assigned the names SSSSTB and the NNNTB, respectively, based on assignments made by Rogers (1990, 1995).

In fact, the author is in total agreement with the idea of assigning high temperate belt names based on their latitudes instead of the number of visible belts. The historical data show that there are probably two components of the NNTB (Rogers, 1995, p. 89); the belt in Table 3 is consistent with the southern component of the NNTB. The NTB had a variable northern border but its northern border was at a latitude consistent with historical values (Rogers, 1995, p. 89). The southern border of the NEB was slightly north of the historical mean. The mean latitude of the NEBs between 1908 and 1947 was 7°.2 N with a standard error of 1°.1 (Peek, 1981, p. 67). The SEBn latitude was near the mean value between 1895-1991 (Rogers, 1995, pp. 166-167). The SEBs latitude is consistent with the mean latitude of 20°.7 S measured between 1940 and 1990 (Rogers, 1995, p. 167). The SSTB had latitudes near the historical means (Rogers, 1995, p. 243).

Parker's images were examined for trends in the relative intensities of Jupiter's belts and zones. On 1991 DEC 09, Parker imaged Jupiter and Ganymede together in integrated light with an infrared-blocking filter. Ganymede has a geometric albedo of 0.44 at a solar phase angle of 0° (*The Astronomical Almanac, 2000*, p. F3). [The solar phase angle is the angle between Earth and the Sun as seen from Jupiter.] The solar phase angle of Ganymede was 11° on 1991 DEC 09 and consequently this reduced Ganymede's albedo to about 0.30. Measurements of the bright and dark dots on the computer printout of the Jupiter-Ganymede image yielded a ratio of the areas of bright to dark areas of 0.47 to 1.00 for Ganymede.

The corresponding ratios for the NEB (average), NTB, SEB (north component) and SEB (south component) were: 0.45, 0.35, 0.55 and 1.00 on the computer printout; and from these ratios approximate albedos are selected as: 0.28, 0.22, 0.34 and 0.50 respectively. These albedos should only be considered approximations; however, accurate values can be made with CCD cameras equipped with filters that have been transformed to the Johnson B, V, R and I system. The relative brightness of the zones, GRS, EB and the polar regions in integrated light with an infrared blocking filter are ranked from brightest to darkest: NTrZ > (STrZ-STZ) > EZn > SEBz > (EZs = GRS) > EB > NPR > SPR.

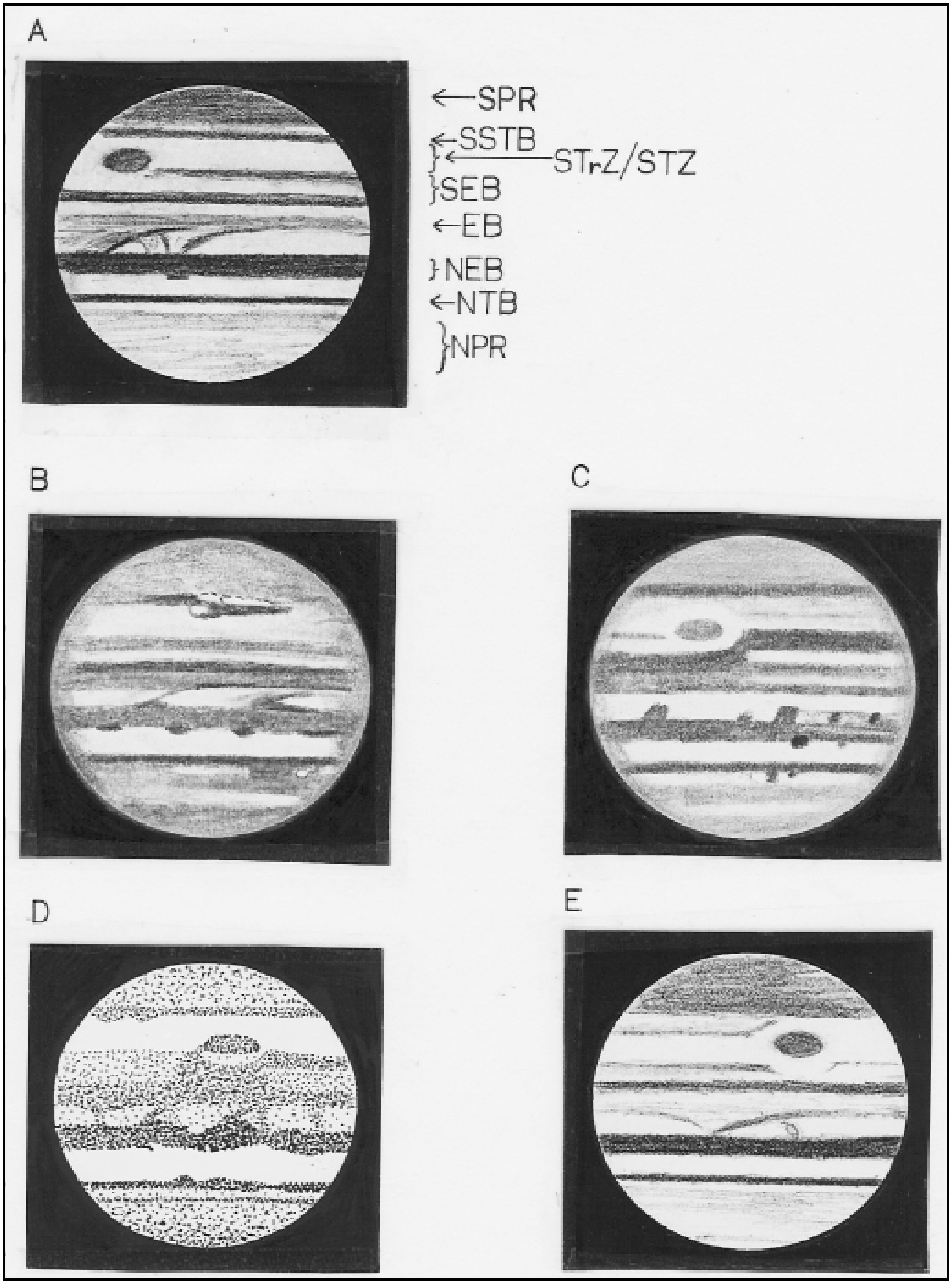

Figure 2: Nomenclature and drawings of Jupiter. The nomenclature is based on the appearance of Jupiter during the 1991-92 Apparition. Descriptions for each of the drawings are: **(A)** C. MacDougal, 1992 MAY 04, 0.15-m Newtonian, 215X, Seeing = 9, λI = 345°, λII = 074°; **(B)** S. Whitby, 1991 NOV 06, 0.15-m Newtonian, 155X, 310X, Seeing = 9, λI = 321°, λII = 340°; **(C)** S. Whitby, 1991 DEC 08, 0.15-m Newtonian, 155X, 310X, Seeing = 7, λI = 267°, λII = 042°; **(D)** H. Vandenbruaene, 1992 FEB 29, 0.25-m Newtonian, 166X, Seeing = 5, λI = 170°, λII = 028°; **(E)** C. MacDougal, 1992 JUN 11, 0.15-m Newtonian, 215X, Seeing = 7, λI = 221°, λII = 019°. Rotational System I (λI; 9h 50m 30.0s) longitudes apply to the EZ, south edge of the NEB, north edge of the SEB and the south edge of the NTB. System II (λII; 9h 55m 40.6s) applies to the rest of the disc. Seeing is on the 0-10 A.L.P.O. Scale, where 0 = worst and 10 = perfect. South at top.

Table 3: Planetographic Latitudes of Belts on Jupiter During the 1991-92 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
NNNTBs	42°.2 N	+/- 1°.0
NNTBn	38°.5 N	+/- 1°.0
NNTBs	34°.4 N	+/- 1°.0
NTBn	(Variable)	-----
NTBs	24°.0 N	+/- 0°.5
NEBn	17°.3 N°	+/- 1°.0
NEBs	8°.2 N°	+/- 1°.0
EBc	3°.0 S	+/- 0°.5
SEBn	7°.6 S	+/- 0°.5
SEBs	20°.7 S	+/- 1°.0
SSTBn	36°.8 S	+/- 1°.0
SSTBs	42°.7 S	+/- 1°.0
SSSTBn	46°.8 S	+/- 1°.0
SSSSTBc	49°.4 S	+/- 2°.0

* Mean includes NEBs projections.

Figures 3-5 (pp. 27, 28, and 30) show strip maps of the southern and northern hemispheres of Jupiter along with the Equatorial Zone. These maps were made by the author from CCD images, strip-maps and full-disc drawings. Jupiter is broken down into six regions in this paper: the GRS, SPR-STrZ, SEB, EZ, NEB, and NTrZ-NPR. Each of these will be discussed separately.

The author measured the sizes of several Jovian features from CCD images; when a dimension is reported in this paper, it is based on the author’s measurements unless stated otherwise. A polar diameter of 133,792 km (Rogers, 1995, p. 4) was used in all measurements.

As an example, if a feature on the central meridian had an east-west dimension of 6/76 of a Jupiter polar diameter, then the dimension was: (6/76) x 133,792 km = 10,563 km or 10,600 km. The feature’s east-west dimension was multiplied by a correction factor of 1/cos[θ] where θ is the distance, in degrees between the central meridian and the center of the feature. A feature’s north-south dimension was multiplied by a correction factor of 1/cos[φ] where φ is the distance, in degrees, between the equator and the center of the feature.

Region I: Great Red Spot (GRS)

Figure 6 (page 32) shows a series of drawings of the GRS. During 1991-92, the GRS had a dark border that was about 1500 km wide. This is similar to the appearance that it had in May, 1991, according to an HST image (Petersen and Brandt, 1995, p. 97; Beebe, 1994, plate 4a). The border was usually darkest on the south and following edges of the GRS. Donald Parker’s images also revealed a dark spot within the GRS, which had an east-west dimension of 10,000 km and a north-south dimension of 1800 km.

Vasavada *et al.* (1998, pp. 270-271) report that the anti-cyclonic GRS has a cyclonic current near its center. This cyclonic current may be related to the dark area in the center of the GRS. Whitby noticed that the north-following portion of the GRS was brightest on 1991 OCT 23. Whitby also noticed that a bright ring surrounded the GRS on 1992 MAR 10. This observation is confirmed in CCD images made by Parker, Benninghoven, MacDougal, Vandenbruaene and Whitby, all showing the GRS as being darker than the Polar Regions.

The GRS appeared darkest with a blue filter and brightest with a red filter, according to most visual observations and CCD images; however, on 1992 MAR 25 and JUN 21, Whitby reported that the GRS was equally dark with blue and orange filters. Based on comments made by Benninghoven, Hays, MacDougal and Whitby, the GRS became slightly darker during the first three months of 1992, but on 1992 MAY 11, Hays reported that the GRS was paler.

There were occasional reports of the GRS appearing to have a different shape. Indeed it is possible for the shape of this storm or others to change. The author carried out measurements of the GRS from Parker’s CCD images and these results are summarized in *Table 4* (page 29), where the dark collar surrounding the GRS is included in the dimensions. The area of the GRS is the same as the value Schmude (1991, p. 113) reported for the 1989-90 Apparition. Rogers (1995, p. 191) reported dimensions for the GRS during 1970-1990 as 24,000 km (east-west) by 14,500 km (north-south); these dimensions are consistent with an area of 2.73 x 10^8 km^2. The 1992 area is 90.4 percent of the 1970-1990 area. The smaller area in 1992 is consistent with an average shrinkage rate of 0.8 percent per year since 1980. This value is only approximate and more data are needed to confirm any shrinkage rate. It must, however, be pointed out that the east-west and north-south dimensions can change due to a changing shape and the area is probably a better indicator of the size of the GRS.

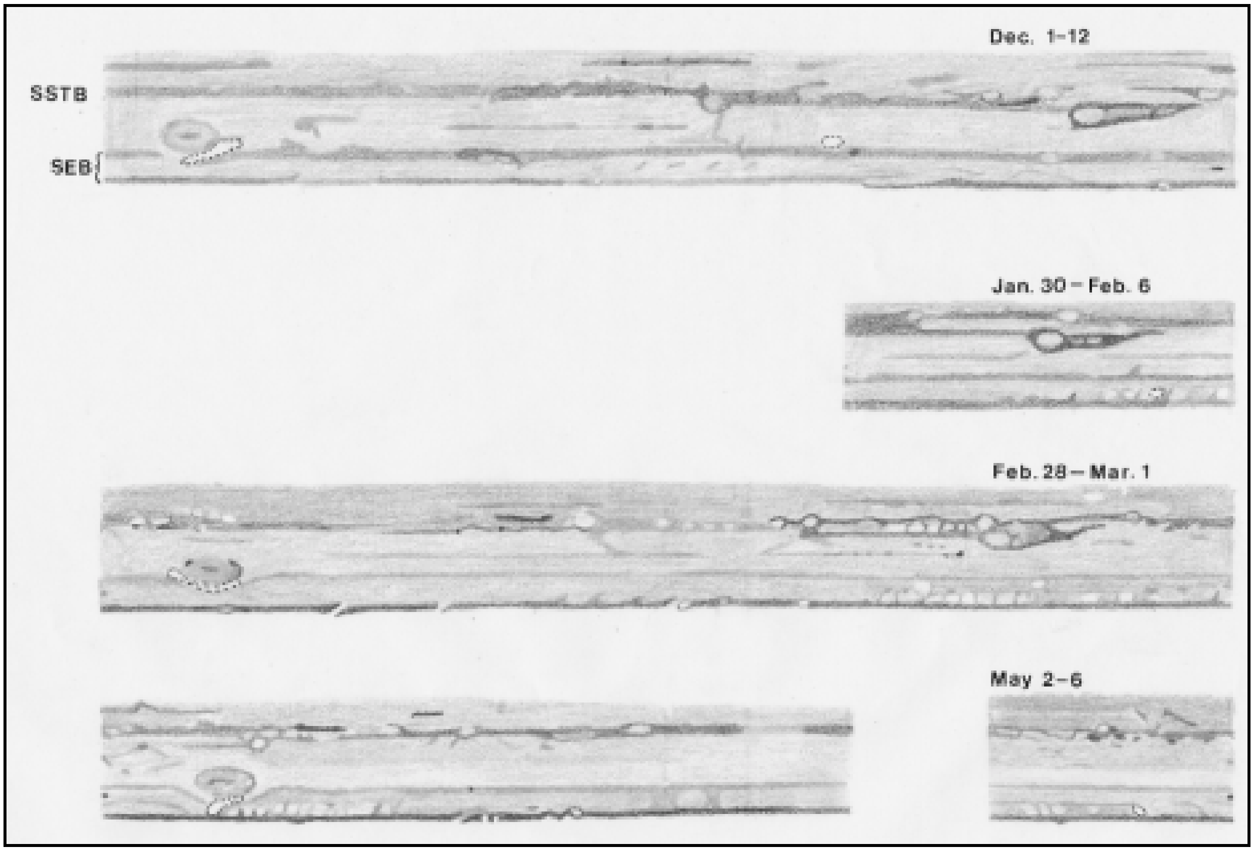

Figure 3: A series of strip maps of the southern hemisphere of Jupiter made on various dates during the 1991-92 Apparition. The dates are shown immediately above each strip map. South at top.

Region II: South Polar Region to the South Tropical Zone

Over one dozen white ovals were observed in this region and most of these lasted long enough to yield rotation periods. The sizes and shapes of these ovals are summarized in Table 4. There was one case where two ovals (B1 and B6 in Table 4) probably merged, creating oval B8. *Figure 6* (page 32) shows the sequence of the probable merger. Both B1 and B6 were visible in a 1992 MAR 08 image but Budine saw only one oval on 1992 APR 01. The activity of B1 and B6 was similar to the merging of ovals FA and BE in March 2000 (Sanchez-Lavega *et al.*, 2001). In both cases, the aspects of the ovals increased as they approached one another. (The aspect is the north-south dimension divided by the east-west dimension.) After merging, the new oval had an area of about 70 percent of the sum of the areas of the merging ovals.

Feature C1 was a bright oval. Whitby reported on 1991 DEC 11 that this oval was brilliant with orange, amber and blue filters. The shape and dimensions of this oval are listed in Table 4. Budine (1992, p. 9) reports that C1 has existed since 1975.

Oval FA was fairly easy to see and it was surrounded by a large dark area; see Figures 1, 2B and 3. Ovals BC and DE were quite difficult to observe because the STB had faded, reducing contrast. With very good seeing, Whitby searched for oval DE on 1992 APR 10 when it was near the central meridian but he could not see it. Whitby did observe oval BC on the same date. Ovals BC and DE were faint, but visible, in Parker's CCD images.

Two white ovals (A0 and A4) were imaged near 52°.4 S . The resulting rotation period and wind speed for these ovals is 9h 55m 13s and -3.7 m/s, which is similar to the rotation period of 9h 55m 30s measured for a spot at 55°S. Garcia-Melendo and Sanchez-Lavega (2001, p. 324) report velocities between 5.4 and 44.8 m/s over the latitude range of 51°S to 55°S.

Region III: South Equatorial Belt

During December, 1991, the northern component of the SEB was darker than the southern component in green, orange, red and integrated light but was equal in intensity to the southern component in blue light. The portion of the southern component following the GRS was much darker than the portion preceding the GRS during early December. Two months later, how-

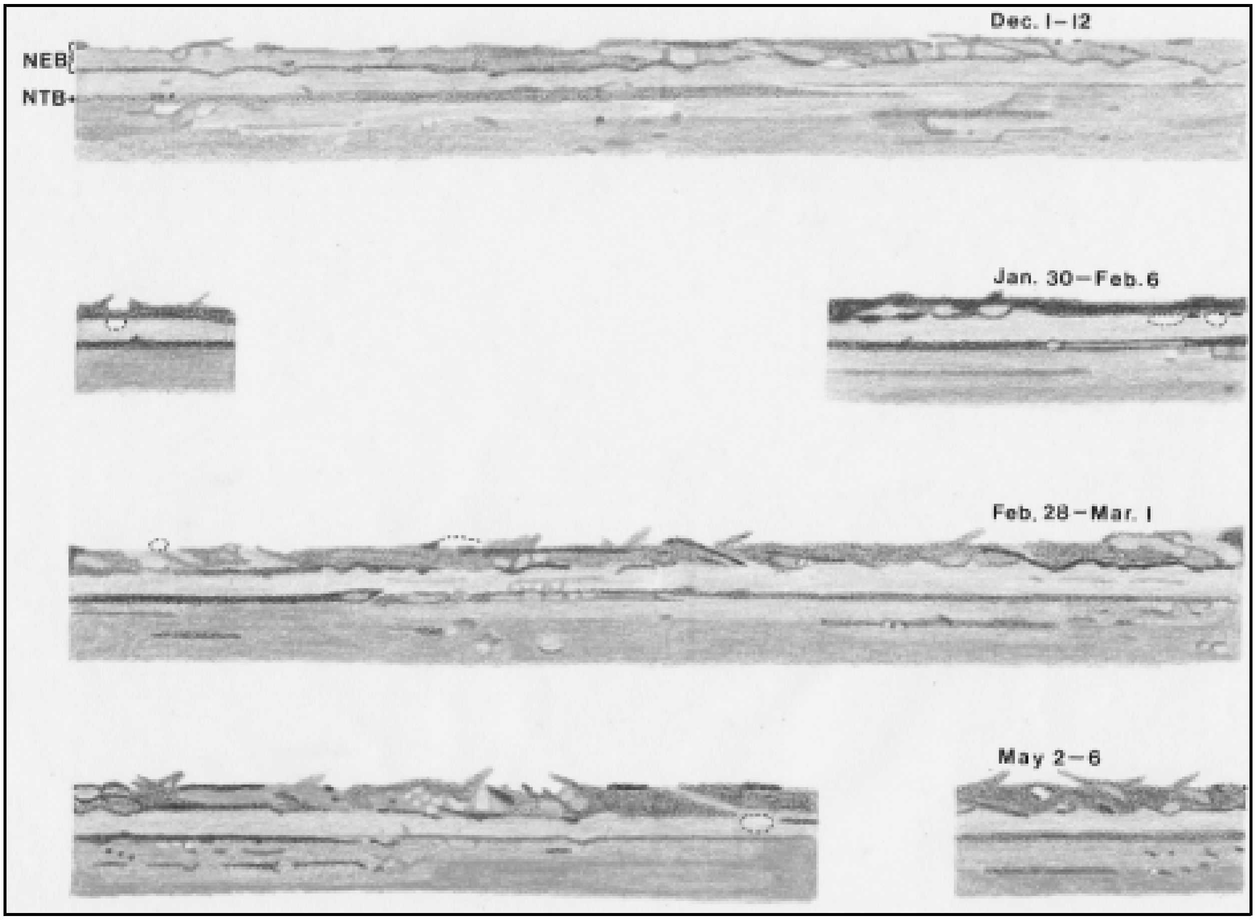

Figure 4: A series of strip maps of the northern hemisphere of Jupiter made on various dates during the 1991-92 Apparition. The dates are shown immediately above each strip map. South at top.

ever, the southern component of the SEB was equally dark on both the preceding and following sides of the GRS; this trend continued until at least May, 1992. Several reports in early 1992 stated that the southern component of the SEB was very faint.

A 2500 km-wide intensely-dark spot, S1 and S2 in Fig. 9, was observed for six months beginning in mid-November, 1991. The longitudes of this feature, along with the GRS, are plotted in *Figure 9* (page 38). Between 1991 NOV 18 and 1992 FEB 27, this spot had a planetographic latitude of 17°.3 S and was losing ground on the GRS at a rate of 0°.25/day or 3.6 m/s. Between late February and late March, 1992, this spot moved at about the same speed as the GRS, but by late March, the latitude of this spot had shifted to 16°.1 S. The dark spot was then gaining on the GRS at a rate of 0°.40/day or 5.4 m/s.

It appears that the much larger GRS pushed this dark spot into a more northerly, and faster-moving, latitude. Isao Miyazaki first noticed these changes and should be given credit for his diligent work. The author has added to Miyazaki's measurements several longitude measurements made by visual observations along with measurements from Parker's CCD images. The sizes and shapes of this feature are summarized in Table 4. It appears that the change in latitude may have changed the shape of this spot.

Region IV: Equatorial Zone

Figure 5 (page 30) shows four maps of the equatorial zone between December, 1991, and April, 1992. At any given time, there were between 7 and 12 large festoons jutting out from the NEB toward the EB. In most cases, the festoon started at the NEBs and spread in a westward direction. In almost all cases, a bright area was west of a festoon and the festoon formed the eastern and southern boundary of the bright area. The bright areas were brightest next to the festoon and became less bright towards the west.

The festoons apparently have no clouds, a low humidity, and are areas where internal heat escapes (Fischer, 2001, pp. 159-162; Rogers, 2001, p. 246; Showman and Dowling, 2000, p. 1757). We have learned from the Galileo mission that escaping internal heat is the main driving force of Jupiter's winds (Hanlon, 2001, p. 105), and so the existence of these

Table 4: Dimensions of White Ovals and the SEBz Dark Spot During the 1991-92 Apparition of Jupiter

(The aspect is the north-south dimension 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 1000 km except for the GRS, S1 and S2, which have uncertainties of 500 km.)

	Dimension (km)			Area
Feature	**East-West**	**North-South**	**Aspect**	**(10^6 km^2)**
GRS	24,000	13,100	0.55	247+/-16
STrZ oval	14,000	4600	0.33	51+/-12
Oval FA	9400	4800	0.51	35+/-9
Oval BC*	11,500	4200	0.37	38+/-10
Oval DE*	6500	4600	0.71	23+/-7
B1	4400	3900	**	13+/-5
B2	5500	4500	0.82	19+/-6
B3	4900	4300	0.88	17+/-5
B4	4900	3600	0.73	14+/-5
B5	4000	4000	1.00	13+/-5
B6	3600	6100	**	17+/-6
B7	3800	4100	1.08	12+/-4
B8	5800	4600	0.79	21+/-6
A0	4300	4000	0.93	14+/-5
A4	4100	3700	0.90	12+/-4
S1 before 1992 FEB 27	3900	2400	0.62	7.4+/-1.8
S1 1992 FEB 27 - MAR 21	3500	1900	0.54	5.2+/-1.6
S2 after 1992 MAR 21	2400	2100	0.88	4.0+/-1.2

* Ovals BC and DE were very weak during the 1991-92 Apparition.

** The aspect changed greatly before the merger; the dimensions correspond to 1992 MAR 08, which was just before these ovals merged.

features may have a large impact on Jovian winds. The bright area just west of a festoon is apparently a cloud that is moving at a speed of 170 m/s; this is much faster than the mean speed of the festoons (105 m/s). Therefore, such a cloud is moving into the festoon at a rate of 65 m/s or 4°.5/day. Once clouds move into a festoon they dissipate (Vasavada *et al.*, 1998).

The mean angle between the directions of all major festoons and that of the NEBs was 25°.4 with a standard deviation of 6°.7. The angles between the NEBs and festoons N1, N2, N6, N10-13 (located near System I longitudes of 020°, 070°, 190°, 245°, 270°, 305° and 340° respectively) were found to decrease at a mean rate of 0°.045/day. The evolution of festoon N10 is shown in Figure 6.

Between 190° and 070° System I longitude, there were seven major festoons spaced 40° or 50,000 km, apart. This spacing remained constant throughout the opposition.

Region V: North Equatorial Belt

Figure 4 shows strip maps of the North Equatorial Belt. The southern border of the NEB had several dark spots and festoon bases. On a few occasions, giant rifts also developed in the NEB. Whitby noticed a large rift located at λII = 300° on 1991 NOV 19 and NOV 26. This rift is present on a 1991 DEC 10 image made by Parker. Benninghoven observed a rift at λII = 294° on 1992 MAR 23 and reports that this rift contained “a series of bright ovals” that extended towards the following limb.

The northern border of the NEB had several dips and low projections; see Figure 4. Many of the projections were stable over a three- to four-month period and were used in determining rotation rates.

Region VI: North Tropical Zone to North Polar Region

The most significant event in this area was the development of a group of dark projections along the NTBs. Miyazaki photographed at least 21 of these features. Parker also imaged several of these spots. Furthermore, Aerts, Benninghoven, Bosselaers, Budine, Carlino, Daerden, Vandenbruaene and Whitby recorded at least one of these features in either their drawings or central-meridian transit timing notes. These features moved at a rate consistent with a rotation period of 9h 49m 14s.

Two dark spots, F2A and F3A, located 10° to 20° apart, moved at respective speeds of 1.9 and 2.1 degrees/day. *Figure 10* (page 39) shows the distance in degrees between these two features throughout early 1992. Until early March, F2A and F3A were approaching one another but after mid-March, the two spots were getting farther apart. Linear extrapolations of all data before 1992 FEB 16, and after MAR 23 show that the spots were closest on MAR 04

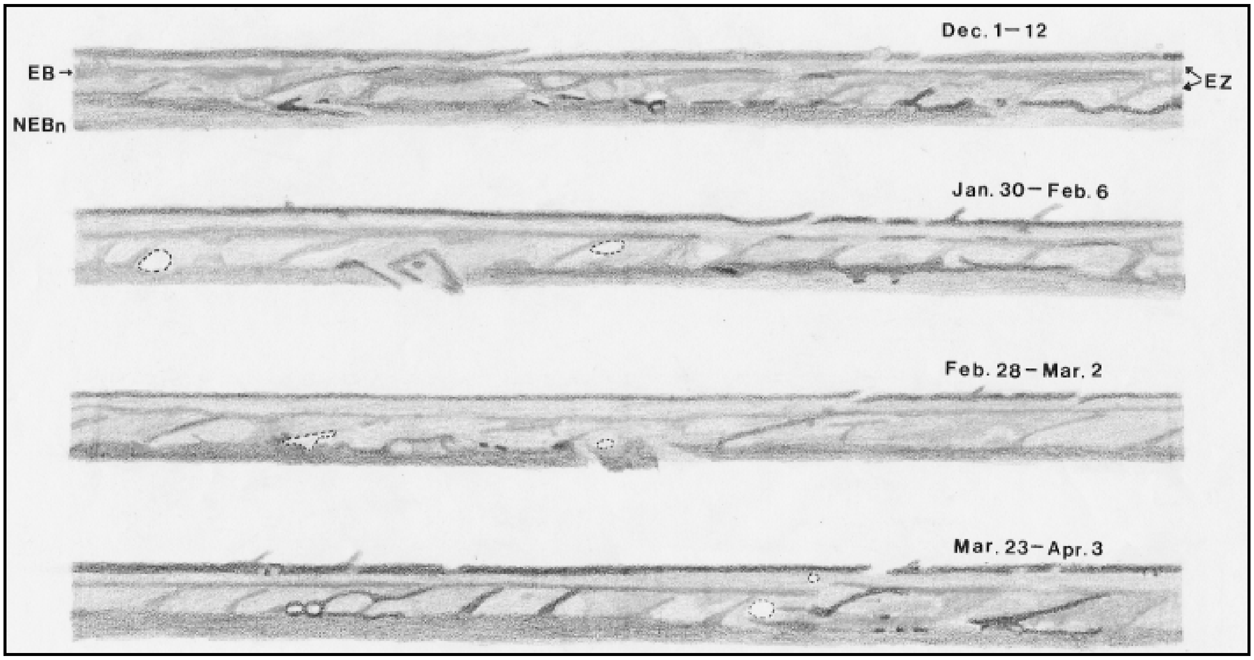

Figure 5: A series of strip maps of the equatorial region of Jupiter made on various dates during the 1991-92 Apparition. The dates are shown immediately above each strip map. South at top.

and were then 11°.2 or 12,900 km apart. Spots F2A and F3A interacted with one another in early March, resulting in different speeds, and consequently they were re-named F2B and F3B. The speeds of these spots are listed in *Table 6* (page 33).

The North Temperate Current C for 1991-92 had a wind speed of 123.5 +/- 0.6 m/s and this is consistent with the 1995-98 result of 125 m/s, but is slower than the 180 m/s measured by Voyagers I and II in 1979, and the 170 m/s measured in 1990 (Garcia-Melendo *et al.* 2000, p. 522). The 1991-92 result confirms the suggestions made by Garcia-Melendo *et al.* (2000, p. 522) that the 1990 NTB disturbance altered the wind speed in the North Temperate Current C.

Satellites

Gary Nowak observed the disc of Ganymede on 1992 MAR 19, APR 26 and MAY 18, using a 0.25-m Tri-Schiefspiegler. On 1992 APR 26, he observed dark polar areas on Ganymede, and this observation was independently confirmed by another observer. Antonio Cidadao, however, imaged bright Polar Regions and a dark equatorial region on Ganymede on Jan. 7, 2001 (Cidadao, 2001, p. 128).

Westfall (1996) has published results of the Galilean satellite eclipse timings for the 1991-92 apparition.

Wind Speeds/Drift Rates

About a dozen observers submitted several hundred central-meridian transit times of Jovian features. Also, the author has made several hundred longitude measurements from Parker's images using a device described by Rogers (1995, p. 391). Features north of the NTB were especially prone to rapid change. Garcia-Melendo and Sanchez-Lavega (2001, pp. 318-319) point out that certain changes not related to winds can influence wind measurements. Some of these changes include: a) cloud growth and contraction, b) wave-like phenomena, and c) large vortices altering the speeds of nearby objects. It will be the author's policy to keep these potential problems in mind in the evaluation of wind speeds.

In the professional literature, System III longitudes are almost exclusively used. System III is based on the rotation rate of Jupiter's magnetic field. According to *The Astronomical Almanac for the Year 2002*, Jupiter's magnetic field rotates 870°.536774/24 hours; this is equal to a rotation period of 9h 55m 29.68s. Planetary scientists also report longitude changes in either degrees/day or in meters/second (m/s), both based on System III. The wind speed is traditionally given the symbol u and is computed in m/s from the equation given in Rogers, 1995 (p. 392),

$$u = [\Delta\lambda\mathrm{III}\cos(\beta')]/2.080 \qquad (1)$$

where $\Delta\lambda\mathrm{III}$ is the drift rate in degrees per 30 days, and β' is the mean latitude as described in Peek (1981, p. 49). The drift rates in System II (or I) per 30 days are listed for various Jovian features in *Tables 5-7* (pp. 31, 33, and 35). *Table 8* (page 37) lists drift rates, rotation rates and wind speeds for several currents.

Table 5: Drift Rates of Features South of the Southern Portion of the South Equatorial Belt, 1991-92 Apparition of Jupiter

	No. of Points	Time Interval (1991/92)	Planetographic Latitude	Drift Rate (λII) (deg./30 days)	Rotation Period
South South South South Temperate Region					
A0	13	DEC 12 - APR 24	52°.5 S	-20.1	9h 55m 13s
A4	13	DEC 10 - APR 09	52°.3 S	-20.2	9h 55m 13s
		Mean	**52°.4 S**	**-20.2**	**9h 55m 13s**
South South Temperate Belt					
B1	26	DEC 10 - MAR 08	42°.1 S	-30.0	9h 55m 00s
B2	13	DEC 09 - MAY 04	42°.7 S	-28.3	9h 55m 02s
B3	20	DEC 10 - APR 24	41°.4 S	-26.3	9h 55m 05s
B4	16	DEC 12 - MAY 04	42°.5 S	-29.6	9h 55m 00s
B5	17	FEB 14 - MAY 06	42°.2 S	-24.5	9h 55m 07s
B6	13	DEC 12 - MAR 08	42°.3 S	-26.6	9h 55m 04s
B7	6	DEC 03 - APR 24	42°.6 S	-25.8	9h 55m 05s
B8	7	APR 01 - MAY 23	42°.3 S	-32.8	9h 54m 56s
		Mean	**42°.3 S**	**-28.0**	**9h 55m 02s**
South Temperate Belt					
Oval FA	29	OCT 13 - APR 23	33°.3 S	-12.9	9h 55m 23s
Oval BC	17	DEC 07 - MAY 24	33°.2 S	-13.3	9h 55m 23s
Oval DE	11	DEC 03 - APR 21	33°.4 S	-12.4	9h 55m 24s
		Mean	**33°.3 S**	**-12.9**	**9h 55m 23s**
South Equatorial Belt (central portion)					
S1	16	NOV 19 - FEB 27	17°.3 S	+8.5	9h 55m 52s
S2	13	MAR 21 - MAY 08	16°.1 S	-11.1	9h 55m 25s
South Tropical Zone					
C1	36	NOV 04 - APR16	20°.0 S	+7.1	9h 55m 50s
GRS	70	NOV 09 - JUL 03	22°.3 S	+1.0	9h 55m 42s

Standard errors of the wind speeds (K), relative to System III, were computed from:

$$K = u\,\{[(\sigma/N)^2 + 0.25]\}/\Delta\lambda III \qquad (2)$$

where u is the wind speed, σ is the standard deviation of the average drift rate, N is the number of spots and the factor 0.25 is an estimate of additional uncertainties due to seeing, the phase effect and telescope aperture. The $[(\sigma/N)^2 + 0.25]$ term was replaced by estimated uncertainties of 0°.5 for the GRS, 1°.0 for features C1, S1, S2 and the entire North North Temperate Current; 2° for F6 and 4° for H3.

The drift rates in Table 8 are in good agreement with previously published results (Peek, 1981, p. 193-194; Rogers, 1995; Garcia-Melendo and Sanchez-Lavega,

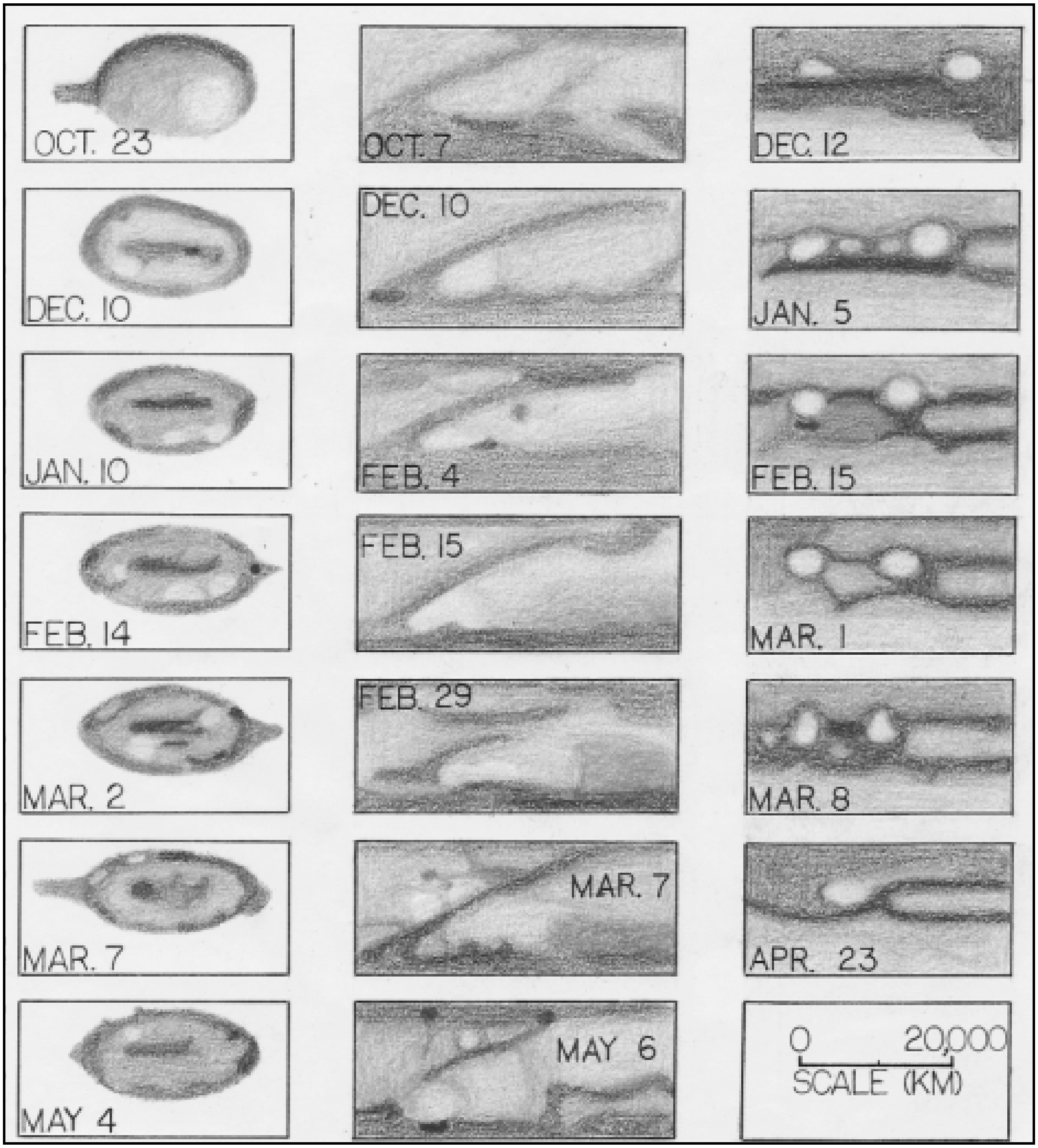

Figure 6: Closeup views of the Great Red Spot (left column); festoon N10, located at a system I longitude near 245° (center column); and the two merging ovals B1 and B6 (right column). The dates during the 1991-92 Apparition are shown on the individual drawings. South at top.

2001, p. 324-326) and with British observations in 1991-92 (Rogers and Foulkes, 1994).

Photoelectric Photometry

Schmude carried out a set of B and V measurements of Jupiter on 1992 JAN 20. He used an SSP-3 solid-state photometer along with filters that have been transformed to the Johnson B and V system. The comparison star was γ Leo and the magnitudes of this star were taken from Iriarte *et al.* (1965, p. 27). The measured magnitudes of Jupiter were B = -1.34, V = -2.27 and (B-V) = +0.93. The magnitudes were corrected for both atmospheric extinction and transformation in the same way that is outlined in Hall and Genet (1988, pp. 196-200).

Table 6: 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, 1991/92 Apparition of Jupiter

Designation	No. of Points	Time Interval (1991/92)	Planetographic Latitude	Drift Rate (λI) (deg./30 days)	Rotation Period
Equatorial Zone (central portion)					
E1	16	NOV 24 - APR 24	1°.5 S	+1.1	9h 50m 32s
E2	21	OCT 07 - MAY 06	1°.3 S	+0.1	9h 50m 30s
E8	15	DEC 10 - MAY 06	0°.8 S	-0.3	9h 50m 30s
		Mean	**1°.2 S**	**+0.3**	**9h 50m 31s**
Equatorial Zone (northern portion)					
E3	24	DEC 04 - MAY 06	7°.8 N	-1.2	9h 50m 29s
E4	17	DEC 09 - MAR 29	7°.8 N	+1.8	9h 50m 33s
E5	17	DEC 04 - MAY 04	8°.3 N	+2.7	9h 50m 34s
E6	7	NOV 24 - JAN 18	6°.3 N	+2.6	9h 50m 34s
E7A	13	OCT 07 - DEC 10	8°.3 N	-2.7	9h 50m 26s
E7B	17	FEB 04 - MAY 06	7°.5 N	+2.4	9h 50m 33s
E9	25	DEC 04 - MAY 04	8°.4 N	+0.8	9h 50m 31s
		Mean	**7°.8 N**	**+0.9**	**9h 50m 31s**
North Equatorial Belt (festoon bases along the southern edge)					
N1	32	NOV 20 - MAY 04	---	+2.3	9h 50m 33s
N2	18	NOV 25 - MAR 08	---	+1.5	9h 50m 32s
N3	17	OCT 22 - MAR 01	---	+2.4	9h 50m 33s
N6	27	OCT 09 - MAR 02	---	+0.8	9h 50m 31s
N10	42	OCT 07 - MAY 10	---	+1.0	9h 50m 31s
N11	17	OCT 07 - FEB 04	---	+2.0	9h 50m 33s
N12	35	OCT 07 - MAY 13	---	+0.2	9h 50m 30s
N13	38	DEC 04 - MAY 04	---	+1.5	9h 50m 32s
		Mean	**(10° N)**	**+1.5**	**9h 50m 32s**
North Temperate belt (southern edge)a					
F1	24	DEC 01 - MAY 27	23°.3 N	-60.9	9h 49m 08s
F2A	14	NOV 18 - FEB 15	23°.3 N	-57.3	9h 49m 13s
F3A	13	NOV 18 - FEB 15	23°.5 N	-64.0	9h 49m 04s
F2B	6	MAR 23 - APR 24	----	-53.1	9h 49m 19s
F3B	7	MAR 23 - APR 24	----	-49.6	9h 49m 23s
F9	14	JAN 29 - JUN 02	23°.5 N	-56.2	9h 49m 15s
F10	14	FEB 16 - JUN 02	23°.5 N	-53.1	9h 49m 19s
		Mean	**23°.4 N**	**-56.3**	**9h 49m 14s**

[a] Latitudes are based on measurements made by Miyazaki.

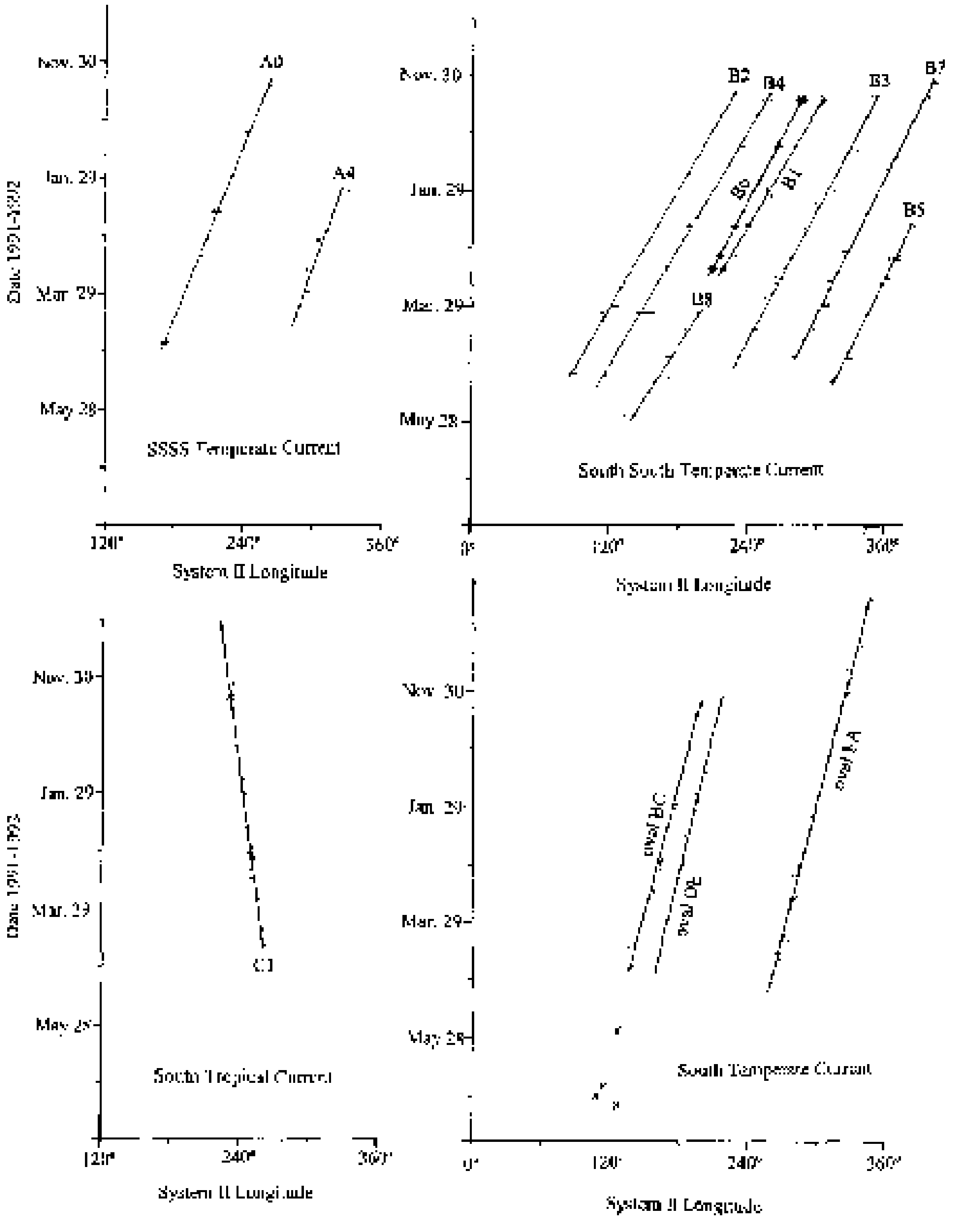

Figure 7: Drift rates for various features in the South South South South Temperate current, the South South Temperate Current, the South Temperate Current and the South Tropical Current (all labeled), during the 1991-92 Apparition of Jupiter. Larger dots correspond to two or more measurements, solid lines are measurements made from drawings and an x is a measurement that is too far away (in time) from the other measurements to be included. If a feature should have been observable but was not observed, a dashed line is shown.

Table 7: Drift Rates of Features North of the Northern Portion of the North Equatorial Belt, 1991/92 Apparition of Jupiter

Designation	No. of Points	Time Inrterval (1991/92)	Planetographic Latitude	Drift Rate (λII) (deg./30 days)	Rotation Period
North Equatorial Belt (northern edge)					
N15	37	DEC 09 - APR 28	---	-2.3	9h 55m 38s
N18	9	NOV 17 - JAN 19	---	+0.6	9h 55m 41s
N19	45	NOV 06 - JUN 08	---	-2.9	9h 55m 37s
N20	27	NOV 17 - APR 23	---	-2.3	9h 55m 38s
N21	12	NOV 20 - FEB 16	---	-1.4	9h 55m 39s
N22	34	OCT 10 - MAY 12	---	-1.6	9h 55m 39s
N23	29	DEC 09 - APR 23	---	+0.1	9h 55m 41s
		Mean	**(15° N)**	**-1.4**	**9h 55m 39s**
North Temperate Zone					
F6	9	NOV 24 - JAN 08	30°.3 N	+7.0	9h 55m 50s
North Tropical Zone					
F7	6	DEC 01 - DEC 10	20°.0 N	(+4)	9h 55.8m
North North Temperate Belt					
G1	7	NOV 17 - DEC 11	38°.4 N	(-7)	9h 55.5m
G2	8	MAR 01 - MAR 07	38°.7 N	(-4)	9h 55.6m
G4	13	FEB 05 - MAR 29	38°.8 N	-3.6	9h 55m 36s
		Weighted mean°	**38°.7 N**	**-4.4**	**9h 55m 35s**
North North North Temperate Belt					
H3	5	NOV 17 - DEC 04	47°.9 N	(-3)	9h 55.6m

*G1 received a weight of 3, G2 received a weight of 1 and G4 received a weight of 9.

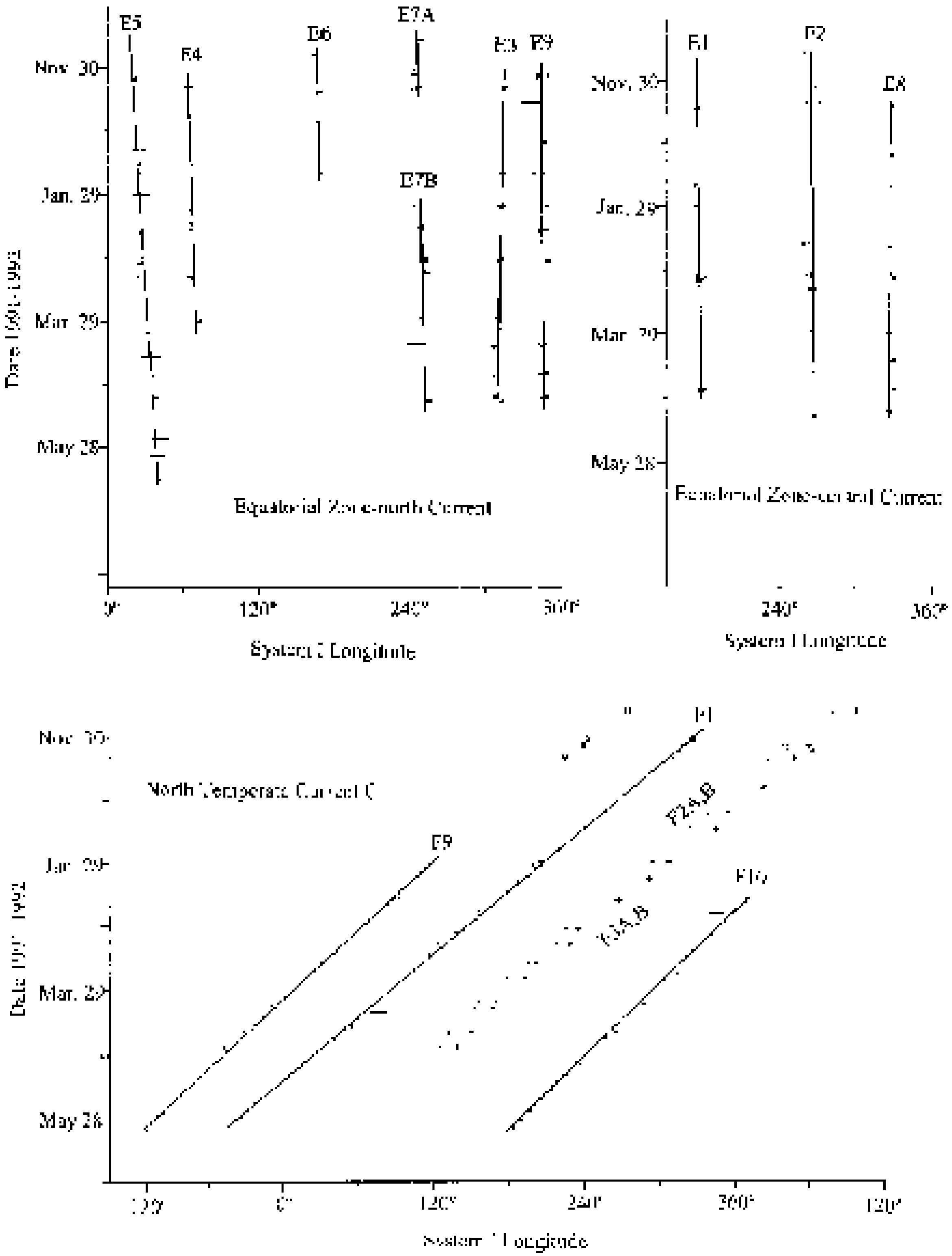

Figure 8: Drift rates for various features in the Equatorial Currents and in the North Temperate Current C (all labeled), during the 1991-92 Apparition of Jupiter. Symbols are explained in the caption for Figure 7.

Table 8: Mean Drift Rates, Rotation Periods and Wind Speeds for Several Currents Jupiter, 1991/92 Apparition

Current	Feature(s)	Drift Rate[c] (deg./30 day)			Rotation Period	Wind Speed (m/s) System III
		Sys. I	Sys. II	Sys. III		
SSSS Temp. Cur.	A0,A4	+208.7	-20.2	-12.2	9h 55m 13s	-3.6+/-0.4
SS Temp. Cur.	B1-7	+200.9	-28.0	-20.0	9h 55m 02s	-7.1+/-0.4
S Temp. Cur.	3 ovals	+216.0	-12.9	-4.9	9h 55m 23s	-2.0+/-0.2
S Trop. Cur.	C1	+236.0	+7.1	+15.1	9h 55m 50s	6.8+/-1.0
S Trop. Cur.	GRS	+229.9	+1.0	+9.0	9h 55m 42s	4.0+/-0.2
Equatorial Cur.[a]	E1,2,8	+0.3	-228.6	-220.6	9h 50m 31s	-106.0+/-0.3
Equatorial Cur.[b]	E3-7A, 7B, 9	+0.9	-228.0	-220.0	9h 50m 31s	-104.8+/-0.5
N Eq. Cur.	N1-3, 6, 10-13	+1.5	-227.4	-219.4	9h 50m 32s	-1.4
N Trop. Cur.	N15, 18-23	+227.5	-1.4	+6.6	9h 55m 39s	3.1+/-0.4
N Temp. Cur. “C”	F1-3A, 9, 10	-56.3	-285.2	-277.2	9h 49m 14s	-123.5+/-0.6
N Temp. Cur.	F6	+235.9	+7.0	+15.0	9h 55m 50s	6.2+/-0.8
NN Temp. Cur.	G1, 2, 4	+224.5	-4.4	+3.6	9h 55m 35s	1.4+/-0.5
NNN Temp. Cur.	H3	+226	(-3)	(+5)	9h 55.6m	(+2) +/-2
SEB Cur.	S1	+237.4	+8.5	+16.5	9h 55m 52s	7.6+/-0.5
SEB Cur.	S2	+217.8	-11.1	-3.1	9h 55m 25s	1.4+/-0.5

[a] Mean planetographic latitude is 1°.2 S.

[b] Mean planetographic latitude is 7°.8 N.

[c] The conversion factors between systems I, II and III longitudes are from Rogers (1995, p. 392).

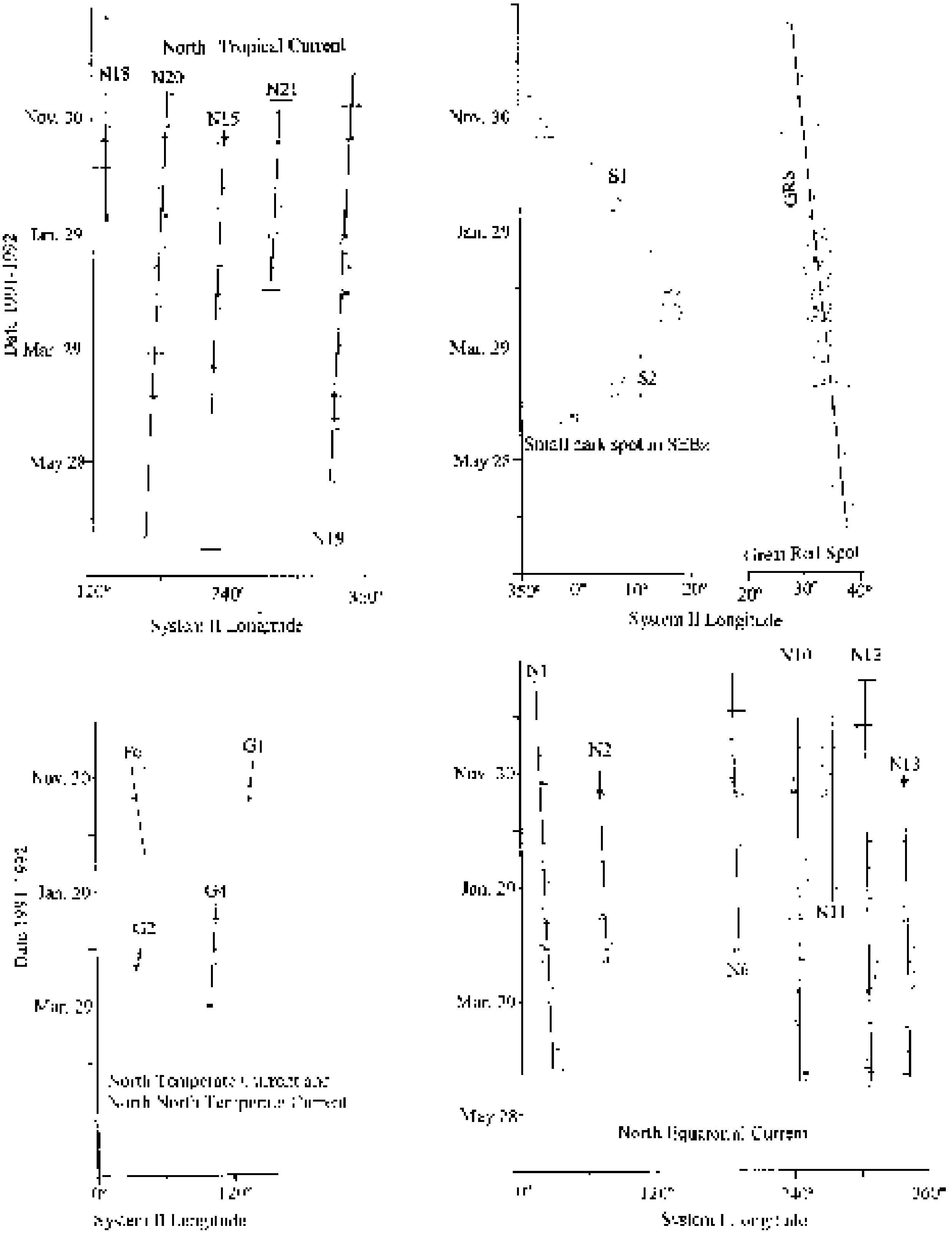

Figure 9: Drift rates for the North Tropical Current, Great Red Spot, South Equatorial Belt Current, North Temperate Current, North North Temperate Current and the North Equatorial Current (all labeled), during the 1991-92 Apparition of Jupiter. Symbols are explained in the caption for Figure 7. Features N22 and N23 were about 15° on either side of N21; for the sake of graph clarity, features N22 and N23 were not plotted.

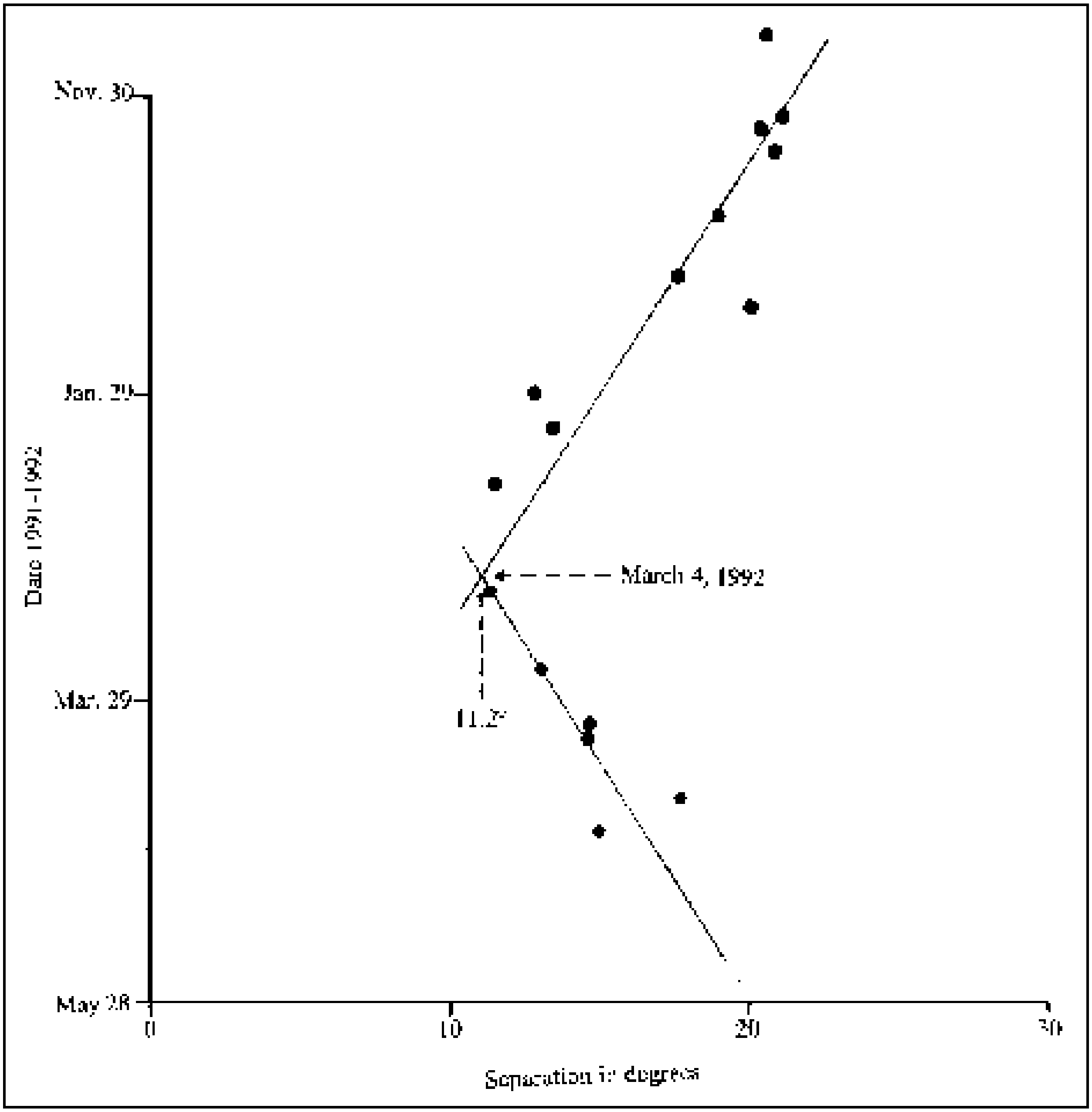

Figure 10: Distances between features F2 and F3 on various dates during the 1991-92 Apparition of Jupiter. Features F2 and F3 are two dark ovals lying along the NTBs.

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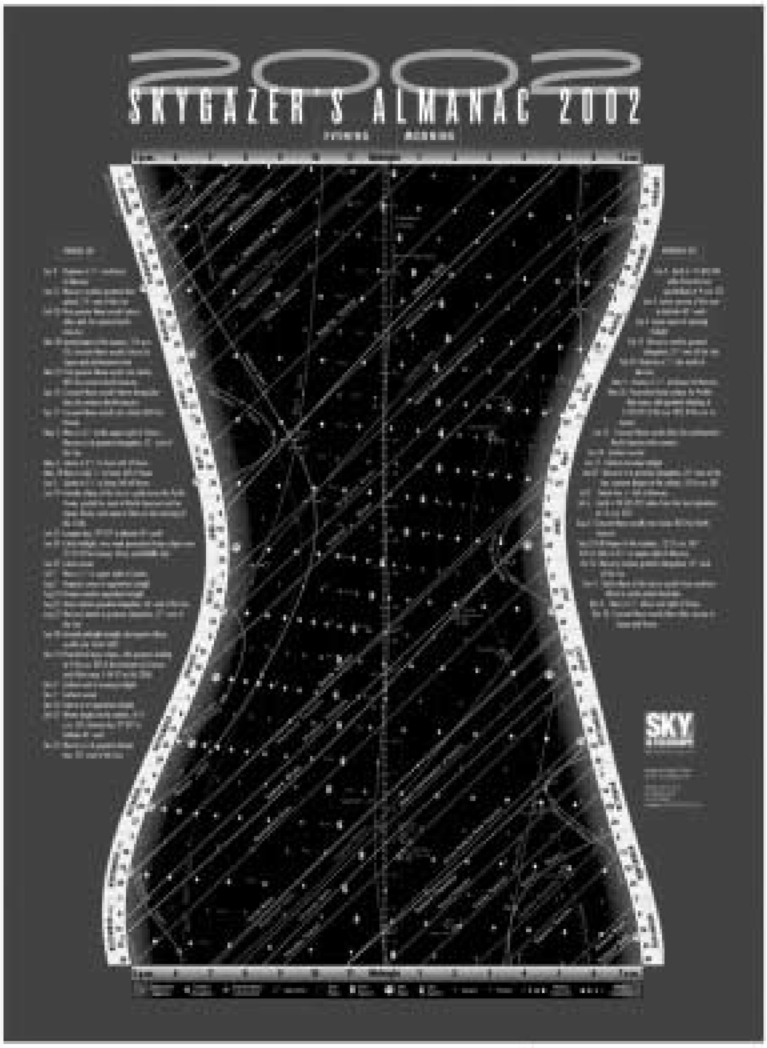
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