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The Strolling Astronomer

Volume 60, Number 3, Summer 2018
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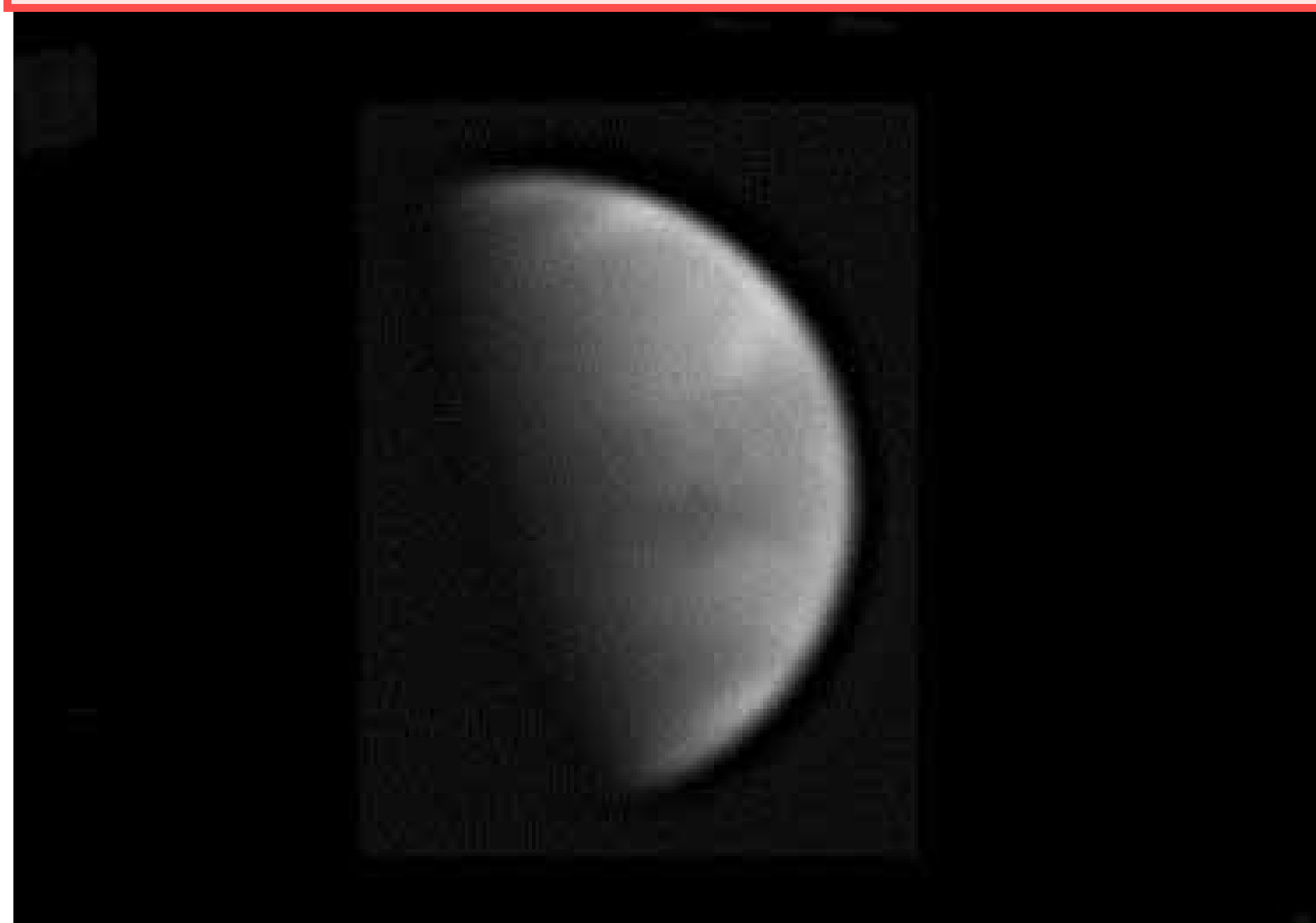

Soft, wispy Venus . . .
(see page 2 for details)

The Society for Astronomical Sciences 2018 Symposium, a joint meeting with the Association of Lunar and Planetary Observers, will be held June 14-15-16, 2018 in Ontario California.

The purpose of this note is to remind you that the Call for Abstracts is active, and to announce that Symposium Registration is now open.

Call for Abstracts: Presentations and Posters are solicited on any topic that is relevant to small-telescope science: photometry, spectroscopy, astrometry of solar system objects, stars, and other objects; instrumentation and data analysis methods; and other related topics. The Call for Abstracts is available here. Abstracts should be sent to program@SocAstroSci.org. Important dates are:

- Abstracts due: March 15, 2018
- Authors will be notified of acceptance by March 22
- Accepted Papers for the Proceedings due by: April 26, 2018

If you have any questions regarding making a presentation, please contact us at program@SocAstroSci.org.

Registration: Symposium registration is now open, at https://socastrosci.z2systems.com/eventReg.jsp?event=7&

Registration is $60 (SAS and ALPO members) or $75 (non-members). The Registration fee includes two days of technical presentations (Friday and Saturday), lunchtime photometry and spectroscopy discussions, Sponsor and Vendor displays, and "Evening with the Pro's" (Thursday) at which Dr. Lance Benner will discuss recent results of radar observations of near-Earth asteroids, and Dr. Jessie Christiansen will discuss the TESS mission.

Two Workshops have been scheduled for Thursday ($50 each).

Eclipsing Binaries "time of minimum" observation and analysis will be presented by Bob Nelson and Dr. Dirk Terrell. The goal of this workshop is to get the participants "up to speed" on the practice of determining Times of Min/Max from their own time-series photometry. The discussion will cover the purpose and value of ToM measurements, observing procedures and pitfalls, methods of data analysis, and interpretation of the results.

Detection of Transients in HII and Star Forming Regions Using Narrow-band Imaging will be presented by Dr. John Bally. This workshop will support a pro/am collaboration in the search for transients within HII clouds and Star Forming Regions of the Milky Way. The project is well suited for the small telescope scientist. The discussion will include the science case, relevant examples of the phenomenon, and recommended observation procedures. Much of the discussion related to narrow-band filter observations will also be applicable to spectroscopy. We will pursue flux calibration of images and comparing ratios of images taken in O [III], S[II], N[II] H-alpha and H-beta and other filters to discover and alert the wider community to transient events of this nature. Advance-reading material will be provided May 1st.

The Closing Banquet will be held on Saturday evening ($40/person). Non-registered guests are welcome at the banquet.

If you have any questions about Registration, please contact us at Program@SocAstroSci.org.

Hotel reservations: The conference venue is the Ontario Airport Hotel & Conference Center (http://www.ontariocaairporthotel.com/). You must make your own reservations. The conference rate for lodging is $96/night (plus taxes). A link for hotel reservations will be put onto the SAS website shortly; or you can call the hotel at 909-980-0400.

Journal of the Association of Lunar & Planetary Observers

The Strolling Astronomer

Volume 60, No.3, Summer 2018
This issue published in June 2018 for distribution in both portable document format (pdf) and 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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Visit the ALPO online at:
http://www.alpo-astronomy.org

Founded in 1947

Inside the ALPO

Point of View The Future of Lunar Observing 2
News of General Interest 3
- Our Cover: Beautiful, Soft and Wispy Venus 3
- Another ALPO Member Honored by the IAU 3
- ALPO Annual Conference 3
- Jupiter Section Staff Changes 3
- Call for JALPO Papers 4

ALPO Interest Section Reports 4
ALPO Observing Section Reports 6
Letter to the Editor 22
Notable Deaths 22
- ALPO Member, Staffer Fr. Ken Delvano 22
- Comet Discover Tom Bopp 23

Papers & Presentations

Index to Volume 56 (2014) of The Strolling Astronomer 25
Terms and Abbreviations Used In This Report 29
A Report on Carrington Rotations 2199 through 2201 (2017 12 30.9382 to 2018 03 22.9368) 29
ALPO Observations of Venus During the 2014 Western (Morning) Apparition 41
ALPO Observations of Jupiter During the 2014-2015 Apparition 53
Galilean Satellite Eclipse Timings: The 2010-2011 Apparition 75
ALPO Observations of the Remote Planets in 2016-2017 79

ALPO Resources

Board of Directors 85
Publications Section 85
Interest Sections 85
Observing Sections 85
ALPO Publications 86
The Monograph Series 86
ALPO Observing Section Publications 87
Back Issues of The Strolling Astronomer 88

Inside the ALPO
Member, section and activity news

Association of Lunar & Planetary Observers (ALPO)

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Lunar Meteoritic Impact Search; Brian Cudnik
Lunar Transient Phenomena; Anthony Cook
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Meteors Section: Robert D. Lunsford
Meteorites Section: Dolores Hill
ALPO Online Section: Larry Owens
Computing Section: Larry Owens
Youth Section: Timothy J. Robertson

Point of View

The Future of Lunar Observing

By Wayne Bailey, ALPO Lunar Topographical Studies Program coordinator

Why observe the Moon? It's the only celestial object that humans have actually visited. It has no rapidly changing atmospheric phenomena to watch. There are no seasonally changing surface features. Lunar orbiting spacecraft have mapped the surface in exquisite detail. What is left for the amateur to do? Isn't the Moon just a nice, bright, easy-to-find object that's fine for beginners to start with before moving on to more difficult and worthy objects? These are all comments that I've heard at various times, and all are correct, but not the complete story.

The Moon is an excellent object to develop observing techniques. Because the Moon is so close, even the poorest first observation typically will reveal some features, and improvements in observing skill produce obvious results. The best results, however, require just as much skill as for any other object, and continuously changing lighting conditions provide ever-changing views.

While even the best observations can't match the resolution of spacecraft images, one of the amateur's advantages is the flexibility to observe a feature any time it is sunlit. In orbit, the observing schedule and lighting are determined by orbital dynamics. The existence of details worth examining in the spacecraft data may only become apparent under very specific lighting conditions. The online spacecraft data is currently under-utilized by amateurs in this regard. Albedo features, such as rays, and their changes with phase are still best studied from Earth rather than lunar orbit because of the constraints of orbital dynamics.

Amateur observations are primarily wide-band digital images, with a small number of visual observations. Few observers use filters other than to improve seeing. But photometric imaging with the use of standard filters offers prospects for new observing projects. And lunar spectroscopy is an unexplored field for amateurs. However, solid state spectral features are typically broad, and mostly in the infrared, so spectroscopy may not offer any advantage over photometry. Finally, polarimetry is

(Go to "The Future of Lunar Observing" on page 23)

Inside the ALPO
Member, section and activity news

News of General Interest

Our Cover: Beautiful, Soft and Wispy Venus

Our cover this time features an image of a planet that's known for showing very little of itself. Yet, it is rather beautiful with what it does show.

Taken by William Schrantz of Nicholasville, KY, on June 23, 2009 at 10:50 UT, employing a 25.4 cm (10.0 in.) Newtonian reflector, this representative UV image of Venus shows the characteristic roughly horizontal V, Y, or ψ (psi)-shaped dusky cloud features in the atmosphere of Venus typically depicted in good quality images at UV wavelengths in good seeing conditions.

Other bright regions and amorphous dusky features are also captured in this image.

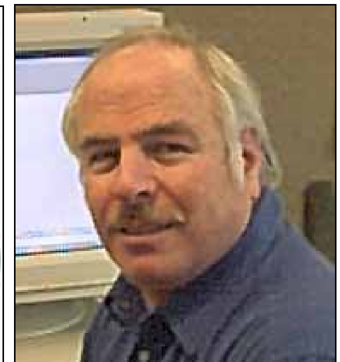
Venus is 58.4% illuminated at visual magnitude -4.2 with an apparent diameter of 20.0". South is at the top of the image.

Another ALPO Member Honored by the IAU


Lunar & Planetary Laboratory

Catalina Sky Survey

Minor Planet
2000 EY70
has been officially designated
(31862) Garfinkle
by the International Astronomical Union
and announced in the Minor Planet Circular 119133
issued by the Minor Planet Center at Harvard Center for Astrophysics
The official citation reads:
Discovered 2000 Mar. 11 by the Catalina Sky Survey
Robert A. Garfinkle (b. 1947) is a Fellow of the Royal Astronomical Society and author of best-selling observational astronomy books and many articles. He is also the British Astronomical Association Lunar Section Historian and the Association of Lunar and Planetary Observers Book Review Editor.


Robert Garfinkle and IAU certificate for Minor Planet "(31862) Garfinkle".

Our collective congratulations go to ALPO Book Review Editor Robert Garfinkle as planet 2000 EY70 has been officially designated "31862 Garfinkle" in his honor by the International Astronomical Union (IAU).

This little chunk of rock is a a main belt asteroid discovered in 2000 and has an orbit characterized by a semi-major axis equal to 2.3765297 AU and an eccentricity of 0.1379013, inclined by 8.64812° with respect to the ecliptic.

ALPO Annual Conference

We received late confirmation that this year's ALPO annual conference will be a joint meeting with the Society for Astronomical Sciences Thursday through Saturday, June 14 through 16, in Ontario, California.

Details and contact information can be found on the inside front cover of this Journal. Please note that the deadline for submitting abstracts for papers to be presented will have passed by the time you see this notice. If you are interested in presenting a paper, please contact the meeting organizing committee directly at *program@SocAstroSci.org*

The March 13, 2018 *Observer's Notebook* podcast features a conversation between host Tim Robertson and conference coordinator Robert K. Buchheim.

More information here: *https://soundcloud.com/observersnotebook/the-observers-notebook-the-2018-joint-conference-with-the-sas-and-the-alpo*

Jupiter Section Staff Changes

Effective immediately, Richard Schmude is once more coordinator of the ALPO Jupiter Section and is also coordinator of the Jupiter Section Galilean Satellites Eclipse Observing program.

These changes come following decisions by Ed Grafton to step down as section coordinator for health reasons and by John Westfall to turn the Galilean satellite program over to Richard.

John McAnally retains his position as coordinator of the Jupiter Section Transit Timing program and Craig MacDougal remains as owner/ moderator of the Jupiter Yahoo e-mail list.

Inside the ALPO
Member, section and activity news

Call for JALPO Papers

The ALPO appreciates articles for publication and encourages its membership to submit written works (with images, if possible).

As with other peer-reviewed publications, all papers will be forwarded to the appropriate observing section or interest section coordinator.

Thus, the best method is to send them directly to the coordinator of the ALPO section which handles your topic.

A complete list of ALPO section coordinators and their contact information can be found in the *ALPO Resources* section of this Journal.

ALPO Interest Section Reports

ALPO Online Section

Larry Owens, section coordinator
Larry.Owens@alpo-astronomy.org

The ALPO web site is now up and fully operational following a major service upgrade by our by our internet service provider.

The ALPO Publications Section portion of the web site is still to be reloaded.

Follow us on Twitter, “friend” us on FaceBook or join us on MySpace.

To all section coordinators: If you need an ID for your section's blog,

contact Larry Owens at *larry.owens@alpo-astronomy.org*

For details on all of the above, visit the ALPO home page online at *www.alpo-astronomy.org*

Computing Section

Larry Owens, section coordinator
Larry.Owens@alpo-astronomy.org

Important links:

- To subscribe to the ALPOCS yahoo e-mail list, *http://groups.yahoo.com/group/alpocs/*
- To post messages (either on the site or via your e-mail program), *alpocs@yahoogroups.com*
- To unsubscribe to the ALPOCS yahoo e-mail list, *alpocs-unsubscribe@yahoogroups.com*
- Visit the ALPO Computing Section online at *www.alpo-astronomy.org/computing*

Lunar & Planetary Training Program & Podcasts

Tim Robertson, program coordinator
cometman@cometman.net

ALPO Lunar & Planetary Training Program

The ALPO Training Program currently has four active students at various stages of the program.

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

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

The course of instruction for the Training Program is two tiered. The first tier, or "Basic Level", includes reading the ALPO's Novice Observers Handbook and mastering the fundamentals of observing. These fundamentals include performing

Inside the ALPO
Member, section and activity news

simple calculations and understanding observing techniques. When the student has successfully demonstrated these skills, he or she can advance to the "Novice Level" for further training where one can specialize in one or more areas of study. This includes obtaining and reading handbooks for specific lunar and planetary subjects. The novice then continues to learn and refine upon observing techniques specific to his or her area of study and is assigned to a tutor to monitor the novice's progress in the Novice Level of the program.

When the novice has mastered this final phase of the program, that person can then be certified to Observer Status for that particular field.

'Observers Notebook' Podcasts

The most recent podcasts posted online for your listening pleasure include a fun conversation with astrophotographer Damian Peach and comet-hunter Don Machholz, who shared some stories of his 11 comet discoveries. I will also be releasing a few of the lectures given by ALPO members at the Georgia Regional Astronomers Meeting (GRAM) in October 2017 as individual podcasts. I am still hoping to get on the podcast John McAnally of the Jupiter Section and Frank Melillo of the Mercury Section as podcast guests as well.

If you have a subject matter that you would like to hear on the podcast, please drop me a note. I would like to have a discussion on the use of color filters for planetary observing and the timings of Galiliean satellite eclipses. If any of you would be interested in discussing those subjects, please let me know.

I am also looking to do member profile pieces where we get to know the members of the ALPO.

The podcast will also be used to “get the word out” on any breaking astronomy news or events happening

Inside the ALPO
Member, section and activity news

in the night sky. So let me know if you have any breaking news that you want out there.

A new podcast is released about every two weeks, and if you subscribe via iTunes it will automatically be downloaded to your device.

Here are a few interesting statistics you might be interested in as well:

- Number of downloads as of January 9, 2017: 8,125
- Number of subscribers (all formats): 200+
- Average of number daily downloads (last 3 months): 42
- iTunes rating: 5 stars!
- Locations of most downloads: USA, UK, Canada, Costa Rica, Germany, Ireland, and The Russian Federation.

You can hear the podcast on iTunes, Stitcher, iHeart Radio, Amazon Echo, and Goggle Play just search for Observers Notebook, you can listen to it at the link below:

https://soundcloud.com/observersnotebook

The Observers Notebook is also on FaceBook. Just search for "Observers Notebook" in the search field near the top of your screen.

You can support the podcast by giving as little as $1 a month: for $5, you receive early access to the podcast before it goes public; for a monthly donation of $10, you receive a copy of the Novice Observers Handbook; and for $35 a month, you receive producer credits on the podcast and a year's membership to the ALPO.

You can help us out by going to the link below:

https://www.patreon.com/ObserversNotebook

For more information about the ALPO Lunar & Planetary Training Program or "The Observers Notebook" podcasts, contact Tim Robertson at: cometman@cometman.net, or Tim Robertson, 195 Tierra Rejada Rd #148, Simi Valley CA, 93065, or go to: www.cometman.net/alpo/

ALPO Observing Section Reports

Eclipse Section

Mike Reynolds, section coordinator
m.d.reynolds@fscj.edu

The full report on the August 21, 2017 total solar eclipse has been postponed and will appear in the autumn issue of this Journal (DJALPO60-4).

Visit the ALPO Eclipse Section online at www.alpo-astronomy.org/eclipseblog

Mercury / Venus Transit Section

John Westfall, section coordinator
johnwestfall@comcast.net

Visit the ALPO Mercury/Venus Transit Section online at www.alpo-astronomy.org/transit

Meteors Section

Robert Lunsford, section coordinator
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We have just passed through the slow time of the year for meteor observers in the northern hemisphere. The only display of note was the Lyrids, which peaked on April 22. Unfortunately we have yet to receive any observations of this shower.

Meteor rates will continue to be low through June but in July, activity will pick up as the alpha Capricornids, Southern delta Aquariids, and even the sporadic activity pick up. The warmer nights will also help entice folks to sit out under the stars and enjoy the heavenly scene.

As always, we look forward to seeing your observations of the upcoming meteor activity.

A reminder here that your section recorder has taken advantage of podcasts to verbally spread the news of upcoming major meteoric events.

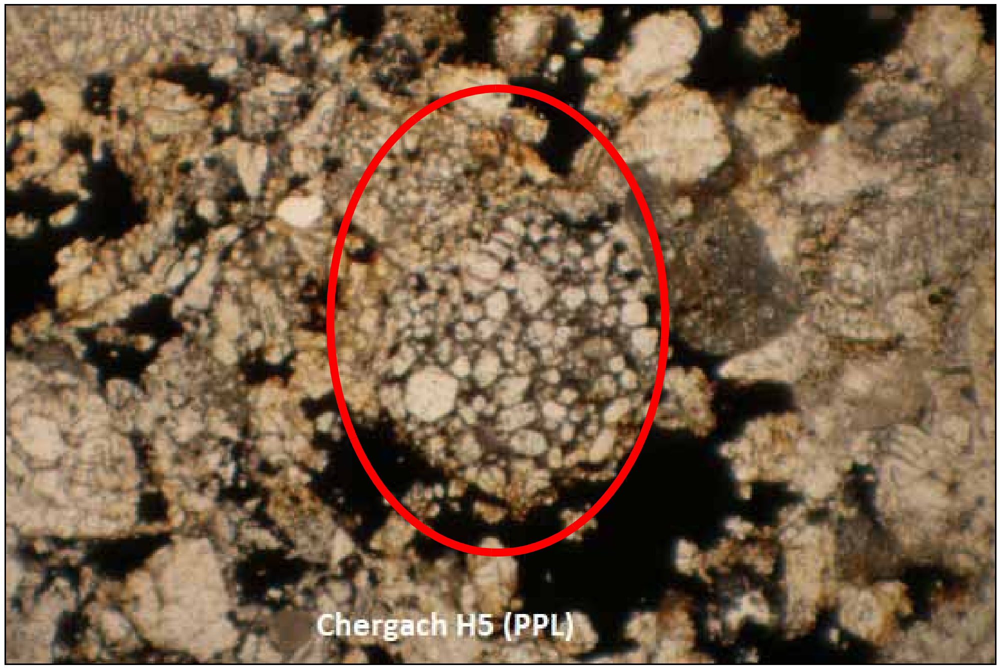
Inside the ALPO
Member, section and activity news

Tim Robertson does a great job asking interesting questions while I try my best not to bore the listener! Give these podcasts a try at:

https://soundcloud.com/observersnotebook

Be sure to also check out the other interesting podcasts offered by the many sections of ALPO!

Visit the ALPO Meteors Section online at www.alpo-astronomy.org/meteorblog/ Be sure to click on the link to viewing meteors, meteor shower calendar and references.



Microscope image in plane polarized light. FOV is approximately 2 mm across. The chondrule (circled) exhibits crystals of olivine set in a glassy groundmass. The irregular dark regions are opaque troilite (iron sulfide) and iron-nickel metal. The rest of the meteorite shows a recrystallized texture typical of type 5 chondrites. *Image by Joe Gianninoto.*

Meteorites Section

Report by Dolores H. Hill, section coordinator
dhill@lpl.arizona.edu

This report includes information about ALPO member contributions, meteorite highlights and new meteorite approvals from February 1, 2018 to April 30, 2018 from the Meteoritical Society's Nomenclature Committee. We received several inquiries of suspected meteorites which were terrestrial and did not require further analysis. A possible new iron-nickel meteorite was brought to the attention of the University of Arizona's Lunar & Planetary Lab. Evaluation is in progress.

ALPO members who collect meteorites are encouraged to report unusual features found in their meteorite samples. One recent example is an inquiry from Joe Gianninoto who has been studying his thin-section collection under a microscope. He inquired about an interesting porphyritic chondrule in the Chergach H5 meteorite that fell in Mali in July 2007.

The Meteoritical Bulletin (https://www.lpi.usra.edu/meteor/) records officially recognized, classified meteorites of the world's inventory. As of April 30, 2018, it contains a total of 58,967 meteorites (in contrast to 761,643 known asteroids recorded by the IAU Minor Planet Center; https://minorplanetcenter.net/mpc/summary). There were 1,536 new meteorites approved; most from hot desert regions of NorthWest Africa and Chile, Arizona, and the cold desert of Antarctica. More analyses will determine if many of the Antarctic meteorites of the same composition are paired with each other (fell at the same time). One interesting find is the Nagara IAB iron-nickel meteorite that was found in Japan.

Newly approved meteorites include 1,413 ordinary chondrites; 47 carbonaceous meteorites; 5 enstatite chondrites; 5 R chondrites; 7 irons; 13 ureilites; 67 HEDs; 6 lunar; 6 Martian; 3 lodranite; 2 ungrouped achondrites; 1 acapulcoite; 1 brachinite. For more information and official details on particular meteorites: https://www.lpi.usra.edu/meteor/metbull.php Yamato 003325 (Y-003325), the L6 chondrite from Antarctica, was the smallest meteorite reported this period with a mass of only 0.17 grams (!). The

Inside the ALPO
Member, section and activity news

largest meteorite approved was the 103.2 kilogram NorthWest Africa 11700 (NWA 11700) H4 chondrite.

Noteworthy falls approved by the Meteoritical Society's Nomenclature Committee this period are the Hamburg, Michigan H4 meteorite fall, Mukundpura CM2 carbonaceous chondrite from India weighing 2 kg that "shattered upon impact" and the Mazichuan diogenite that fell in China in 2016. The latter two witnessed falls were accompanied by loud detonations.

Visit the ALPO Meteorites Section online at *www.alpo-astronomy.org/meteorite/*

Comets Section

Report by Carl Hergenrother, section coordinator
chergen@lpl.arizona.edu

Comet Giacobini-Zinner was captured by the Kitt Peak 0.9-m telescope on 31 October 1998. North is up with east to the left. Image Credit: N.A.Sharp/NOAO/AURA/NSF

There is no denying that the first half of 2018 has been lacking in bright comets. The good news is things are about to change. The months of July, August and September will see a number of comets come within range of small telescope and binocular visual observers. The brightest should be periodic comet 21P/Giacobini-Zinner which is predicted to reach 6th-7th magnitude in September. Two long-period comets, C/2016 M1 (PANSTARRS) and C/2017 T3 (ATLAS), should brighten to 8th magnitude though both will be too far south for most northern observers. Another long-period comet, C/2017 S3 (PANSTARRS), was predicted to reach 7th-8th magnitude in July. Unfortunately, this dynamically new comet is brightening at such a slow rate that it may not even break 10th magnitude before moving too close to the Sun for observation.

No less than five short-period comets are expected to become brighter than magnitude 12.0:

- The brightest should be 21P/Giacobini-Zinner. Many long-time observers may remember this comet's last excellent return in the fall of 1985 just as Comet Halley was rapidly approaching its February 1986 perihelion. This year marks G-Z's 16th observed return since its visual discovery in 1900 by Michel Giacobini (Nice, France). The comet was visually re-discovered 2 returns later in 1913 by Ernst Zinner (Bamberg, Germany), hence the double appellation. Perihelion and closest approach to Earth both occur on September 10 at 1.01 AU and

Inside the ALPO

Member, section and activity news

Ephemerides for Comets 21P/Giacobini-Zinner, 364P/PANSTARRS, 38P/Stephan-Oterma, 46P/Wirtanen, 48P/Johnson, C/2016 M1 (PANSTARRS), C/2017 S3 (PANSTARRS) and C/2017 T3 (ATLAS)

Date	R.A.	Decl.	r (au)	d (au)	Elong. (deg.)	m1	Const	Max. El 40° N	Max. El 40° S
Comet 21P/Giacobini-Zinner									
2018 Jul 01	21 28.31	+50 08.0	1.41	0.85	97	11.1	Cyg	79	0
2018 Jul 11	21 58.62	+55 48.5	1.32	0.76	95	10.4	Cep	74	-6
2018 Jul 21	22 42.45	+61 05.7	1.24	0.68	92	9.6	Cep	69	-11
2018 Jul 31	23 50.46	+65 14.9	1.17	0.60	88	8.8	Cas	65	-15
2018 Aug 10	01 30.66	+66 28.7	1.11	0.53	85	8.1	Cas	62	-17
2018 Aug 20	03 21.80	+62 08.3	1.06	0.46	82	7.5	Cam	62	-12
2018 Aug 30	04 47.50	+51 16.3	1.03	0.41	80	7.0	Per	62	-3
2018 Sep 09	05 43.77	+35 33.0	1.01	0.39	79	6.8	Aur	60	10
2018 Sep 19	06 21.18	+18 17.6	1.02	0.40	80	6.9	Gem	53	25
2018 Sep 29	06 47.32	+02 47.6	1.05	0.44	83	7.3	Mon	45	38
Comet 38P/Stephan-Oterma									
2018 Jul 01	02 29.50	-01 41.6	2.26	2.49	65	16.2	Cet	6	42
2018 Jul 11	02 49.32	-00 11.4	2.18	2.32	69	15.7	Cet	13	43
2018 Jul 21	03 09.79	+01 17.2	2.11	2.16	73	15.1	Cet	20	43
2018 Jul 31	03 30.95	+02 44.1	2.03	2.00	76	14.4	Tau	26	43
2018 Aug 10	03 52.81	+04 09.7	1.96	1.85	80	13.8	Tau	33	42
2018 Aug 20	04 15.35	+05 34.6	1.89	1.71	83	13.2	Tau	39	41
2018 Aug 30	04 38.53	+06 59.8	1.83	1.57	87	12.6	Tau	45	40
2018 Sep 09	05 02.29	+08 26.9	1.77	1.45	90	12.0	Ori	50	39
2018 Sep 19	05 26.49	+09 58.0	1.72	1.33	94	11.5	Ori	55	37
2018 Sep 29	05 51.00	+11 36.0	1.68	1.22	97	10.9	Ori	59	36
Comet 46P/Wirtanen									
2018 Jul 01	00 14.50	-13 18.1	2.19	1.76	100	18.5	Cet	21	63
2018 Jul 11	00 28.34	-13 13.6	2.11	1.58	106	18.1	Cet	26	63
2018 Jul 21	00 41.86	-13 24.9	2.03	1.40	112	17.6	Cet	31	63
2018 Jul 31	00 54.98	-13 54.9	1.94	1.24	118	16.8	Cet	34	64
2018 Aug 10	01 07.54	-14 47.0	1.86	1.08	124	16.0	Cet	35	65
2018 Aug 20	01 19.29	-16 04.6	1.77	0.94	130	15.2	Cet	34	66
2018 Aug 30	01 30.01	-17 49.9	1.69	0.81	136	14.3	Cet	32	68
2018 Sep 09	01 39.36	-20 03.7	1.60	0.69	140	13.4	Cet	30	70
2018 Sep 19	01 46.95	-22 43.0	1.52	0.59	143	12.5	Cet	27	73
2018 Sep 29	01 52.57	-25 38.8	1.43	0.50	144	11.5	For	24	76
Comet 48P/Johnson									
2018 Jul 01	22 28.95	-16 26.1	2.03	1.26	125	11.9	Aqr	31	66
2018 Jul 11	22 36.53	-17 38.9	2.02	1.18	133	11.6	Aqr	32	68
2018 Jul 21	22 41.46	-19 14.4	2.01	1.11	142	11.4	Aqr	31	69
2018 Jul 31	22 43.58	-21 08.3	2.01	1.06	150	11.3	Aqr	29	71
2018 Aug 10	22 42.98	-23 11.7	2.01	1.03	158	11.2	Aqr	27	73
2018 Aug 20	22 40.13	-25 11.5	2.01	1.01	163	11.1	PsA	25	75
2018 Aug 30	22 36.04	-26 53.5	2.01	1.02	162	11.2	PsA	23	77
2018 Sep 09	22 31.89	-28 06.1	2.02	1.06	155	11.3	PsA	22	78
2018 Sep 19	22 28.93	-28 42.9	2.03	1.11	147	11.6	PsA	21	79
2018 Sep 29	22 28.13	-28 43.7	2.04	1.18	139	11.8	PsA	21	79
364P/PANSTARRS									
2018 Jul 01	08 18.64	-04 58.9	0.81	0.29	37	10.9	Hya	-26	18
2018 Jul 11	07 23.09	-17 34.1	0.84	0.25	39	10.8	Cma	-50	7

0.39 AU, respectively. This will be the comet's closest approach to Earth since 1959 when it passed 0.35 AU from Earth. In case you're wondering, the orbit of G-Z currently passes within 0.016 AU of Earth's. As a result, G-Z is responsible for the annual Draconids (sometimes called the Giacobinids) meteor shower that experienced large storms in 1933 and 1946. The closest G-Z is known to have come to Earth was during the meteor storm year of 1946 at 0.26 AU. 2018 will be its closest to Earth until 2078 when it passes us at 0.32 AU.

G-Z starts July near magnitude 11. The comet will steadily brighten to magnitude 10 by mid-July, 9 by late July, 8 by mid-August and 7 by the beginning of September. It will be well placed for northern comet watchers as it glides through Cygnus, Cepheus, Cassiopeia, Camelopardalis and Perseus during July and August. During September the comet will peak around magnitude 6.8 and start moving south through Auriga, Gemini and Monoceros. For all three months it will remain a morning object.

- 38P/Stephens-Oterma is returning for the first time since 1980. This comet has a bit of an interesting backstory. In 1867, it was first sighted by Jérôme E. Coggia (Marseilles, France) who thought he had found an uncatalogued nebula. Over the following nights, followup observations by E. J. M.

Inside the ALPO

Member, section and activity news

Stephens (Marseilles, France) uncovered the true nature of the object. For some reason, the discovery announcement cited Stephens as the discoverer with no mention of Coggia. Though Coggia would go on to discover six more comets, 38P was his first. After being missed at its next return in 1904, the comet was photographically rediscovered in 1942 by Liisi Oterma (Turku, Finland).

This quarter, 38P will be a morning object as it brightens from 16th magnitude in early July to magnitude 11 by the end of September and ultimately peak around magnitude 9.0 to 9.5 in late November. In 1980, Stephens-Oterma approached to within 0.59 AU of Earth and brightened to between magnitude 8.5 and 9.0. This year's return will be a little further away at 0.76 AU, hence the slightly fainter maximum brightness. Perihelion occurs this year on November 10 at 1.59 AU.

- 46P/Wirtanen starts July at a very faint 18th magnitude. While only as bright as 11th magnitude by the end of September, this comet will pass within 0.08 AU of the Earth in mid-December at which time it should become the brightest comet of 2018 as a naked eye object of 3rd magnitude. The comet spends this summer and early fall moving slowly to the south. That will rapidly change in late October as the comet stars moving rapidly northward becoming well placed for both hemispheres when at its brightest.

Wirtanen's perihelion distance has seem rapid evolution due to frequent close approaches to Jupiter. When discovered photographically in 1947 by Carl Wirtanen (Palomar Obs.), its perihelion was at 1.63 AU. This distance dropped to 1.25 AU in

Ephemerides for Comets 21P/Giacobini-Zinner, 364P/PANSTARRS, 38P/Stephan-Oterma, 46P/Wirtanen, 48P/Johnson, C/2016 M1 (PANSTARRS), C/2017 S3 (PANSTARRS) and C/2017 T3 (ATLAS) (Continued)

2018 Jul 21	06 04.74	-28 09.6	0.91	0.24	56	11.4	Col	-31	35
2018 Jul 31	04 42.97	-33 38.8	0.99	0.25	76	12.4	Cae	-11	59
2018 Aug 10	03 32.02	-35 12.0	1.08	0.29	96	13.6	For	5	78
2018 Aug 20	02 32.10	-34 40.4	1.18	0.33	114	14.9	For	14	85
2018 Aug 30	01 41.34	-32 52.2	1.29	0.38	130	16.2	Scl	17	83
2018 Sep 09	00 59.81	-30 13.2	1.39	0.45	144	16.6	Scl	20	80
2018 Sep 19	00 28.10	-27 06.8	1.50	0.54	152	17.0	Scl	23	77
2018 Sep 29	00 05.87	-23 55.6	1.60	0.64	153	17.4	Cet	26	74
C/2016 M1 (PANSTARRS)									
2018 Jul 01	17 39.23	-46 24.6	2.26	1.30	153	8.6	Ara	3	83
2018 Jul 11	16 51.59	-51 31.4	2.24	1.37	139	8.7	Ara	-2	78
2018 Jul 21	16 5.73	-54 33.6	2.22	1.48	124	8.8	Nor	-6	75
2018 Jul 31	15 28.01	-56 6.2	2.21	1.63	111	9.0	Cir	-10	74
2018 Aug 10	15 0.47	-56 53.7	2.21	1.78	100	9.2	Cir	-14	70
2018 Aug 20	14 42.17	-57 28.3	2.21	1.95	91	9.4	Cir	-18	63
2018 Aug 30	14 31.15	-58 7.5	2.22	2.11	82	9.6	Cen	-22	55
2018 Sep 09	14 25.65	-58 59.4	2.24	2.27	75	9.8	Cen	-25	48
2018 Sep 19	14 24.35	-60 7.3	2.26	2.41	69	10.0	Cen	-28	42
2018 Sep 29	14 26.33	-61 32.4	2.28	2.54	63	10.1	Cen	-30	37
C/2017 S3 (PANSTARRS)									
2018 Jul 01	03 01.69	+59 24.5	1.24	1.56	52	14.0	Cas	34	-15
2018 Jul 11	03 59.45	+58 25.9	1.03	1.31	50	13.2	Cas	33	-15
2018 Jul 21	05 14.84	+54 18.2	0.81	1.05	45	12.1	Aur	28	-16
2018 Jul 31	06 47.49	+42 05.8	0.56	0.83	33	10.7	Aur	15	-14
2018 Aug 10	08 27.17	+15 43.6	0.30	0.78	12	9.0	Cnc	-10	-8
2018 Aug 20	09 59.40	+01 37.4	0.26	1.16	11	9.5	Sex	-25	-10
2018 Aug 30	10 49.81	+06 14.0	0.51	1.51	5	11.7	Sex	-17	-13
2018 Sep 09	11 21.83	+10 02.6	0.76	1.76	5	13.1	Leo	-12	-19
2018 Sep 19	11 46.76	+12 48.3	0.99	1.96	11	13.9	Leo	-10	-25
2018 Sep 29	12 07.86	+14 59.1	1.20	2.12	17	14.6	Com	-4	-27
C/2017 T3 (ATLAS)									
2018 Jul 01	05 18.76	+05 24.6	0.89	1.69	26	9.5	Ori	-21	8
2018 Jul 11	06 00.82	-02 11.8	0.84	1.53	31	9.0	Ori	-25	12
2018 Jul 21	06 53.17	-10 51.2	0.83	1.41	35	8.7	Mon	-31	15
2018 Jul 31	07 57.21	-19 23.4	0.86	1.35	39	8.8	Pup	-38	14
2018 Aug 10	09 09.30	-26 00.4	0.92	1.38	41	9.2	Pyx	-45	10
2018 Aug 20	10 20.33	-29 39.9	1.02	1.49	42	9.8	Ant	-40	14
2018 Aug 30	11 22.11	-30 49.5	1.13	1.66	41	10.6	Hya	-33	17
2018 Sep 09	12 12.27	-30 34.0	1.25	1.86	39	11.3	Hya	-28	17
2018 Sep 19	12 52.36	-29 42.7	1.38	2.07	35	12.0	Hya	-24	15
2018 Sep 29	13 24.88	-28 41.1	1.51	2.29	30	12.7	Hya	-22	11

Inside the ALPO
Member, section and activity news

1974, 1.08 in 1986, 1.06 in 1997 and its current 1.05 in 2013. After a few more returns, Wirtanen's perihelia will start moving back out again to 1.06 AU in 2029, 1.08 in 2035, 1.22 in 2046 and 1.99 in 2059. 2018 is this comet's 12th observed return (missed only in 1980).

46P/Wirtanen is the focus of an amateur-professional collaboration called the 4*P Coma Morphology Campaign (https://www.psi.edu/41P45P46P). The collaboration is being organized by researchers at the Planetary Science Institute and requests images of the near-nucleus region of the comet. The images will be used to determine the rotational state of the nucleus, characterization of the nucleus' activity, characterization of outbursts, gas and dust properties in the coma (e.g., outflow velocities), chemical origin of gas species in the coma, and temporal behavior of the tail structure. The Comet Section will share appropriate images of 46P to the 4*P Coma Morphology Campaign with the consent of the observer.

- 48P/Johnson has a rather large perihelion distance (2.00 AU) for a (relatively) bright short-period comet. Perihelion and closest approach to Earth (1.01 AU) occur within a week of each other in mid-August making this as good a return as possible for 48P. The comet should spend the entire period from July through September between 11th and 12th magnitude as it moves among the stars of Aquarius and Piscis Austrinus. This year marks its 11th observed return since it was discovered in 1949 by Ernest L. Johnson on photographs taken at the Union Observatory in Johannesburg, South Africa.
- The last short-period comet is 364P/PANSTARRS. Discovered in 2013, 364P is making its second observed return. It has a relatively short period (4.9 years) and is only active for a few months around perihelion. It is similar to other usually inactive comets that are only active near or within 1 AU of the Sun (such as 169P/NEAT, 249P/LINEAR and 300P/Catalina). This year perihelion occurs on June 24 at 0.80 AU. If its activity is similar to 2013's, 364P should still be active as July beings and around 11th magnitude. At this time the comet will only be observable from the southern hemisphere (and even then at small elevations). Though the comet rapidly becomes less active it becomes much better placed for southern observers in mid-July into August after passing 0.24 AU from Earth on July 18. By mid-August, the comet will once again be visible to northern observers though by then it will have faded to 14th magnitude. Activity should have ceased by early September allowing CCD users the opportunity to directly image an inactive comet nucleus (between 16-17th magnitude). During this comet's next return in 2023, it will pass even closer to the Earth (0.12 AU) but this time while inbound and well placed for northern observers.

Three long-period comets should be brighter than 12th magnitude for some part of this quarter:

- The brightest is C/2016 M1 (PANSTARRS) which was discovered in June 2016 at 19th magnitude by the Pan-STARRS asteroid survey. The comet is dynamically old and has been brightening faster than expected. If it continues to brighten at a similar rate, it should start July around magnitude 8.6. Though the comet is still approaching an August 10 perihelion at 2.21 AU, it will be past opposition and should slowly fade to magnitude 9 by late July and 10 by mid September. This is another comet that will be located at far southern declination making it visible only from the southern hemisphere.
- The next comet, C/2017 S3 (PANSTARRS), is a big question mark. Dynamically new and intrinsically faint, this comet has displayed a very slow intrinsic brightening since its September 2017 discovery. It will reach a small perihelion distance of 0.21 AU on August 15. Though the comet will be located too close to the Sun at that time, the hope was it would become bright (7th-8th magnitude) before becoming lost in the glare of the Sun. The predicted magnitudes in the ephemeris table is an

Inside the ALPO
Member, section and activity news

extrapolation of Its recent slow brightening trend. To be honest, it is likely wrong and the comet's actual brightness may be many magnitudes brighter or fainter. There is also a real possibility that this comet is small and will disintegrate at it nears the Sun. Imagers (and if brighter, visual) observers are asked to monitor this comet during July as it will still be observable in the far northern sky. If the comet is still with us and bright, it will be visible in the SOHO LASCO C3 FOV in late August through early September.

- C/2017 T3 (ATLAS) will only be visible from the southern hemisphere as a morning object. This comet has some good things going for it, such as being dynamically old and brightening rapidly. The downside, other than not being visible to northerners, is it will be located rather far from Earth when it reaches its July 19 perihelion at 0.83 AU. The comet should start July around magnitude 9.5, peak at 8.7 near the time of perihelion and then fade to 9 in early August, 10 in late August and 12.7 by the end of September.

As always, the ALPO Comets Section solicits comet observations of all kinds for these and all comets, past and present. Please e-mail your observations to this section coordinator's e-mail address given at the beginning of this report.

Drawings and images of current and past comets are being archived in the ALPO Comets Section image gallery at http://www.alpo-astronomy.org/gallery/main.php?g2_itemId=4491

Please consider reporting all your comets observations, past and present, to ALPO Comets Section Coordinator Carl Hergenrother at the email address listed at the beginning of this report.

Visit the ALPO Comets Section online at www.alpo-astronomy.org/comet

Solar Section

Report by Rik Hill, section coordinator & science advisor
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Things remain stable and quiet in the ALPO Solar Section, just like the Sun itself. This report indicates as much with the solar activity of the last quarter. So far this year (May 1), we have had 71 days without spots, which is 68% of the 104-day total of 2017. We are likely to top 150 such days for the year.

Due to the greatly decreased solar activity, some observers reduced their observing activity. This is normal and happened in previous solar minima as well. However we did manage to welcome a new member, Jeffrey Carels, and we look forward to his participation. Welcome aboard Jeffrey!

Since the last ALPOSS report, the website - and most particularly the Archive (aka "Gallery3") - was migrated to a new server environment. While this involved the work of Assistant Coordinator Theo Ramakers, much of the work was done by the ISP itself and Larry Owens, ALPO Online Section and ALPO Computing Section coordinator. The Solar Section archive was reconstructed from scratch using backed-up data from over 36,672 reports and images in 552 folders.

Our email list continues its important function as a vital communications link to observers under the watchful eye of Assistant Coordinator Rick Gossett giving, observers a way of sharing observations during this web-outage period and providing the staff a means of promulgating information about solar and section activity. Assistant Coordinator Pam Shivak continues to keep our presence on FaceBook, where a lot of our new members come from and where the ALPO has its own page.

To join the Yahoo Solar ALPO e-mail list, please go to https://groups.yahoo.com/neo/groups/Solar-Alpo/info

For information on solar observing – including the various observing forms and information on completing them – go to www.alpo-astronomy.org/solar

Mercury Section

Report by Frank J. Melillo, section coordinator
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I am hoping that many of you had a fine view of Mercury in the evening sky last March. It was standing pretty high in the west about 30 minutes after sundown, especially on March

Inside the ALPO
Member, section and activity news

15, when it reached its Greatest Elongation from the Sun. With the naked eye, Mercury displayed a brighter-than-average magnitude of -0.3. It looked like a rosy color twinkling against the darkening sky.

Normally, Mercury is more eye-catching when it is near a bright object such as a planet or even a thin crescent Moon during the course of an apparition. Well, it was no exception in March. First, on February 17, Mercury reached Superior Conjunction with the Sun and then became an evening object.

It wasn't until March 3 that Mercury slid just over 1 degree to right of Venus. They made a nice pair but were low in the bright twilight.

Another opportunity came on March 18, and that time, it was a thin crescent Moon that joined the group. It was a stunning view with the naked eye. It was also quite rare to see Mercury above Venus and even the crescent Moon! Unfortunately, it wasn't a very close conjunction, and they were pretty much far apart. The Moon passed nearly 7 ½ degrees south of Mercury while Venus remained exactly in the middle! This author took the opportunity to image all three objects in a single frame.

By the time you read this, Mercury is again in the evening sky, but in a less-than-favorable position, though it may be visible briefly around mid-July about 1 hour after sundown. This time, Mercury will display a fainter-than-average magnitude of only +0.7 with a nearby crescent Moon again on July 14.

If you wait until the second half of August, Mercury will shine at somewhat the best morning apparition of the year. (It may even tie with another favorable morning apparition later in December. More about that in JALPO60-4.) On August 26, Mercury will reach its Greatest Elongation 18 degrees west of the Sun, which is not a great distance. But the ecliptic is very steep and Mercury will lie directly above the sunrise point.

From our northern hemisphere, this makes Mercury easily visible - it will be at 0.0 magnitude. But take note…if you wait a week later, for instance September 4, Mercury will shine a full magnitude brighter at -1! It will be easily visible with the naked eye 45 minutes before sunrise.

Visit the ALPO Mercury Section online at *www.alpo-astronomy.org/mercury*

Venus Section

Report by Julius Benton, section coordinator
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Venus appears in the evening sky throughout the summer months, attaining greater altitude above the western horizon as it attains greatest elongation east on August 17 and reaching theoretical dichotomy (half phase) on August 15th.

During the current 2018 Eastern (Evening) Apparition Venus continues to pass through its waning phases (a progression from a nearly fully illuminated disk through crescent phases). Thus, observers are witnessing the leading hemisphere of the planet as it increases its apparent diameter at the time of sunset on Earth. It will reach greatest brilliancy on September 22 at visual magnitude -4.7, and will enter into inferior conjunction with the Sun on October 27, ending the eastern (evening apparition.

The accompanying Table of Geocentric Phenomena in Universal Time (UT) for the eastern (evening) Venus apparition is included here for the convenience of observers.

As of early April, the ALPO Venus Section is awaiting for observers to submit their digital images of Venus taken in integrated light, with color filters, and at UV and IR wavelengths as well as visual drawings for the first several months of the eastern (evening) apparition.

Readers of this Journal should be well-acquainted with our on-going

Geocentric Phenomena of the 2018 Eastern (Evening) Apparition of Venus in Universal Time (UT)

Superior Conjunction	2018 Jan 09^d 10^h (angular diameter = 9.7″)
Greatest Illuminated Extent	Sep 22 00 UT (m_v = –4.7)
Predicted Dichotomy	Aug15.22 ^{d} (Venus is predicted to be exactly half-phase)
Greatest Elongation East	Aug 17 00 (46°)
Inferior Conjunction	Oct 27 11 (angular diameter = 61.8″)

Inside the ALPO
Member, section and activity news

collaboration with professional astronomers as exemplified by our sharing of visual observations and digital images at various wavelengths during ESA's previous Venus Express (VEX) mission that ran from 2006 and ended in 2015. It was a tremendously successful Pro-Am effort involving ALPO Venus observers around the globe. These observations shall remain important for further study and will continue to be studied and analyzed for several years to come as a result of this endeavor. For reference, the VEX website is

http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=38833&fbodylongid=1856.

A follow-up Pro-Am effort remains underway with Japan's (JAXA) *Akatsuki* mission that began full-scale observations back in April 2016. The mission is continuing well into 2018, and the website for *Akatsuki* mission has already "gone live" so that interested and adequately equipped ALPO observers can register and start submitting images if they have not already done so. More information will continue to be provided on the progress of the mission in forthcoming reports in this Journal.

It is extremely important that all observers participating in the programs of the ALPO Venus Section always first send their observations to the ALPO Venus Section at the same time submittals are contributed to the *Akatsuki* mission.

This will enable full coordination and collaboration between the ALPO Venus Section and the *Akatsuki* team in collection and analysis of all observations whether they are submitted to the Akatsuki team or not. If there are any questions, please do not hesitate to contact the ALPO Venus Section for guidance and assistance.

Those still wishing to register to participate in the coordinated observing effort between the ALPO and Japan's (JAXA) *Akatsuki* mission should utilize the following link:

https://akatsuki.matsue-ct.jp/

The observation programs of the ALPO Venus Section are listed on the Venus page of the ALPO website at http://www.alpo-astronomy.org/venus as well as in considerable detail in the author's *ALPO Venus Handbook* available from the ALPO Venus Section as a pdf file.

Observers are urged to attempt to make simultaneous observations by performing digital imaging of Venus at the same time and date that others are imaging or making visual drawings of the planet. Regular imaging of Venus in both UV, IR and other wavelengths is important, as are visual numerical relative intensity estimates and reports of features seen or suspected in the atmosphere of the planet (for example, dusky atmospheric markings, visibility of cusp caps and cusp bands, measurement of cusp extensions, monitoring the Schröter phase effect near the date of predicted dichotomy, and looking for terminator irregularities).

Routine use of the standard ALPO Venus observing form will help observers know what should be reported in addition to supporting information such as telescope aperture and type, UT date and time, magnifications and filters used, seeing and transparency conditions, etc. The ALPO Venus observing form is located online at:

http://www.alpo-astronomy.org/gallery/main.php?g2_view=core.DownloadItem&g2_itemId=85642

Venus observers should monitor the dark side of Venus visually for the Ashen Light and use digital imagers to capture any illumination that may be present on the plane as a cooperative simultaneous observing endeavor with visual observers. Also, observers should undertake imaging of the planet at near-IR wavelengths (for example, 1,000 nm), whereby the hot surface of the planet becomes apparent and occasionally mottling shows up in such images attributable to cooler dark higher-elevation terrain and warmer bright lower surface areas in the near-IR.

The ALPO Venus Section encourages readers worldwide to join us in our projects and challenges ahead.

Individuals interested in participating in the programs of the ALPO Venus Section are encouraged to visit the ALPO Venus Section online http://www.alpo-astronomy.org/venusblog/

Inside the ALPO
Member, section and activity news

Lunar Section

Lunar Topographical Studies / Selected Areas Program

Report by Wayne Bailey, program coordinator
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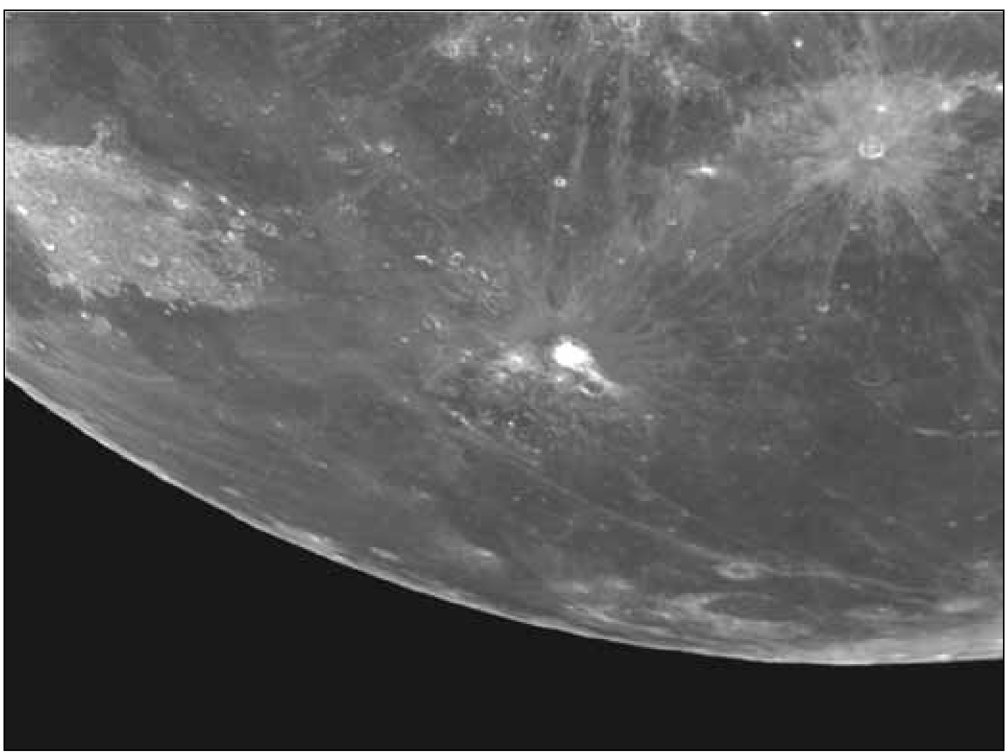
The ALPO Lunar Topographical Studies Section (ALPO LTSS) received a total of 162 observations from 14 observers during the January-March quarter.

Fifteen contributed articles were published in addition to numerous commentaries on images submitted.

Bill Dembowski continued the series of articles on lunar rays and the *Focus-On* series continued under Jerry Hubbell with an article on Mountains & Mountain Ranges. The next *Focus-On* subject will be Craters-Latest & Greatest.

All electronic submissions should now be sent to both me and Assistant Coordinator Jerry Hubbell (*jerry.hubbell@alpo-astronomy.org*). Hard copy submissions should continue to be mailed to me at the address listed in the ALPO Resources section of the Journal.

Visit the following online web site for more info (including current and archived issues of *The Lunar Observer*):
moon.scopesandscapes.com



Aristarchus as imaged by Juan Manuel Biagi, Oro Verde, Argentina, April 21, 2016, 2209 UT, 25-cm Schmidt-Cassegrain (Meade LX200), QHYCCD QHY5-II CCD video camera, north/up, east/right. (Source: May 2018 *The Lunar Observer*.)

Lunar Meteoritic Impacts

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Please visit the ALPO Lunar Meteoritic Impact Search site online at *www.alpo-astronomy.org/lunar/lunimpacts.htm*.

Lunar Transient Phenomena

Report by Dr. Anthony Cook, program coordinator
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We welcome new participants in our program, whether they are experienced visual observers, or high-resolution lunar imagers. This helps us to solve some past historical lunar observational puzzles.

A list of dates and UTs to observe repeat illumination events can be found on: *http://users.aber.ac.uk/atc/lunar_schedule.htm*, and LTP observational alerts are given on this Twitter page: *https://twitter.com/lunarnaut*

Finally, please visit the ALPO Lunar Transient Phenomena site online at *http://users.aber.ac.uk/atc/alpo/ltp.htm*

Lunar Domes

Report by Raffaello Lena, acting program coordinator
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On March 2018, Lunar Planetary Science Conference abstracts were published regarding domes in Cauchy shield and near the crater Delisle. The published abstracts of our recent studies are online at the following

Inside the ALPO
Member, section and activity news

Lunar Calendar for July through September 2018 NEW

Date	UT	Event
Jul 06	03:51	Last Quarter
12	08:01	Moon Extreme North Dec.: 20.8° N
12	22:48	New Moon
12	23:01	Partial Solar Eclipse
13	04:28	Moon Perigee: 357400 km
13	22:50	Moon Ascending Node
14	18:04	Moon-Mercury: 2.2° S
15	23:31	Moon-Venus: 1.6° S
19	15:52	First Quarter
20	19:57	Moon-Jupiter: 4.8° S
25	02:10	Moon-Saturn: 2.2° S
25	16:55	Moon Extreme South Dec.: 20.8° S
27	01:44	Moon Apogee: 406200 km
27	16:21	Full Moon
27	16:22	Total Lunar Eclipse
27	18:40	Moon Descending Node
Aug 04	14:18	Last Quarter
08	18:33	Moon Extreme North Dec.: 20.8° N
10	09:40	Moon Ascending Node
10	14:05	Moon Perigee: 358100 km
11	05:47	Partial Solar Eclipse
11	05:58	New Moon
14	09:35	Moon-Venus: 6.4° S
17	06:38	Moon-Jupiter: 4.8° S
18	03:49	First Quarter
21	05:55	Moon-Saturn: 2.4° S
21	22:58	Moon Extreme South Dec.: 20.8° S
23	07:23	Moon Apogee: 405700 km
24	00:51	Moon Descending Node
26	07:56	Full Moon
Sep 02	22:37	Last Quarter
05	02:56	Moon North Dec.: 20.8° N
06	18:42	Moon Ascending Node
07	21:21	Moon Perigee: 361400 km
09	14:01	New Moon
13	22:21	Moon-Jupiter: 4.6° S
16	19:15	First Quarter
17	12:46	Moon-Saturn: 2.3° S
18	05:35	Moon Extreme South Dec.: 20.9° S
19	20:54	Moon Apogee: 404900 km
20	05:30	Moon Descending Node
24	22:53	Full Moon

Table courtesy of William Dembowski and NASA's SkyCalc Sky Events Calendar

links:

https://www.hou.usra.edu/meetings/lpsc2018/pdf/1005.pdf

https://www.hou.usra.edu/meetings/lpsc2018/pdf/1009.pdf

We received many images, including some by Mike Wirths and Rafael Benavides about Marius. Presently we are working on a report on Marius domes which is scheduled to appear in the ALPO Journal 60-4 (September 2018 release). For this study we analyzed 16 CCD images. Further, 30 images regarding other lunar domes have been received and made by Francesco Badalotti, Richard Hills, KC Pau, Ivica Zajac, Tom Astron, Rafael Benavides and Mike Wirths.

The purpose of future activity of the program is to update the lunar domes classification introduced by GLR group, the lunar domes catalogue, and to study the association with further volcanic structures and events that have occurred on the Moon, such as presence of lunar cones and pyroclastic material, originated by explosive activity, in contrast with the lava effusion characterizing the classical lunar mare domes.

Another aspect on which future studies might concentrate is spectral studies to identify the dome-forming minerals based on the recent data acquired by the Chandrayann-1's Moon Mineralogy Mapper (M^3) dataset.

Moreover, another promising aspect of future research activity on lunar domes is the analysis of the complex morphology of putative intrusive

Inside the ALPO
Member, section and activity news

domes associated with crustal fractures and faults which might be the "traces" of the laccolith-forming intrusion of pressurized magma between rock layers of the lunar crust, and the study of domes where different and subsequent effusive episodes occurred.

Interested observers can participate in the lunar domes program contacting and sending their observations to both me at *raffaello.lena@alpo-astronomy.org* and Jim Phillips at *thefamily90@gmail.com*

Mars Section

Report by Roger Venable, section coordinator
rjvmd@hughes.net

This favorable Mars apparition is now entering its best months as the July 28 opposition draws near. Right now is the time to start observing the recession of the South Polar Cap from week to week. We're all on alert for the development of dust storms. Many observers have committed themselves to studying Mars, as they'll not get a comparable chance for another 15 years.

What colors do you see in the bright and dark albedo features? Visual reports of color are interesting, as images have the disadvantage of lacking faithfulness to visual impressions of color. I have seen the "deserts" as red or as orange or as ochre, while the darker features sometimes appear blue and sometimes green. Do you detect any color in the polar caps, as some observers have? If an observer makes repeated descriptions of perceived color, the observations can be analyzed to ascertain whether the perceived color is related to phase angle, or to aperture, or to Mars' apparent brightness. Some observers may be able to measure color by using consistent image processing techniques. What can you do?

Once you get to know the albedo features of Mars, observing them is like seeing your old friends. . . like greeting the stars in the evening as they come into view in the deepening twilight. I hope you renew your acquaintance with the Red Planet this year.

Send your reports directly to me at the address below my name at the beginning of this report or post them

South is up in this remarkably clear image of Mars made by Damian Peach. Note the South Polar Cap visible through the clouds of the thinning South Polar Hood, and the detail in the dark albedo features. Made on April 17, 2018, at 10:27 UT, using a Ritchey-Chrétien telescope of 1 meter aperture (the Chilescope instrument — see *http://www.chilescope.com/about/chilescope/*). Seeing good, transparency good.

Inside the ALPO
Member, section and activity news

in the photos section of the Yahoo Mars observers group at https://groups.yahoo.com/neo/groups/marsobservers . As of this writing, there are 1,444 members of this group, so you'll be in good company.

We'll soon have observations to add to the Mars Section's recent observations page at www.alpo-astronomy.org/mars. For detailed information about observing Mars, be sure to check out the Mars Observers' Cafe — find the link in the list on the right side of the Mars page on the ALPO website.

Minor Planets Section

Frederick Pilcher, section coordinator
pilcher35@gmail.com

Some of the highlights published in the *Minor Planet Bulletin*, Volume 45, No. 2, 2018 April-June, are hereby presented. These highlights represent the recent achievements of the ALPO Minor Planets Section.

Minor planet 3122 Florence made an approach to 0.047 AU from Earth 2017 Aug. 30. Radar observations at Goldstone revealed the shape of this large (about 4.4 km) Earth-approacher, and that it had two satellites. Many people obtained rotational lightcurves over the interval 2017 Aug. 30 to Oct 6. These lightcurves all showed a rotation period of 2.357 hours.

A team led by Onofre Rodrigo observed ligthcurve dips due to transits/occultations by a satellite (called satellite events) indicating an orbital revolution period of 11.899 hours. Another team led by Lorenzo Franco found that the observed synodic rotation period decreases as the daily rate of change of phase angle bisector increases, suggestive of retrograde rotation. Franco obtained the reflectance spectrum with a diffraction grating that shows colors very close to those for a typical taxonomic class S asteroid. Franco also constructed from lightcurve data alone a shape model very similar to the shape found from radar data.

Robert Stephen and Brian Warner find several asteroids with two superposed periods. The Trojan 2759 Idomeneus has a long period of 479 +/- 5 hours and a less well-defined short period near 33.2 hours or 19.3 hours, amplitude 0.15 magnitudes. An explanation is suggested that this object is a wide binary, one component with slow rotation and the other with much faster rotation. For 4039 Souseki, primary rotation period 2.7720 hours, there are dips in the lightcurve suggesting a satellite with orbital revolution period 26.42 hours.

Brian Warner obtained new lightcurves of the previously well-observed objects 607 Jenny, 1864 Daedalus, and (17511) 1992 QN. Combining the new lightcurves with several that were previously obtained enabled him to construct lightcurve inversion models of the spin and shape. Sidereal periods thus found are: 607 Jenny, 8.52234 hours; 1864 Daedalus, 8.571974 hours; (17511) 1992 QN, 5.986762 hours.

In addition to asteroids specifically identified above, lightcurves with derived rotation periods are published for 149 other asteroids as listed below:

59, 126, 184, 295, 300, 435, 451, 597, 763, 775, 868, 892, 904, 917, 920, 958, 964, 965, 1034, 1065, 1105, 1118, 1134, 1167, 1173, 1181, 1182, 1197, 1218, 1255, 1283, 1405, 1426, 1439, 1499, 1529, 1590, 1599, 1637, 1639, 1664, 1677, 1741, 1883, 1888, 1953, 2052, 2144, 2241, 2353, 2440, 2483, 2578, 2633, 2733, 2847, 2881, 2893, 2951, 2998, 3107, 3176, 3200, 3262, 3561, 3694, 3737, 3809, 3849, 4297, 4317, 4435, 4576, 4650, 4692, 4911, 5049, 5130, 5189, 5392, 5585, 5605, 5661, 6490, 6669, 6693, 6779, 7336, 7505, 7996, 8037, 8256, 8433, 8484, 8551, 9671, 10132, 10498, 11745, 14158, 16852, 16943, 17182, 17428, 17915, 19743, 20885, 21374, 21766, 23738, 24388, 25980, 26083, 26203, 29564, 33982, 41488, 46436, 51511, 51888, 53110, 54469, 60984, 69315, 81645, 82660, 102588, 140158, 143404, 146042, 154589, 171576, 174621, 177200, 225482, 418849, 438430, 2000 RE52, 2003 UV11, 2004 SS, 2006 XY, 2008 YZ32, 2017 QQ32, 2017 UK8, 2017 VC, 2017 VD, 2017 WL1, 2017 WX12.

Secure periods have been found for some of these asteroids, and for others only tentative or ambiguous periods. Some are of asteroids with no previous lightcurve photometry, others are of asteroids with previously published periods that may or may not be consistent with the newly determined values.

Inside the ALPO
Member, section and activity news

The *Minor Planet Bulletin* is a refereed publication and that it is available online at *http://www.minorplanet.info/mpbdownloads.html*.

Annual voluntary contributions of $5 or more in support of the publication are welcome.

Please visit the ALPO Minor Planets Section online at *http://www.alpo-astronomy.org/minor*

Jupiter Section

Report by section staff members Schmude, MacDougal and McAnally

Richard Schmude is once more at the helm of this section following the unfortunate choice by Ed Grafton to step down for health reasons. All wish Ed the best. In addition, Richard now also is coordinator of the Galilean Satellites Eclipse Program following the decision by John Westfall to also step down.

- *(From Richard Schmude)* Richard continues to collect brightness measurements of Jupiter in the Johnson V filter along with the near-infrared J and H filters. He proofread the 2014-2015 Jupiter apparition report and this should be available shortly. He hopes to start working on the 2015-2016 Jupiter apparition report sometime this year.
- *(From Craig MacDougal)* The ALPO_Jupiter Yahoo Group has 507 members as of May 1, 2018. The main activity of the group has been sharing copies of the images ALPO members have been submitting to the coordinators. The first images of the 2017 -2018 apparition were posted Dec 19 2017. As of May 1, 2018 over 240 images have been posted. The imagers have consistently

ALPO Book Authors

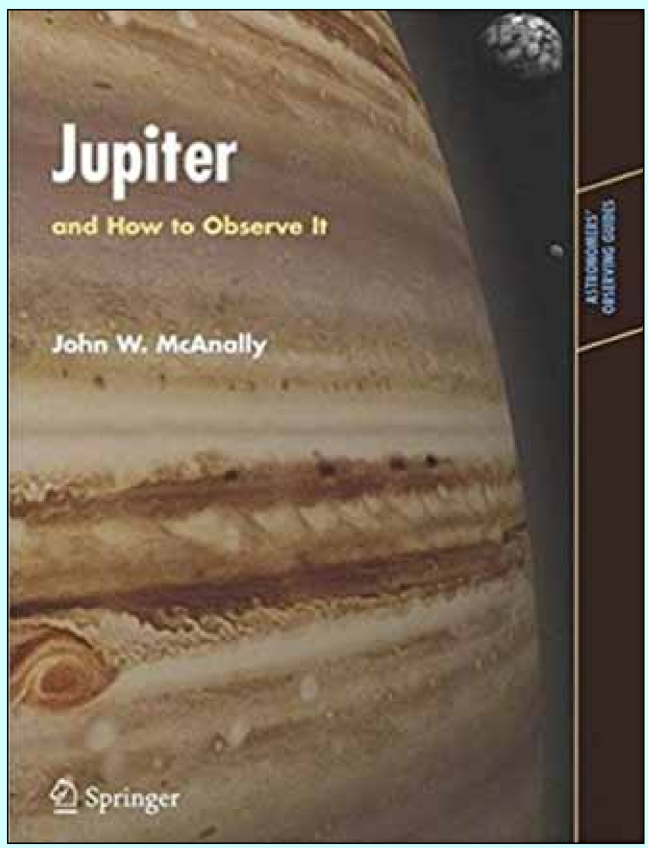
Besides this Journal, which includes detailed observation reports and similar data from various ALPO section coordinators, there are also a number of books written by ALPO members about various facets of solar system astronomy.

These books are published by Springer and are available at all the usual online and many brick-and-mortar outlets.

Beginning with this issue of your Journal, we will include mention of one of these books. Please consider adding any or all to your own personal collection.

Jupiter and How to Observe It (authored by John W. McAnally (Assistant Coordinator of the ALPO Jupiter Section Galilean Transit Timings program) can be found at booksellers such as *Amazon.com* and *Springer.com.* Besides the *Sky & Telescope* magazine review below, see also the past review in *Astronomy* magazine.

"McAnally gives you the background to make real contributions to our knowledge of Jupiter. He discusses how to make scientifically meaningful visual records as well as CCD images. … The book is a great read: McAnally's enthusiasm and experience shine through each page, and it's generously illustrated with color images and diagrams. As the latest addition to Springer's Astronomers' Observing Guide series, its scientific accuracy is assured by author, astrophysicist, and series editor Mike Inglis. … is an impeccable must-read for Jupiter enthusiasts!" (Jennifer Birriel, *Sky & Telescope* magazine, August, 2008)



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"It is a book … written by an amateur astronomer who has been analyzing Jupiter data for the Association of Lunar & Planetary Observers for several years. … This will prove a very useful book for those new to the giant planet." (Richard McKim, *The Observatory*, Vol. 128 (1207), December, 2008)

Inside the ALPO
Member, section and activity news

commented that the SEB following the GRS has been quite turbulent so far in the apparition. More than one of the imagers has been able to capture detail within the GRS.

- *(From John McAnally)* As the current apparition of Jupiter is underway, we encourage observers to make and record visual transit timings. Even in this age of CCD and web camera (web cam) imaging, we believe visual transit timings continue to be of great importance.

  Why important? Well, for one reason, an observer might be that one person who has clear weather the night an important feature can be seen. Or, one might be the only observer to confirm the sighting of a feature reported by another observer. In this day of web cam and CCD imaging, perhaps the most important reason for visual transit timings is the training value this procedure provides. The beginner especially needs to become familiar with the features that can be seen and what events may take place on the planet. The only way to know that something new has occurred is to be familiar with what has been going on. Consistent, repeated observation is the only true way to gain this knowledge. The surface features on Jupiter change often, and one apparition to the next is never exactly the same.

  There are publications that explain the procedures for making, recording, and reporting transit timings. One resource I am very proud of is my book, *Jupiter and How to Observe It*, published by Springer. This book was written so that an amateur can understand how to make a valuable observation the very first night out with Jupiter.

  So, even though the number of visual transit timing reports has declined recently, it is still a very valuable observation to perform and we strongly encourage participation. We are here to help folks get started! Send your reports directly to John at CPAjohnM@aol.com

Visit the ALPO Jupiter Section online at http://www.alpo-astronomy.org/jupiter

Galilean Satellite Eclipse Timing Program

Report by John Westfall, program coordinator
johnwestfall@comcast.net

An Excel catalog of this program's observations from the 1975/76 through the 2000/01 Jupiter apparitions is available from this section coordinator. The read-only, two-megabyte file contains the results of 10,308 visual timings, with 20 entries for each timing.

The data are more detailed than given in the reports published in this Journal over the years, and include observed UT, delta-t, the predicted event time based on the Lieske E-2 ephemeris, as well as the observer name, instrument aperture, and observing conditions.

Contact John Westfall via e-mail at johnwestfall@comcast.net or via postal mail at 5061 Carbondale Way, Antioch, CA 94531 USA to obtain an observer's kit, also available on the Jupiter Section page of the ALPO website.

Saturn Section

Report by Julius Benton, section coordinator
jlbaina@msn.com

Saturn is now reasonably well-placed for observation throughout the summer months, reaching opposition on June 27 and visible most of the night.

The accompanying Table of Geocentric Phenomena for the 2018-19 Apparition in Universal Time (UT) is included here for the convenience of observers.

As of this writing, the ALPO Saturn Section has started receiving excellent images of the planet at visual and infrared wavelengths during the 2018-19 apparition. Observers are reporting discrete atmospheric phenomena in Saturn's northern hemisphere, including what appears to be a recurring white spot in the EZn (northern half of the Equatorial Zone), as well as a few small possible white spots in the far northern latitudes, all best depicted in images at 685nm IR wavelength.

It will be extremely worthwhile to continue to monitor Saturn for the possible continued appearance of the aforementioned features and perhaps other similar features as the apparition progresses to determine their longevity and limits of visibility. Observers should be watchful for any new atmospheric phenomena that might suddenly appear. With the rings tilted as much as +26° towards our line of sight from Earth in 2018-19, observers will still have near-optimum views of the northern hemisphere of the globe and north face of the rings during the apparition.

Pro-Am cooperation with the Cassini mission continued during the previous 2016-17 apparition as NASA's unprecedented close-range surveillance of the planet for nearly thirteen years, that started back on April 1, 2004, concluded its remarkable odyssey on September 15, 2017 when it plunged into Saturn's atmosphere.

For years to come, however, planetary scientists will be carefully studying the vast database of images and data gleaned from the Cassini mission, and ALPO

Inside the ALPO
Member, section and activity news

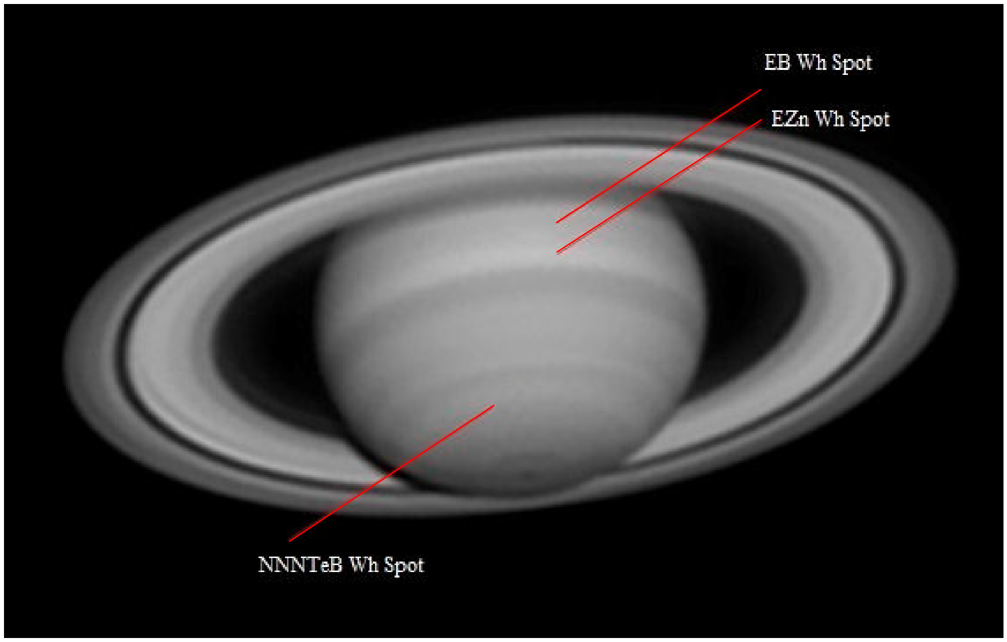
Saturn observers who were participating in our on-going Pro-Am activities are reminded that observations and images obtained prior to the time the spacecraft entered Saturn's atmosphere last September should still be submitted for comparative analysis with Cassini results.

Furthermore, our conscientious Pro-Am efforts will not cease in 2018-19, as we regularly monitor atmospheric phenomena on Saturn and actively share our results and images with the professional community. Thus, anyone who wants to join us in our observational endeavors is highly encouraged to submit systematic observations and digital images of the planet at various wavelengths throughout the new 2018-19 apparition as well as during the next observing season.

ALPO Saturn observing programs are listed on the Saturn page of the ALPO website at http://www.alpo-astronomy.org/saturn as well as in more detail in the author's book, *Saturn and How to Observe It*, available from Springer, Amazon.com, etc., or by writing to the ALPO Saturn Section for further information.

Observers are urged to pursue digital imaging of Saturn at the same time that others are imaging or visually monitoring the planet (that is, simultaneous observations). Also, while regular imaging of the Saturn is very important, far too many experienced observers neglect making visual numerical relative intensity estimates, which are badly needed for a continuing comparative analysis of belt, zone, and ring component brightness variations over time.

The ALPO Saturn Section thanks all observers for their dedication and perseverance in regularly submitting so many excellent reports and images. *Cassini* mission scientists, as well as other professional specialists, continue to



Excellent image of Saturn taken by Clyde Foster of Centurion, South Africa, on March 4, 2018 at 02:19 UT. His 685nm IR image was captured in good seeing using a 35.6cm (14.0 in.) SCT. His image shows the recurring diffuse white spot within the EZn adjacent to the EB, plus other white spots in Saturn's northern hemisphere, plus numerous other belts and zones on Saturn. Cassini's division (A0 or B10) is quite obvious running all the way around the circumference of the rings except where the globe blocks our view of the rings. Also seen are Keeler's gap (A8) and Encke's "complex" (A5) as well as a few additional "intensity minima" at the ring ansae. The north polar hexagon is also visible. The apparent diameter of Saturn's globe was 16.9 arc-seconds, with a ring tilt of +25.7°. CMI = 85.5°, CMII = 163.0°, CMIII = 12.8°. Visual magnitude +0.6, and South is at the top of the image.

Geocentric Phenomena for the 2018-19 Apparition of Saturn in Universal Time (UT)

Conjunction	2017 Dec 21^d UT
Opposition	2018 Jun 27^d
Conjunction	2019 Jan 02^d
Opposition Data for June 27, 2018:	
Equatorial Diameter Globe	18.3″
Polar Diameter Globe	161″
Major Axis of Rings	41.5″
Minor Axis of Rings	18.2″
Visual Magnitude (m_v)	0.0
B = Declination Constellation	+26.0° -22..5° Ophiuchus

Inside the ALPO
Member, section and activity news

request drawings, digital images, and supporting data from amateur observers around the globe in an active Pro-Am cooperative effort.

Information on ALPO Saturn programs, including observing forms and instructions, can be found on the Saturn pages on the official ALPO Website at *www.alpo-astronomy.org/saturn*

All are invited to also subscribe to the Saturn e-mail discussion group at *Saturn-ALPO@yahoogroups.com*

Remote Planets Section

Report by Richard W. Schmude, Jr., section coordinator
schmude@gordonstate.edu

The planets Uranus and Neptune will be visible in the early morning hours during July and August. The best way to image albedo features on both planets is to use a red or near-infrared filter. Several people have succeeded in imaging features with telescopes as small as 0.3 meters (12 inches). Brightness measurements of both planets are also needed. The ALPO Remote Planets Section is currently investigating how the brightness of both planets changes with time.

This coordinator has received brightness measurements from Jim Fox. These will be combined with measurements made by Richard Schmude Jr. Several people have also submitted images of both planets.

Pluto will reach opposition in July. A worthwhile project will be to use a CCD camera to image this planet and measure its brightness. Accurate brightness measurements are possible with telescopes as small as 0.25 meters (10 inches).

This coordinator plans to start writing the next Remote Planets apparition report in June of 2018.

[Editor's Note: *skyandtelescope.com* is a great source to find specific locations of sky objects.]

Finally, a reminder that the book *Uranus, Neptune and Pluto and How to Observe Them*, which was authored by this coordinator, is available from Springer at *www.springer.com/astronomy/popular+astronomy/book/978-0-387-76601-0* or elsewhere (such as *www.amazon.ca/Uranus-Neptune-Pluto-Observe-Them/dp/0387766014*) to order a copy.

Visit the ALPO Remote Planets Section online at *www.alpoastronomy.org/remote*

Letter to the Editor

To the editor:

Richard Schmude's article, "The North Polar Region of Mars in 2016" (*JALPO 60*(2): pp. 49-56) alerts us to a type of large, annular cloud that may not have been noticed by amateurs. These clouds are typically documented by orbiting spacecraft -- first, the Mars Orbiter Camera aboard Mars Global Surveyor, and now the Mars Color Imager (MARCI) aboard the Mars Reconnaissance Orbiter -- and have occasionally been imaged by the Hubble Space Telescope. In principle, they should be detectable by Earth-bound observers, in view of their size.

The prime observing time for them, as Schmude states, is late northern spring to the middle of northern summer, speaking of Martian seasons rather than those of Earth. In the current apparition, this favorable observing time ended in February of this year, and Mars' apparent diameter was quite small during that time. I have scanned the 2016 and 2014 apparitions of the planet for ALPO observations showing any annular cloud in the North Polar Region, and though there are occasional clouds documented there, none clearly appears to be an annulus. It therefore seems that these will be a challenge to observe.

Schmude stated, "They are not true cyclones," as they do not rotate, and they last less than a day, forming after sunrise and dissipating before sundown. I want to emphasize that, though they have an annular shape like that of a cyclone, they are quite different from the storms and cyclones that I measured along the North Polar Front (the edge of the North Polar Hood) before it dissipated with the beginning of northern spring. Those that I measured all lasted longer than one sol (Martian day), and occurred at an Ls different from that of the annular clouds. In two successive issues of the JALPO, we Mars Section coordinators have presented studies of two types of round cloud patterns in the North Polar Region, and I want to be sure that the two are not convolved.

-- Roger Venable
Coordinator, ALPO Mars Section

Notable Deaths

ALPO Member, Staffer Fr. Ken Delvano

By Matthew L. Will and John E. Westfall

We learned last Christmas through a holiday correspondence from his sister Dolores Cote that former ALPO Lunar Domes Recorder Father Kenneth J. Delano passed away on May 28, 2017 at the age of 83.

For some ALPO members that go far enough back to remember, Fr. Ken became involved with the ALPO Lunar Section in July 1965, as a lunar recorder (we now call them coordinators) and

Inside the ALPO
Member, section and activity news

beginning in February 1966, headed the Lunar Dome Survey until November 1976.

Besides his lunar domes work, Fr. Ken also studied dark-haloed lunar craters and the satellites of Saturn. He also authored two books: *Astrology; Fact or Fiction?* (1973) and *Many Worlds, One God* (1977).

Although not active in the ALPO in recent years, in the past, Fr. Ken also contributed to the Journal, attended ALPO conventions, and was an ALPO member for much of his life until his passing last May.

Fr. Ken was born in Taunton, Massachusetts, on April 12, 1934. He was ordained to the Catholic priesthood on April 2, 1960 and served in various capacities as a parochial vicar and pastor for a number of parishes in Massachusetts and retired from the priesthood in 2003.

In addition to astronomy, he enjoyed traveling, wildlife, and his family. He is survived by his sister, Dolores Cote, her husband, Paul W. Cote, of Taunton, and sister-in-law, Dorothea Delano of North Carolina, wife of his late brother, Donald. Fr. Ken also leaves several nieces and nephews.

(Portions of this obituary were provided by The Anchor, Taunton Daily Gazette, and Legacy.com)

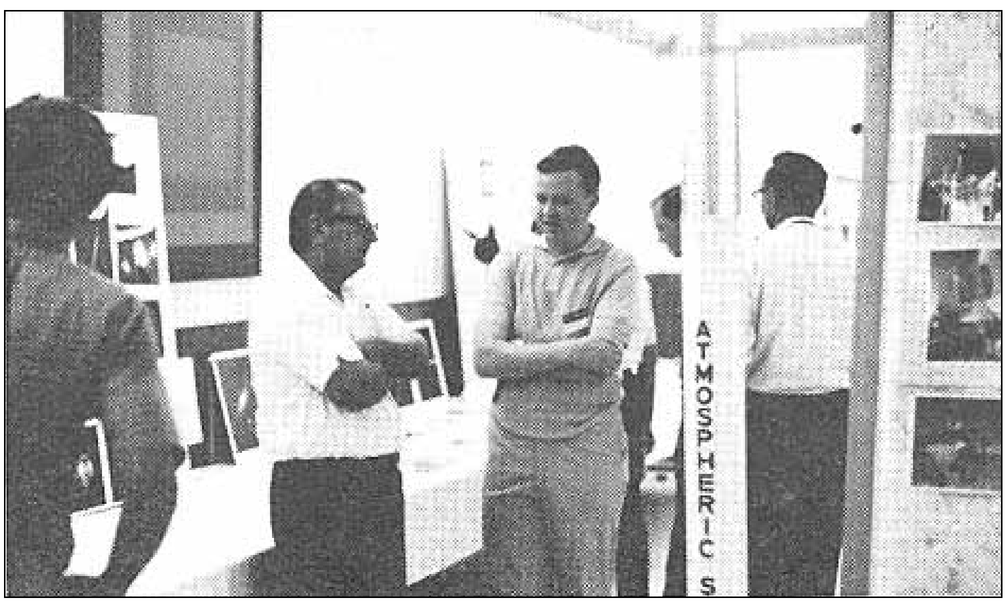
The Future of Lunar Observing

Continued from page 2

another under-explored field. This is basically imaging through a polarizer, so it should be possible for amateurs.

So far, I've concentrated on topics related to the ALPO Topographical Studies section of which I'm the coordinator. However, there are other sections within the Lunar Studies area: Meteoritic Impacts, Transient Phenomena and the newly re-activated Lunar Domes program. The Lunar Domes program analyzes images to determine the structural characteristics of observed domes. Transient Phenomena has traditionally been a somewhat controversial phenomenon; the current emphasis of the program is on re-observing reported sites to determine whether the events are their normal appearance under special conditions. Meteoritic impact studies is a relatively new field that detects optical flashes produced by impacts on the Moon.

Contact information for the coordinators of each of these programs is included in the ALPO Resources section in every issue of this Journal.



Kenneth Delano (center) conversing with Tom Cave (left) at the 1968 Southwestern Astronomy Conference in Las Cruces, New Mexico, photograph by Frederick W. Jaeger, from the Journal of the ALPO, Volume 21, Nos. 3-4, p. 65.

Comet Discover Tom Bopp

By Carl Hergenrother, ALPO Comets Section Coordinator

Thomas Joel Bopp, co-discoverer of comet Hale-Bopp, passed away on January 5, 2018 in Phoenix Arizona. He was 68 years old and the cause of death was liver failure, said his daughter, April Esch.

Born in Denver on Oct. 15, 1949, and raised in Youngstown, Ohio, Tom was a young boy when his father introduced him to astronomy and bought him his first telescope, a 4-inch reflector. After serving in the Air Force, he attended Youngstown State University. Years later, his alma mater would award him an honorary doctorate of science for his discovery of Comet Hale-Bopp.

In 1980, he moved to the Phoenix area where he worked for an asphalt and concrete supply company as a parts manager. It was during this time on the

Inside the ALPO
Member, section and activity news

fateful night of July 22/23, 1995 that Tom was observing in the Arizona desert with a group of friends. There, he was using a 17.5-inch Dobsonian owned by Jim Stevens, a close friend and local amateur. While observing M70, a globular cluster in Sagittarius, Tom noticed a 10th magnitude diffuse object nearby. Since no such object was known at that position, they continued to observe and after noticing motion realized the object was a comet. This was the first comet Tom had ever observed.

At nearly the same exact time, New Mexico astronomer Alan Hale also came across the comet that would share their names. After both Hale and Bopp reported their findings to the Minor Planet Center, the comet was designated C/1995 O1 (Hale-Bopp). Hale wrote the following in the Alamogordo (NM) Daily News after Bopp's passing, "For several months around the time of Hale-Bopp's brightest appearance, both of its discoverers were media darlings, and even after the comet receded back into the outer solar system, both discoverers found their lives irrevocably changed. Bopp maintained an active speaking schedule to schools and other such institutions for many years, although declining health forced him to curtail this some during the recent past."

When the comet was at its brightest, tragedy struck, as Tom's brother and sister-in-law were killed by a car while they were standing in the desert imaging the comet.

Comet Hale-Bopp was one of the great comets of the 20th century. It didn't pass especially close to the Sun (0.91 AU) or Earth (1.32 AU), but it was intrinsically bright and active. Best estimates for the size of its nucleus place it as one of the largest known comets to pass within the inner solar system at 60 +/- 20 km. The comet holds the record for duration of observability, with naked eye observations spanning 18 months.

Comet hunters David Levy, Don Yeomans, Alan Hale and Thomas Bopp at a 1997 viewing of the Hale-Bopp and Wild 2 comets. Mr. Bopp and Hale were memorialized in the name of the Hale-Bopp comet, which they discovered within minutes of each other in 1995. (Mike Nelson/AGENCE FRANCE-PRESSE/GETTY IMAGES; *https://www.washingtonpost.com/local/obituaries/thomas-bopp-whose-name-was-memorialized-in-a-comet-dies-at-68/2018/01/09/4e081bc6-f552-11e7-b34a-b85626af34ef_story.html?utm_term=.d827ad7a99a7*)

Though discovered in 1995, a photographic pre-discovery observation by the Siding Spring Observatory (near Coonabarabran, New South Wales, Australia) was found from April 27, 1993. Twenty years later, the last reported observation of the comet was made on August 13, 2013 at 24th magnitude with one of the Very Large Telescopes (VLT) on Cerro Paranal in the Atacama Desert of northern Chile. At that time, the comet was located 34.6 AU from the Sun. Future observations are still possible and in fact, a group of astronomers have recently attempted another observation of the comet with the Gemini-South telescope (at 40.9 AU!).

Hale's piece in the Alamogordo Daily News includes the following on their mutual place in history: "Bopp and this author could be considered members of another unique fraternity, i.e., those who have discovered Great Comets — a fraternity especially meaningful for us sky-watchers in the northern hemisphere who have not had a Great Comet to view since Hale-Bopp's appearance in 1997 — although the southern hemisphere has had two during the interim. With Bopp's passing, only six members of this fraternity – this author among them – remain with us, although in theory, this should increase again when another Great Comet comes our way."

Feature Story:

Index to Volume 56 (2014) of The Strolling Astronomer

By Michael Mattei
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PUBLICATION DATA

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Issue Number:
1., Winter 2014 .... pp. 1-59
2. Spring 2014 .... pp. 1-71
3. Summer 2014 .... pp. 1-55
4. Autumn 2014 .... pp. 1-71

AUTHOR INDEX

Bailey, Wayne
China's First Lunar Lander: Change's 3 and YUTU
No.2 .... pp. 22-30
Wrinkles and Rills
No. 4 .... pp. 22-31
Lunar Section: Lunar Topographical Studies/Selected Areas Program
No. 1 .... pp. 11-12
No. 2 .... pp. 11-12
No. 3 .... pp. 8-9
No. 4 .... pp. 9-10

Benton, Julius
ALPO Observations of Saturn During the 2010-2011 Apparition
No. 2 .... pp. 31- 66
ALPO Observations of Venus During the 2009-2010 Western (Morning) Apparition
No. 3 .... pp. 19-33
Saturn Section
No. 1 .... pp. 15-16
No. 2 .... p. 16
No. 3 .... pp. 11-12
No. 4 .... pp. 13-14
Venus Section
No. 1 .... pp. 9-11
No. 2 .... pp. 10-11
No. 3 .... pp. 7-8
No. 4 .... pp. 8-9

Cook, Anthony
Lunar Transient Phenomena
No. 1 .... pp. 12-13
No. 2 .... p. 12
No. 3 .... p. 9
No. 4 .... p. 10

Cudnik, Brian
Lunar Meteoric Impacts
No. 1 .... p. 12
No. 2 .... p. 12
No. 3 .... p. 9
No. 4 .... p. 10

Dembowski, William, M.
Lunar Calendar, First Quarter. 2014
No. 1 .... p. 10
Lunar Calendar Second Quarter 2014
No. 2 .... p. 10
Lunar Calendar July thru September 2010
No. 3 .... p. 9
Lunar Calendar October thru December 2010
No. 4 .... p. 10

Dobbins, Thomas
Expectations and Observation
No. 4 .... pp. 19-21
The Recent Evolution of the Planetary Telescope: Part 2
No. 1 .... pp. 29-35

Eskildsen, Howard
Concentric Lunar Craters
No.1 .... pp. 36-44

Grafton, Ed
Jupiter Section: (See Schmude for Jupiter Section 1)
No. 2, ... p.14
No. 3 .... p. 11
No. 4 .... p. 12

Hay, Kim
Solar Section
No. 1 .... pp. 7-9
No. 2 .... p. 9
No. 3 .... pp. 3-4
No. 4 .... pp. 6-7

Hergenrother, Carl
From "Comet of the Century" to "Thanksgiving Turkey"
No. 1 .... pp. 22-28
Comet Section
No. 1 .... pp. 5-7
No. 2 .... pp. 7-9
No. 3 .... pp. 5-6
No. 4 .... pp. 4-6

Hill, Dolores
Meteorites Section
No. 1 .... p. 5
No. 2 .... p. 7
No. 3 .... p. 5
No. 4 .... p. 4

Hubbell, G.R.
A study of the Southern Lunar Highlands The Identification and Measurement of a Peak 27 km South of Kinau P, 66 km West of the Terminator at Colongitude 335.9°
No. 3 .... pp. 44- 50

Lunsford, Robert
Meteors Section
No. 1 .... p. 5
No. 2 .... p. 7
No. 3 .... pp. 4-5
No. 4 .... p. 4

Mattei, Michael
Index to Volume 53 (2011) of The Strolling Astronomer
No. 3 .... pp.15-18

Milillo, Frank, J.
ALPO Observations of Mercury During the 2012 Apparition
No. 2 .... pp. 17-21
Mercury Section
No. 1 .... p. 9
No. 2 .... pp. 9-10
No. 3 .... p. 7
No. 4 .... p. 7

Owens, Larry
Web Services
No. 1 .... p. 3
Computing Section
No. 1 .... pp. 3-4
No. 2 .... p. 6
No. 3 .... pp. 3-4
No. 4 .... p. 5
ALPO Online Section
No. 2 .... p. 6
No. 3 .... p. 3
No. 4 .... p. 3

Pilcher, Frederick
Minor Planets Section
No. 1 .... pp. 13-14
No. 2 .... pp. 13-14
No. 3 .... p. 10
No. 4 .... pp. 10-12

Poshedly, Ken
Point of View: Making Things Better and Smoother for You
No. 1 .... p. 2
No. 2 .... p. 2
Point of View: A Full Issue and a Sad Parting
No. 3 .... p. 2

Reynolds, Mike
Point of View: A Most Convenient Eclipse
No. 4 .... p. 2
Eclipse Section
No. 1 .... p. 5

Robertson, Tim
Lunar & Planetary Training Program
No. 1 .... p. 4
No. 2 .... p. 6
No. 3 .... p. 4
No. 4 .... p. 3

Schmude, Richard W.
ALPO Observations of Jupiter During the 2011- 2012 Apparition
No. 4 .... pp. 46-66
Jupiter Section
No. 1 .... p. 14
No. 2 .... p. 14
No. 3 .... p. 11
No. 4 .... p. 12
Remote Planets Section
No. 1 .... pp. 16-17
No. 2 .... p. 16
No. 3 .... p. 12
No. 4 .... p. 14

Sheehan, William
A Tale of Two Transits – Visual Observations of the Transits of Venus in 2004 and 2012
No. 3 .... pp. 34-43

Venable, Roger
High Clouds at the Sunrise Terminator of Mars – Revisited
No. 4 .... pp. 32-45
Mars Section
No. 1 .... p. 11
No. 2 .... p. 13
No. 3 .... pp. 9-10
No. 4 .... p. 10

Warner, Brian
Something Old, 'Something New': Three Binary Discoveries from the Palmer Divide Observatory
No. 1 .... pp. 45-54

Will, Matthew L. (ALPO membership Secretary/ treasurer)
Minutes of Board Meeting
No. 4 .... pp. 15-17

Westfall, John
Galilean Satellite Eclipse Timing Program
No. 1 .... p. 14
No. 2 .... pp. 14-15
No. 3 .... p. 11
No. 4 .... pp. 12-13
Mercury / Venus Transit Section
No. 1 .... p. 4
No. 2 .... p. 6
No. 3 .... p. 4
No. 4 .... p. 4

SUBJECT INDEX

ALPO
Board of Directors
No. 1 .... p. 2
No. 2 .... p. 2
No. 3 .... p. 2
No. 4 .... p. 2
Board Meetings
No. 4 .... pp. 15-17

Staff E-Mail Directory and Online Readers
No. 1 .... p. 57
No. 2 .... p. 69
No. 3 .... p. 53
No. 4 .... p. 69

ALPO Announcements (Section Changes, Other ALPO News) Membership
Commentary & Opinion
No. 1 .... pp. 17-18

Sponsors, Sustaining Members, and Newest Members
No. 1 .... pp. 19-21

Announcing, the ALPO Lapel Pin
No. 1 .... p. 3
No. 2 .... p. 3
No. 3 .... p. 4

Inside the ALPO
No. 1 .... pp. 1-20
No. 2 .... pp. 1-16
No. 3 .... pp. 1-13
No. 4 .... pp. 1-14

Reminder: Address changes
New E-Mail Address for Walter Haas
No. 1 .... p. 3

ALPO Pages (Members, Section and Activity News)
ALPO Online Section Created
No. 2 .... p. 5
ALPO Comet Section Changes
No. 2 .... p. 7
Historical Section Staff Changes
No. 1 .... p. 4
News of General Interest
No 2 .... pp. 1-6
Jupiter Section Staff Changes
No. 1 .... p. 15
Lunar Section Staff Changes

No. 1 .... p. 11

ALPO Resources

No. 1.......................................pp. 55-59
No. 2.......................................pp. 67-71
No. 3.......................................pp. 51-55
No. 4.......................................pp. 67-71

ALPO Convention

No. 2...........................Inside back cover

ALPO Interest Sections Reports

Comets Section
No. 1 ....pp. 5-7
No. 2 ....pp. 7-9
No. 3 ....pp. 5-6
No. 4 ....pp. 4-6

Computing Section
No. 1 ....pp. 3-4
No. 2 .... p. 6
No. 3 ....pp. 3-4
No. 4 .... p. 5

Eclipse Section
No. 1 .... p. 5

Jupiter Section
No. 2 .... p.14
No. 3 .... p. 11
No. 4 .... p. 12

Lunar Section
No. 1 ....pp. 11-12
No. 2 ....pp. 11-12
No. 3 ....pp. 8-9
No. 4 ....pp. 9-10

Mars Section
No. 1 .... p. 11
No. 2 .... p. 13
No. 3 ....pp. 9-10
No. 4 .... p. 10

Mercury Section
No. 1 .... p. 9
No. 2 ....pp. 9-10
No. 3 .... p. 7
No. 4 .... p. 7

Meteors Section
No. 1 .... p. 5
No. 2 .... p. 7
No. 3 ....pp. 4-5
No. 4 .... p. 4

Meteorites Section
No. 1..p. 5
No. 2..p. 7
No. 3..p. 5
No. 4..p. 4

Minor Planets Section
No. 1................................ pp. 13-14
No. 2................................ pp. 13-14
No. 3..p. 10
No. 4................................ pp. 10-12

Online Section
No. 2..p. 6
No. 3..p. 3
No. 4..p. 3

Remote Planets Section
No. 1................................ pp. 16-17
No. 2..p. 16
No. 3..p. 12
No. 4..p. 14

Saturn Section
No. 1................................ pp. 15-16
No. 2..p. 16
No. 3................................ pp. 11-12
No. 4................................ pp. 13-14

Solar Section
No. 1.................................... pp. 7-9
No. 2..p. 9
No. 3.................................... pp. 3-4
No. 4.................................... pp. 6-7

Topographical Studies/ Selected Areas Program
No. 1................................ pp. 11-12
No. 2................................ pp. 11-12
No. 3.................................... pp. 8-9
No. 4.................................. pp. 9-10

Venus Section
No. 1.................................. pp. 9-11
No. 2................................ pp. 10-11
No. 3.................................... pp. 7-8
No. 4.................................... pp. 8-9

Web Services
No. 1 ....p. 3

Book Reviews

Scientific Astrophotography: How Amateurs Can Generate and Use Professional Imaging Data (Reviewed by Wayne Bailey)
No.3....................................... p. 14

Lunar Domes: Properties and Formation Processes (Reviewed by Robert Garfinkle)
No. 4 ....p. 18

Comets

Section
No. 1 ....pp. 5-7
No. 2 ....pp. 7-9
No. 3 ....pp. 5-6
No. 4 ....pp. 4-6

Computers

Section
No. 1 ....pp. 3-4
No. 2 ....p. 6
No. 3 ....pp. 3-4
No. 4 ....p. 5

Eclipse

Galilean Satellite Eclipse Timing Program
No. 1 ....p. 14
No. 2 ....pp. 14-15
No. 3 ....p. 11
No. 4 ....pp. 12-13

Index

Index to Volume 53 (2011) of The Strolling Astronomer
No. 3 .... pp.15-18

In Memoriam

Joseph Liu: 1931-2014

Jupiter

Observations of Jupiter During the 2011-2012 Apparition
No. 4 ....pp. 46-66

Jupiter Section
No. 2 .... p.14
No. 3 ....p. 11
No. 4 ....p. 12

Lunar

(Quarterly Calendars)
First Quarter. 2014
No. 1 ....p. 10
Second Quarter 2014
No. 2 ....p. 12
Third Quarter 2014
No. 3 ....p. 8
Fourth Quarter 2014
No. 4 ....p. 9

Lunar & Planetary Training Program
No. 1 .... p. 4
No. 2 .... p. 6
No. 3 .... p. 4
No. 4 .... p. 3

Meteoric Impacts
No. 1 .... p. 12
No. 2 .... p. 12
No. 3 .... p. 9
No. 4 .... p. 10

Topographical Studies/ Selected Areas Program
No. 1 .... pp. 11-12
No. 2 .... pp. 11-12
No. 3 .... pp. 8-9
No. 4 .... pp. 9-10

Transient Phenomena
No. 1 .... pp. 12-13
No. 2 .... p. 12
No. 3 .... p. 9
No. 4 .... p. 10

Mars
Section
No. 1 .... p. 11
No. 2 .... p. 13
No. 3 .... pp. 9-10
No. 4 .... p. 10

Mercury
Section
No. 1 .... p. 9
No. 2 .... pp. 9-10
No. 3 .... p. 7
No. 4 .... p. 7

Meteorites
Section
No. 1 .... p. 5
No. 2 .... p. 7
No. 3 .... p. 5
No. 4 .... p. 4

Meteors
Section
No. 1 .... p. 5
No. 2 .... p. 7
No. 3 .... pp. 4-5
No. 4 .... p. 4

Minor Planets
Section
No. 1 .... pp. 13-14
No. 2 .... pp. 13-14
No. 3 .... p. 10
No. 4 .... pp. 10-12

Moon
Moon: Craters, Features, and Regions
Concentric Lunar Craters
No.1 .... pp. 36-44

A study of the Southern Lunar Highlands
The Identification and Measurement of a Peak 27 km South of Kinau P, 66 km West of the Terminator at Colongitude 335.9
No. 3 .... pp.44- 50

Remote Planets, Uranus, Neptune, Pluto
Section
No. 1 .... pp. 16-17
No. 2 .... p. 16
No. 3 .... p. 12
No. 4 .... p. 14

Saturn
Observations of Saturn During the 2010-2011 Apparition
No. 2 .... pp. 31- 66

Observations of Venus During the 2009-2010 Western (Morning) Apparition
No. 3 .... pp. 19-33

Section
No. 1 .... pp. 15-16
No. 2 .... p. 16
No. 3 .... pp. 11-12
No. 4 .... pp. 13-14

Solar
Section
No. 1 .... pp. 7-9
No. 2 .... p. 9
No. 3 .... pp. 3-4
No. 4 .... pp. 6-7

Venus
Visual Observations of the Transits of Venus in 2004 and 2012
No. 3 .... pp.34-43

Section
No. 1 .... pp. 9-11
No. 2 .... pp. 10-11
No. 3 .... pp. 7-8
No. 4 .... pp. 8-9

Web Services
Section
No. 1 .... p. 3

Our Advertisers
33rd Annual Symposium on Telescope Science
No. 1 .... Inside front cover
No. 2 .... Inside front cover

ALCon 2014 San Antonio, TX
No. 2 .... Inside rear cover
No. 3 .... Inside rear cover

Sky & Telescope
No. 1 .... Outside rear cover
No. 2 .... Outside rear cover
No. 3 .... Outside rear cover
No. 4 .... Outside rear cover

Catseye
No. 1 .... p. 7
No. 2 .... p. 4
No. 3 .... p. 6
No. 4 .... p. 5

New Mercury Globe from Sky & Telescope
No. 2 .... p. 9

Feature Story: ALPO Solar Section

A Report on Carrington Rotations 2199 through 2201 (2017 12 30.9382 to 2018 03 22.9368)

By Richard (Rik) Hill,
Coordinator &
Scientific Advisor,
ALPO Solar Section
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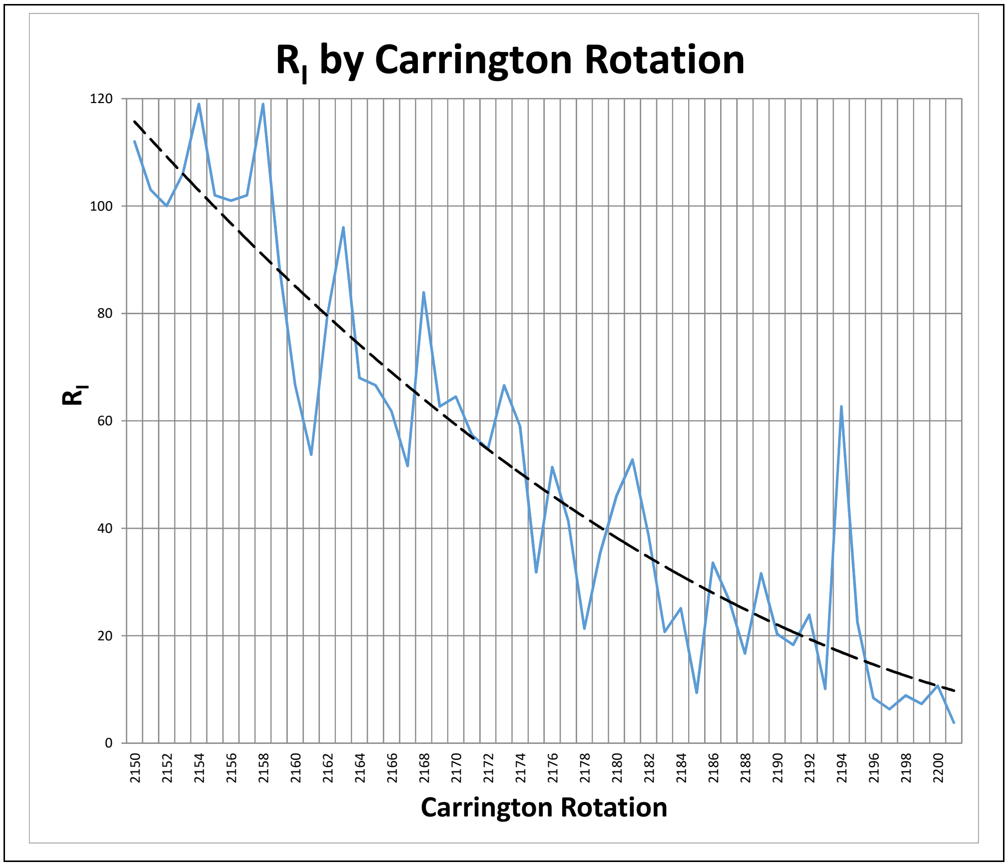


To our hard-copy readers: This paper can be viewed in full-color in the online (pdf) version of this Journal.

Overview

Activity dropped to very low levels during this reporting period as we head for minimum sometime in 2020. These were the lowest levels seen since mid-2009. There was a total of 9 Active Regions designated during the roughly 3 months of this reporting period! The most active and largest Active Region was AR 2699 which got only to 230 millionths of the solar disk, about a quarter the minimum size for it to be a "naked eye" spot. There were 45 days with no sunspots at all. The vast majority of flares during this period were due to AR 2699 but all were A-C class with the strongest being C4.6.

Terms and Abbreviations Used In This Report

While this brief section is similar to the same in earlier reports it should be at least reviewed. As in previous reports, the ALPO Solar Section will be referred to as "the Section" and Carrington Rotations will be called "CRs". Active Regions are designated by the National Oceanic and Atmospheric Administration (NOAA) and will refer to all activity in all wavelengths for that region and will be abbreviated "AR" with only the last four digits of the full number being used. The term "groups" refers to the visible light or "white light" sunspots associated with an Active Region. Statistics compiled by the author have their origin in the finalized daily International Sunspot Number data published by the WDC-SILSO (World Data Center - Solar Index and Long Term Solar Observations) at the Royal Observatory of Belgium. All times used here are Coordinated Universal Time and dates are reckoned from that. Dates will be expressed numerically, with month/day such as "9/6" or "10/23". Carrington Rotation commencement dates are from the table listed on the Section webpage on the ALPO website *http://alpo-astronomy.org/solarblog/wp-content/uploads/ephems/CNSun_2159_2306_A.pdf*

The terms "leader" and "follower" are used instead of "east" or "west" on the Sun to avoid misunderstandings. This follows the "right-hand rule" where, using your right hand, your thumb pointing up is the north pole and the rotation follows the curl of your fingers. Orientation of images shown here will be north up and celestial west to the right (northern hemisphere chauvinism). The cardinal directions (north, south, east, west) if used at all, will be abbreviated as N, S, E and W.

The abbreviation to indicate white-light observations is "w-l", while hydrogen-alpha is "H-a" and calcium K-line is "CaK". "Naked-eye sunspots"

Table 1. Contributors to This Report

Observer	Location	Telescope (aperture, type)	Camera	Mode	Format
Michael Borman	Evansville IN	102mm, RFR	Point Grey GS3	w-l	digital images
		90mm		H-a	
		102mm, RFR		CaK	
Richard Bosman	Enschede, Netherlands	110mm, RFR	Basler Ace 1280		
		355mm, SCT			
Raffaello Braga	Milano, Italy	112mm,RFR	PGR Chameleon mono 2.0	H-a	digital images
Tony Broxton	Cornwall, UK	127mm, SCT	N/A	w-l	drawings
Jean-Francois (Jeff) Coliac	France	30mm, Projection	N/A	w-l	drawings
Gabriel Corban	Bucharest, Romania	120mm, RFL-N	Point Grey GS3-U3	H-a	digital images
				w-l	
Brennerad Damacenco	Sao Palo, Brazil	90mm, MCT	ASI224MC	w-l	digital images
Franky Dubois	West-Vlaanderen, Belgium	125mm, RFR	N/A	visual sunspot reports	
Howard Eskildsen	Ocala, FL	80mm, RFR	DMK41AF02	w-l wedge	digital images
				CaK	
Joe Gianninoto	Tucson, AZ	115mm, RFR	N/A	w-l	drawings
		80mm, RFR		H-a	
		90mm, MCT		w-l, H-a	
Guilherme Grassmann	Curitiba, Brazil	60mm, RFR	Lumenera Skynyx 2.0	H-a	digital images
Richard Hill	Tucson, AZ	90mm, MCT	Skyris 445m	w-l	digital images
		120mm, SCT			
Bill Hrudey	Grand Cayman	200mm, RFL-N	ASI174MM	w-l	digital images
		60mm, RFR		H-a	
David Jackson	Reynoldsburg, OH	124mm, SCT	N/A	w-l	drawings
Jamey Jenkins	Homer, IL	102mm, RFR	DMK41AF02	w-l	digital images
		125mm, RFR		CaK	
Pete Lawrence	Selsey, UK	102.5mm, RFR	ZWO ASI174MM	H-a	digital images
Monty Leventhal	Sydney, Australia	250mm, SCT	N/A	w-l/H-a	drawings
			Canon-Rebel	H-a	digital images
Efrain Morales	Aguadilla, Puerto Rico	50mm, RFR	Point Grey Flea 3	H-a	digital images
German Morales C.	Bolivia	200mm, SCT	N/A	visual sunspot reports	
Theo Ramakers	Oxford, GA	80mm, RFR	ZWO ASI174MM	H-a	digital images
		11 in. SCT	DMK41AU02AS	w-l	
		40mm, H-a PST	DMK21AU03AS	H-a	
		40mm, CaK PST		CaK	
Ryc Rienks	Baker City OR	203mm, SCT	N/A	w-l	drawings
		40mm, H-a PST		H-a	
Chris Schur	Payson, AZ	152mm, RFR	DMK51	CaK	digital images
				w-l (CaK-offband continuum)	
		100mm, RFR	DMK51	H-a	
Randy Shivak	Prescott, AZ	152mm, RFR	ZWO-ASI174	H-a	digital images
Avani Soares	Canoas, Brazil	120mm, RFR	ZWO-ASI 224	w-l	digital images
Randy Tatum	Bon Air, VA	180mm, RFR	DFK31AU	W-L-pentaprism	digital images
David Teske	Starkville MS	60mm, RFR	N/A	W-L/H-a	drawings
			Malincam	W-L	digital images
James Kevin Ty	Manila, Philippines	TV101, RFR	ZWO-ASI 120MM	H-a	digital images
David Tyler	Buckinghamshire, UK	178mm, RFR	ZWO	W-L	digital images
		90mm, RFR		H-a	
Christian Viladrich	Nattages, France	300mm, RFN	Basler 1920-155	W-L	digital images

NOTE: Telescope types: Refractor (RFR), Newtonian Reflector (RFL-N), Schmidt Cassegrain (SCT) Maksutov-Cassegrain (MCT), Meade Personal Solar Telescope (PST).

means the ability to see these spots on the Sun without amplification but through proper and safe solar filtration. As a reminder, you should never look at the Sun, however briefly, without such filtration even at sunrise/set.

Areas of regions and groups are expressed in the standard units of millionths of the solar disk, with a naked-eye spot generally being about 900-1,000 millionths for the average observer. The McIntosh Sunspot Classification used here is the one defined by Patrick McIntosh of NOAA (McIntosh 1981, 1989) and detailed in an article in the JALPO Volume 33 (Hill 1989). This classification system is also detailed by the author on the Section website at *http://www.alpo-astronomy.org/solar/W-Lft.html* in an article on white-light flare observation. This will be referred to as the McIntosh Class. The magnetic class of regions is assigned by NOAA and will be entered parenthetically after the McIntosh class or elsewhere referred to as "mag. class".

Lastly, due to the constraints of publishing, most of the images in this report have been cropped, reduced or otherwise edited. The reader is advised that all images in this report, and a hundred times more, can be viewed at full resolution in the ALPO Solar Archives. This can be accessed by going to the Solar Section webpage and following the Archives link at the top of the right sidebar. You can also go to the Archives through this link: *http://www.alpo-astronomy.org/gallery/main.php?g2_itemId=1699*

Section observers, their equipment and modes of observing are summarized in Table 1 on this page. While not all individuals necessarily contributed to this specific report, they have contributed to recent reports and are ALPO Solar Section members. This should be used as a reference throughout this report.

References

Hill, R.E., (1989) “A Three-Dimensional Sunspot Classification System” Journal of the Assn of Lunar & Planetary Observers, Vol. 33, p. 10. *http://articles.adsabs.harvard.edu/cgi-bin/nph-iarticle_query?1989JALPO..33...10H&data_type=PDF_HIGH&whole_paper=YES&type=PRINTER&filetype=.pdf*

Livingston, W., Penn, M.; (2008) “Sunspots may vanish by 2015.” *https://wattsupwiththat.files.wordpress.com/2008/06/livingston-penn_sunspots2.pdf*

McIntosh, Patrick S., (1989) “The Classification of Sunspot Groups” Solar Physics, Vol. 125, Feb. 1990, pp. 251-267.

McIntosh, Patrick S., (1981) The Physics Of Sunspots. Sacramento Peak National Observatory, Sunspot, NM; L.E. Cram and J.H.Thomas (eds.), p.7.

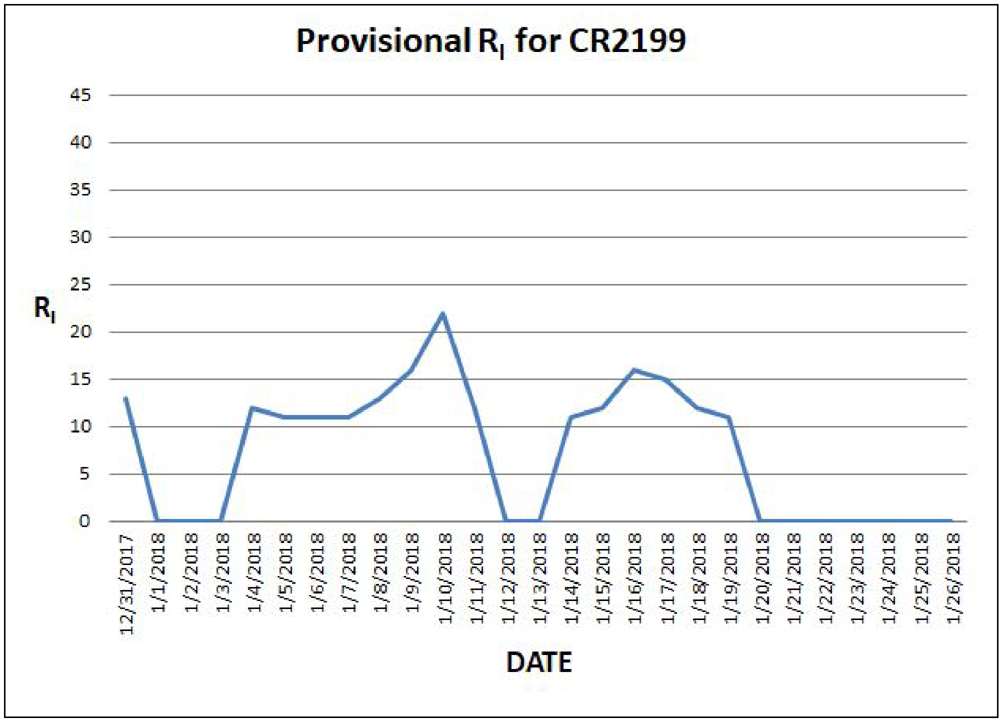
Additional references used in the preparation of this report:

Solar Map of Active Regions *https://www.raben.com/maps/date*

SILSO World Data Center *http://sidc.be/silso/home*

SILSO Sunspot Number *http://www.sidc.be/silso/datafiles*

The Mass Time-of-Flight spectrometer (MTOF) and the solar wind Proton Monitor (PM) Data by Carrington Rotation *http://umtof.umd.edu/pm/crn/*



Carrington Rotation 2199

Dates: 2017 12 30.9382 to 2018 01 27.2771

Avg. R_I= 7.3
High R_I = 22 (1/10)
Low R_I = 0 (12 days)

Of the four regions designated during this rotation, none exceeded 30 millionths in area and the one region that did, AR2696, attained that size for only one day. There were 12 days of no sunspots and only a half-dozen flares for the entire rotation!

Even so, there were some notable observations that deserve some mention. A a w-l image by Ramakers (Figure 1) shows the largest group, AR2696, on 1/18, a day after maximum area. It was classed as a Bxo region of 20 millionths area (mag. Beta). An H-alpha image the same day, also by Ramakers, shows the main group in a bright tight plage with a clear E-W magnetic neutral line dividing the plage just above the main spot (Figure 2). The region was preceded by a dark filament. Levinthal noted this filament as a small prominence on the limb on 1/24.

There were several notable prominences seen in this rotation. Both of these observations were by Ramakers as well. The earliest one was on 1/04 and appears to be a tornadic prominence off the SE limb not associated with an active region (Figure 3) and the latter is beautifully detailed prominence image on 1/15 on the NW limb also not associated with a designated active region (Figure 4).

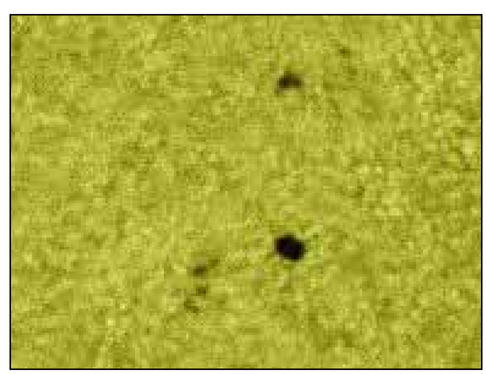


Figure 1. A w-l image of AR 2696 by Ramakers on 1/18 at 16:40 UT.

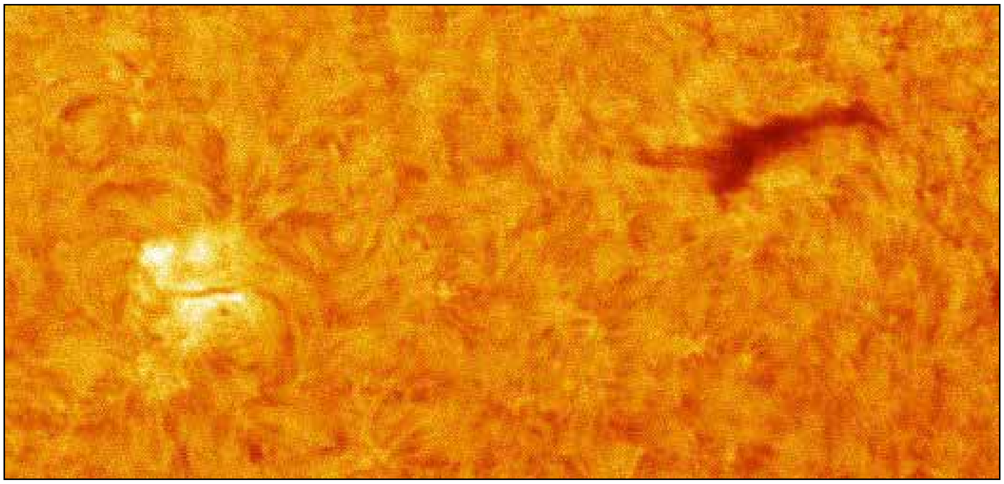


Figure 2. An H-a image of AR 2696 at 1/18 at 16:48 UT by Ramakers.

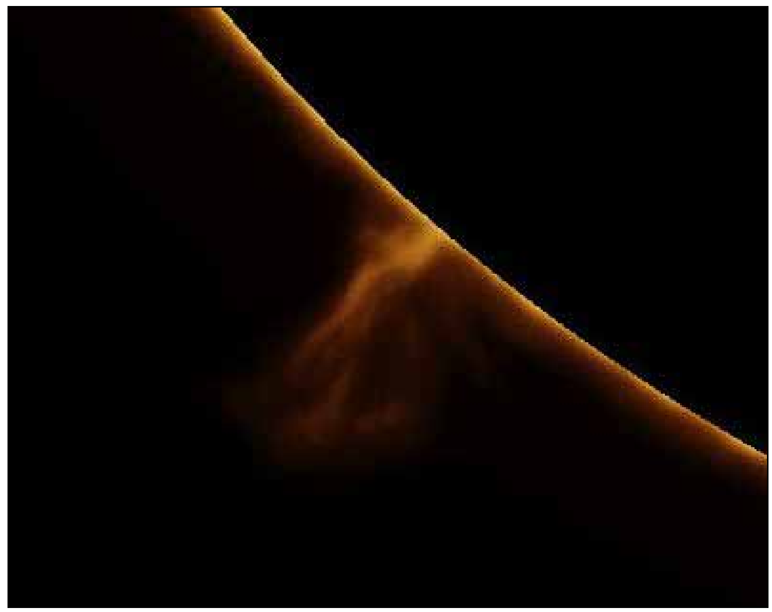


Figure 3. A Ramakers H-a image of SE limb prominence on 1/4 at 15:19 UT.

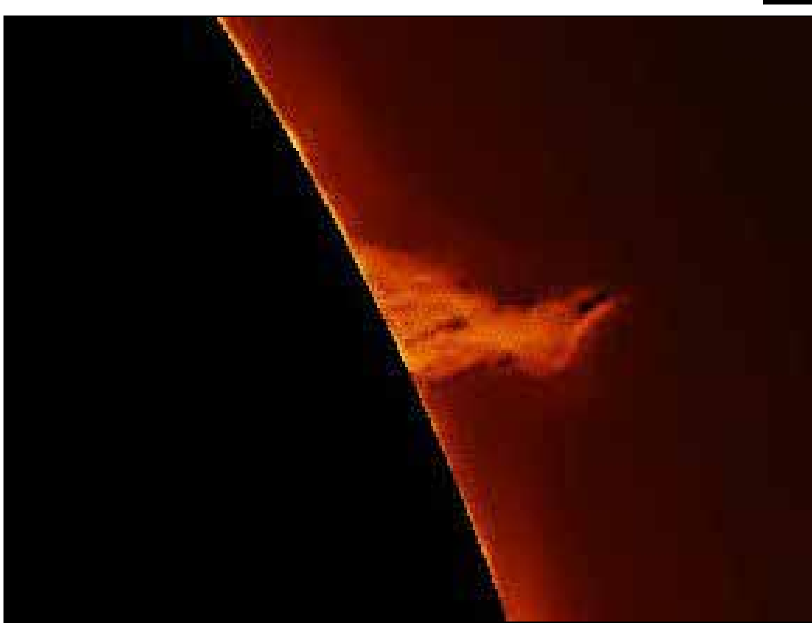
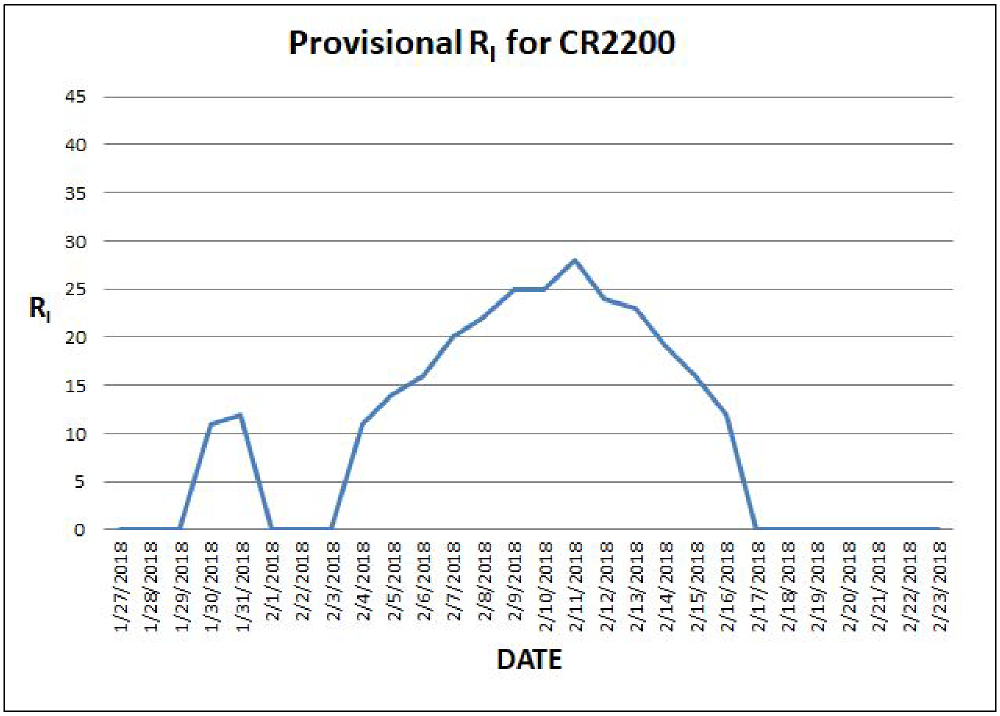


Figure 4. A prominence on the NW limb in H-a by Ramakers on 1/15 at 15:33 UT.



Carrington Rotation 2200

Dates: 2018 01 27.2771 to 2018 02 23.6167

Avg. R_I = 10.7
High R_I = 28 (2/11)
Low R_I = 0 (13 days)

With an average RI of 10.7, this was the most active rotation of the reporting period! There were 13 days with no sunspots at all, one more than the previous rotation and only three active regions of which AR 2699 accounted for the bulk of the activity.

AR 2699 came fully onto the disk on 2/5, though the first hints of it were seen by Grassmann in H-a on 2/4 (Figure 5). We get a good view of the region on 2/5 in a pair of Grassmann H-a images (one online and the other shifted off-line to simulate w-l) that show good activity in the follower portions of the region. The leader was seen to be two large umbrae in one penumbra followed by a small umbra with rudimentary penumbra; this was followed by a N-S arc of about a dozen spots, the northernmost with fragmentary penumbra (Figure 6).

On 2/7, Tyler gives us a good w-l view of this region now classed as Dao (160 millionths, mag. class beta) (Figure 7). The two umbrae in the leader were merged into a N-S-oriented mass in one well-organized penumbra, followed by a small middle spot that was a few tiny umbrae in rudimentary penumbra. There was a curious white arc in the photosphere following this leader that was parallel to the edge of its penumbra. The follower consisted of one large spot that was four or five umbrae in one penumbra with an arc of umbral spots and fragmentary penumbrae originating from the following side of the follower spot arcing to the N, ending at the middle spot. During the previous 48 hours there had been over 40 flares all of A-C class.

We got another good comprehensive look at this region on 2/9 in quasi-w-l, H-a and CaK images by Grassmann (Figure 8). At this time, it was classed as Dai (200 millionths, mag. class beta-gamma). The "quasi-w-l" is again an off-line continuum image through the H-a filter. In that image, the leader umbra had split into four pieces with a bright E-W light bridge running through them. In the middle

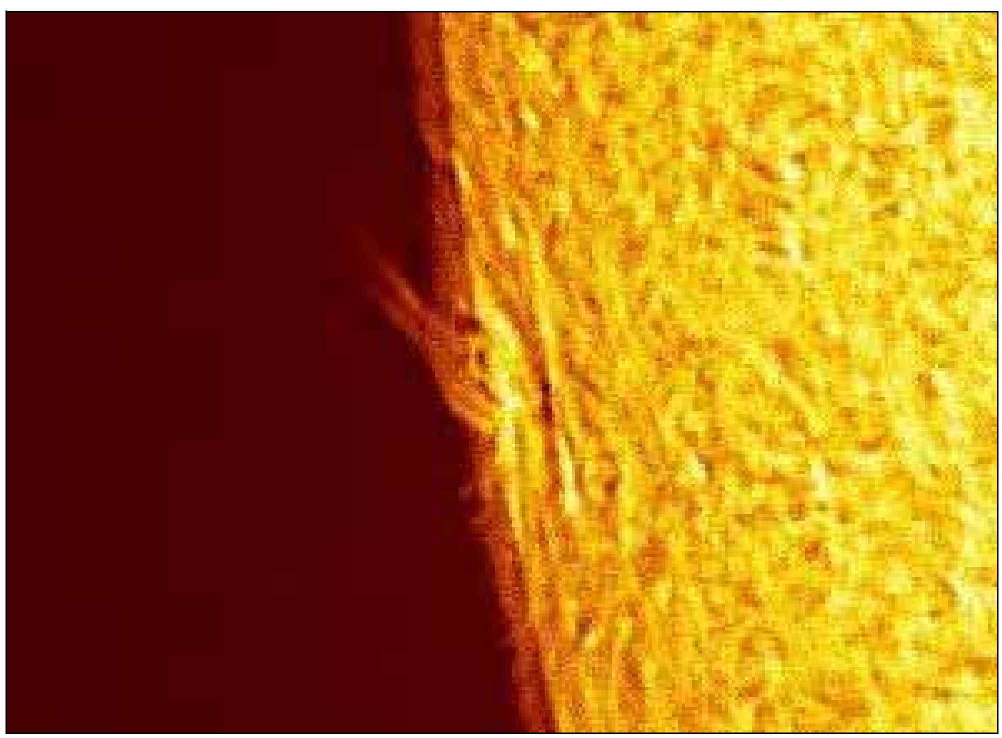


Figure 5. An H-a image of AR 2699 on 2/4 at 12:00 UT by Grassmann.

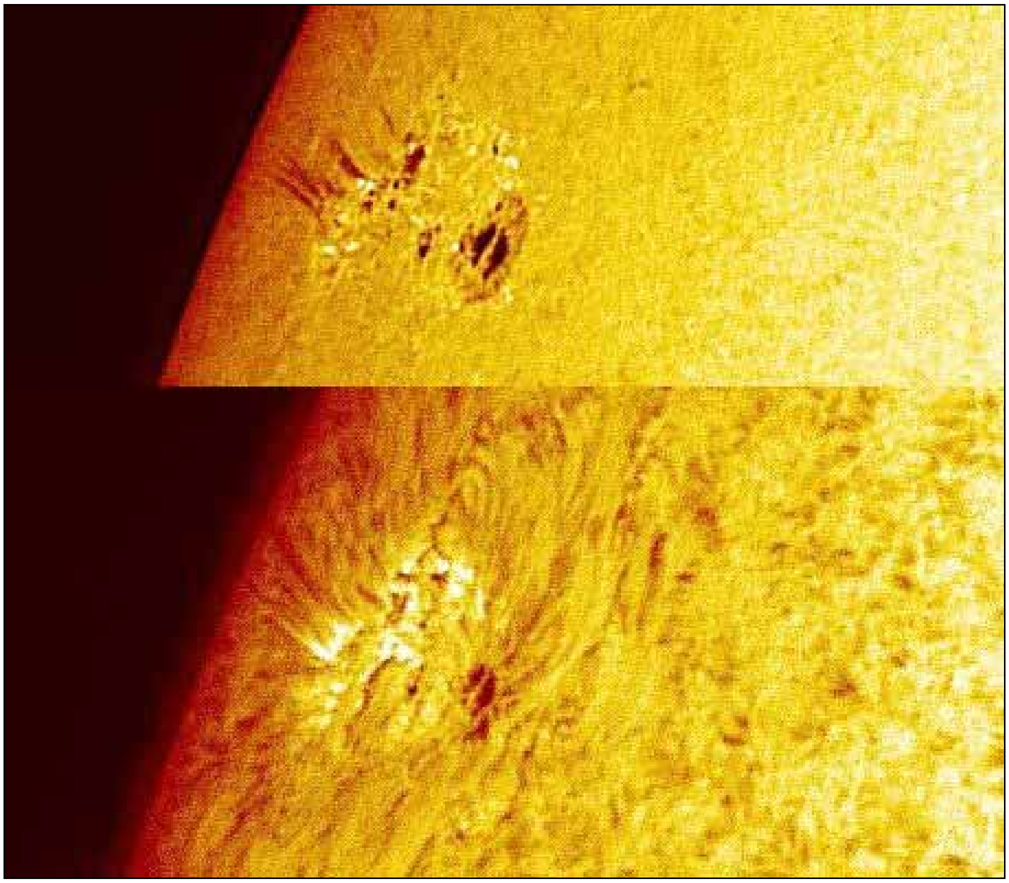


Figure 6. Two H-a views of AR 2699 on 2/5, one on-line (below at 13:09 UT) and one off-line (above at 13:02 UT) by Grassmann.

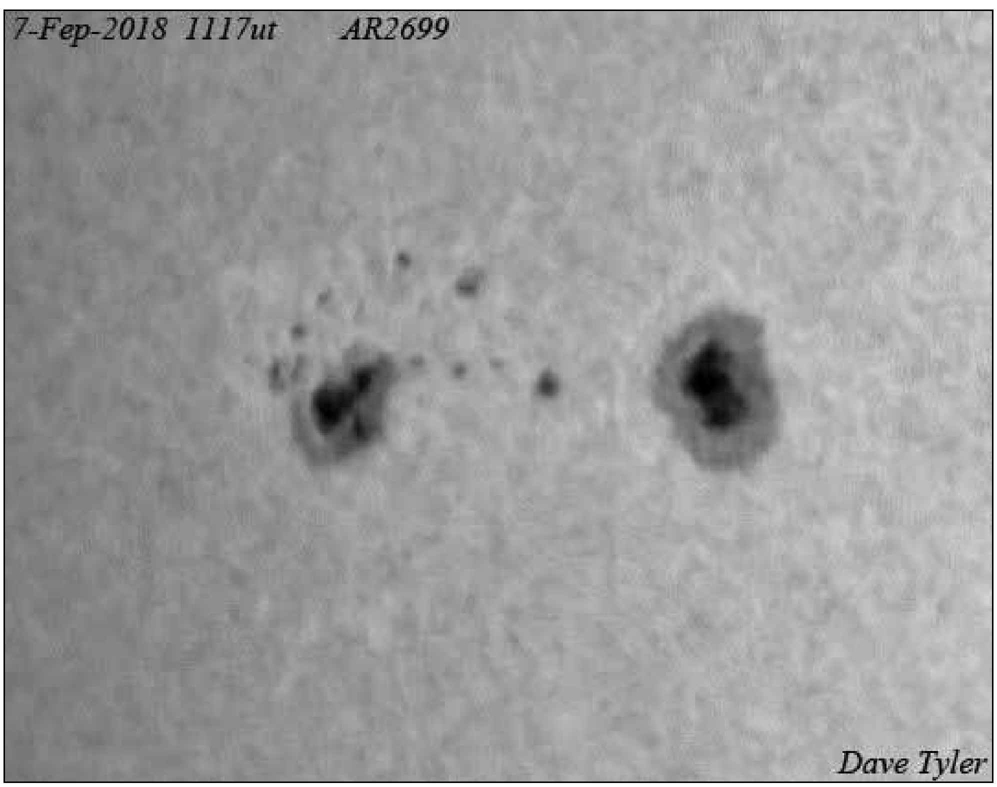


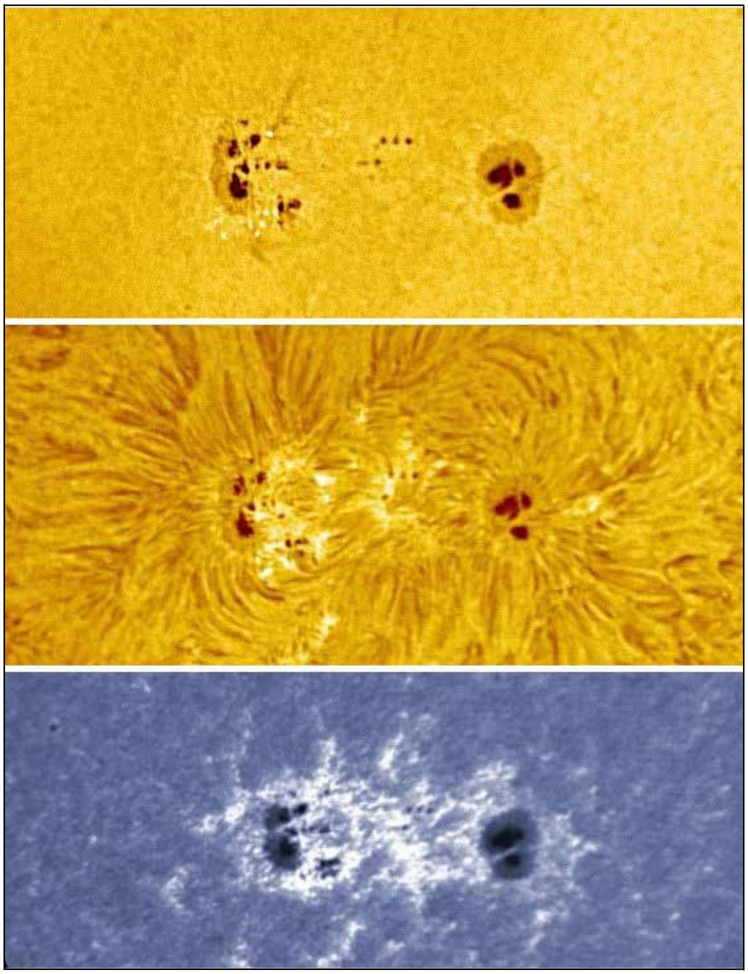
Figure 7. A w-l view of AR 2699 by Tyler on 2/7 at 11:17 UT.

of the group were six or seven small umbral spots in two short parallel lines. The follower was a spot almost as big as the leader consisting of four N-S arranged umbrae with penumbra only on the following side with separated umbral spots on the preceding side. There were hot spots seen to the S and one to the N that showed a jet. In H-a, the region on the preceding side of the follower was hot or bright and an obvious site for flaring. The CaK image displays much the same thing.

A three-pane w-l montage by Hill shows the evolution of the group from 2/9-2/11 (Figure 9). The notable developments shown were the increase in area and number of spots in the middle of the group, the decrease in area of the large follower spot, and smaller surrounding follower spots and the changes in the light bridge in the leader spot. By 2/11, the day of meridian passage and maximum development, there were two collections of middle spots while the whole group was classed as Dai (240 millionths, mag. class beta) and still producing about one B- or C-class flare per hour.

Tyler gives us a nice look at the region in w-l and H-a on 2/12 (Figure 10). It mostly shows the middle spots becoming more consolidated and from the H-a image they are clearly the center of flare activity. But the most interesting thing is the bright region leading the leader spot with what looks to be a leading filament emanating from it. The region was little changed, still Dai (230 millionths, mag. class beta), but flare production had dropped by half to about one every two hours.

This was the last detailed look our members got of this region until it was on the limb on but three of our whole disk visual observers (Broxton, Levinthal, and Teske) did follow it and



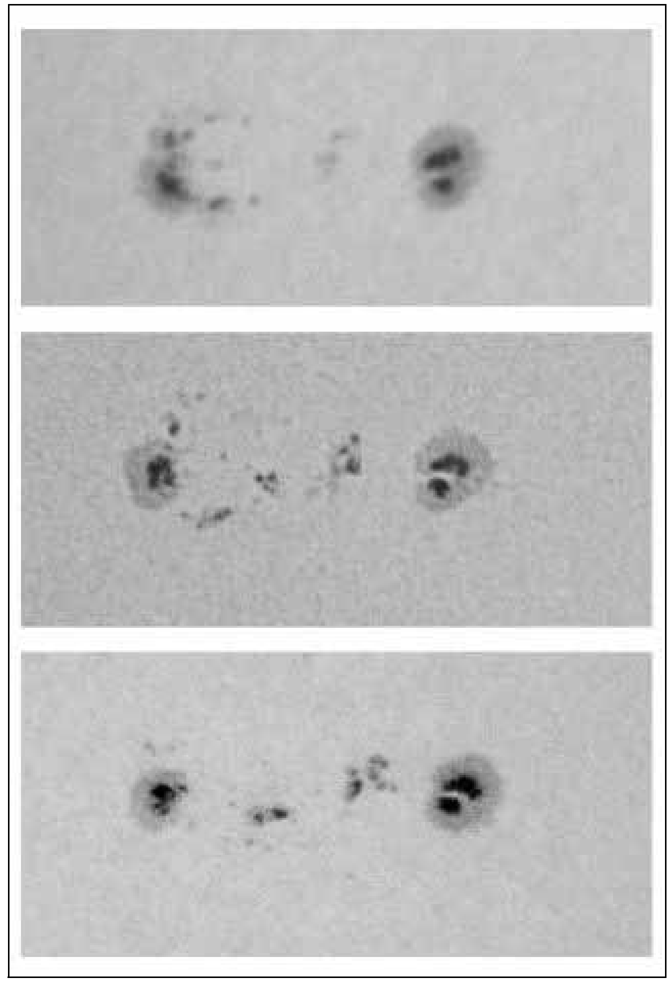


Figure 8. AR 2699 on 2/9 by Grassmann. Upper off-line H-a at 11:09 UT. Middle H-a at 11:09 UT. Lower CaK at 12:01 UT.
Figure 9. Three w-l views of AR 2699 by Hill: top 2/9 at 22:44 UT, middle 2/10 21:38 UT and bottom 2/11 21:01 UT.

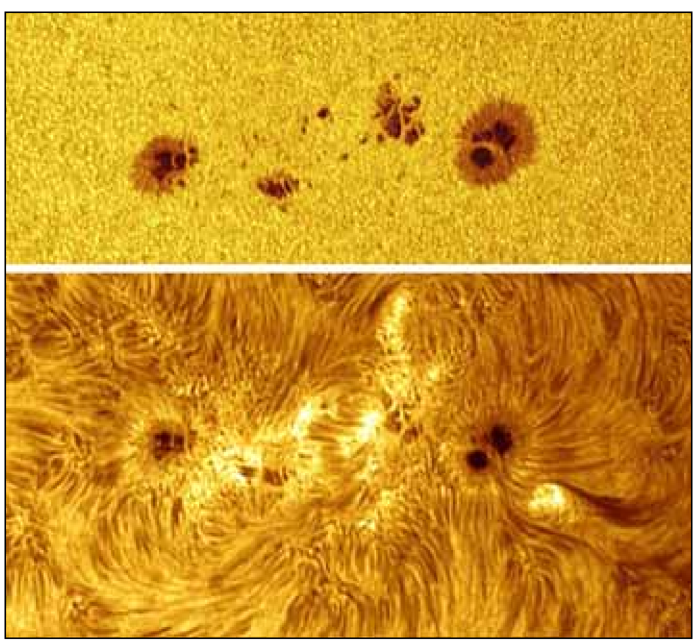


Figure 10. Tyler images of AR 2699 on 2/12: top w-l at 10:50 UT, bottom H-a at 11:14 UT.

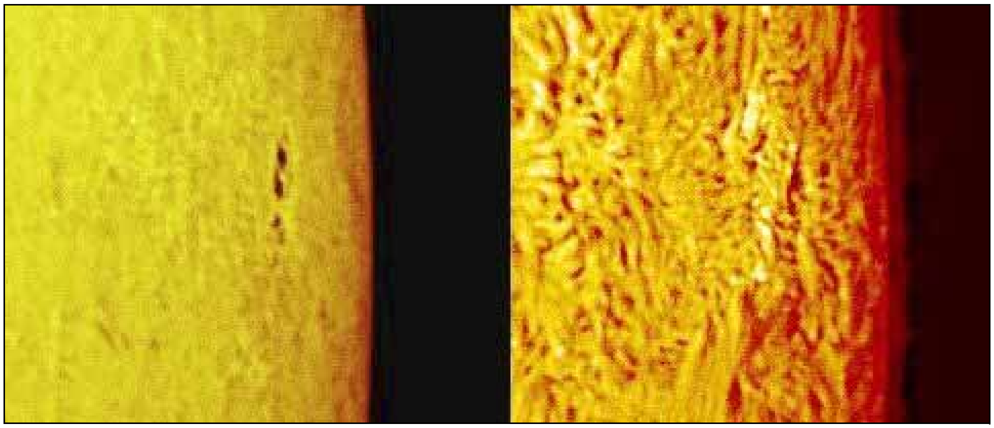


Figure 11. Last views of AR 2699 on the limb by Grassmann: left off-line H-a at 11:10 UT, right on-line H-a 10:55 UT.

showed the region to be reducing in area and complexity. On 2/17, Grassmann got a last on-line/off-line pair of H-a images of the region as it was very near the limb (Figure 11). By this time, it was reduced to Cao (100 mil, mag. class beta).

Carrington Rotation 2201

Dates: 2018 02 23.6167 to 2018 03 22.9368

Avg. R_I = 8.89
High R_I = 16 (2/26)
Low R_I = 0 (20 days)

The activity can't get much lower. There were only three active regions for this rotation, and only one got above 10 millionths, and that was AR2700 with 30 millionths for one day and classed as Cro (mag. class beta) with only 10 B-class flares.

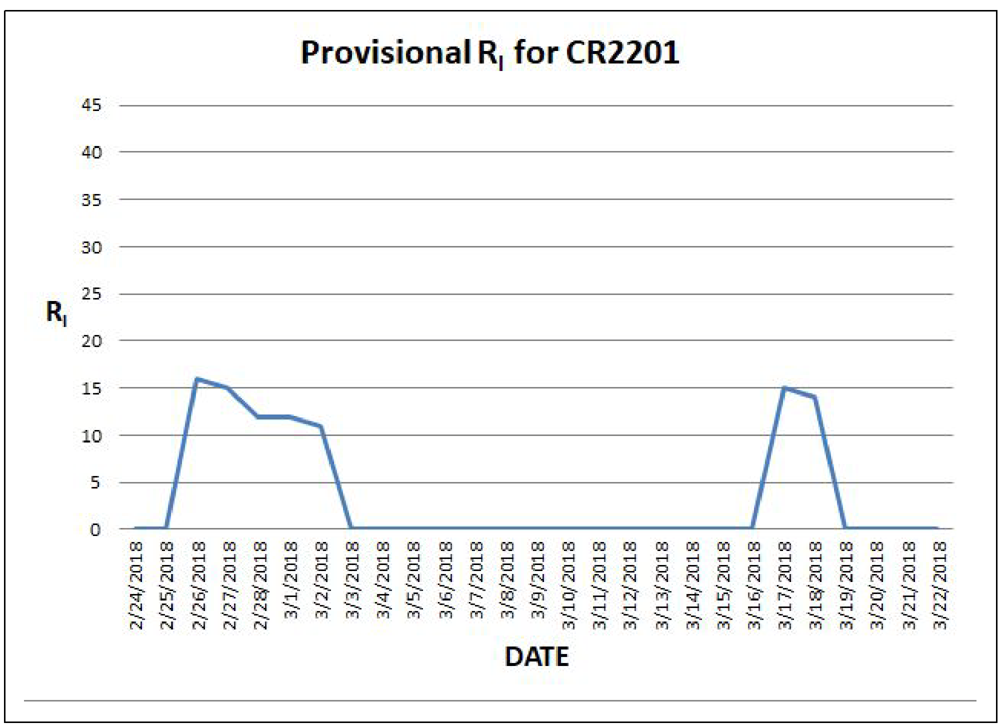
However, even with this low level of activity, there were some interesting things happening on the Sun in the form of limb prominences. The major prominence was one observed by three observers from 3/02-3/03. The first image was by Ramakers on 3/02 at 17:27 UT (Figure 12). It shows a broad bright column prominence perpendicular to the SE limb. A day later, Grassmann shows the core of this prominence and several small ones at 11:49 UT (Figure 13). Three hours later, at 14:25 UT, Ramakers again caught this prominence showing the outer feathery portions. The larger one was possibly tornadic (Figure 14). Finally Teske got a last look at 17:20 UT, revealing even more of the outer details (Figure 15).

Conclusion

While activity is low, it will get lower. How low and for how long we can't know for certain, though some predictions are for a long, very low (read zero) period of spot numbers. However, observers should be alert for McIntosh class A and B groups that pop up and are so short lived that they don't get a designation before they are gone. But then there are the surprises like AR 2699, where we have some good activity in the middle of doldrums.

What we do need in our archive are prominence images that are identified as to which limb they are on, and what Active Region they are associated with. When both pieces of information are missing, it is difficult to know the level of activity of the prominence or region.

The work that is being submitted, though lower in numbers, is of generally good quality, so keep up the diligent observing!



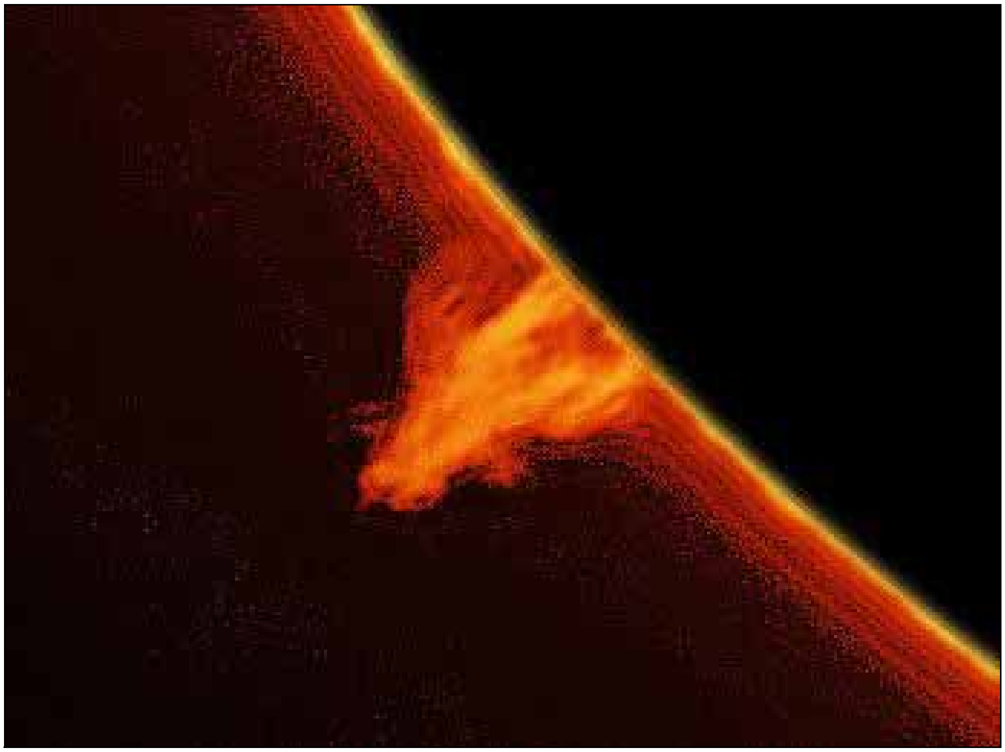


Figure 12. SE limb prominence by Ramakers on 3/2 at 17:27 UT.

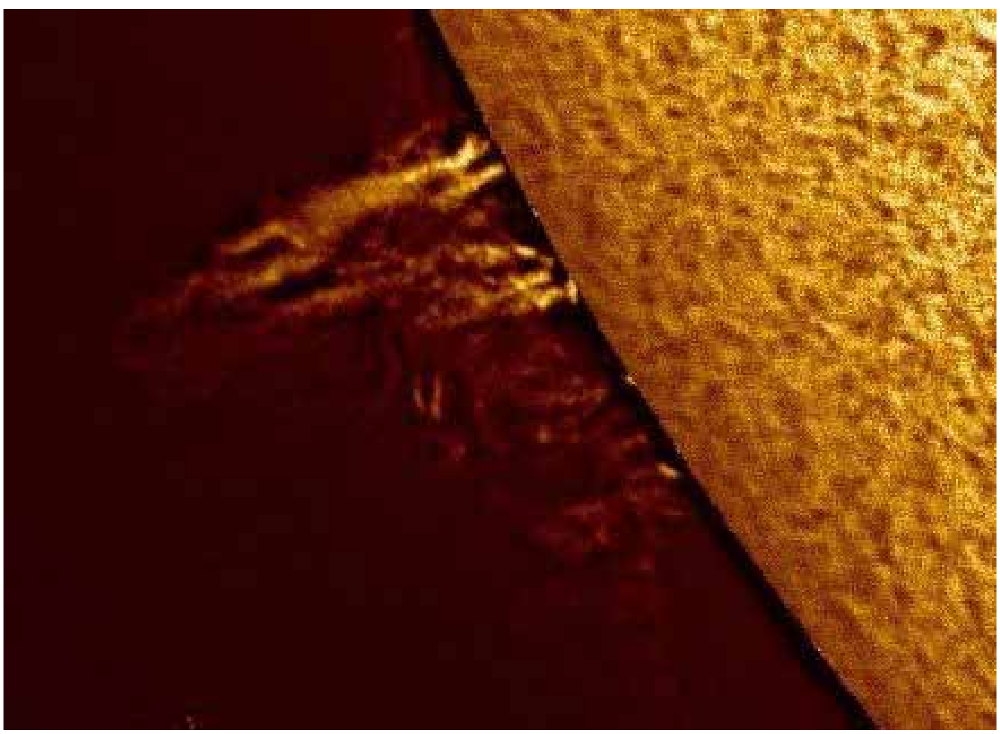


Figure 13. Promence by Grassmann on 3/3 at 11:49 UT.

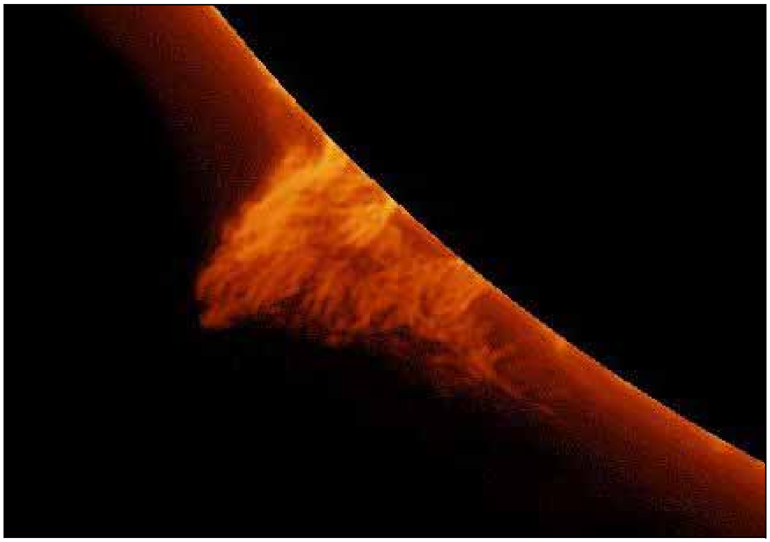


Figure 14. SE limb prominence by Ramakers on 3/3 at 14:25 UT.

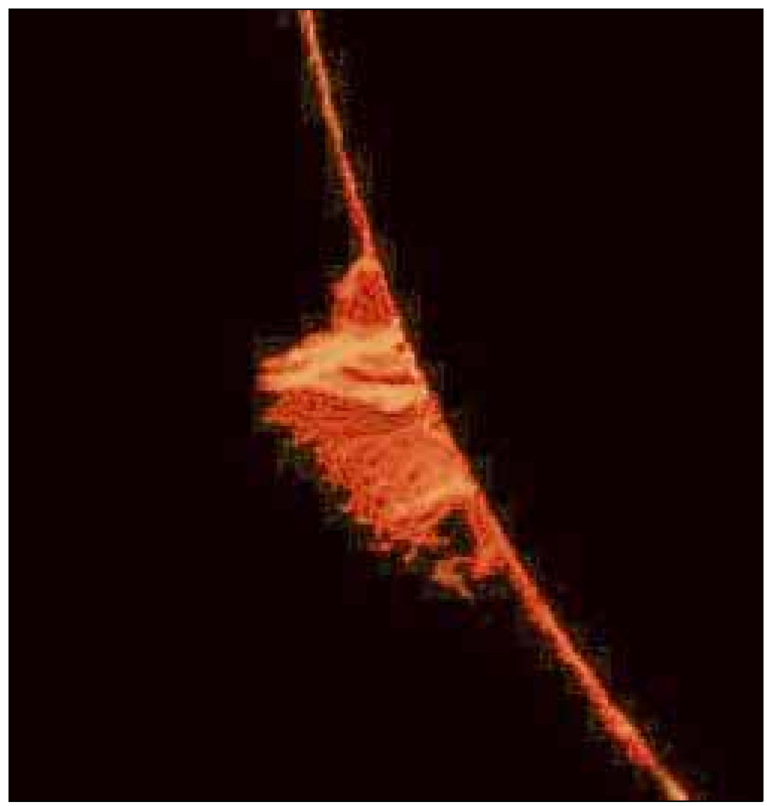


Figure 15. Teske limb prominence image on 3/3 at 17:20 UT.

A.L.P.O. Solar Section

OBSERVER____

ADDRESS____

DATE/TIME____UT

SEEING________________ CLOUDS________________ WIND________________

APERTURE_____________mm FOCAL LENGTH_____________mm TYPE________

EYEPIECE_________mm FILTRATION_____________________________________

OBSERVATION: ***DIRECT*** OR ***PROJECTED***? (CIRCLE ONE)

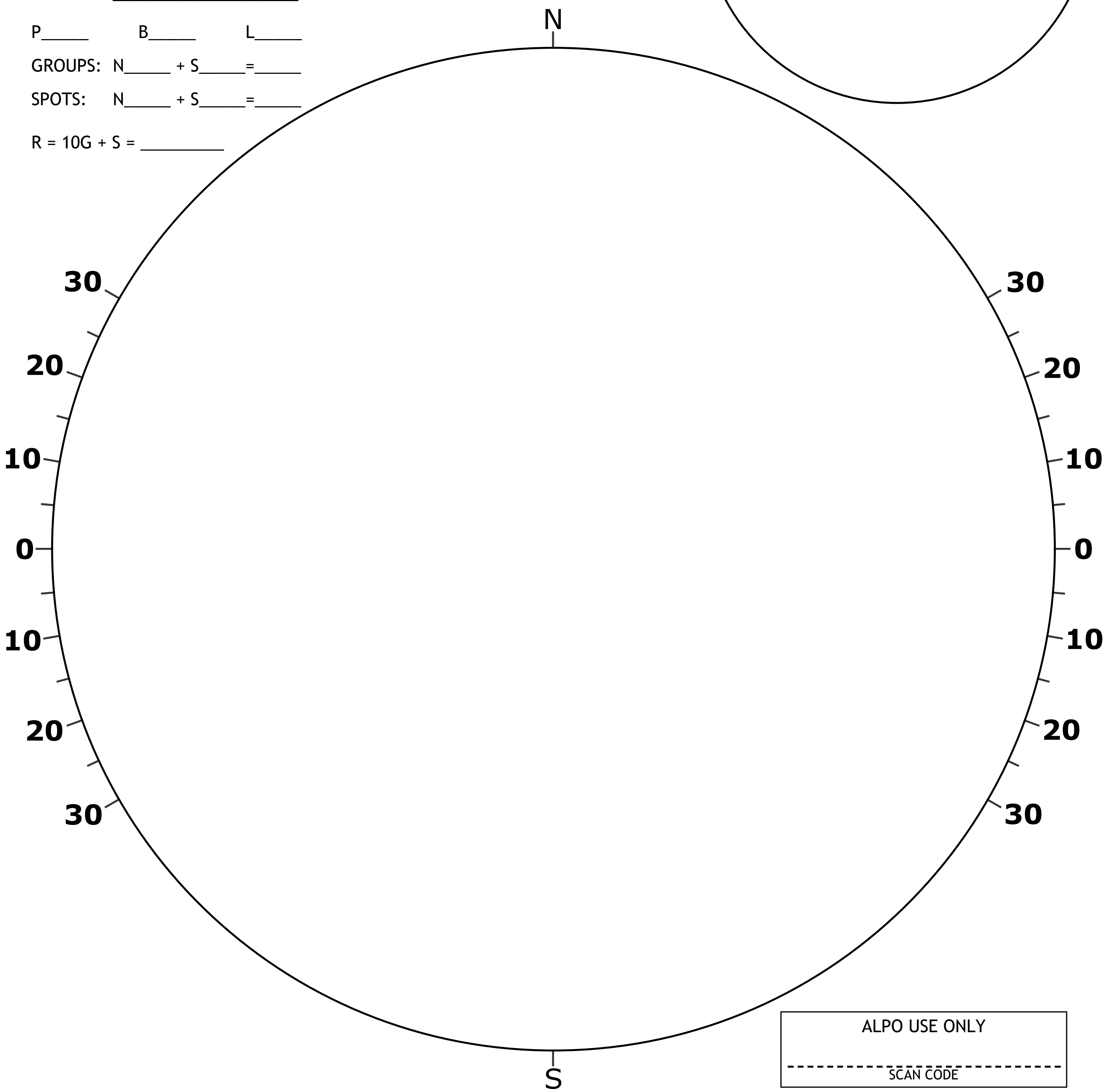
ROTATION___________________

P_____ B_____ L_____

GROUPS: N_____ + S_____=_____

SPOTS: N_____ + S_____=_____

R = 10G + S = __________



ALPO USE ONLY

SCAN CODE

A.L.P.O.SOLAR SECTION

ACTIVE REGION DRAWING REPORT FORM

SKY/SITE

Date/Time(UT) ____

Rotat.No. _______ A.R. __________ Cen.Meridian _________ Altitude _________

Sky cond. _____________ Seeing __________ Clouds _____________ Wind ________

Observatory type (circle one): roll off roof, roll off bldg., dome, none

TELESCOPE:

Inst. type ________________________ Mounting type ___________________________

Clock drive? ______ Type of drive ____

Full aperture ___________________________ Focal length ____________ f/________

Aperture stop/type ___________________________ Final f/_______________________

Address: Phone No. ( )area code_______________________

Feature Story: Venus

ALPO Observations of Venus During the 2014 Western (Morning) Apparition

By Julius L. Benton, Jr., coordinator
ALPO Venus Section
jlbaina@msn.com

To our hard-copy readers: This paper can be viewed in full-color in the online (pdf) version of this Journal.

Abstract

Only five observers from the United States, France, Germany, and Sweden contributed digital images and visual observations (drawings and descriptive reports) to the ALPO Venus Section during the 2014 Western (Morning) Apparition, which was considered to be one of the more poorly observed apparitions in recent years. This report summarizes the results of the small sample of 82 total observations. Types of telescopes and accessories used in making the observations, as well as sources of data, are discussed. Comparative studies take into account observers, instruments, visual and photographic results. The report includes illustrations and a statistical analysis of the long-established categories of features in the atmosphere of Venus, including cusps, cusp-caps, and cusp-bands, seen or suspected at visual wavelengths in integrated light and with color filters, as well as digital images captured at visual, ultraviolet (UV), and infrared (IR) wavelengths. Terminator irregularities and the apparent phase phenomena, as well as results from continued monitoring of the dark hemisphere of Venus for the enigmatic Ashen Light are discussed.

Introduction

The ALPO Venus Section received only 82 observations for the 2014 Western (Morning) Apparition, comprised of visual drawings, descriptive reports, and digital images from just five observers residing in the United States, France, Germany, and Sweden. Geocentric phenomena in Universal Time (UT) for this observing season are given in *Table 1*, while *Figure 1* shows the distribution of observations by month during the apparition. *Table 2* gives the location where observations were made, the number of observations submitted, and the telescopes utilized.

Observational coverage of Venus during this apparition was considered poor in comparison with the 2013-14 Eastern (Evening) Apparition and other recent observing seasons. Nevertheless, monitoring of the planet started early on for at least one observer, Michel Legrand, who sketched the crescent Venus at 14:02 UT on January 22, 2014, slightly less than two weeks following inferior conjunction on January 11, 2014 [Refer to Illustration No. 001]. The observational reports upon which this report is based covered the period from January 22, 2014 through August 28, 2014, with 86.6% of the total contributions for March through August 2014. There was a noticeable gap in observational coverage for about two months between the end of August and superior conjunction on October 25, and several individuals commented that unusually cloudy weather and poor seeing conditions contributed to the lapse in observational coverage during that period.

For the 2014 Western (Morning) Apparition of Venus, observers witnessed the trailing hemisphere of Venus at the time of sunrise on Earth

Terminology: Western vs Eastern

"Western" apparitions are those when an "inferior" planet (Mercury or Venus, whose orbits lie inside the Earth's orbit around the Sun) is **west of the Sun**, as seen in our morning sky before sunrise.

"Eastern" apparitions are those when that planet is **east of the Sun,** as seen in our sky after sunset.

Online Features

Left-click your mouse on:

- The author's e-mail address in blue text to contact the author of this article.
- The references in blue text to jump to source material or information about that source material (Internet connection must be ON).

Observing Scales

Standard ALPO Scale of Intensity:
0.0 = Completely black
10.0 = Very brightest features
Intermediate values are assigned along the scale to account for observed intensity of features

ALPO Scale of Seeing Conditions:
0 = Worst
10 = Perfect

Scale of Transparency Conditions:
Estimated magnitude of the faintest star observable near Venus, allowing for daylight or twilight

IAU directions are used in all instances.

(a progression from crescent through gibbous phases) as the planet passed through greatest brilliancy (–4.6m_v), dichotomy, and maximum western elongation from the Sun (47.0°). Observers are encouraged to carry out systematic observations of Venus when seeing conditions permit from conjunction to conjunction, and the ALPO Venus Section is fortunate to have a team of dedicated observers who have tried very hard to do that in recent observing seasons.

Figure 2 shows the distribution of observers and contributed observations by nation of origin for this apparition, where it can be seen that 40.0% of the participants in our programs were located in the United States, their observations accounting for 13.4% of the total submitted.

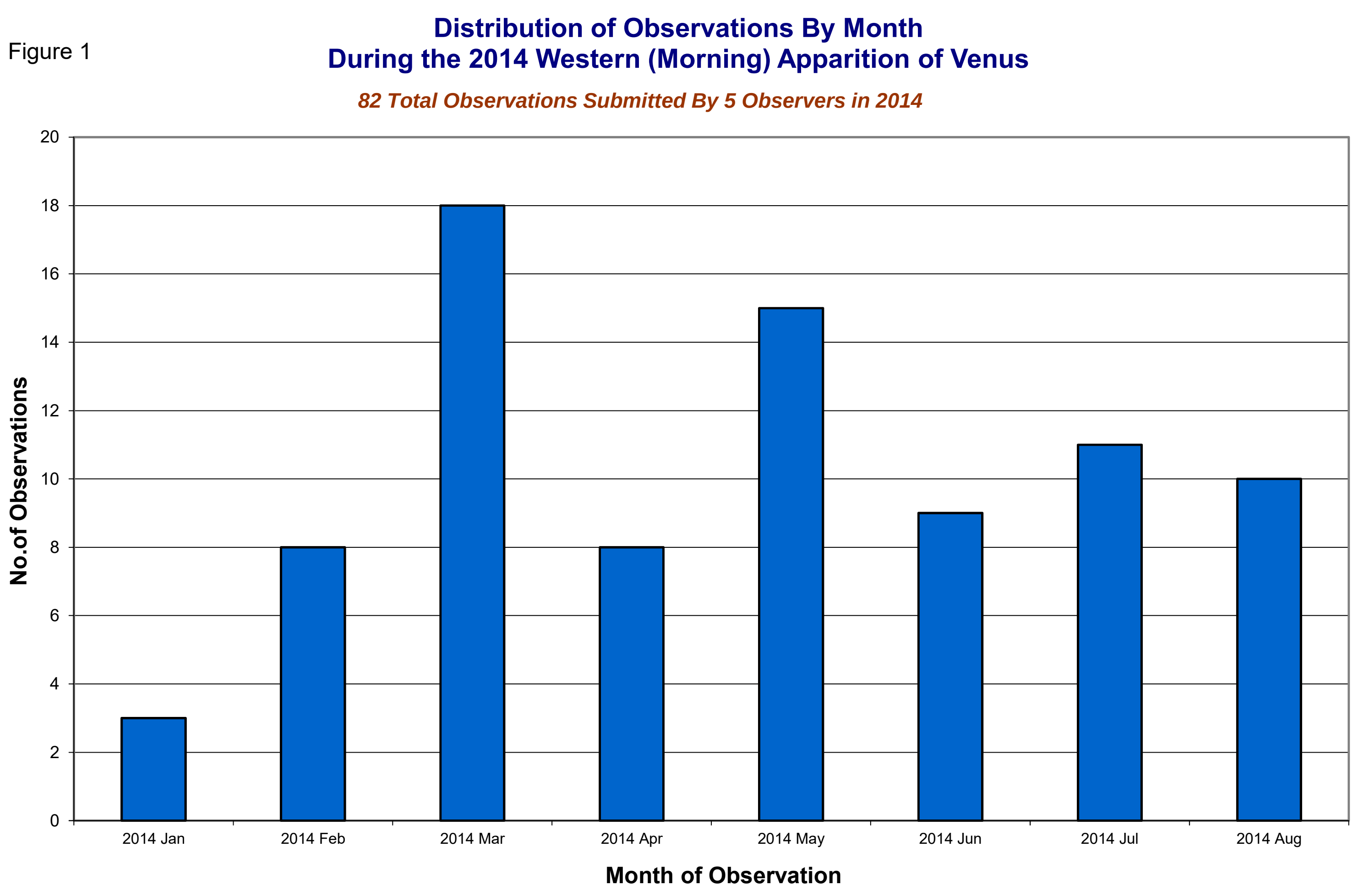
Table 1: Geocentric Phenomena in Universal Time (UT) Table for the 2014 Western (Morning) Apparition of Venus

Inferior Conjunction	2014 Jan 11^d $12{:}00^h$ UT
Initial Observation	Jan 22 13:45
Greatest Illuminated Extent	Feb 15 09:00 (m_v = –4.6)
Greatest Elongation West	Mar 22 20:00 (47.0˚)
Dichotomy (predicted)	Mar 23 17:31:12 (23.73^d)
Final Observation	Aug 28 04:30
Superior Conjunction	Oct 25 08:00
Apparent Diameter (observed range):	59.2″ (2014 Jan 22) ↔ 10.3″ (2014 Aug 28)
Phase Coefficient, ***k*** (observed range):	0.045 (2014 Jan 22) ↔ 0.964 (2014 Aug 28)

Continued international cooperation took place during this observing season, whereby 60.0% of the observers resided outside the United States and contributed 86.6% of the overall observations. The ALPO Venus Section always welcomes a widening global team of observers in the future.

The types of telescopes used to observe and image Venus are shown

Figure 1



in *Figure 3*. Apertures less than 15.2 cm (6.0 in.) accounted for 49.4% of all observations in 2014, with the remaining percentage (50.6%) were made with instruments ranging from 15.2 cm (6.0 in.) to 25.4 cm (10.0 in.). During the observing season, the frequency of use of classical designs (refractors and Newtonians) was 47.6%, while utilization of catadioptrics (Schmidt Cassegrain, Schmidt-Newtonians, and Maksutov-Cassegrain) was 52.4%. All visual and digital observations were performed under twilight or daylight conditions, generally because most experienced Venus observers recognize that viewing during twilight or in full daylight substantially reduces the excessive glare associated with the planet. Also, doing visual work or imaging Venus when it is higher in the sky markedly cuts down on the detrimental effects of atmospheric dispersion and image distortion prevalent near the horizon.

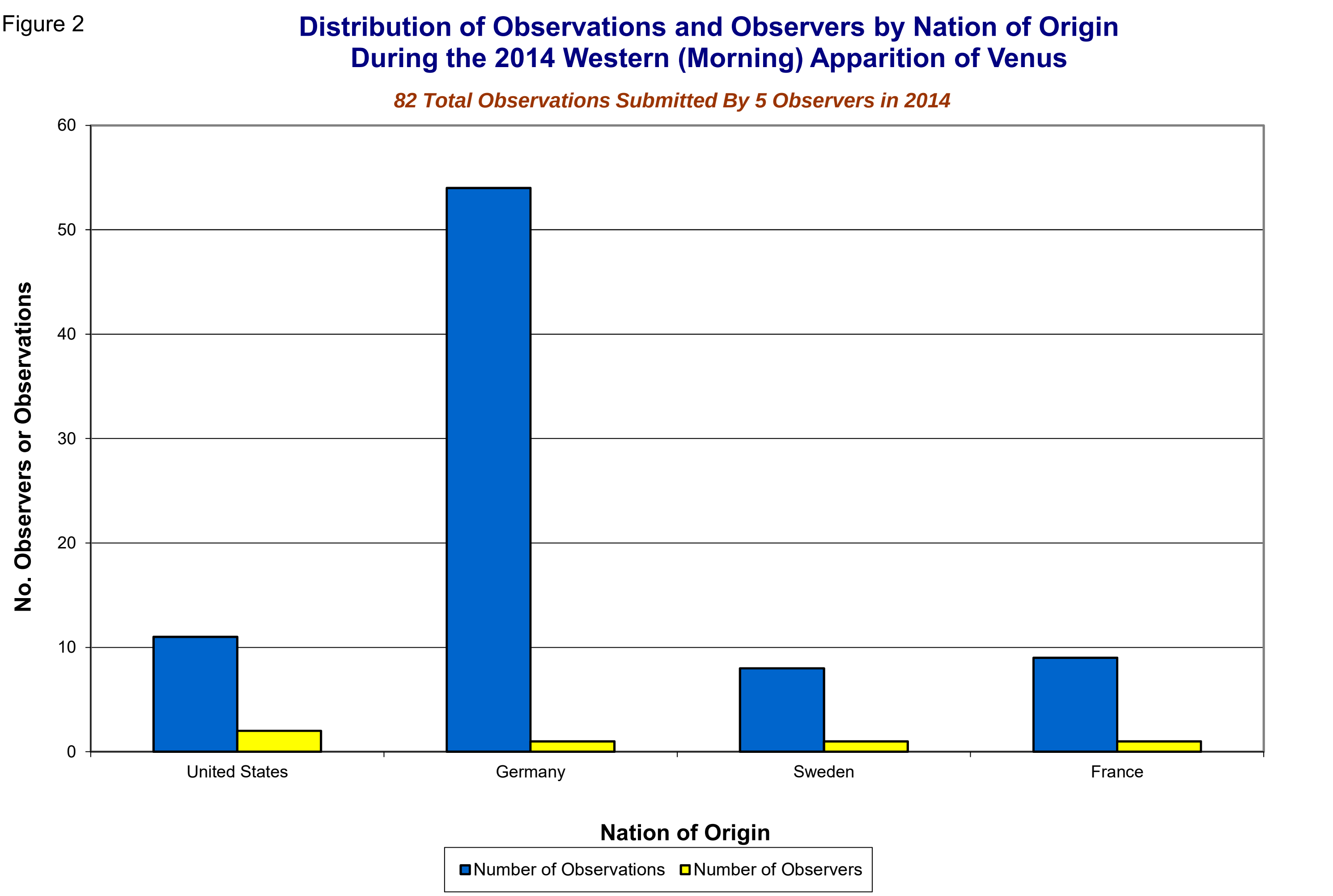
Despite the small number of observers and observations for 2014, the writer is grateful for the reports that were contributed in the form of

Table 2 — ALPO Observing Participants in the 2014 Western (Morning) Apparition of Venus

Observer and Observing Site	No. Obs.	Telescope(s) Used*
Benton, Julius L., Wilmington Island, GA	10	9.0 cm (3.5 in) MAK
Legrande, Michel, Le Baule, France	9	21.0 cm (8.3 in) NEW
Lindberg, H.G., Skultuna, Sweden	8	25.4 cm (10.0 in) SCH-NEW
Melillo, Frank J., Holtsville, NY	1	25.4 cm (10.0 in) SCT
Niechoy, Detlev, Göttingen, Germany	31 23	10.2 cm (4.0 in) REF 20.3 cm (8.0 in) SCT
Total No. of Observers	5	
Total No. of Observations	82	

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

Figure 2



drawings, descriptive reports, and digital images of Venus in 2014. Readers who want to follow Venus in coming apparitions are urged to join the ALPO and start participating in our observational studies. The significant brightness of Venus makes it an easy object easy to find, and around the dates of greatest elongation from the Sun, the planet can be as much as 15 times brighter than Sirius and can even cast shadows when viewed from a dark, moonless observing site. Getting started in the ALPO Venus Section programs requires only minimal aperture, ranging from 7.5 cm (3.0 in.) for refractors to 15.2 cm (6.0 in.) reflectors.

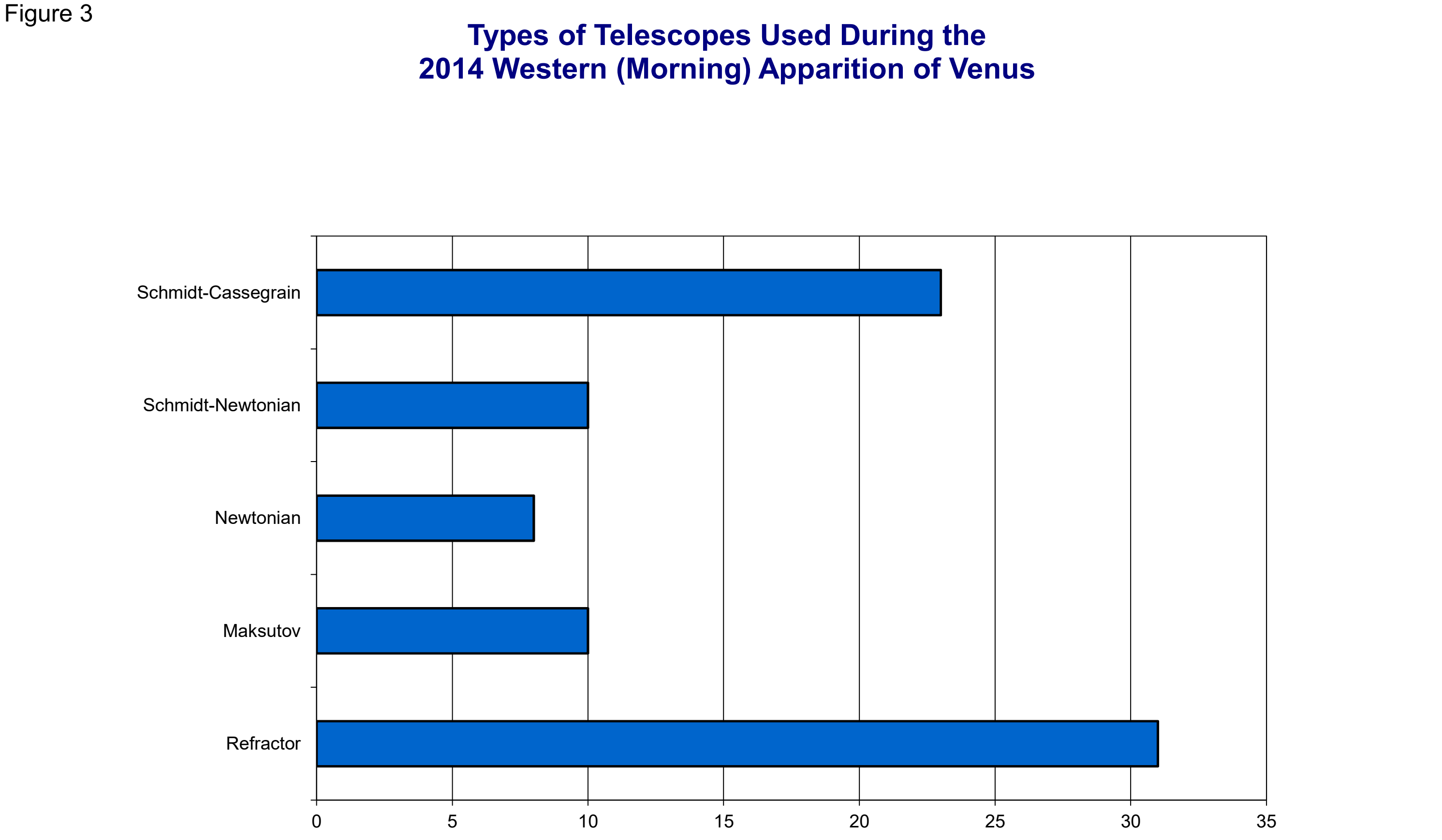
Observations of Atmospheric Details on Venus

The methods and techniques for visual studies of the especially faint, elusive "markings" in the atmosphere of Venus are described in detail in ***The Venus Handbook***, available from the ALPO Venus Section in printed or *.pdf format. Readers who maintain archives of earlier issues of this Journal may also find it useful to consult previous apparition reports for a historical account of ALPO studies of Venus.

Most of the drawings and digital images used for this analytical report were made at visual wavelengths, but several observers routinely imaged Venus in infrared (IR) and ultraviolet (UV) wavelengths. Some examples of submitted observations in the form of drawings and images accompany this report to help readers interpret the level and types of atmospheric activity reported on Venus this apparition.

Represented in the photo-visual data for this apparition were all of the long-established categories of dusky and bright markings in the atmosphere of Venus, including a small fraction of radial dusky features, described in the literature cited earlier in this report. *Figure 4* shows the frequency of readily identifiable forms of markings seen or suspected on Venus. Most observations referenced more than one category of marking or feature, so totals exceeding 100% are not unusual. At least some level

Figure 3



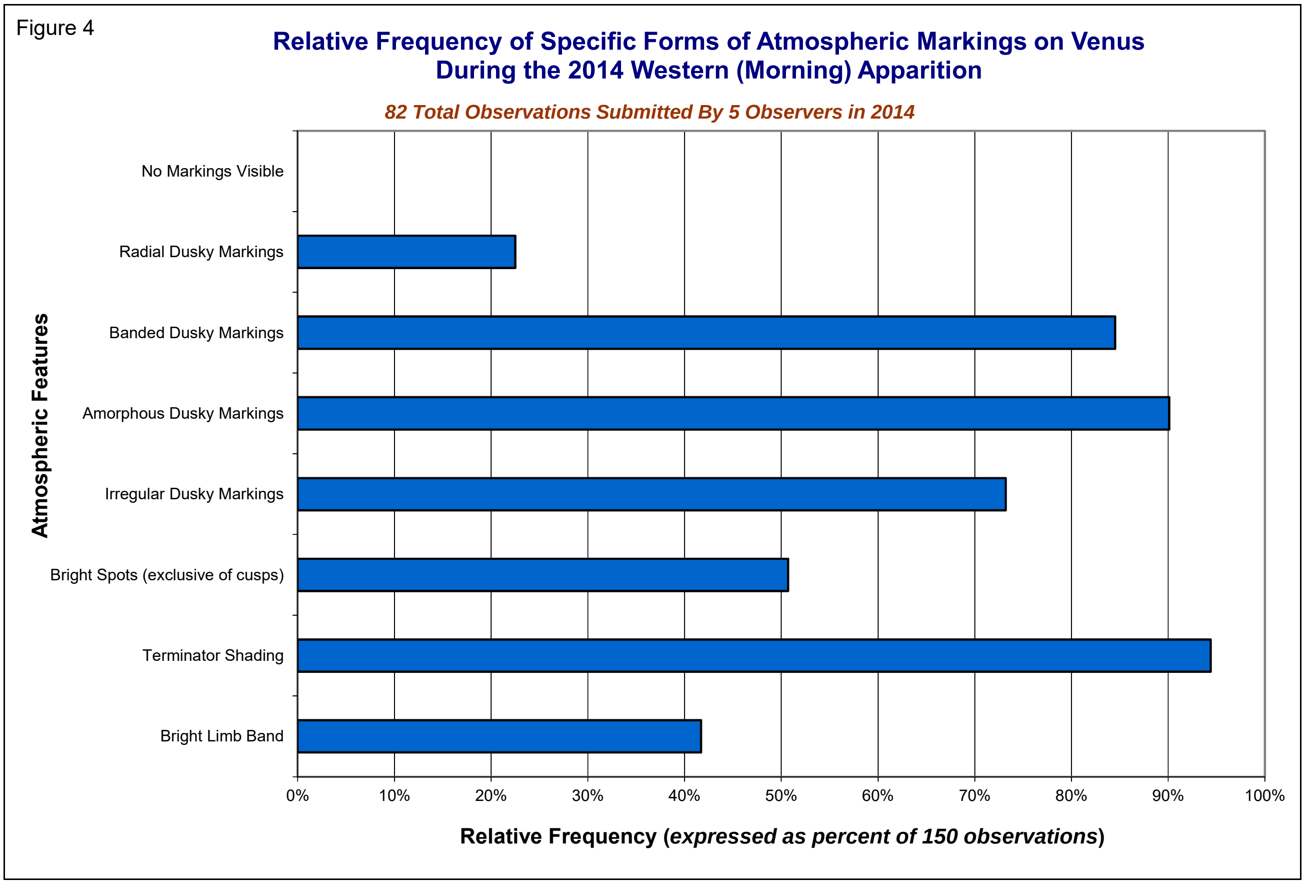


Figure 4
Relative Frequency of Specific Forms of Atmospheric Markings on Venus
During the 2014 Western (Morning) Apparition
82 Total Observations Submitted By 5 Observers in 2014
Atmospheric Features
No Markings Visible
Radial Dusky Markings
Banded Dusky Markings
Amorphous Dusky Markings
Irregular Dusky Markings
Bright Spots (exclusive of cusps)
Terminator Shading
Bright Limb Band
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Relative Frequency (expressed as percent of 150 observations)

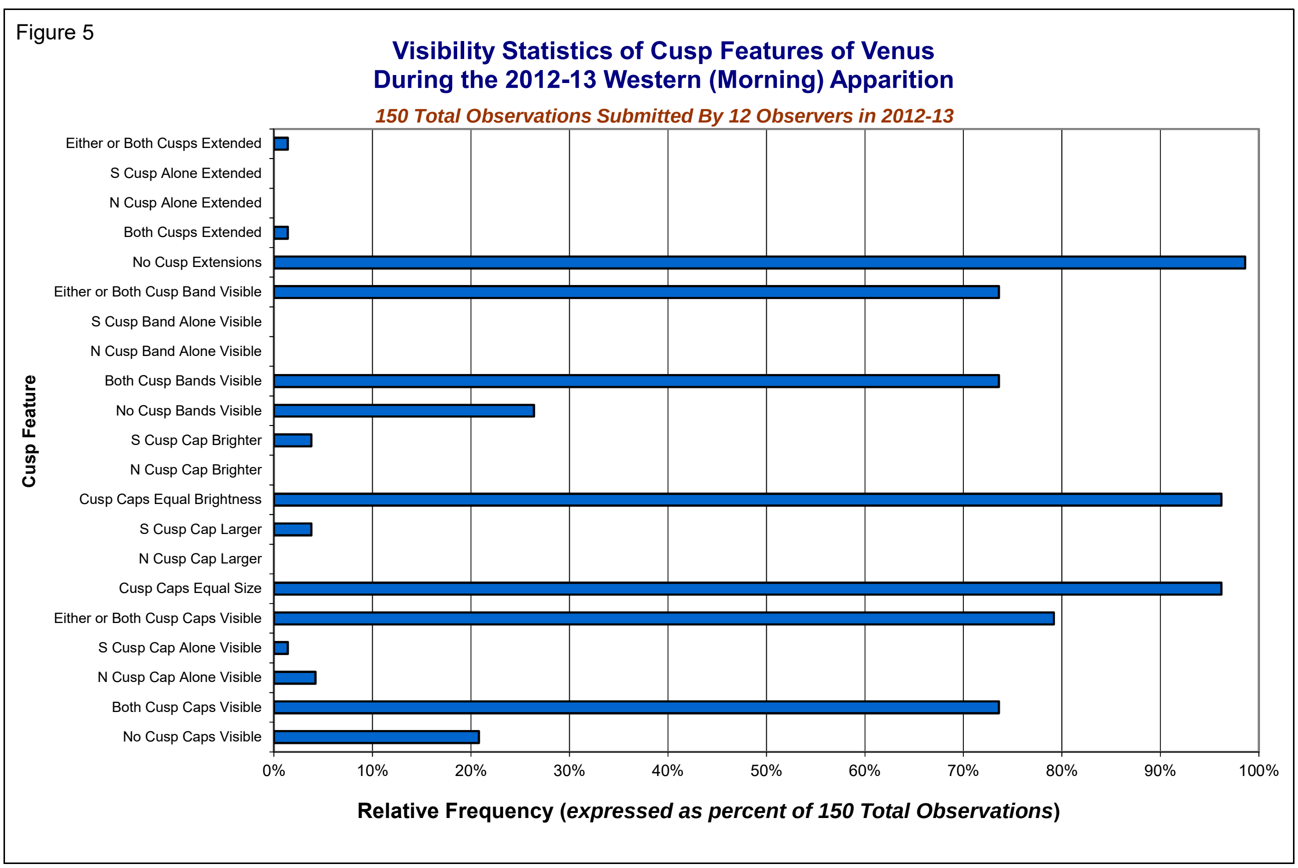


Figure 5
Visibility Statistics of Cusp Features of Venus
During the 2012-13 Western (Morning) Apparition
150 Total Observations Submitted By 12 Observers in 2012-13
Cusp Feature
Either or Both Cusps Extended
S Cusp Alone Extended
N Cusp Alone Extended
Both Cusps Extended
No Cusp Extensions
Either or Both Cusp Band Visible
S Cusp Band Alone Visible
N Cusp Band Alone Visible
Both Cusp Bands Visible
No Cusp Bands Visible
S Cusp Cap Brighter
N Cusp Cap Brighter
Cusp Caps Equal Brightness
S Cusp Cap Larger
N Cusp Cap Larger
Cusp Caps Equal Size
Either or Both Cusp Caps Visible
S Cusp Cap Alone Visible
N Cusp Cap Alone Visible
Both Cusp Caps Visible
No Cusp Caps Visible
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Relative Frequency (expressed as percent of 150 Total Observations)

***General Caption Note for Illustrations 1-16**. REF = Refractor, SCT = Schmidt-Cassegrain, CAS = Cassegrain, MAK = Maksutov, NEW = Newtonian; UV = Ultra Violet light; Seeing on the Standard ALPO Scale (from 0 = worst to 10 = perfect); Transparency = the limiting naked-eye stellar magnitude.*

of subjectivity is inevitable when visual observers attempt to describe, or accurately represent on drawings, the variety of highly elusive atmospheric features on Venus, and this natural bias had some effect on the data represented in *Figure 4*. It is assumed, however, that conclusions discussed in this report are, at the very minimum, sensible interpretations.

The dusky markings of Venus' atmosphere are always troublesome to detect using normal visual observing methods, and this well-known characteristic of the planet is generally independent of the experience of the observer. When color filters and variable-density polarizers are utilized as a routine practice, however, views of cloud phenomena on Venus at visual wavelengths are often measurably improved. Without neglecting vital routine visual work, the ALPO Venus Section urges observers to try their hand at digital imaging of Venus at UV and IR wavelengths. The morphology of features captured at UV and IR wavelengths is frequently quite different from what is seen at visual regions of the spectrum, particularly atmospheric radial dusky patterns (in the UV) and the appearance of the dark hemisphere (in IR). Similarities do occasionally occur, though, between images taken at UV wavelengths and drawings made with blue and violet filters. The more of these that the ALPO Venus Section receives during an observing season, the more interesting are the comparisons of what can or cannot be detected visually versus what is captured by digital imagers at different wavelengths.

Figure 4 illustrates that all visual observations and digital images during the 2014 Western (Morning) Apparition referred to the usual categories of dusky features seen or suspected on the brilliant disc of Venus, the highest percentage falling into the category of "Amorphous Dusky Markings" (90.1%), followed by "Banded Dusky Markings" (84.5%), "Irregular Dusky Markings" (73.2%) [Refer to Illustrations No. 001, 002, 003, 004, and 005], and "Radial Dusky Markings" (22.5%) [Refer to Illustrations No. 003 and 005], whereby the latter are normally only revealed in UV images along with the characteristic "Y- shaped" cloud features in the atmosphere of Venus.

Terminator shading was reported in 94.4% of the observations, as shown in *Figure 4*. Terminator shading normally extended from one cusp of Venus to the other, and the dusky shading was progressively lighter in

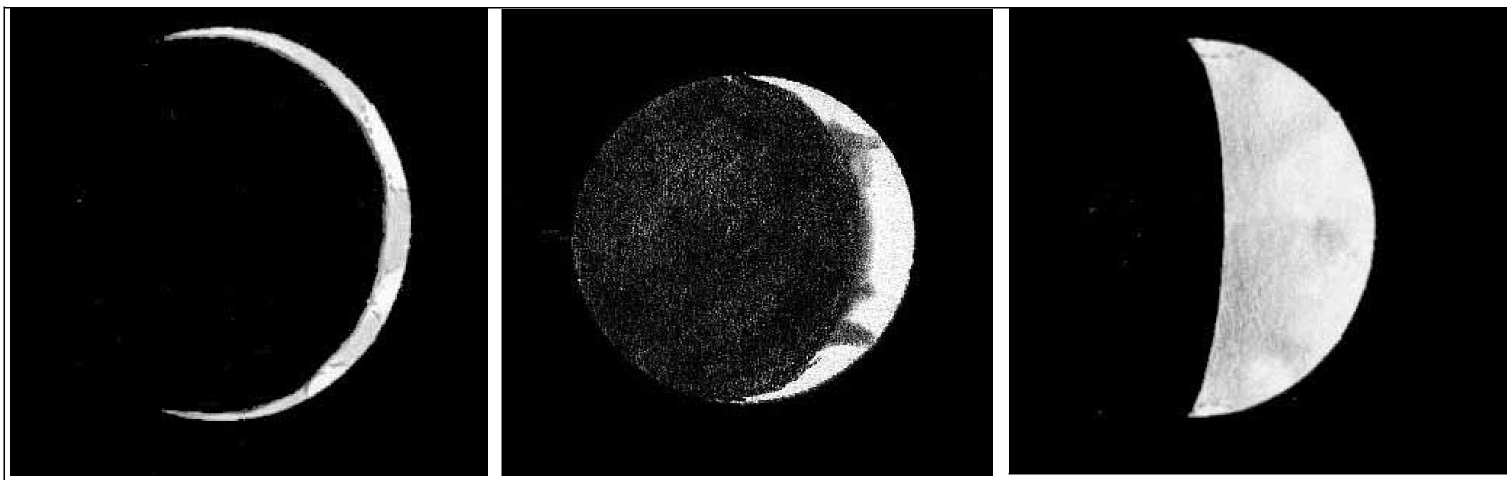


Illustration 001 (top left) 2014 January 22 14:02UT. Drawing by Michel Legrand. 21.0 cm (8.3 in.) SCT at 157X to 210X and W80A (light blue), W47 (violet), and W38 (deep blue) filters. Seeing 6.0, Transparency 4.0. Phase (k) = 0.049, Apparent Diameter = 58.8". Very nice drawing shows the thin crescent of Venus a little less than two weeks after Inferior Conjunction with banded dusky markings and bright areas along the limb. S is at the top of the image.

Illustration 002 (top middle) 2014 February 10 05:43UT Drawing by Detlev Niechoy. 10.2 cm (4.0 in.) REF at 52X using a W15 (deep yellow) filter. Seeing 3.0 (interpolated), Transparency (not specified). Phase (k) = 0.214, Apparent Diameter = 44.3". Banded and amorphous dusky markings are visible along the shaded terminator. S is at the top of the image.

Illustration 003 (top right) 2014 March 09 07:23UT. Drawing by Michel Legrand. 21.0 cm (8.3 in) SCT at 157X to 251X and W80A (light blue) and W38 (deep blue) filters. Seeing 6.0, Transparency 5.0. Phase (k) = 0.418, Apparent Diameter = 29.3". Excellent drawing depicting banded and radial dusky markings, small N and S cusp caps and associated cusp bands, and a shaded regular terminator. S is at the top of the image.

tone (higher intensity) from the region of the terminator toward the bright planetary limb. Many observers described this upward gradation in brightness as ending in the Bright Limb Band. A considerable number of images at visual wavelengths showed terminator shading, but it was most obvious on many UV images [Refer to Illustrations No. 003, 005, 006, 007, and 008].

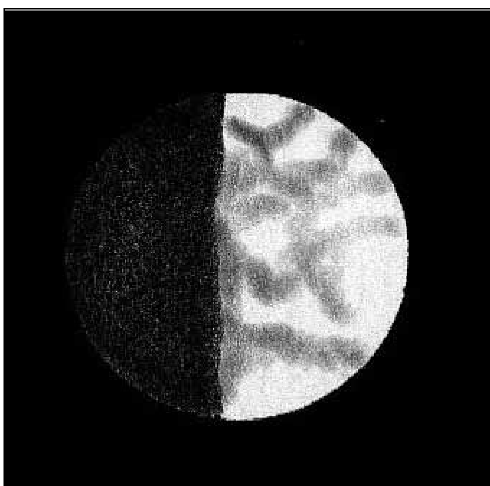
The mean numerical relative intensity for all of the dusky features on Venus this apparition averaged about 8.7. The ALPO Scale of Conspicuousness (a numerical sequence from 0.0 for "definitely not seen" up to 10.0 for "definitely seen") was used regularly, and the dusky markings in Figure 4 had a mean conspicuousness of ~3.5 throughout the apparition, suggesting that the atmospheric features on Venus were within the range from very indistinct impressions to fairly strong indications of their actual presence.

Figure 4 also shows that "Bright Spots or Regions," exclusive of the cusps, were seen or suspected in as many as 50.7% of the submitted observations [Refer to Illustrations No. 009 and 010]. A prominent bright spot was imaged on May 26, 2014 at 06:26 UT at UV wavelength 365nm by Michel Legrand [Refer to Illustrations No. 011]. As a customary practice, when visual observers detect such bright areas, it is standard procedure to denote them on drawings by using dotted lines to surround them.

This apparition, observers regularly used color filter techniques when viewing Venus, and when results were compared with studies in Integrated Light, it was evident that color filters and variable-density polarizers improved the visibility of otherwise indefinite atmospheric markings on Venus.

The Bright Limb Band

Figure 4 illustrates that a little over two-thirds of the submitted observations (41.7%) this apparition referred to a conspicuous "Bright Limb Band" on the illuminated hemisphere of Venus. When the Bright Limb Band was visible or imaged, it appeared as a continuous, brilliant arc running from cusp to cusp only 6.7% of the time, while it was interrupted or only marginally visible along the limb of Venus in 93.3% of the positive reports. The bright limb band was more likely to be incomplete in UV images than those captured at visual wavelengths as well as submitted drawings. The mean numerical intensity of the Bright Limb Band was 9.6, perhaps slightly noticeable with color filters or variable-density polarizers. This very bright feature, usually reported by visual observers this apparition [Refer to Illustration No. 012], was also seen on many of the digital images of Venus received [Refer to Illustration No. 005].



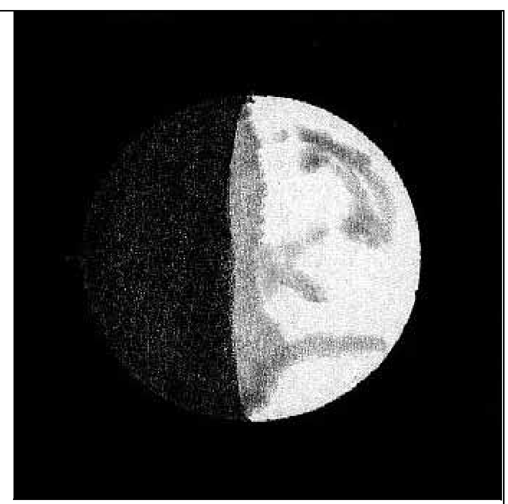


Illustration 004 (bottom left) 2014 April 24 03:56UT Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 163X in Integrated Light (no filter). Seeing 3.0 (interpolated), Transparency (not specified). Phase (k) = 0.641, Apparent Diameter = 18.1". Banded, amorphous, and irregular shadings are shown along with a shaded slightly irregular terminator. S is at the top of the image.

Illustration 005 (bottom middle) 2014 May 29 06:28UT. Digital image by H.G. Lindberg. 25.4 cm (10.0 in.) SCH-NEW with 365nm UV filter. Seeing (not specified), Transparency (not specified). Phase (k) = 0.763, Apparent Diameter = 14.2". Banded, amorphous, and radial dusky markings are visible with a discontinuous bright limb band and shaded irregular terminator. S is at the top of the image.

Illustration 006 (bottom right) 2014 April 02 04:31UT Drawing by Detlev Niechoy. 10.2 cm (4.0 in.) REF at 65X and a W25 (red) filter. Seeing 3.0 (interpolated), Transparency (not specified). Phase (k) = 0.547, Apparent Diameter = 22.1". Banded and irregular dusky markings adjacent to the shaded terminator. S is at the top of the image.

Terminator Irregularities

The terminator is the geometric curve that separates the brilliant sunlit and dark hemispheres of Venus. A deformed or asymmetric terminator was reported in 68.1% of the observations. Amorphous, banded, and irregular dusky atmospheric markings often seemed to merge with the terminator shading, possibly contributing to some of the reported incidences of irregularities. Filter techniques usually improved the visibility of terminator asymmetries and associated dusky atmospheric features. Bright features adjacent to the terminator can sometimes appear as "bulges" while darker markings may look like wispy hollows [Refer to Illustration No. 004 and 005].

Cusps, Cusp-Caps, and Cusp-Bands

When the *phase coefficient*, **k**, is between 0.1 and 0.8 (the phase coefficient is the fraction of the disc that is illuminated), atmospheric features on Venus with the greatest contrast and overall prominence are consistently sighted at or near the planet's cusps, bordered sometimes by dusky cusp-bands. *Figure 5* shows the visibility statistics for Venusian cusp features for this apparition.

When the northern and southern cusp-caps of Venus were reported this observing season, *Figure 5* graphically shows that these features were equal in size 96.2% of the time and also by the same percentage (96.2%) in brightness. So, there were minimal instances when the southern and northern cusp-caps were larger and/or brighter than each other. Both cusp-caps were visible in 73.6% of the observational reports, and their mean relative intensity averaged 9.7 during the observing season. Dusky cusp-bands were detected flanking the bright cusp-caps in 73.6% of the observations when cusp-caps were visible, and when visible, the cusp-bands displayed a mean relative intensity of about 7.5 (see *Figure 5*) [Refer to Illustration No. 008].

Cusp Extensions

In 98.6% of the submitted visual observations during the apparition, cusp extensions were not reported in integrated light or with color filters beyond the 180° expected from simple geometry (see Figure 5). While Venus was passing through its crescent phases following inferior conjunction on January 11, 2014, rare instances of cusp extensions were detected from time to time, ranging from 2° to 8°, but not predominantly evident on any contributed drawings and were rather vague in images submitted. Cusp extensions are notoriously hard to image because the sunlit regions of Venus are overwhelmingly brighter than faint cusp extensions, but observers are still encouraged to try to record these features using digital imagers in upcoming apparitions.

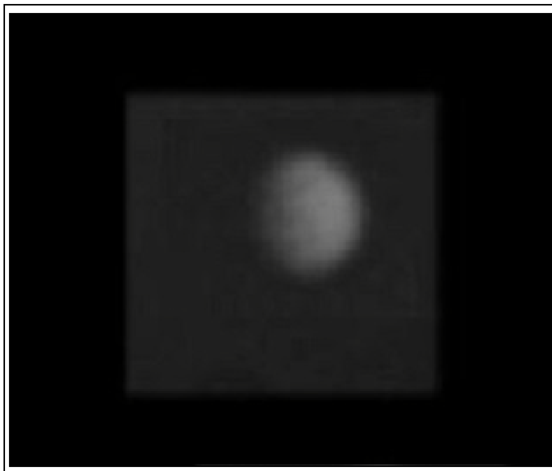
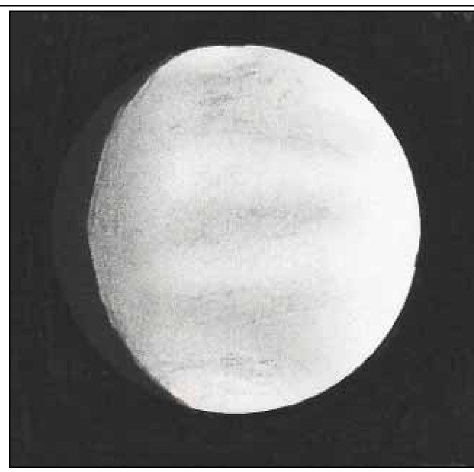




Illustration 007 (top left) 2014 July 22 14:15UT. Digital image by Frank Melillo. 25.4 cm (10.0 in.) SCT using Schott UG-1 UV filter. Seeing = 6.0, Transparency (not specified). Phase (k) = 0.903, Apparent Diameter = 11.2". Banded and radial dusky features are captured on this UV image with terminator shading. S is at the top of the image.

Illustration 008 (top middle) 2014 July 22 13:58UT. Drawing by Julius Benton. 9.0 cm (3.5 in.) MAK at 180X in Integrated Light (no filter) and W80A (light blue) filter. Seeing 5.0, Transparency 4.5. Phase (k) = 0.903, Apparent Diameter = 11.2". Banded dusky markings appear in this drawing including both cusp caps and cusp bands and terminator shading. Compare this drawing with the near-simultaneous image by Frank Melillo on the same date at 14:15UT. S is at the top of the image.

Illustration 009 (top right) 2014 February 18 08:39UT. Drawing by Michel Legrand. 21.0 cm (8.3 in.) SCT at 210X and 314X using W80A (light blue) and W38 (deep blue) filters. Seeing 7.0, Transparency 5.0. Phase (k) = 0.283, Apparent Diameter = 38.8". Very good sketch depicting amorphous and radial dusky markings and a bright spot midway between the cusps and a discontinuous bright limb band toward the N and S along the limb. S is at the top of the image.

Estimates of Dichotomy

A discrepancy between predicted and observed dates of dichotomy (half-phase) is often referred to as the "Schröter Effect" on Venus. The predicted half-phase occurs when k = 0.500, and the phase angle, i, between the Sun and the Earth as seen from Venus equals 90°. Although theoretical dichotomy occurred on March 23:73d, visual dichotomy estimates were not received this apparition.

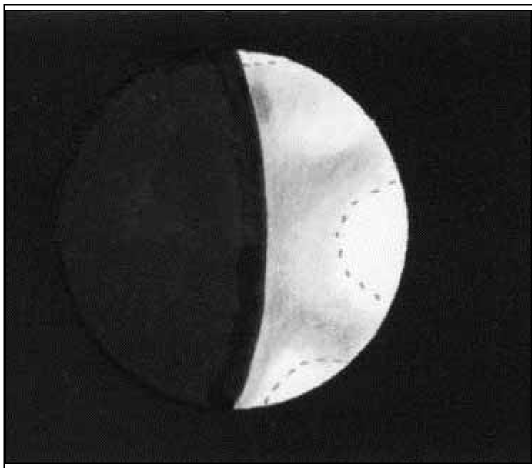
Ashen Light Observations and Dark Hemisphere Phenomena

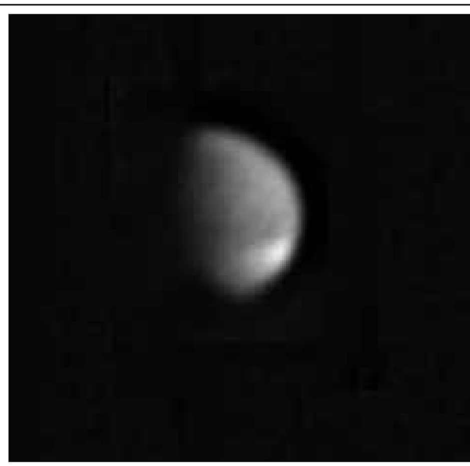
The Ashen Light, reported the first time by G. Riccioli in 1643, is an extremely elusive, faint illumination of Venus' dark hemisphere. Some observers describe the Ashen Light as resembling Earthshine on the dark portion of the Moon, but the origin of the latter is clearly not the same. It is natural to presuppose that Venus should ideally be viewed against a totally dark sky for the Ashen Light to be detectable, but such circumstances occur only when the planet is very low in the sky where poor seeing adversely affects viewing. The substantial glare from Venus in contrast with the surrounding dark sky is a further complication. Nevertheless, the ALPO Venus Section continues to receive reports nearly every apparition from experienced visual observers, viewing the planet in twilight, who are absolutely convinced they have seen the Ashen Light, and so the controversy continues. It would be immensely valuable if two or more observers could simultaneously confirm visual impressions of any suspected Ashen Light on the same date and at the same time. Moreover, Venus observers who are routinely doing digital imaging can hopefully capture and document any illumination that may be present on the planet monitor the dark side of Venus, ideally as part of a cooperative simultaneous observing endeavor with visual observers.

In 2012-13, there were no digital images submitted that suggested the presence of the Ashen Light, but Detlev Niechoy strongly suspected the Ashen Light using a W25 (red) filter as depicted in his rather interesting drawing on February 9, 2014 at 06:02 UT [Refer to Illustration No. 013].

Because the instruments and methods are not that complicated, the ALPO Venus Section encouraged observers to conduct systematic imaging of the planet in the near-IR. At these wavelengths, the hot surface of the planet becomes quite apparent and occasionally mottling shows up in such images, which are attributed to the presence of cooler dark higher-elevation terrain and warmer bright lower surface areas in the IR. There were no IR images submitted during the 2014 apparition of the dark hemisphere

There were several suspected instances during crescentic phases when the dark hemisphere of Venus allegedly appeared *darker* than the





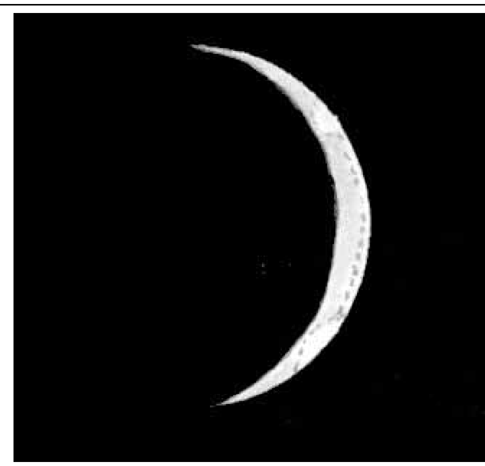


Illustration 010 (bottom left) 2014 March 04 07:51UT. Drawing by Michel Legrand. 21.0 cm (8.3 in.) SCT at 210X using W80A (light blue) and W38 (deep blue) filters. Seeing 6.0, Transparency 5.0. Phase (k) = 0.386, Apparent Diameter = 31.4". Detailed drawing showing radial dusky markings and bright spots on the disk of Venus plus a shaded regular terminator. S is at the top of the image.

Illustration 011 (bottom middle) 2014 May 25 06:26UT. Digital image by H.G. Lindberg. 25.4 cm (10.0 in.) SCH-NEW with 365nm UV filter. Seeing (not specified), Transparency (not specified). Phase (k) = 0.753, Apparent Diameter = 14.5". Amorphous and banded dusky markings are captured in the image. Notice in particular the prominent bright spot along the N limb of Venus. S is at the top of the image.

Illustration 012 (bottom right left) 2014 January 25 10:54UT. Drawing by Michel Legrand. 21.0 cm (8.3 in.) SCT at 210X using W80A (light blue) and W47 (violet) filters. Seeing 5.0, Transparency 3.0. Phase (k) = 0.071, Apparent Diameter = 56.7". This sketch of the crescent Venus illustrates a bright limb band along the limb of the disk with possible associated bright spots. S is at the top of the image.

background sky during the 2014 Western (Morning) Apparition, a phenomenon that is probably nothing more than a spurious contrast effect.

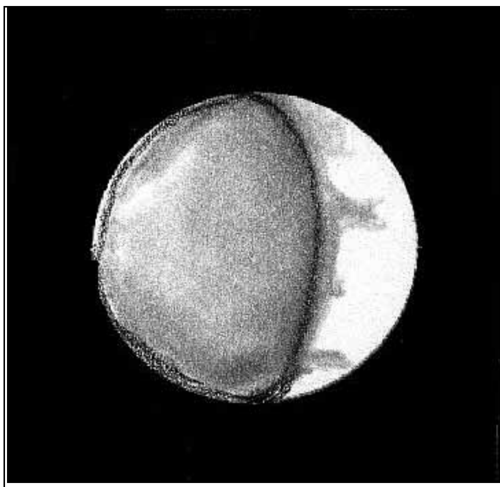
Simultaneous Observations

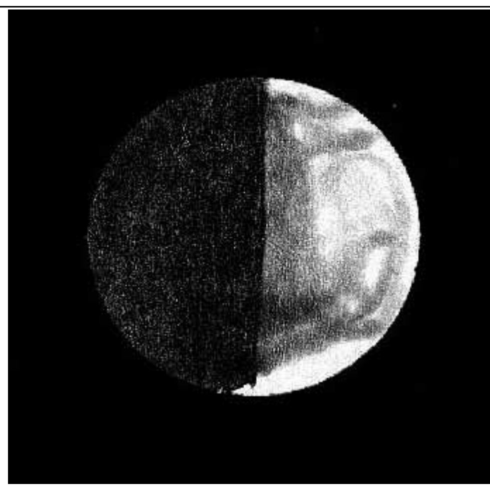
The atmospheric features and phenomena of Venus are elusive, and it not unusual for two observers looking at Venus at the same time to derive somewhat different impressions of what is seen. Our challenge is to establish which features are real on any given date of observation, and the only way to build confidence in any database is to increase observational coverage on the same date and at the same time. Therefore, the ideal scenario would be to have simultaneous observational coverage throughout any apparition. Simultaneous observations are defined as independent, systematic, and standardized studies of Venus carried out by a large group of observers using the same techniques, similar equipment, and identical observing forms to record what is seen. While this standardized approach emphasizes a thorough visual coverage of Venus, it is also intended to stimulate routine digital imaging of the planet at visual and various other wavelengths, such as infrared and ultraviolet. By these exhaustive efforts, we would hope to be able to at least partially answer some of the questions that persist about the existence and patterns of atmospheric phenomena on Venus.

Amateur-Professional Cooperative Programs

The ALPO Venus Section continues to routinely share visual observations and digital images at various wavelengths with the professional community. As readers will recall, the European Space Agency's (ESA's) Venus Express (VEX) mission that started systematically monitoring Venus at UV, visible (IL) and IR wavelengths back in May 2006, ended its highly successful campaign early in 2015 as it made its final descent into the atmosphere of the planet. It was a tremendously successful Pro-Am collaborative effort involving ALPO Venus observers around the globe, and those who actively participated are commended for their perseverance and dedication. It should be emphasized that it is still ***not too late*** for those who want to send their digital images to the ALPO Venus Section and the VEX website (see below) to do so. Sought after also are drawings of Venus in Integrated Light and with color filters of known transmission while the VEX mission was in progress. These collective data are important for further study and will continue to be analyzed for several years to come as a result of this endeavor. The VEX website is *http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=38833&fbodylongid=1856*.

As of this writing, a follow-up Pro-Am effort to the previously concluded Venus Express mission, is already underway with Japan's *Akatsuki* (JAXA) mission that began full-scale observations back in April 2016. And although that mission is continuing in 2017-18, the website for the *Akatsuki* mission has "gone live" so that interested and adequately





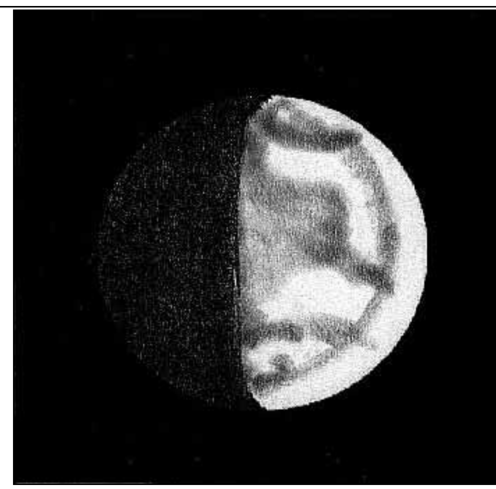


Illustration 013 (top left) 2014 February 09 06:02UT Drawing by Detlev Niechoy. 10.2 cm (4.0 in.) REF at 62X and a W25 (red) filter. Seeing 2.5 (interpolated), Transparency (not specified). Phase (k) = 0.205, Apparent Diameter = 45.0". In addition to banded dusky features, the Ashen Light was very strongly suspected. S is at the top of the image.

Illustration 014 (top middle) 2014 March 14 05:01UT Drawing by Detlev Niechoy. 10.2 cm (4.0 in.) REF at 62X and a W25 (red) filter. Seeing 2.5 (interpolated), Transparency (not specified). Phase (k) = 0.450, Apparent Diameter = 27.4". In addition to banded, irregular, and amorphous dusky features, both Cusp Caps and cusp bands are seen (the South cusp cap is comparatively larger). S is at the top of the image.

Illustration 015 (top right) 2014 April 16 03:59UT Drawing by Detlev Niechoy. 10.2 cm (4.0 in.) REF at 65X in Integrated Light (no filter). Seeing 2.5.0 (interpolated), Transparency (not specified). Phase (k) = 0.609, Apparent Diameter = 19.4". In addition to amorphous and irregular dusky markings, the Bright Limb Band is apparent. S is at the top of the image.

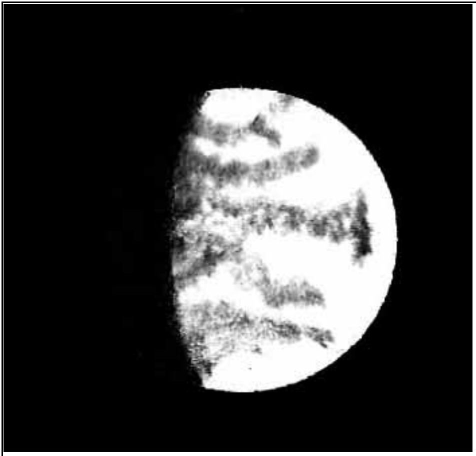


Illustration 016 2014 May 26 03:35UT Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 225X in W25 (red) filter. Seeing 2.5.0 (interpolated), Transparency (not specified). Phase (k) = 0.753, Apparent Diameter = 14.4". In addition to amorphous and irregular dusky markings, both cuso caps and cusp bands are shown. S is at the top of the image.

equipped ALPO observers can register and start submitting images. More information will continue to be provided in forthcoming reports in this Journal. It is extremely important that all observers participating in the programs of the ALPO Venus Section always send their observations to the ALPO Venus Section at the same time submittals are contributed to the *Akatsuki* mission. This will enable full coordination and collaboration between the ALPO Venus Section and the *Akatsuki* team in collection and analysis of all observations whether they are submitted to the *Akatsuki* team or not. To repeat, there will be more updates forthcoming on this Pro-Am effort in later articles in this Journal

Conclusions

Analysis of minimal collection of ALPO observations of Venus during the 2014 Western (Morning) Apparition revealed that vague shadings on the disc of the planet were occasionally apparent to visual observers who utilized standardized filter techniques to help show the extremely elusive atmospheric features. Indeed, it is often very difficult to be sure visually what is real and what is merely illusory at visual wavelengths in the atmosphere of Venus. Increased confidence in visual results is improving as more and more program participants are attempting simultaneous observations. Readers and potential observers should realize that well-executed drawings of Venus are still a vital part of our overall program as we strive to improve the opportunity for confirmation of highly elusive atmospheric phenomena, to introduce more objectivity, and to standardize observational techniques and methodology. It is especially good to see that to a greater extent, Venus observers are contributing digital images of the planet at visual, near-UV, and near-IR wavelengths. It is also meaningful when several observers working independently, with some using visual methods at the same time others are employing digital imaging, to produce comparable results. For example, atmospheric banded features and radial ("spoke") patterns depicted on drawings often look strikingly similar to those captured with digital imagers at the same date and time.

Many of our best UV images are routinely sought after by the professional community, and cooperative involvement of amateurs and professionals on common projects took another step forward with the establishment of the *Venus Amateur Observing Project* (VAOP) in 2006, coincident with the *Venus Express* (VEX) mission, which continued until 2015. The opportunity for future Pro-Am collaboration is continuing in support of the Japanese *Akatsuki* (JAXA) mission that commenced in 2016.

Active international cooperation by individuals making regular systematic, simultaneous observations of Venus remain our main objective, and the ALPO Venus Section encourages interested readers to join us in our many projects and challenges in the coming years.

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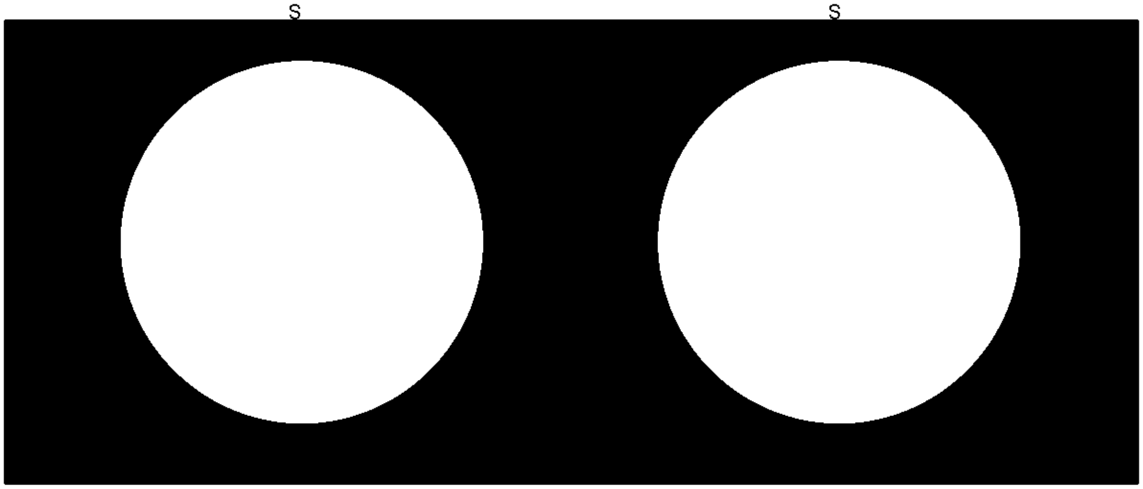
Association of Lunar and Planetary Observers (A.L.P.O.): Venus Section

A.L.P.O. Visual Observation of Venus

Drawing Blank — S   *Intensity Estimates Blank* — S

p  f

N   (*all coordinates are IAU*)   N

Observer_______________________________Location____

UT Date _____________ UT Start _______________ UT End _______________ D = __________″ k_m = __________ k_c = ___________

m_v = ___________ Instrument ____ Magnification(s) _____________ x_{min} _____________ x_{max}

Filter(s) IL(none) __________ f_1 __________ f_2 __________ f_3 ____________ Seeing ______________ Transparency _______________

Sky Illumination (*check one*): [ ] Daylight [ ] Twilight [ ] Moonlight [ ] Dark Sky

Dark Hemisphere (*check one*): [ ] No dark hemisphere illumination [ ] Dark hemisphere illumination suspected
[ ] Dark hemisphere illumination [ ] Dark hemisphere darker than sky

Bright Limb Band (*check one*): [ ] Limb Band not visible
[ ] Limb Band visible (complete cusp to cusp)
[ ] Limb Band visible (incomplete cusp to cusp)

Terminator (*check one*): [ ] Terminator geometrically regular (no deformations visible)
[ ] Terminator geometrically irregular (deformations visible)

Terminator Shading (*check one*): [ ] Terminator shading not visible
[ ] Terminator shading visible

Atmospheric Features (*check, as applicable*): [ ] No markings seen or suspected [ ] Radial dusky markings visible
[ ] Amorphous dusky markings visible [ ] Banded dusky markings visible
[ ] Irregular dusky markings visible [ ] Bright spots or regions visible (exclusive of cusp regions)

Cusp-Caps and Cusp-Bands (*check, as applicable*): [ ] Neither N or S Cusp-Cap visible [ ] N and S Cusp-Caps both visible
[ ] N Cusp-Cap alone visible [ ] S Cusp-Cap alone visible
[ ] N and S Cusp-Caps equally bright [ ] N and S Cusp-Caps equal size
[ ] N Cusp-Cap brighter [ ] N Cusp-Cap larger
[ ] S Cusp-Cap brighter [ ] S Cusp-Cap larger
[ ] Neither N or S Cusp-Band visible [ ] N and S Cusp-Bands both visible
[ ] N Cusp-Band alone visible [ ] S Cusp-Band alone visible

Cusp Extensions (*check, as applicable*): [ ] No Cusp extensions visible [ ] N Cusp extended (angle = _____°)
[ ] S Cusp extended (angle = _____°)

Conspicuousness of Atmospheric Features (*check one*): [ ] 0.0 (nothing seen or suspected) [ ] 3.0 (indefinite, vague detail)
[ ] 5.0 (suspected detail, but indefinite) [ ] 7.0 (detail strongly suspected)
[ ] 10.0 (detail definitely visible)

IMPORTANT: Depict morphology of atmospheric detail, as well as the intensity of features, on the appropriate blanks at the tope of this form. Attach to this form all supporting descriptive information, and please do not write on the back of this sheet. The intensity scale is the *Standard A.L.P.O. Intensity Scale*, where 0.0 = completely black ⇔ 10.0 = very brightest features, and intermediate values are assigned along the scale to account for observed intensity of features.

Feature Story:

ALPO Observations of Jupiter During the 2014-2015 Apparition

By: Richard W. Schmude, Jr.,
Assistant Coordinator,
ALPO Jupiter Section
schmude@gordonstate.edu

To our hard-copy readers: This paper can be viewed in full-color in the online (pdf) version of this Journal.

Abstract

Drift rates for over a dozen currents are reported. The Great Red Spot underwent changes in appearance in late 2014. Oval BA also underwent changes during that time. Brightness measurements covering the wavelength range of 0.37 µm to 1.65 µm are reported. Selected photometric constants in the J and H filters are presented. The U and V filter measurements are consistent with previously published models.

Introduction

The characteristics of Jupiter for the 2014-2015 apparition are summarized in Table 1. Belt, zone and current names and their abbreviations are listed in Table 2. Abbreviations are used in this report. Those observers who submitted observations, images or measurements of Jupiter to either the writer or to the website *http://alpo-j.asahikawa-med.ac.jp/Latest/Jupiter2008Apparition.htm* are included in Table 3. This writer was unable to gain access to the website at the Arkansas Sky observatory; hence, those who submitted observations there may not be in Table 3.

This paper follows certain conventions. The planetographic (or zenographic) latitude is always used. Latitudes were measured using WinJUPOS software (Hahn and Mettig, 2016). "West" refers to the direction of increasing longitude. Longitude is designated with the Greek letter λ and a subscript Roman numeral, which is the longitude system. For example, $\lambda_I = 54°$ means the System I longitude equals 54° W. The three longitude systems are described in (Rogers, 1995, 11). All dates and times are in Universal Time (UT). Unless stated otherwise, all data are based on visible light images. All methane band images were made in light with a wavelength believed to be near 0.89 µm. Currents, except where noted, are named in accordance with Rogers (1990, 88). In all cases, the drift rate, except where noted, is for the center of the feature. Feature names contain a letter and a number. Names are assigned based on the description in Schmude (2010, 31) with one exception: features in the NNNNTC start with the letter J and those further north start with the letter K. All features are renamed every apparition except for the GRS and Oval BA. Therefore, feature B1 is probably not the same as B1 in the previous apparition.

Table 1 Characteristics of the 2014-2015 Apparition of Jupiter[a]

First conjunction date	July 24, 2014
Opposition date	Feb. 6, 2015
Second conjunction date	Aug. 26, 2015
Brightness at opposition (stellar magnitudes)	–2.6
Equatorial angular diameter at opposition	45.4 arc-seconds
Right Ascension at opposition	9h 21m
Declination at opposition	16.5° N
Planetographic latitude of the Earth at opposition	0.2° S
Planetographic latitude of the Sun at opposition	0.0°
[a] Data are from the Astronomical Almanac (2013, 2014)	

Disk Appearance

Figures 1 and 2 illustrate the appearance of Jupiter during 2014-2015. Figure 3 illustrates the appearance of the GRS. Figure 4 shows the appearance of Oval

All Readers

Your comments, questions, etc., about this report are appreciated. Please send them to: *ken.poshedly@alpo-astronomy.org* for publication in the next Journal.

Online Features

Left-click your mouse on:

- The author's e-mail address in blue text to contact the author of this article.
- The references in blue text to jump to source material or information about that source material (Internet connection must be ON).

Observing Scales

Standard ALPO Scale of Intensity:
- 0.0 = Completely black
- 10.0 = Very brightest features
- Intermediate values are assigned along the scale to account for observed intensity of features

ALPO Scale of Seeing Conditions:
- 0 = Worst
- 10 = Perfect

Scale of Transparency Conditions:
- Magnitude of the faintest star visible near Jupiter when allowing for moonlight and twilight

Table 2: Names and Abbreviations of Belts and Zones on Jupiter

Belt and zone name	Abbreviated form	Current name	Abbreviated form
South Polar Region	SPR	South Polar Current	SPC
South Polar Belt	SPB	South South South South Temperate Current	S^4TC
South South South Temperate Zone	S^3TZ	South South South Temperate Current	S^3TC
South South Temperate Belt	SSTB	South South South Temperate Current jetstream	S^3TC jetstream
South Temperate Zone	STZ	South South Temperate Current	SSTC
South Temperate Belt	STB	South Temperate Current	STC
South Tropical Zone	STrZ	South Temperate Belt North jetstream	STBn jetstream
South Equatorial Belt	SEB	South Tropical Current	STrC
South Equatorial Belt Zone	SEBZ	South Equatorial Belt Current, barges	SEBC, barges
Equatorial Zone	EZ	South Equatorial Belt revival	SEB revival
Equatorial Band	EB	North Equatorial Current	NEC
North Equatorial Belt	NEB	North Intermediate Current	NIC
North Tropical Zone	NTrZ	North Tropical Current, barges	NTrC, barges
North Temperate Belt	NTB	North Tropical Current	NTrC
North Temperate Zone	NTZ	North Temperate Current B	NTC-B
North North Temperate Belt	NNTB	North Temperate Current	NTC
North North Temperate Zone	NNTZ	North North Temperate Current Jetstream	NNTC jetstream
North North North Temperate Belt	N^3TB	North North Temperate Current	NNTC
North North North Temperate Zone	N^3TZ	North North North Temperate Current	N^3TC
North Polar Region	NPR	North North North North Temperate Current	N^4TC
Great Red Spot	GRS	North Polar Current	NPC

BA in late 2014 along with two important graphs showing the latitude of the NEB since 1995 and the area of oval B11 during 2014-2015. Figures 5 through 7 contain the longitude versus time graphs for Jupiter's albedo features.

Cudnik, Jackson and Sweetman submitted over 300 light intensity estimates of Jupiter's albedo features. These estimates were made on the scale of 0 = black to 10 = white. Mean light intensities are: SPR (5.9), STrZ (9.5), SEB (3.5), EZs (8.6), EB (7.1), EZn (8.7), NEB (3.2), NTrZ (8.5), GRS (5.0) and NPR (6.1). The mean standard deviation is 0.57 intensity units. Intensity values were similar to those values in the

Table 3: List of Contributors to This Jupiter Apparition Report[a, b]

Name; Location (Type of Observation)	Name; Location (Type of Observation)	Name; Location (Type of Observation)	Name; Location (Type of Observation)
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R. Barzacchi, Italy (I)	C. Go, Philippines (I)	F. Melillo, USA (I)	G. Stelmack, Canada (I)
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J. Boudreau, USA (I)	R. Heffner, Japan (I)	T. Olivetti, Thailand (I)	F. Ucha, Spain (I)
S. Bruno, Romania (I)	R. Hill, USA (I)	S. Ota, Japan (I)	T. Usude, Japan (I)
R. Bullen, UK (I)	M. Hood, USA (I)	H. Oyamada, Japan (I)	A. Vaccaro, Italy I)
J. Camarena, Spain (DN, I)	K. Horii, Japan (I)	K. Ozaki, Japan (I)	M. Vedovato, Italy (m)
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R. Christensen, USA (I)	R. Iwamasa, Japan (I)	C. Perez Lopez, Spain (I)	M. Walo, Poland (I)
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F. Emil, Romania (I)	H. Kondou, Japan (I)	J. Rozakis, Greece (I)	C. Zannelli, Italy (I)
K. Endo, Japan (I)	S. Kowollik, Germany (I)		

[a]Type of observation: D = drawing, DN = descriptive notes, I = image, m = map, PP = photoelectric photometry, Re = Interim report, ss = strip sketch and TT = transit times

[b]All those who submitted images to the ALPO Japan Latest website in the Jupiter archive or to the writer are acknowledged in this table.

Images from the following individuals were used in constructing Figure 4I: K Ando, G. Angelo, T. Akutsu, C. Ashcraft, T. Barry, D. Blesser, G. Blesser, F. Camilo, F. Carvalho, D. Chang, E. Chappel, R. Christensen, A. Coffelt, V. Da Silva Jr., K. Endo, E. De Giorgio, X. Dupont, P. Edwards, H. Einaga, K. Endo, C. Fattinnanzi, L. J. Fernandez, F. Fortunato, C. Foster, A. Garbelina, S. Ghomizadeh, Y. Girin, C. Go, T. Hansen, H. Hashino, R. A. Hillebrecht, K. Horii, T. Horiuchi, T. Ishibashi, R. Iwamasa, W. Jaeschke, S. Kanno, H. Karasawa, M. Kardasis, A. Kazemoto, D. Kolovos, T. Kozawa, T. Kumamori, A. Lasala, P. Lawrence, M. R. Lewis, B. Macdonald, A. Maniero, E. Martinez, M. Matsumoto, P. Maxson, F. Melillo, T. Mishina, S. Mogami, E. Morales-Rivera, M. Naitou, P. Oberc, A. Ohkuma, T. Ohsugi, T. Olivetti, T. Ootomo, J. Ortega, S. Ota, K. Ozaki, A. Pace, D. Parker, D. Peach, C. Pellier, M. Phillips, J. J. Poupeau, D. Put, K. Quin, J. Rozakis, K. Sasaki, I. Sharp, F. Silva-Correa, A. Soares, E. Solito, C. Sprianu, G. Stelomack, K. Suzuki, T. Suzuki, G. Tarsoudis, K. Tokujiro, G. Walker, A. Wesley, F. Willems, A. Yamazaki, T. Yoshida, K. Yunoki, C. Zanelli, L. Zieke.

previous apparition (Schmude, 2017, 42).

Table 4 lists latitudes of five belts. The largest change, compared to the previous apparition, is the southward shift in the North edge of the NNTB. It was at 32.4° N in the current apparition and at 35.4° N in the previous one (Schmude, 2017, 44). This is a difference of 3.0°. One other change is the thicker NNTB in the current apparition compared to the previous one.

Figure 2I shows the latitudes of the north and south edges of the NEB measured between May 1995 and July 2017. Monthly latitudes are based on measurements made at different longitudes in images made mostly in visible light. Between 1995 and 2017, this belt underwent large expansion events in 1996, 2000, 2004, 2009, 2012 and 2017. Almost all of the expansion has been at the northern edge. The southern edge may change by ~0.5° every 10-15 years. More measurements, however, are needed to confirm this.

Table 5 lists latitudes for a few features in methane band light. The northern edge of the bright South Polar Cap was 4.0° farther north in the current apparition compared to the previous one. The bright North Polar Cap, however, was 4.0° farther south in the current apparition than in the previous one. The north edge of the NNTB was similar to what it was in the previous apparition (Schmude, 2017, 44).

Measurement of White, Red, Brown and Gray Ovals on Jupiter

The mean feature sizes are summarized in Table 6. In all cases, the software package WinJUPOS (Hahn and Mettig, 2016) was used in measuring the north, south, east and west edges. The difference in the east and west edge was taken to be the E-W length. Similarly, the difference in the north and south edges was taken to be the N-S length. Unless noted otherwise, the dimensions of just the bright portion of white ovals are reported. Most of the values are the average of two or more measurements. Oval dimensions (in km) were computed in the same way as in the 2011-2012 apparition (Schmude, 2014b, 49) except that the R_P^2 replaces the 1 in the numerator; that is X component of K = $R = (R_P^2/[TAN^2(B))+(R_P^2/R_E^2])^{1/2}$.

Several features were bright in methane band images as shown in Table 6. Anything appearing bright in these images probably extends to a high altitude (Rogers, 1995, 64). Some ovals may have been too small to be imaged in methane band images. Higher resolution methane band images in future years may reveal the true nature of the smaller ovals.

Region I: Great Red Spot

Several observed the GRS visually. Abel reported that it was difficult to see on Nov. 15 even though it was near the central meridian. Adachi reported the GRS had an orange color on February 24 when it was near the central meridian. Two days later Abel reported the same color. Almost two weeks later, he described it as having a reddish color when it was ~50° from the central meridian. He also drew the southern half darker than the northern half. Sweetman described the GRS as being darker on the south edge than on the north edge on both April 19 and May 11. Kassl reported it had an orange color on March 8 and stated the color was stronger than in the previous apparition.

The GRS underwent several changes. Figures 1F, 1G, 1K, 1L, 2A and 2D give its general appearance. Figures 3A-3L illustrate how it changed between October 6 and December 6, 2014. In mid-November, a large dark arc surrounded it (see Figure 3D). The arc's

Table 4: Planetographic Latitudes of Belts on Jupiter(based on Images Made in Visible Wavelengths in February 2015

Feature	South Edge	North Edge
South Polar Belt	66.9° S ± 1.5°	62.2° S ± 1.5°
South Equatorial Belt	22.2° S ± 1.0 °	8.1° S ± 1.0°
North Equatorial Belt	6.8° N ± 0.3°	17.6° N ± 0.3°
North Temperate Belt	27.6° N ± 1.5°	29.9° N ± 1.5°
North North Temperate Belt	32.4° N ± 1.0°	38.0° N ± 1.0°

Table 5: Planetographic Latitudes of Belts on Jupiter Based on Methane-Band Images Made at a Wavelength of 0.889 μm in February 2015

Feature	South Edge	North Edge
South Polar Cap	–	67.5° S ± 1.0°
South Equatorial Belt	20.9° S ± 1.5°	6.3° S ± 1.5°
North Equatorial Belt	8.6° N ± 2.0°	18.1° N ± 1.5°
North Temperate Belt	22.7° N ± 0.5°	27.5° N ± 1.5°
North North Temperate Belt	35.0° N ± 1.5°	39.5° N ± 1.5 °
North Polar Cap	70.7° ± 3.5°	–

Table 6: Dimensions of White, Red and Dark Oval Features

Feature (current)	Length (degrees)		Dimensions km N-S/E-W	Aspect	Area (Mm^2)	Bright in CH_4
	N-S	E-W				
A2b (SPC)	2.1	3.6	2,500/2,400	1.06	5	
A3b (SPC)	2.3	5.0	2,700/3,400	0.81	7	Yes
A1 (SSSTC)	2.2	3.7	2,700/3,000	0.88	6	Yes
B1 (SSTC)	3.0	4.3	3,600/4,100	0.88	12	
B2 (SSTC)	2.7	4.2	3,300/4,000	0.82	10	Yes
B4 (SSTC)	2.1	4.6	3,800/4,400	0.88	13	Yes
B5 (SSTC)	2.0	2.6	2,500/2,600	0.94	5	Yes
B6 (SSTC)	2.2	3.4	2,700/3,300	0.81	7	Yes
B7 (SSTC)	3.2	4,1	3,900/3,900	1.00	12	
B8 (SSTC)	2.6	3.5	3,100/3,400	0.82	8	Yes
B9 (SSTC)	2.4	3.5	3,000/3,300	0.89	8	Yes
B10 (SSTC)	1.8	2.6	2,200/2,600	0.85	4	
B11 (SSTC)	2.9	4.4	3,600/4,300	0.84	12	Yes
B12 (SSTC)	2.1	3.2	2,500/3,000	0.84	6	Yes
B15 (SSTC)	1.8	2.3	2,200/2,200	0.98	4	
BA (STC)	5.5	7.7	6,700/8,100	0.83	43	Yes
GRS (STrC)	10.4	14.7	12,800/17,100	0.75	172	Yes
F3 (NTC)	1.2	2.1	1,500/2,300	0.66	3	Yes
F6 (NTC)	2.3	2.8	2,800/2,900	0.96	7	
H1 (NNTC-jet)[a]	2.5	3.5	3,100/3,700	0.83	9	
H2 (NNTC-jet)[a]	3.1	5.8	3,800/6,100	0.62	18	
H3 (NNTC-jet)[a]	2.8	3.4	3,400/3,600	0.96	10	
H5 (NNTC-jet)[a]	3.2	4.0	3,900/4,200	0.94	13	
H8 (NNTC-jet)[a]	2.8	3.6	3,400/3,800	0.91	10	
H9 (NNTC-jet)[a]	3.2	5.7	3,900/6,000	0.65	19	
G2 (NNTC)	3.5	5.0	4,300/4,800	0.88	16	Yes
G3 (NNTC)	2.1	2.8	2,600/2,700	0.98	5	No
G5 (NNTC)	1.5	2.0	1,800/1,900	0.92	3	
I1 (NNNTC)	1.6	1.9	1,900/1,700	1.15	3	Yes/No[b]
I2 (NNNTC)	1.2	2.6	1,500/2,300	0.62	3	
J1 (NNNNTC)	2.3	3.6	2,700/2,700	1.01	6	
J4 (NNNNTC)	1.8	2.5	2,100/1,900	1.12	3	
J5 (NNNNTC)	1.6	3.5	1,900/2,700	0.72	4	

[a]The outer dark edge was measured as in previous apparitions. This is the first apparition where this writer noticed small white cores inside of the dark NNTC Jetstream features.

[b]Bright on Nov. 22 and Feb. 11 but not bright on March 16 and April 11

southwestern portion (upper right in Figure 3) underwent many changes during this time. The GRS had returned to a normal appearance by February 11, 2015 (see Figure 1G). Similar arcs may have been present on July 3, 1938 (Rogers, 1995, plate P7) and February 1, 1979 (Rogers, 1995, plate P17). A second unusual feature developed in late February. Damian Peach captured several images of two large white streaks cutting into the northeastern portion of the GRS (see Figure 3M). These steaks were ~5000 km long. They were not discerned in a methane band image made about 10 hours later. There was no sign of them on a February 24 image made at 20:34 made by M. Jacquesson; however, lower resolution may have been the cause of this. The streaks may have dissipated rapidly as well since there is no sign of them on a February 28 image made at 3:37.8 by Michael Phillips. T. Olivetti also imaged a white streak cutting into the northern portion of the GRS on Nov. 22 at 22:50. It was best seen in his RGB image. C. Go and M. Lewis also imaged similar streaks on April 3 (see Figure 3Q) and April 23 at 19:26.

Shortly after Damian Peach made his image showing white streaks in the GRS, Chris Go imaged it in methane band light (see Figure 3N). There was a large white extension on the western side which extended for thousands of kilometers. The visible light image taken at nearly the same time shows no unusual activity (see Figure 3O). Two days later, this extension had become weaker but signs of it were still present (see Figure 3P). I myself have not seen a feature like this before. The fact that the white extension was bright in methane band light suggests it had a high altitude on February 26 and the altitude either fell or the cloud creating the extension faded by February 28.

Two other new features were also imaged in methane band light. A large white area just north of the GRS was imaged by D. Parker on January 18 (see Figure 3S). Just over four months later, C. Go may have imaged a dark arc inside the bright GRS (see Figure 3T). It may be worthwhile for observers to adjust the exposure time for their methane band images in future years to bring out methane-band details inside of the GRS.

The mean longitude of the GRS, within 15 days of opposition, was 222.0° ± 0.3° W. The uncertainty is the standard deviation divided by the square root of the number of measurements (24). The mean longitude is close to the predicted value of 218° W (Schmude, 2016a, 74). The mean dimensions of the GRS were 5-10% larger than in the previous apparition. This change was unexpected since the GRS was separated from the SEB in both apparitions and, hence, the dark border was included in GRS measurements in both apparitions.

The mean System II drift rate of the GRS in 2014-2015 was 1.4 ±0.1 degrees/30 days. The uncertainty includes only random error. Error caused by Jupiter's phase effect is not included. The drift rate is similar to the rate in the previous apparition (Schmude, 2017, 46).

Region II: South Polar Region to the South Tropical Zone

A faint South Polar Belt (SPB) was visible (see Figures 1D, 1G and 2A). Its position was similar to that in January 2014 (Schmude 2017, 44). This belt was usually a little darker in red filter images than in blue filter images.

In methane band images both Polar Regions appeared bright. The bright area over the SPR was larger and brighter than the one over the NPR which is consistent with the previous apparition (Schmude, 2017, 55). The bright South Polar Hood often had northward projections. One of them extended 2° (or over 2,000 km) farther north at 306° W in a February 27 image by C. Go. Several similar extensions were also imaged by C. Go in late May.

In visible light, both polar regions were observed to have nearly the same light intensity according to Cudnik and Sweetman. A t-test was carried out at the = 0.10 (two-tailed) confidence level and it was found that there is no statistical difference between the intensity for the NPR and SPR in 2014-2015 (Larson and Farber, 2006, 418).

Rogers (1995, 192; 2008, 15) has shown the GRS has shrunk since the 19th century. This writer was curious about whether a large white oval in the SSTC underwent a size change over several months. Therefore, feature B11 was selected and the results are shown in Figure 4J. There seems to be little change in the area over several months. The same is true for the north-south and the east-west dimensions. Therefore any changes in size are below the limits of detection.

The thickness of the dark outer portion of oval B11 was measured to be 1,200 km on March 2. The thickness was determined by measuring the sizes outside and inside of the dark outer portion. The differences were computed yielding the mean thickness.

Abel made two visual observations of Oval BA. On Nov. 15, he reported it had an orange color. Almost five months later, however, he reported it had no color and only its dark border could be seen.

Oval BA underwent changes in late 2014 (see Figures 4A-4H). It passed the GRS in late September, which may have initiated the changes. One change was the development of a thick, dark cloud wall in November. By late December, this wall had become thinner (see Figures 4A-

Table 7: Planetographic Latitudes and Drift Rates of Features South of the EZ

Feature (description)	Number of points	Latitude	Drift rate deg./30 days	Feature (description)	Number of points	Latitude	Drift rate deg./30 days
South Polar Current near 60° S (SPC near 60° S) *See also see Figure 7*							
A2a (wo)	9	61.6° S	–30.0	A2b (wo)	28	59.9° S	–1.1
A2c (wo)	7	60.2° S	–17.8	A3a (wo)	11	61.1° S	–39.1
A3b (wo)	33	58.7° S	4.5				
Average						*60.3° S*	*–16.7*
South South South South Temperate Current (SSSSTC)							
A5 (b)	18	54.9° S	–27.1				
South South South Temperate Current (SSSTC)							
A1 (wo)	60	50.8° S	7.3	A4 (wo)	24	46.0° S	–18.1
Average						*48.4° S*	*–5.4*
South South South Temperate Current Jetstream (SSSTC Jet)							
A6 (wo)	8	43.7° S	-101.1				
South South Temperate Current (SSTC)							
B1 (wo)	45	41.3° S	–29.2	B2 (wo)	42	41.3° S	–29.8
B3 (wo)	15	39.8° S	–27.3	B4 (wo)	44	41.9° S	–28.5
B5 (wo)	41	38.2° S	–24.9	B6 (wo)	48	41.0° S	–25.9
B7 (wo)	44	41.0° S	–28.6	B8 (wo)	42	40.5° S	–28.5
B9 (wo)	47	41.5° S	–27.2	B10 (wo)	23	39.2° S	–29.1
B11 (wo)	45	41.8° S	–28.7	B12 (wo)	52	41.7° S	–27.7
B15 (wo)	19	40.6° S	–24.8				
Average						*40.8° S*	*–27.7*
South Temperate Current (STC)							
BA (wo)	51	33.5° S	–13.4	C1 (ds)	21	33.9° S	–4.4
C2 (wo)	30	34.1° S	–11.6	C3 (f)	69	30.1° S	–15.2
C4 (ds)	12	32.8° S	–10.9				
Average						*32.9° S*	*–11.1*
STBn Jetstream (STBn Jet)							
D1 (ds)	29	26.6° S	–92.6	D3 (ds)	5	29.5° S	–86.7
D4 (ds)	5	28.3° S	–87.4	D5 (ds)	4	26.4° S	–68.5
D6 (ds)	5	27.9° S	–105.5				
Average						*27.7° S*	*–88.1*
Great Red Spot (GRS)							
GRS (ro)	81	23.1° S	1.4±0.1				
South Equatorial Belt Current (SEB Current)							
D7 (b)	34	17.1° S	6.2	D8 (b)	15	17.0° S	5.0
D9 (b)	9	17.3° S	12.3	D10 (b)	10	17.1° S	5.2
Average						*17.1° S*	*7.2*
Note in description: wo = white oval, ds = dark spot, b = barge, f = festoon, ro = red oval, ws = bright spot, lp = low projection, rb = red barge, wb=white bay. Approximate drift rates are in parentheses.							

4E). A second change was the development of an inner orange ring. This ring persisted from at least October 2, 2014 to June 9, 2015. Similar orange rings developed during the three previous times Oval BA passed the GRS (See the following images at the ALPO Japan Latest website (*http://alpo-j.asahikawa-med.ac.jp/Latest/Jupiter2008Apparition.htm*): Sept. 13, 2012, 9:22.3 UT image by Willingham; Sept. 1, 2010, 18:12.3 UT by Wesley; and July 5, 2008, 13:55.4 UT by Wesley). Oval BA passed the GRS in June 2008, August 2010 and September 2012; hence, all three images just mentioned occurred when Oval BA had just passed the GRS.

Mean drift rates for features between 62° S and 20° S are summarized in Table 7. These rates are mostly consistent with the four previous apparitions (Schmude 2012, 38; 2014b, 52, 2016a, 65; 2017, 59). Three currents are described in more detail.

One current which had a change in drift rate was near 60° S. During the last four apparitions, features near this latitude usually had a constant drift rate (Schmude, 2012, 49; 2014b, 60; 2016a, 72 and 2017, 59). The exceptions were A2 in 2012-2013 (Schmude, 2016a, 72) and A1 in 2013-2014 (Schmude, 2017, 59). During 2014-2015, both features (A2 and A3) near 60° S had a drift rate which changed (see Figure 5). A changing latitude may have caused the drift rate change. Schmude (2014a, 38) reported the drift rate changed at about the same time the latitude changed for a feature near 50° S in 2011-2012. Therefore, the data for A2 were broken into three parts based on the drift rate: A2a (Oct. 11-28), A2b (Nov. 1, 2014-March 27, 2015) and A2c (March 30-May 16). Similarly the A3 data were broken into two parts: A3a (Oct. 20-Nov. 30) and A3b (Dec. 2, 2014-May 16, 2015). Graphs of the System II longitude versus time for these features are shown in Figure 7. Latitudes are summarized in Table 7. The mean latitudes with standard deviations (sd) and the number of measurements (n) for A2a, A2b and A2c are: (61.6° S, sd = 1.14°, n = 7); (59.9° S, sd = 1.07°, n = 10) and (60.2° S, sd = 1.06°, n = 8), respectively. The corresponding values for A3a and A3b are: (61.1° S, sd = 0.84°, n = 8) and (58.7° S, sd = 1.21°, n = 11), respectively. A t-Test was carried out at the = 0.10 (two-tailed) confidence level to determine whether there is a statistical difference for the latitudes of A2a/A2b/A2c and for A3a/A3b (Larson and Farber, 2006, 418). There is a statistical difference between the latitudes for A2a and A2b. Similarly, there is a statistical difference for the latitudes of A3a and A3b. Therefore, the different drift rates for A2a/A2b and A3a/A3b may be the result of a change in latitude. There was, however, no statistical difference between the latitudes of A2b and A2c.

One feature, A1 in the SSSTC, oscillated a few degrees in longitude (see Figure 5). It is not clear what caused this oscillation, but changing latitude is suspected.

The drift rate of A6 in the SSSTC Jetstream was –101.1°/30 days which is more negative than those measured in 2010-2011, 2011-2012 and 2013-2014 which were all near –91°/30 days (Schmude, 2012, 38; 2014b, 52; 2017, 46). A latitude difference in 2014-2015 is probably not the cause of the difference. More measurements of the SSSTC jetstream will need to be made before determining the cause in the difference between the drift rate in 2014-2015 and previous years.

Region III: South Equatorial Belt

Several observed the SEB. Abel reported the SEB zone was dark with bright sections on Dec. 29. Almost one month later, he reported it had an orange color with dark sections. Adachi described the SEB as having a grayish-brown color on April 25. In RGB images it was darker than oval BA but was not as dark as the NEB. Adachi mentioned the NEB was darker than the SEB on Jan. 16.

Just over three weeks later he reported the SEB was "hard to see". It did not have a wide bright zone cutting across its center at all longitudes but did have shorter zones spanning up to 140° of longitude. In fact, on March 2 Adachi drew a dark strip running across the central portion of the SEB at a system II longitude of 240° W to 60° W. This observation is different from methane band images on Nov. 22, February 11 and May 3, which show a bright band running across the SEB.

This belt had at least four dark barges in it (D7-D10). Their drift rates and latitudes are summarized in Table 7. The corresponding longitude versus time graph is shown in Figure 5.

Region IV: Equatorial Zone

The EB was often drawn by Cudnik and Adachi. Sweetman usually drew portions of it. This band is visible in several of the images in Figure 1. Its light intensity was similar to what it was in the previous apparition. Adachi reported the EB had a bluish color on March 2 and 8, but reported it was hard to see on February 7.

The EZ was reported to be bright by several visual observers. Adachi reported it appeared bluish on March 17. He also reported the southern portion was brighter than the northern portion on April 30.

This writer followed three festoons during late 2014 and early 2015. See Table 8 and Figure 5. Figure 1F shows two of these (F1 and F2). The long narrow festoon starting just left (east) of the central meridian is F1 and the thicker and shorter festoon just to the right of F1 is F2. Figure 1D shows F4, which is the thick feature about 30° to the right (west) of the central meridian. The mean drift rate of these features is similar to that in the previous apparition (Schmude, 2017, 47).

Region V: North Equatorial Belt

The NEB had a brownish color in RGB images made on Nov. 22, February 11 and May 3. It was darkest in Olivetti's B filter image and lightest in his R filter image which is consistent with a reddish color. Adachi reported the central and northern portions of the belt were reddish on March 2. Almost two months later, he reported it had an orange-brown color. On. February 26, Abel reported the NEB was much browner than the SEB. On at least three dates (Oct. 25, Nov. 6 and Dec. 29), he reported the northern border of the NEB was irregular and curved in places.

The drift rates of two shallow bays, a diffuse white spot (N1) and two dark spots are in Table 9. Feature N1 was difficult to observe because it was in the NTrZ, but it caused a bay in the NEB. It is visible in Figure 1C about 40° to the right (west) of the central meridian. It is also visible in Figure 2A near λ_{II} = 30°.

Region VI: North Tropical Zone to the North Polar Region

Figure 2 shows the general appearance of the northern portion of Jupiter. The NTB was dark at some longitudes and faint at others (see figures 1D, 1F, 1G and 2A). Abel described it as being "vague in places" on February 26 at λ_{II} = 230° W. Almost two months later he reported that there is "hardly any sign of the NTB or NNTB". He reported the NNTB had a grayish-brown color on April 5 when λ_{II} = 216° W. This observation is consistent with a color image made by Stelmack on the same day.

The drift rates for several currents between 30° N and 63° N are summarized in Table 9. Most of the currents have mean drift rates consistent with those in the previous apparition (Schmude, 2017, 48). A few features are described in more detail.

A dark barge (F1) in the NTC was first measured on Sept. 14, 2014 and was followed until April 23, 2015. This feature was distinct and is shown in Figure 1G just left (east) of the central meridian and in Figure 2A near λ_{II} = 172° W. Adachi drew it on March 8 and described it as having a "chocolate" color. It was darkest in blue and lightest in red light on Nov. 1.0. This observation is consistent with it reflecting more red than blue light. Three weeks later, Olivetti imaged this feature. In this image, it had a light brown color on the preceding side and a dark brown color on the following side. On April 13, it was stretching out and fading. Sweetman did not record it in his April 7 drawing even though F1 was ~20° east of the central meridian. This feature had mean NS × EW dimensions of 2.25° × 10.0° (Nov. 15-April 5) and 2° × 13° (April 13-23). Therefore, it grew longer and fainter in mid-April. The shape of F1 also changed in early 2015. For example, on February 20, it had a uniform bar shape, like a hot dog, but 10 days later, its north-south dimension was widest on the preceding side. In an April 5 image, its north-south dimension was widest on the following side.

The dark ovals in the NNTC jetstream developed small white cores (see Figure 1G). This characteristic is different than in previous apparitions (Schmude, 2014b, 54; 2016a, 64; 2017, 45). One possible reason for this change is the larger size of these features in 2014-2015. The mean north-south by east-west dimensions were 2,300 by 2,700 km for 2013-2014 and 3,600 by 4,600 km for 2014-2015. In spite of changes in size and appearance for the two apparitions, the drift rate for the NNTC jetstream remained nearly the same.

The dimensions of the inner white areas inside of H1-H3, H5, H8 and H9 were also measured. Their mean area was 1.5 Mm^2 where Mm^2 = one square megameter or 1,000,000 square kilometers. The mean thickness of the dark portion of these features on the north and south sides was 1,170 ± 60 km, whereas the corresponding value for the east and west sides was 1640 ± 200 km. Therefore, if the outer north-south and east-west dimensions were only 2,300 by 2,700 km, then the dark portion would extend to the center.

The white oval G2 may be the same as G5 (a little red spot) in the previous apparition. The longitudes, mean latitudes and sizes of the two ovals are consistent with them being the same feature. There is one difference though: Oval G5 in the previous apparition was bright in methane band light whereas G2 in the current apparition was not bright in Chris Go's Nov. 12 methane band image. Therefore, on that date, G2 did not extend as high as G5 in the

Table 8: Planetographic Latitudes and Drift Rates of Features Inside the EZ (Notes are as before.)

Feature (Description)	Number of Points	Latitude	Drift Rate System I Deg./30 Days	Feature (Description)	Number of Points	Latitude	Drift Rate Deg./30 Days
E1 (f)	28	6.8° N	8.3	E2 (f)	30	6.8° N	14.2
E4 (f)	58	6.8° N	6.9				
Average						*6.8° N*	*9.8*

Table 9: Planetographic Latitudes and Drift Rates of Features North of the EZ (Notes are as before)

Feature (description)	Number of points	Latitude	Drift rate deg./30 days	Feature (description)	Number of points	Latitude	Drift rate deg./30 days
North Equatorial Belt Current (NEB Current)							
N1 (ws)	57	19.2 ° N	–8.1	N3 (wb)	10	16.1° N	4.1
N4 (wb)	10	16.7° N	4.1	N5 (ds)	11	18.1° N	–34.4
N6 (ds)	21	18.8° N	–0.7	N7 (b)	8	16.1° N	–3.6
Average						*17.5° N*	*–6.4*
North Temperate Current (NTC)							
F1 (ds)	49	30.2° N	13.0	F2 (ds)	39	29.7° N	9.7
F3 (wo)	19	32.1° N	14.6	F4 (wo)	8	32.6° N	11.0
F5 (wo)	9	33.6° N	4.0	F6 (wo)	24	33.0° N	13.3
F7 (wo)	27	32.2° N	16.6				
Average						31.9° N	11.7
North North Temperate Current Jetstream (NNTC Jet)							
H1 (ds)	38	34.3° N	–81±1.6	H2 (wo)	25	34.5° N	–75.6±0.8
H3 (wo)	24	34.5° N	–77.2±0.9	H5 (wo)	26	34.6° N	–82.9±0.7
H8 (wo)	23	34.5° N	–84.7±0.7	H9 (wo)	16	34.2° N	–74.8±0.9
H12 (wo)	6	33.9° N	–77.5±4.5				
Average						34.4° N	–79.1
North North Temperate Current (NNTC)							
G1 (f)	41	38.2° N	–0.7	G2 (wo)	51	40.3° N	–4.1
G3 (wo)	48	41.8° N	–7.9	G4 (wo)	16	41.6° N	–10.1
G5 (wo)	36	41.1° N	–4.7	G10 (ds)	11	38.6° N	9.4
Average						40.3° N	–3.0
North North North Temperate Current (NNNTC)							
I1	24	46.3° N	–21.6	I2	18	45.2° N	–23.4
Average						45.8° N	–22.5
North North North North Temperate Current (NNNNTC) *See also see Figure 7*							
J1a (wo)	12	53.7° N	–4.7	J1b (wo)	32	54.6° N	–27.2
J1c (wo)	7	53.4° N	8.6	J3 (wo)	16	52.2° N	8.6
J4 (wo)	29	54.9° N	–13.4	J5 (wo)	49	54.2° N	–21.3
Average						*53.8° N*	*–8.2*
North Polar Current (NPC)							
K2 (wo)	10	63.3° N	–6.2				

previous apparition. It will be interesting to see if it changes in 2016.

Two features (J1 and J5) in the NNNNTC did not have a consistent drift rate. White oval J5 oscillated several degrees in longitude with a period of ~120 days. It is not clear what caused this oscillation, but a periodic change in latitude is suspected. A second feature, white oval J1, underwent a change in drift rate in early November and again in early April (see Figure 6). Once again, Schmude decided to treat J1 as three features: J1a, J1b and J1c. The mean latitudes with standard deviations (sd) and the number of measurements (n) are: Sept. 9 - Nov. 9 (53.68° N, sd = 1.53°, n = 11) for J1a, Nov. 10 - April 3 (54.64° N, sd = 0.54°, n = 11) for J1b and April 9 - May 26 (53.36 N, sd = 0.88, n = 7) for J1c. There is a marginal statistical difference (based on a t-Test) between the latitudes at the = 0.10 (two-tailed) confidence level for J1a and J1b. There is a significant statistical difference between the mean latitudes for J1b and J1c (Larson and Farber, 2006, 418). A latitude change, therefore, may be the cause for the drift rate changes for J1a, J1b and J1c.

Wind Speeds

Table 10 summarizes mean wind speeds. These values are with respect to the System III longitude. They are computed in the same way as in Rogers (1995, 392).

Satellites

Several individuals imaged one satellite either occult or eclipse a second one. (An occultation occurs when one satellite moves in front of another one, whereas an eclipse occurs when the shadow of one satellite falls on a second one.) Table 11 summarizes measured times for several of these events. The measured time was compared to the predicted time (Astronomical Almanac, 2014, F38-F39), or in one case with the IMCCE ephemeris. Differences between the measured and predicted times are one minute or less and the mean difference of all measurements is 0.02 ± 0.50 minutes. The negligible difference suggests that the orbital parameters of the satellites in the Astronomical Almanac (2014) are

Table 10: Mean Drift Rates and Wind Speeds for Several Currents on Jupiter in 2014-2015

Current	Feature(s)	Drift Rate (degrees/30 days)			Mean Wind Speed (m/s)
		Sys. I	Sys. II	Sys. III	
SPC near 61° S	A2a, A3a	194	–35	–27	6
SPC near 59° S	A2b, A3b	231	2	10	–2
SSSSTC	A5	202	–27	–19	6
SSSTC	A1, A4	224	–5	3	–1
SSSTC Jet	A6	128	–101	–93	33
SSTC	B1-B12, B15	201	–28	–20.	7
STC	BA, C1-C4	218	–11	–3	1
STBn Jet	D1, D3-D6	141	–88	–80.	35
GRS	GRS	230.3	1.4	9.4	–4.2
SEB Current	D7-D10	236	7	15	–7
EC	E1, E2, E4	10.	–219	–211	101
NEB Current	N3-N6	223	–6	2	–1
NTC	F1-F7	241	12	20.	–8
NNTC Jet	H1-H3, H5, H8, H9, H12	150.	–79	–71	29
NNTC	G1-G5, G10	226	–3	5	–2
NNNTC	I1, I2	206	–23	–15	5
NNNNTC	J1a-c, J3-J5	221	–8	0	0
NPC near 63° N	K2	223	–6	2	0

accurate. Delcroix used a CCD camera to measure the brightness as Ganymede moved in front of Io. His measurements began at 21:40:55.36 on April 21 and ended ~11 minutes later. He used an IR > 742 nm filter along with a ZWO ASI174MM camera and Iris software to carry out brightness measurements. Delcroix reported the mid-time of the eclipse occurred at 21:46:13.4 which was 5.6 seconds later than predicted from the IMCCE ephemeris. He also reported a flux drop of 0.174 magnitudes at the mid-time (Delcroix, private communication, 2017).

Peach posted an excellent image of Io transiting Jupiter on February 25. It showed the usual dark polar regions of Io. Schmude carried out measurements and each dark polar region extended down to 28° ± 4° which is a little closer to the pole than measurements made in 2002-03. During that apparition, Io's dark North Polar Region extended to 24° N and its dark South Polar Region extended to 19° S (Schmude, 2007, 33). This change may be related to a difference in resolution between the two apparitions.

Photoelectric Photometry

Table 12 lists ultraviolet (U) and visible (V) light brightness measurements of Jupiter. An SSP-3 photometer along with a 0.09 Maksutov telescope and filters transformed to the Johnson U and V system were used in making all measurements. All measurements were corrected for atmospheric extinction and color transformation. Transformation coefficients of ε_U = -0.017 and ε_V = -0.0555 were used. The U and V filter measurements are consistent with published models (Mallama and Schmude, 2012, 212).

Table 13 lists near-infrared brightness measurements. All measurements were made with an SSP-4 photometer along with filters transformed to the Mauna Kea J and H system (Tokunaga and Vacca, 2005, 421); (Simmons and Tokunaga, 2002, 169); (Tokunaga et al., 2002, 180). The J and H filters have band passes centered at 1.250 ± 0.042 m and 1.650 ± 0.045 m, respectively. More information about the equipment may be found elsewhere (Schmude, 2016b). All measurements were corrected for extinction and color transformation. Transformation coefficients of ε_U = -0.017 and ε_V = -0.0555 were used. The star-pair method was used in measuring the transformation coefficients (Hall and Genet, 1988, 199) except J - H replaced B - V. Comparison star J and H magnitude values were taken from Henden (2002, 16).

Since Jupiter's distance from Earth and the Sun changed, the brightness changed. To correct this, the normalized brightness, $J(1,\alpha)$ is

$$J(1,\alpha) = J_m - 5 \log [r\ \Delta] \quad (1)$$

where r and Δ are the Jupiter-Sun and Jupiter-Earth distances in astronomical units and J_m,is the measured J filter brightness. $H(1,\alpha)$ values were computed in the same way. The brightness may also change with the solar phase angle, α. The solar phase angle is the distance between

Table 11: Measurement of Occultation and Eclipse Times of Mutual Satellite Events (Note: In all cases satellites are designated as Roman Numerals: Io-I; Europa-II and Ganymede-III)

Date (2015) type[a]	Satellites	Measured time	Predicted time	Individual	Difference O–C (minutes)
Feb. 12 Oc.	I, III	21:25	21:25:30	L. Aerts	–0.5
Feb. 12 Oc.	I, III	21:25:36	21:25:30	J. Sussenbach	0.1
Feb. 12 Ec.	I, III	21:47	21:47:30	J. Sussenbach	–0.5
Feb. 12 Ec.	I, III	21:48	21:47:30	T. Hansen	0.5
Feb. 26 Oc.	I, II	22:21:30	21:21	P. Abel	0.5
March 2 Oc.	I, II	11:20	11:20:30	T. Usude	–0.5
March 3 Oc.	I, III	4:09	4:08	F. Melillo	1.0
April 21 Oc.	I, III	21:46:13.4	21:46:7.8[b]	M. Delcroix	0.0933
April 21 Oc.	I, III	21:45:30	21:46	P. Abel	–0.5
May 24[c] Oc.	I, III	11:01	11:01	H. Einaga	0.0
Mean discrepancy					0.02 ± 0.17 St. dev. = 0.53

[a]Oc = occultation; this is where a satellite move in front of a second satellite and Ec = eclipse; this is where the shadow of one satellite falls on a second satellite.

[b]From Delcroix based on the IMCCE ephemeris.

[c]The date he lists is May 26, but he uploaded this image into the May 24 spot and his system II longitude is consistent with a May 24 date.

the Sun and the observer measured from Jupiter in degrees.

The J(1, α) values were fit to an equation of the form J(1, 0) = J(1,α) + cα, where α is the solar phase angle in degrees and both J(1,0) and c are constants to be determined.

The H(1, α) values were fit to the same equation. The resulting J(1,0), H(1, 0) and c values for both filters are summarized in Table 14. The solar phase angle coefficient, c, was small for the J filter and insignificant for the H filter. The geometric albedos are consistent with reflectance spectra of that planet (Clark and McCord, 1979, 182). The H-filter results are in agreement with those in the previous apparition (Schmude, 2017, 53). The J(1,0) value is 0.09 magnitudes brighter than in the previous apparition. Part of the discrepancy may be caused by the difference in solar phase angle (0° in the current apparition and 9.2° in the previous one). Other possible causes for the discrepancy are a slight variability in the comparison star magnitude and real changes taking place on Jupiter.

A thorough error discussion for J and H filter measurements of Saturn is given elsewhere (Schmude, 2016b). The uncertainties are believed to be similar for Jupiter (0.06 and 0.04 magnitudes for each J and H filter measurements, respectively). The estimated uncertainty (Uc) for the mean J(1,α) and H(1,α) value is computed using:

$$Uc = [(0.06/\sqrt{n})^2 + (0.04)^2]^{0.5} = 0.041 \text{ magnitude} \quad (2)$$

where the 0.04 is the estimated uncertainty of the brightness for the comparison star in stellar magnitudes.

In many cases, Alpha-Bootes was used as a comparison star. It is reported to be a "microvariable" (Schmude, 2000, 241). Because of this, an uncertainty of 0.04 magnitudes is selected for the J and H filter magnitudes for this star. For the J and H filters n = 18. The same approach was taken for the mean H(1,α) value except 0.06 in equation 2 was replaced by 0.04. For the J - H value, the uncertainty was computed by determining the square root of the sum of the squares of the uncertainty for the J and H magnitudes. Uncertainties for the V - J and V - H color indexes were determined in the same way. The J and H filter albedos of Jupiter were computed in the same way as in Mallama and Schmude (2012, 213). The J(1,0) and H(1,0) values for our Sun were assumed to equal –27.86 and –28.17, respectively (Roddier et al., 2000, 306).

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Table 12: Photoelectric Brightness Measurements of Jupiter During the 2014-2015 Apparition in Filters Transformed to the Johnson U and V System

Date	Filter	Solar Phase Angle (Degrees)	Measured Magnitude	Normalized Magnitude X(1,α)	Comparison Star
Oct. 15.408, 2014	U	9.7	–0.55	–7.94	Beta-Gem
Oct. 15.437, 2014	U	9.7	–0.55	–7.93	Beta-Gem
Feb. 8.198, 2015	V	0.3	–2.59	–9.42	Omicron-Leo
June 6.077, 2015	V	9.6	–1.92	–9.37	Omicron-Leo
June 6.096, 2015	V	9.6	–1.93	–9.38	Omicron-Leo

Table 13: Photoelectric Brightness Measurements Made of Jupiter During the 2014-2015 Apparition In Filters Transformed to the J and H System

Date	Filter	Magnitude		Date	Filter	Magnitude	
		Meas. (–)	X(1, α) (–)			Meas. (–)	X(1, α) (–)
Oct. 4.42, 2014	J	2.18	9.59	Feb. 6.20, 2015	H	2.25	9.08
Oct. 4.43	H	1.64	9.05	Feb. 6.21	J	2.80	9.62
Oct. 16.41	J	2.22	9.60	Feb. 8.15	J	2.80	9.62
Oct. 16.43	H	1.71	9.09	Feb. 8.17	H	2.27	9.10
Oct. 27.38	J	2.25	9.57	Feb. 12.10	H	2.29	9.12
Oct. 27.39	H	1.77	9.09	Feb. 12.11	J	2.82	9.65
Oct. 27.41	J	2.24	9.56	Feb. 15.14	J	2.76	9.59
Oct. 27.43	H	1.76	9.08	Feb. 15.16	H	2.23	9.06
Nov. 19.32	J	2.39	9.57	Feb. 20.12	J	2.74	9.59
Nov. 19.33	H	1.87	9.04	Feb. 20.14	H	2.20	9.04
Dec. 1.32	J	2.50	9.59	Feb. 28.10	J	2.74	9.60
Dec. 1.34	H	1.97	9.06	Feb. 28.11	H	2.22	9.09
Jan. 1.20, 2015	J	2.72	9.63	Mar. 8.07	J	2.70	9.60
Jan. 1.22	H	2.17	9.09	Mar. 8.09	H	2.18	9.07
Jan. 1.29	J	2.72	9.63	Mar. 11.11	H	2.21	9.12
Jan. 1.31	H	2.19	9.10	Mar. 11.13	J	2.72	9.63
Jan. 11.16	J	2.84	9.71	Mar. 15.13	H	2.17	9.10
Jan. 11.17	H	2.27	9.15	Mar. 15.15	J	2.71	9.64
Jan. 11.19	J	2.81	9.69	Mar. 28.09	J	2.57	9.58
Jan. 11.20	H	2.28	9.15	Mar. 28.11	H	2.06	9.06
Jan. 17.17	J	2.76[a]	9.61	Apr. 5.10	J	2.53	9.58
Jan. 17.18	H	2.17[a]	9.03	Apr. 5.11	H	2.00	9.05
Jan. 17.22	H	2.21	9.06	Apr. 5.13	J	2.53	9.58
Jan. 17.24	J	2.74	9.59	Apr. 5.15	H	2.01	9.07
Jan. 19.26	J	2.76	9.61	Apr. 9.12	J	2.53	9.60
Jan. 19.28	H	2.23	9.07	Apr. 9.13	H	2.01	9.09
Jan. 19.32	J	2.75	9.60	Apr. 30.13	J	2.42	9.64
Jan. 19.33	H	2.23	9.07	Apr. 30.14	H	1.87	9.09
Jan. 25.17	J	2.82	9.66	May 2.09	J	2.34	9.57
Jan. 25.19	H	2.27	9.10	May 2.11	H	1.85	9.09
Jan. 28.18	J	2.83	9.66	May 7.12	J	2.36	9.63
Jan. 28.19	H	2.27	9.10	May 7.13	H	1.86	9.13
Jan. 29.18	J	2.78	9.61	May 9.07	H	1.79[b]	9.08
Jan. 29.20	H	2.27	9.10	May 10.13	J	2.35[b]	9.64
Jan. 31.17	J	2.82	9.64	May 21.08	H	1.82	9.18
Jan. 31.19	H	2.26	9.09	May 21.09	J	2.31	9.67
Feb. 6.09	H	2.28	9.11	May 22.12	J	2.25[c]	9.62
Feb. 6.10	J	2.80	9.62	May 23.08	J	2.24[c]	9.61
Feb. 6.14	H	2.25	9.07	June 18.06[d]	H	1.66	9.15
Feb. 6.15	J	2.78	9.60	June 18.08	J	2.09	9.58

[a] Questionable or variable extinction. [b] Same transformation correction as on May 7, 2015. [c] Same transformation correction as on May 21, 2015. [d] Measurements were made on June 5 but were ~0.2 magnitudes brighter than expected; more than likely thin and invisible clouds were present. The June 5 measurements are not included.

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Table 14: Photometric Constants of Jupiter Based on J And H Filter Measurements Made in 2014-2015. (The units for all photometric constants are in stellar magnitudes.)

Parameter	Value
J(1,0)	–9.63 ± 0.04
H(1,0)	–9.09 ± 0.04
Solar Phase angle coefficient J filter	0.0023 magnitude/degree
Solar Phase angle coefficient H filter	–0.0002 magnitude/degree
Mean J – H color index	–0.54 ± 0.06
Mean V – J color index	0.23 ± 0.04
Mean V – H color index	–0.31 ± 0.04
J filter geometric albedo (at $\alpha = 0°$)	0.24 ± 0.01
H filter geometric albedo (at $\alpha = 0°$)	0.109 ± 0.004

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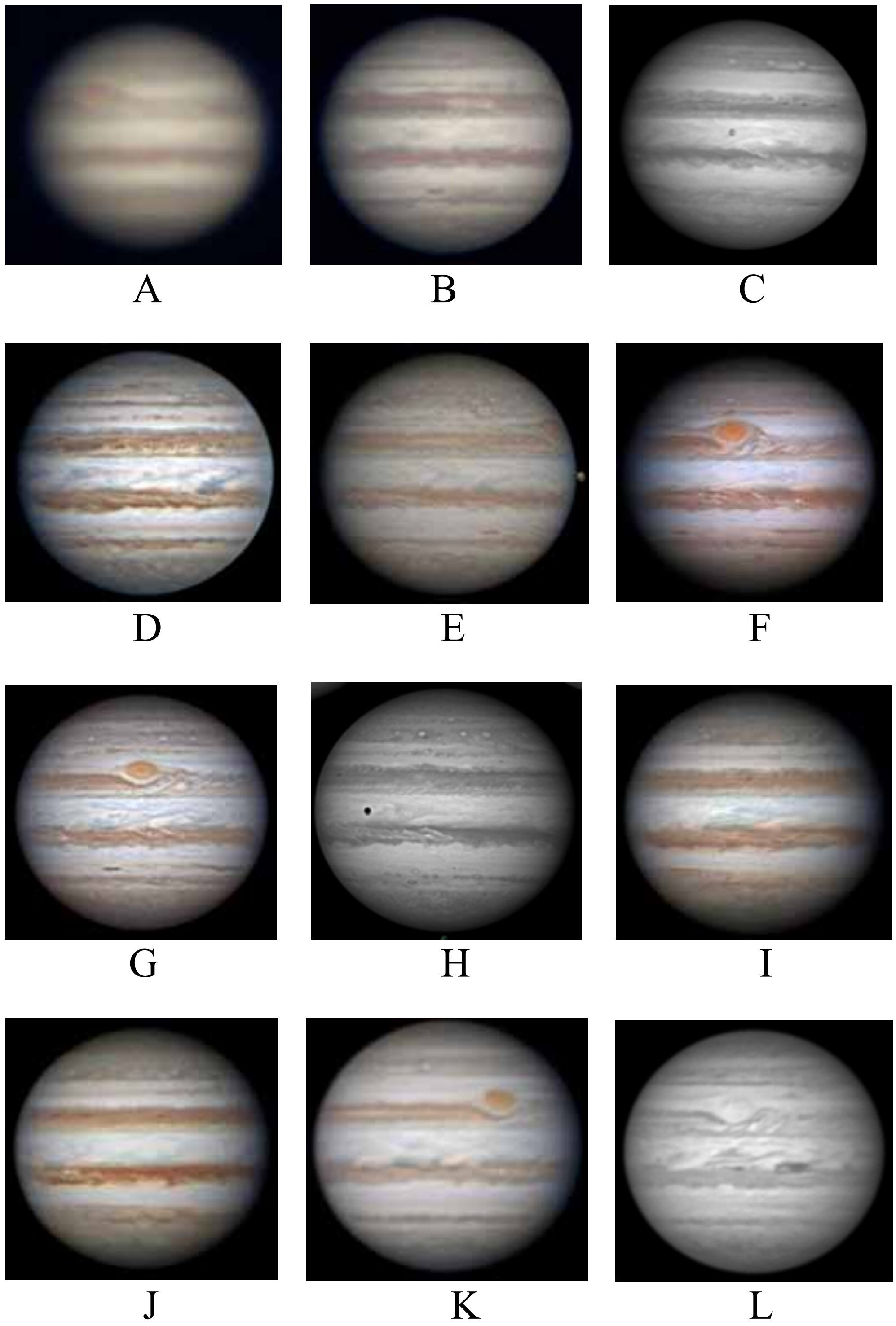


Figure 1: Images of Jupiter, 2014-2015 Apparition. South is at the top in all images. **A**: Aug. 19 (20:11.9) by H. Einaga, 0.30 m RL, l_I = 4° W, l_{II} = 243° W; **B**: Sep. 16 (20:41.1) by H. Einaga, 0.30 m RL, l_I = 118° W, l_{II} = 144° W; **C**: Oct. 18 (23:02) by T. Olivetti, G filter, 0.41 m DK, l_I = 214° W, l_{II} = 354° W; **D**: Nov. 12 (11:24.4) by B. Macdonald, 0.36 m SC, l_I = 135° W, l_{II} = 88° W; **E**: Dec. 14 (9:45.4) by M. Hood, 0.36 m SC, l_I = 89° W, l_{II} = 158° W; **F**: Jan. 11 (4:48.6) by D. Parker, 0.36 m SC, l_I = 12° W, l_{II} = 230° W; **G**: February 11 (14:59.4) by A. Wesley, 0.41 m RL, l_I = 244° W, l_{II} = 222° W; **H**: March 16 (14:03.9) by T. Olivetti, G filter, 0.41 m DK, l_I = 24° W, l_{II} = 110° W; **I**: March 21 (11:43) by C. Go, 0.36 m SC, l_I = 7° W, l_{II} = 56° W; **J**: April 17 (18:45) by Y. Girin, 0.20 m SC, l_I = 206° W, l_{II} = 47° W; **K**: May 17 (18:00.6) by M. Kardasis, 0.36 m SC, l_I = 231° W, l_{II} = 204° W; **L**: July 14 (7:19.2) by A Wesley, near Infrared, 0.41 m RL, l_I = 346° W, l_{II} = 239° W.

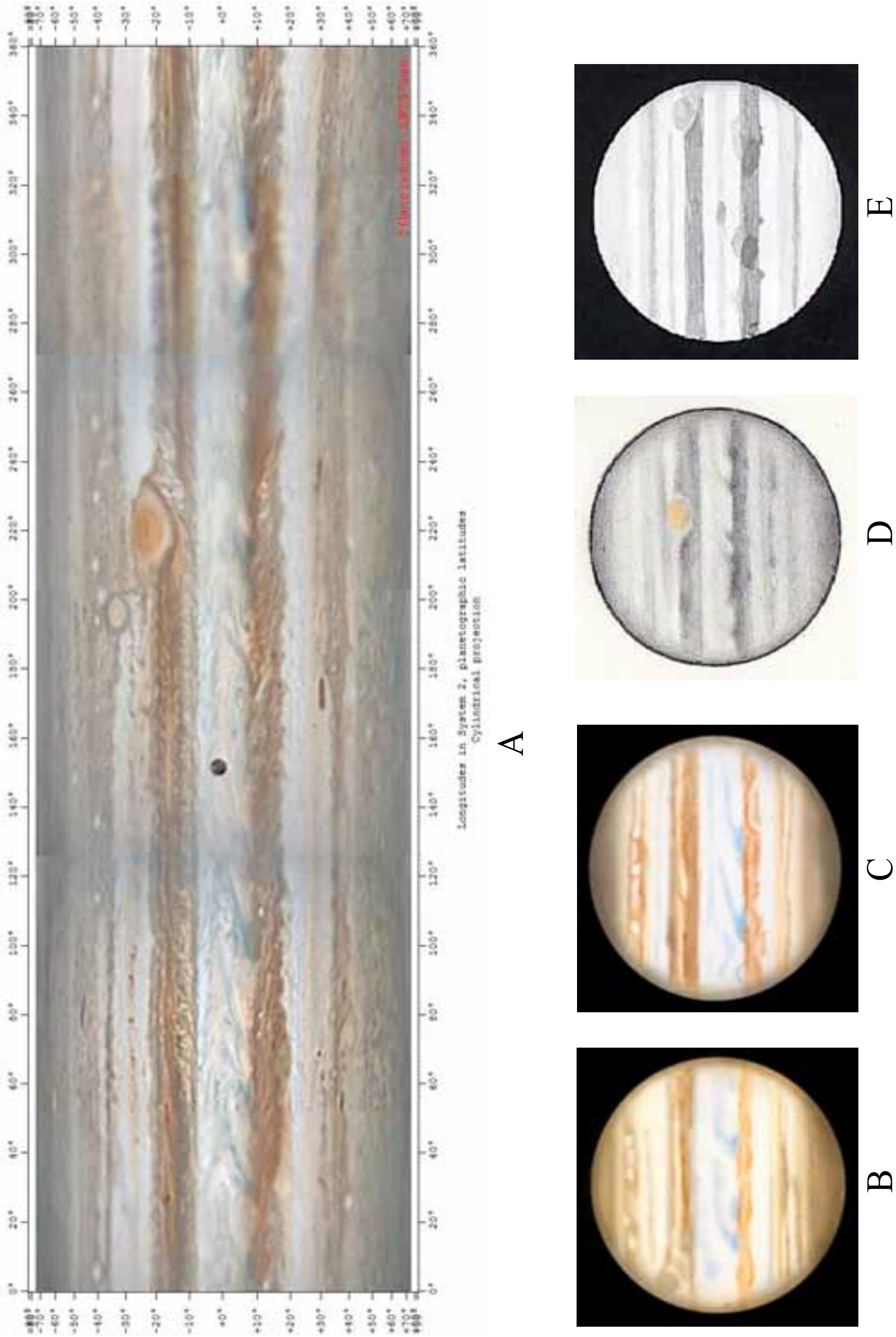


Figure 2: Map and drawings of Jupiter, 2014-2015 Apparition. South is at the top in all images. **A**: Map of Jupiter made by Marco Vedovato and the WinJUPOS Team from images made on Nov. 14 and 15, 2014; **B**: Oct. 5 (5:08-5:20) by P. Abel, 0.20 m RL, 250 X, seeing Antoniadi = IV, l_{I} ~ 35° W. l_{II} ~ 280° W; **C**: Nov. 6 (3:45-4:01) by P. Abel, 0.20 m Reflector, 250 X, seeing: Antoniadi = II to III, l_{I} ~ 357° W, l_{II} ~ 359° W; **D**: Dec. 30 (14:30) by M. Adachi, 0.31 m Reflector, 400, seeing = “1 (2)/10”, l_{I} = 270° W, l_{II} = 216° W; **E**: April 26 (5:00 UT) by B. Cudnik, l_{I} = 43° W, l_{II} = 179° W. South is on top in all drawings.

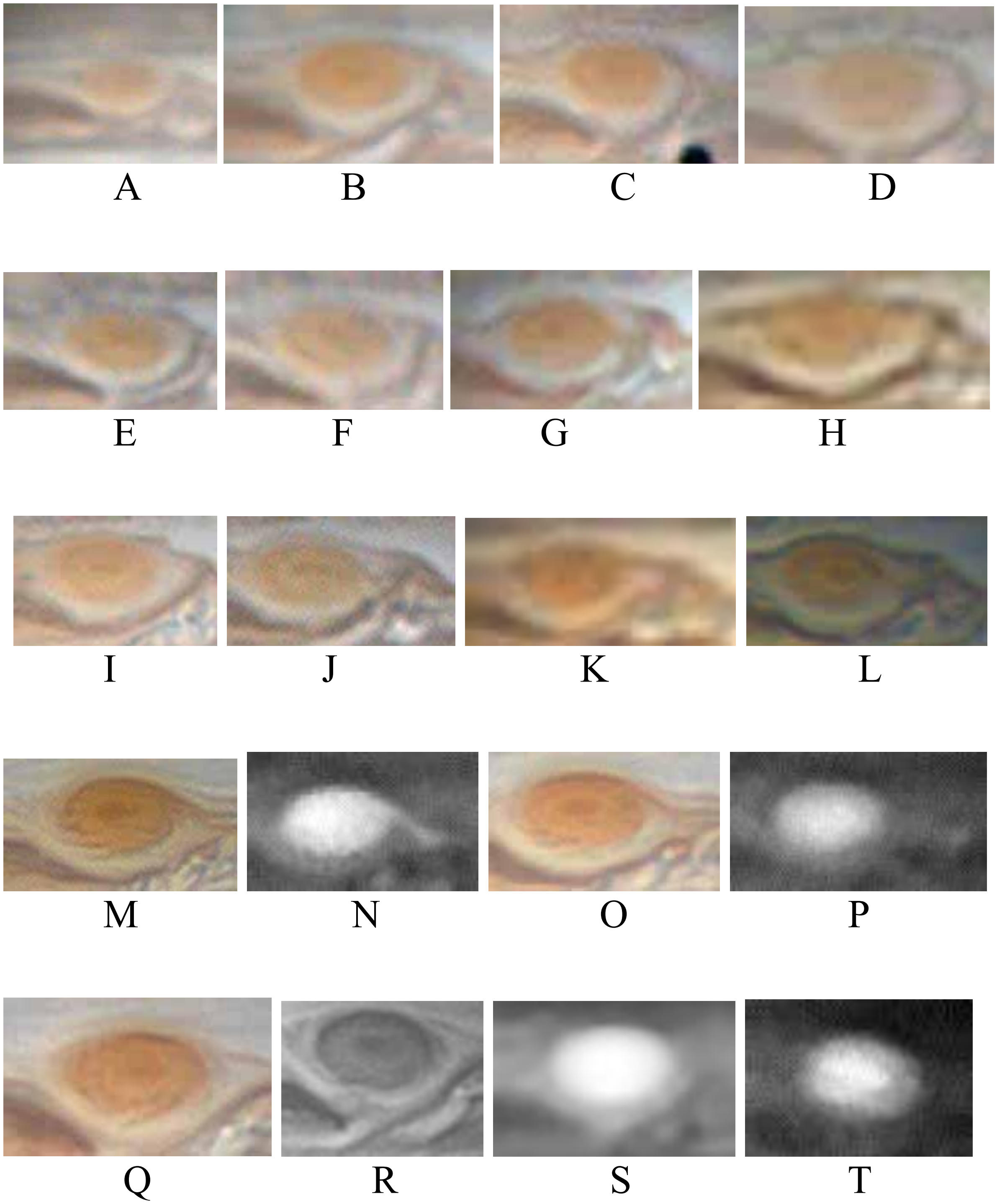
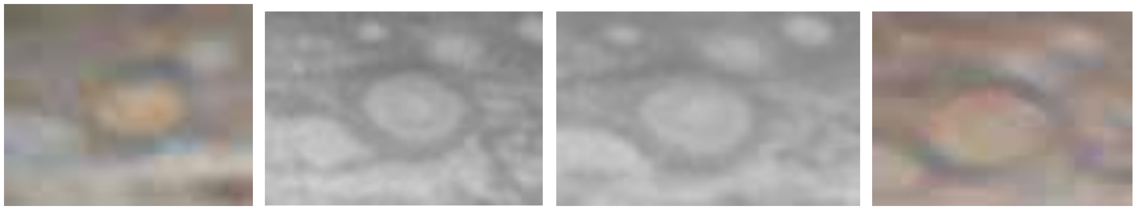
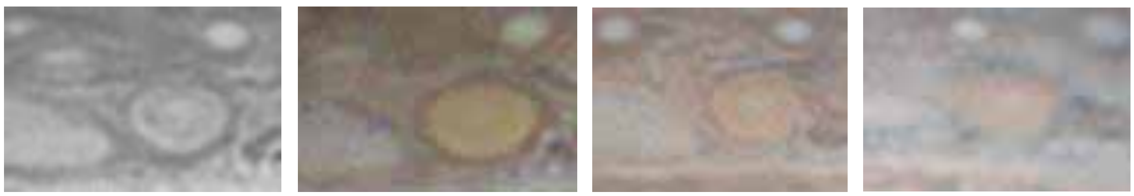


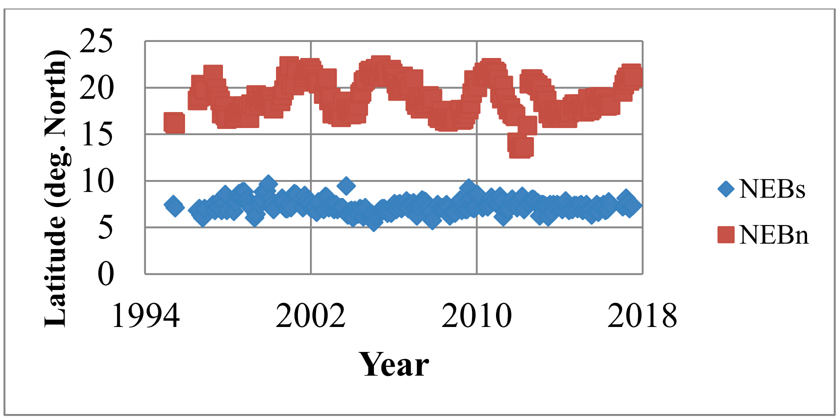
Figure 3: Images of the GRS. South is at the top in all images and unless otherwise noted the images were made in color; probably with RGB filters. A: Oct. 6 (19:26.3) by H. Einaga, 0.30 m RL; B: Oct. 12 (4:33.9) by C. Zannelli (0.36 m SC); C: Oct. 17 (22:41) by T. Olivetti, G filter (0.41 m DK); D: Oct. 19 (4:56) by A. Maniero (0.35 m DK); E: Oct. 23 (18:05.4) by H. Einaga (0.30 m RL); F: Oct. 27 (21:19.3) by H. Einaga (0.30 m RL); G: Oct. 31 (5:50) by J. Camarena (0.30 m SC); H: Nov. 5 (4:13.3) by X. Dupont (0.18 m RL); I: Nov. 15 (22:15), by T. Olivetti, 0.41 m DK; J: Nov. 20 (21:18.8) by H. Einaga (0.30 m RL); K: Nov. 29 (4:24) by M. Jacquesson (0.20 m SC); L: Dec. 6 (4:18.3) by P. Casquinha (0.36 m SC); M: February 26 (2:26) by D. Peach (0.36 m SC); N: February 26 (12:38) by C. Go in methane band light (0.36 m SC); O: February 26 (12:27) by C. Go (0.36 m SC); P: February 28 (13:49) by C. Go in methane band light (0.36 m SC); Q: April 3 (12:12) by C. Go (0.36 m SC); R: April 5 (13:17.8) by T. Olivetti, G filter, (0.41 m DK); S: Jan. 18 (5:07.8) by D. Parker (0.36 m SC); T: May 26 (10:17) by C. Go in methane band light (0.36 m SC).



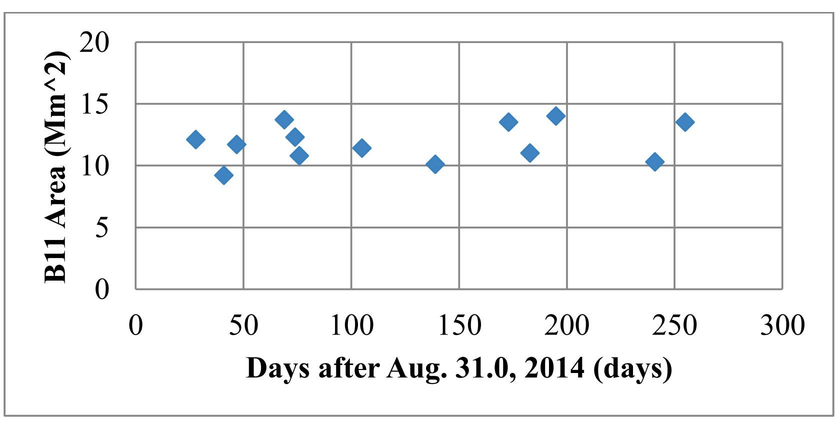
A B C D



E F G H



I



J

Figure 4: Images of Oval BA and two graphs. South is at the top in all images. A: Nov. 10 (3:00:02) by A. Obukhov, 0.28m SC; B: Nov. 15 (21:18) by T. Olivetti, 0.41 m DK; C: Nov. 22 (22:08) by T. Olivetti, 0.41 m DK; D: Nov. 30 (12:04) by M. Hood, 0.36 m SC; E: Dec. 26 (19:51.1) by T. Olivetti, 0.41 m DK; F: Dec. 30, (3:26.2) by D. Peach (0.36 m SC); G: Jan. 24 (18:23.1) by T. Olivetti, 0.41 m DK; H: February 8 (15:13.3) by A. Wesley (0.41 m RL); I: A graph of NEB latitudes ; J: A graph of the area of Oval B11 versus time. A megameter (Mm) is 1,000,000 m or 1,000 km; therefore 1.0 Mm2 = Mm^2 = 1,000,000 km2.

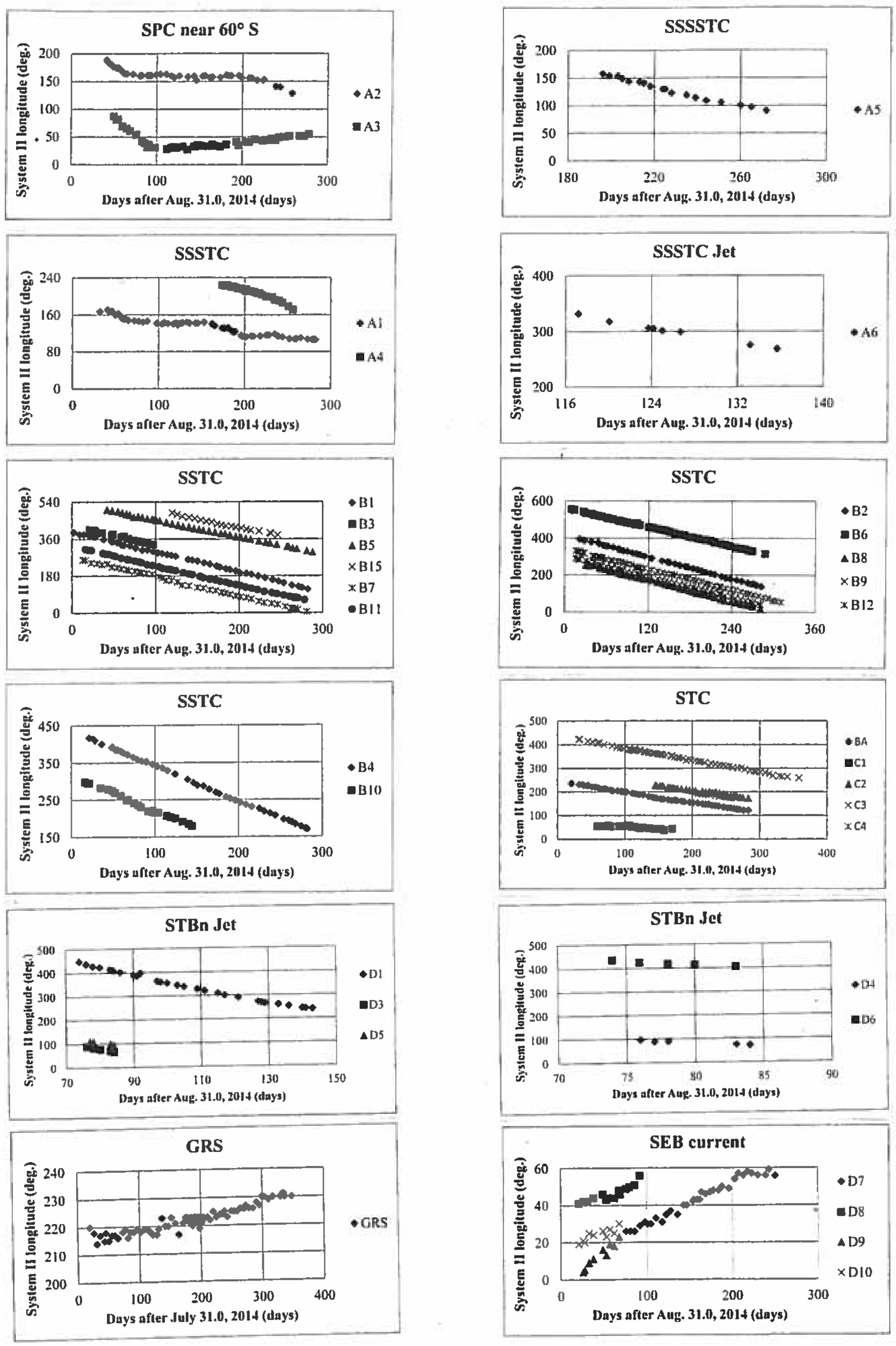


Figure 5: Drift rates for features south of 10° S.

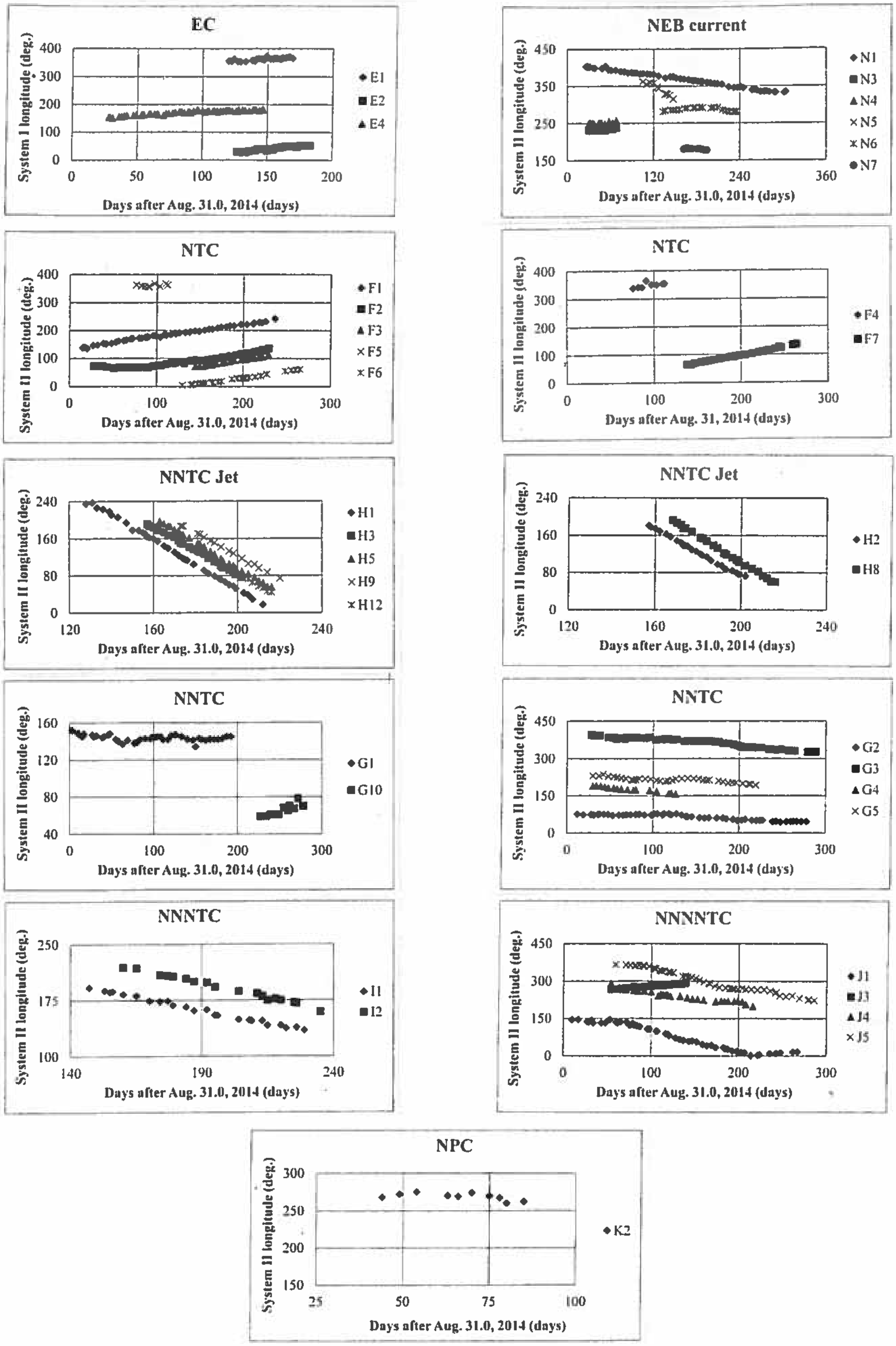


Figure 6: Drift rates for features north of 10° S.

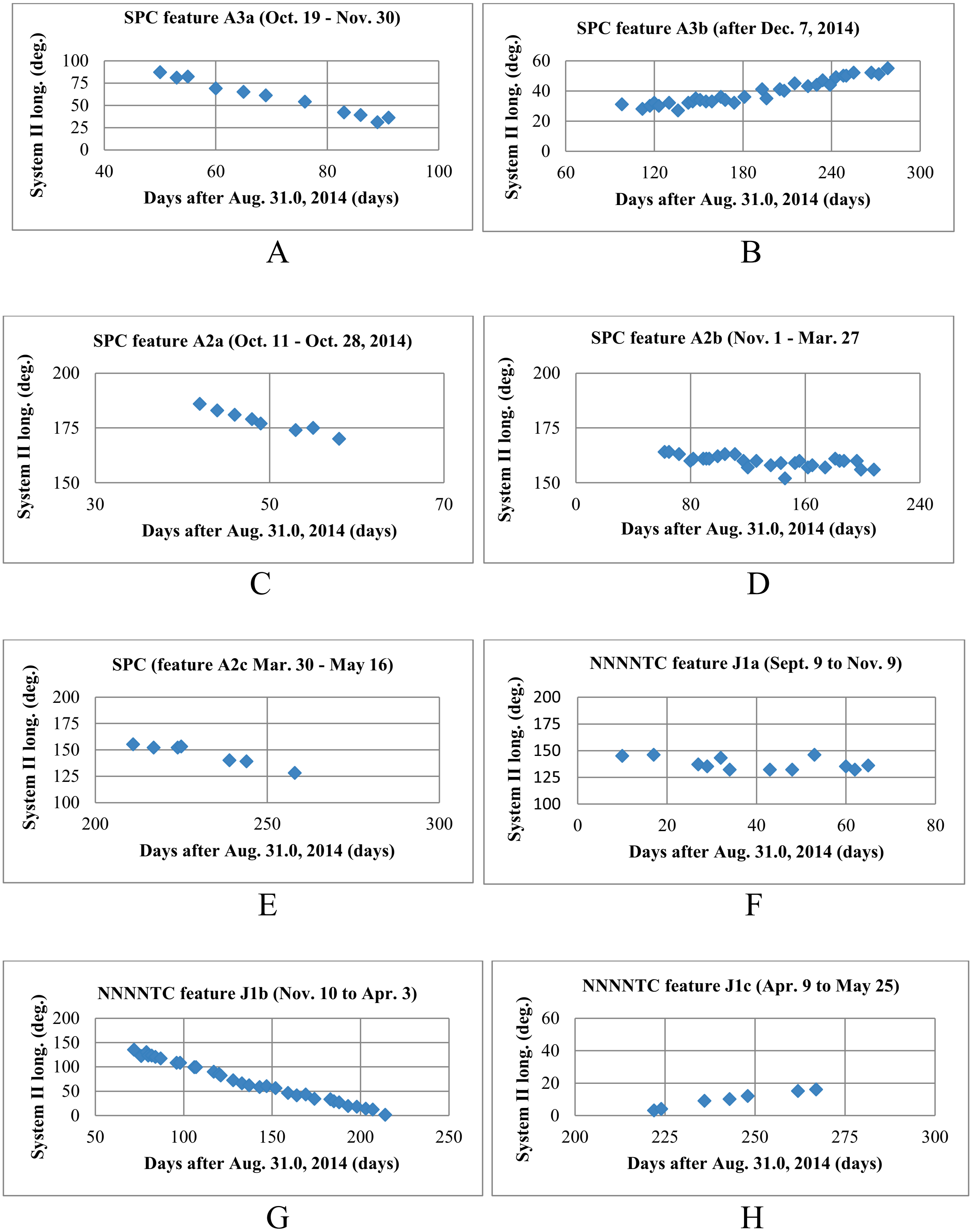


Figure 7: Features in the SPC and NNNNTC which had changing drift rates.

Feature Story:

Galilean Satellite Eclipse Timings: The 2010-2011 Apparition

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Abstract

During the 2010 - 2011 Jupiter apparition, four observers made 80 visual timings of the eclipses of Jupiter's four Galilean satellites - Io, Europa, Ganymede and Callisto. We compare the means of their observed eclipse disappearance and reappearance times with the predictions of the IMCCE (Institut de Méchanique Céleste et de Calcul des Éphémérides) E-5 ephemeris.

Introduction

The apparition covered here is the 33rd observed by the ALPO Jupiter Section's Galilean Satellite Eclipse Timing Program, consisting of visual timings of the eclipses by Jupiter of the four Galilean satellites Io, Europa, Ganymede and Callisto. Our observers timed the "last speck" visible when a satellite entered Jupiter's shadow (*disappearance*) and the "first speck" visible when it emerged from eclipse (*reappearance*). Our 1998/99 Apparition report described in detail our method of reduction, which also cited the reports for the previous apparitions. (Westfall 2009: 40, 42, 48; see also Westfall 2012, 2015, 2016a, 2016b, and 2017) We have compared our reduced timings with the Institut de Méchanique Céleste et de Calcul des Éphémérides (IMCCE) predictions, using the INPOP13C planetary theory and Lieske E-5 satellite theory.

Table 1. Circumstances of the 2010-2011 Jupiter Apparition

Apparition		Observing Season	
Initial solar conjunction	2010 FEB 28, 11h	First eclipse timing§	2010 MAY 10 (+71d)
First maximum phase angle	2010 JUN 23, 22h (10.71°)	Last eclipse timing§	2011 FEB 13 (-52d)
Opposition to the Sun*	2010 SEP 21, 12h (δ = -2.1°)	Duration	279d
Closest approach to Earth†	2010 SEP 20, 21h (D = 49.8”)	Solar Elongation Range	054°W-040°E
Second maximum phase angle	2010 DEC 16, 14h (11.46°)	Sources: Meeus 2015; *Astronomical Almanac*, 2010 and 2011 editions; JPL *HORIZONS* website. Dates and times throughout this report are in Universal Time (UT).	
Final solar conjunction	2011 APR 06, 15h		

* δ = Jupiter’s declination at opposition.
† D = Jupiter’s equatorial diameter in arc-seconds.
§ In parentheses are the number of days after initial solar conjunction (+) or before final solar conjunction (-).

All Readers

Your comments, questions, etc., about this report are appreciated. Please send them to: *ken.poshedly@alpo-astronomy.org* for publication in the next Journal.

Online Features

Left-click your mouse on:

- The author’s e-mail address in blue text to contact the author of this article.
- The references in blue text to jump to source material or information about that source material (Internet connection must be ON).

Table 1 lists the pertinent dates and other circumstances of the 2010 - 2011 Apparition.

Jupiter reached perihelion on 2011 May 17, 4.9 percent closer than its mean distance, with the result that the planet, along with its satellites, appeared somewhat larger and brighter than in an average apparition.

Observations and Observers

The 80 timings received for 2010/11 brought our 33-apparition total to 10,944 observations, and show a

Table 2. Number of Eclipse Timings, 2010 - 2011 Apparition

Number of Timings	80
Timings before Opposition	40 (50%)
Timings after Opposition	40 (50%)
Disappearance Timings	41 (51%)
Reappearance Timings	39 (49%)

welcome increase from the 73 received for the 2009/10 Apparition. Table 2 gives descriptive statistics for the 2010/11 observations.

Table 3. Participating Observers, 2010 - 2011 Apparition

Observer and Telescope					ALPO Timing Program Total	
I.D. No.	Name	Nationality	Telescope Aper. (cm)	Number of Timings (total)	Number of Apparitions	Number of Timings
1a 1b	Büttner, D.	Germany	6.3 10	8 4 (12)	16	119
2a 2b	Hays, R.H., Jr.	USA (IL)	13 15	5 24 (29)	21	327
3	Talbot, J.*	New Zealand	25	7	1	7
4a 4b	Westfall, J.	USA (CA)	12.7 35.6	18 14 (32)	30	556
Mean Number of Timings per Observer				20.0		
* Video timings, KT&C 350BH camera at f/4.						

Table 4. Timing Residual Statistics, 2010 - 2011 Apparition

Satellite and Event	Quantity	Satellite and Event	Quantity
Io		**Ganymede**	
1D: No. of Timings	15 (14)	3D: No. of Timings	12 (11)
1D: Mean	+95.4±3.4s	3D: Mean	+267.3±14.8s
1D: Median	+97.0s	3D: Median	+274.0s
1R: No. of Timings	14 (12)	3R: No. of Timings	8 (7)
1R: Mean	-99.2±2.8s	3R: Mean	-230.4±8.2s
1R: Median	-100.0s	3R: Median	-222.0s
(1D+1R)/2: Means	-2.1±2.2s	(3D+3R)/2: Means	+18.4±8.5*
(1D+1R)/2: Medians	-1.5s	(3D+3R)/2: Medians	+26.0s
Europa		**Callisto**	
2D: No. of Timings	10 (8)	4D: No. of Timings	4
2D: Mean	+112.4±4.8s	4D: Mean	+359.5±34.2s
2D: Median	+113.5s	4D: Median	+363.5s
2R: No. of Timings	12 (11)	4R: No. of Timings	5
2R: Mean	-113.6±5.3s	4R: Mean	-336.4±37.6s
2R: Median	-117.5s	4R: Median	-346.0s
(2D+2R)/2: Means	-0.6±3.6s	(4D+4R)/2: Means	+11.6±25.4s
(2D+2R)/2: Medians	-2.0s	(4D+4R)/2: Medians	+9.8s

Satellites are designated: 1 = Io, 2 = Europa, 3 = Ganymede and 4 = Callisto; D = disappearance, R = reappearance. Numbers of timings in parentheses are the numbers used in the analysis after those with unusually large residuals (most often due to poor observing conditions) were omitted. In the right-hand column, values are the means of means or medians of the three apparitions weighted equally; * shows a mean observed-predicted difference that is significantly different from 0 at the 5-percent level.

The 2010/11 observation set is remarkable in that it shows a balanced distribution of observations, with equal numbers of timings before and after opposition as well as an almost-equal number of disappearance and reappearance timings. This symmetric distribution helps increase the weight of our statistical results.

Table 3 lists the participants in our program during 2010/11, with their nationalities, instrument apertures and number of timings, both short-term and long-term.

It is pleasing to see that three of our observers have continued with our program for sixteen or more apparitions.

The contributors all used moderate-size telescopes in the aperture range 6.3-35.6 cm. The mean aperture, weighted by number of observations, was 17.7 cm.

Timings Analysis: Satellite Positions

The individual eclipse timings made by our participants in 2010/11 are listed in Table 5 at the end of this report. Table 4 summarizes the eclipse timings made in this period, with the means, standard errors of the means, and medians of the differences ("residuals") between our timings and the IMCCE E-5 ephemeris. In preparing the data for Table 4, all the residuals were corrected for oblique contact with Jupiter's shadow at disappearance and reappearance, using the formula $R' = R \cos \beta'$, where R' is the corrected residual, R the original residual, and β' the zenographic latitude of the satellite relative to

Jupiter's shadow. This correction made a difference of at most a few seconds for Io and Europa, but could reach over a minute for Ganymede and several minutes for Callisto.

In 2010/11 Io closely followed the IMCCE E-5 ephemeris. Europa's mean position all was close to the E-5 ephemeris, which differs from its behavior in most previous apparitions. As in the previous two apparitions, the observed position of Ganymede was significantly different from the ephemeris. Finally, Callisto did not differ significantly from the E-5 ephemeris.

Callisto is a special case. The outermost Galilean satellite

Table 5. Galilean Satellite Eclipse Timings, 2010 - 2011 Apparition

UT	LD	Lat	ObN	STB	Dif
Io Disappearances					
00510	17	+10	3	000	+93
00528	21	+10	4b	211	+113
00620	24	+11	4b	200	+94
00706	25	+11	2b	100	+113
00722	24	+12	2b	000	+111
00729	23	+12	2b	000	+102
00805	21	+12	4b	100	+108
00807	21	+12	2b	000	+99
00814	19	+12	4b	100	+105
00821	16	+13	4b	201	+84
00830	13	+13	4b	201	+78
			2b	000	+100
00906	9	+13	4a	000	+81
00915	4	+13	4a	100	+79
00920	0	+13	4a	000	+53
Io Reappearances					
01001	6	+14	4a	200	-43
01011	11	+14	1a	000	-108
01018	14	+15	1a	011	-103
01022	16	+14	3	001	-96
01031	19	+14	2b	000	-103
01102	20	+14	2b	000	-115
01107	21	+14	3	111	-103
01109	21	+14	2a	100	-98
			4a	000	-83
01116	22	+15	2b	000	-111
			4a	100	-88
01218	23	+15	2b	000	-106
10103	21	+16	2b	000	-115

UT	LD	Lat	ObN	STB	Dif
Io Reappearances – Continued					
10209	14	+16	4a	200	-45
Europa Disappearances					
00704	39	+13	1b	001	+85
00718	39	+14	2b	000	+129
00725	38	+15	4b	100	+135
00812	31	+16	2a	000	+118
00819	27	+16	4b	100	+125
00826	23	+16	2b	200	+93
00902	17	+16	4a	000	+102
00906	14	+17	1a	100	+115
00913	8	+17	2a	001	+68
00920	2	+17	4a	100	+42
Europa Reappearances					
00927	6	+18	4a	000	-80
01001	9	+18	2b	001	-128
01008	15	+19	2a	000	-121
01015	21	+19	2a	100	-129
01018	22	+19	1a	000	-135
01022	25	+19	3	001	-121
01102	31	+20	2b	000	-139
01109	34	+20	4a	100	-93
01116	36	+20	4a	100	-112
01211	38	+22	2b	010	-130
10105	33	+23	2b	000	-140
10203	20	+24	4a	200	-25
Ganymede Disappearances					
00712	62	+27	1a	000	+219
00719	61	+29	2b	000	+326
00726	59	+29	2b	000	+364

UT	LD	Lat	ObN	STB	Dif
Ganymede Disappearances Cont.					
00726	59	+29	4b	200	+385
00831	29	+32	4b	100	+361
			2b	000	+368
01118	19	+38	4a	100	+322
01125	22	+39	4a	100	+307
01202	23	+39	3	222	+183
01231	22	+41	4a	100	+270
10128	11	+43	1a	111	+299
			1b	111	+374
Ganymede Reappearances					
00929	11	+34	2b	101	-277
01006	21	+35	2b	000	-310
			4a	100	-189
01013	29	+36	3	111	-272
01111	53	+38	2b	000	-335
01118	56	+38	4a	100	-282
01231	53	+41	4a	100	-266
10205	35	+44	2b	200	-309
Callisto Disappearances					
00804	89	+64	2b	000	+826
			4b	000	+1001
00906	30	+73	1a	001	+930
			1b	001	+1250
Callisto Reappearances					
00529	62	+50	4b	101	-563
00804	63	+62	4b	000	-975
00821	40	+66	4b	200	-597
00906	11	+72	1b	001	-1120
			1a	001	-882

Column headings: UT = Universal Time, expressed as ymmdd, where y is the last digit of the year; LD = distance of satellite from Jupiter's limb in arc seconds; Lat = zenographic latitude of satellite on Jupiter's shadow cone in degrees; ObN = observer number as in Table 3; STB = observing conditions, where S = seeing, T = transparency and B = field brightness, all expressed in terms of 0 = condition not perceptible, 1 = condition perceptible but does not affect accuracy and 2 = condition perceptible and does affect accuracy; and Dif = (observed – calculated) eclipse time in seconds. Underlined timings were excluded during analysis due to unusually large differences from the other observations. Note that these "raw" residual values have not been corrected for oblique contact with Jupiter's shadow.

experiences eclipses by Jupiter only half the time - during three-year periods separated by three years without eclipses. Near the beginning and end of an eclipse series, Callisto enters and leaves Jupiter's shadow very obliquely, which prolongs the duration of shadow entry and exit and magnifies deviations of the satellite from its ephemeris.

Such was the case during the 2010-11 Apparition, near the end of the 2008-10 eclipse series, and is reflected by the large residuals for Callisto in Table 5."

Conclusion

The analysis of our program's timings made during the 2010/11 Jupiter apparition showed the following

- The times of eclipses by Jupiter of Io, Europa and Callisto did not differ significantly from the IMCCE E-5 ephemeris.

- Ganymede's observed timings, however, disagreed significantly from the ephemeris, its eclipse times averaging about 18 seconds later than the ephemeris.

We thank the observers who contributed timings during 2010-11, and hope that they continue with our program. We also invite others who are interested in this visual observing program, which requires only modest-sized telescopes, to contact the program coordinator (John Westfall at *johnwestfall@comcast.net*, 5061 Carbondale Way, Antioch, CA 94531 USA). He will be happy to furnish interested observers with a copy of observing instructions, a timing report form, and a table of Galilean satellite eclipse predictions for the coming apparition.

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Feature Story:

ALPO Observations of the Remote Planets in 2016-2017

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Abstract

This report summarizes brightness measurements of Uranus and Neptune and brief descriptions of each planet's disk. A brightness model for the normalized V-filter brightness of Uranus in terms of the solar phase angle and sub-Earth latitude is presented. Mean normalized magnitudes for Uranus and Neptune in the U, B and V filters are also presented.

Introduction

Three recent papers review the brightness of Uranus and Neptune. Schmude et al. (2015b) review brightness measurements of Uranus made since the early 1950s. Essentially, there is a small brightness change corresponding to the changing sub-Earth latitude for the V filter. This is caused by both polar flattening and the polar regions reflecting more light. The data are consistent with Uranus being about 7% brighter when its polar region faces us than when its equator faces us in the Johnson V system. Schmude et al. (2016) also reviewed the brightness measurements of Neptune made with Johnson filters. The U, B, V, R and I filter brightness measurements of Uranus and Neptune are also summarized in Mallama et al. (2017).

Hueso et al. (2017, 89) describes long-lived atmospheric features on Neptune. Some of these were imaged by both amateur and professional astronomers. Drift rates are reported. These features had north-south and east-west dimensions of 4,500 km and 5,100 km, respectively in Hubble Space telescope images made in light with a wavelength of 657 nanometers.

The photometric data covered here span wavelengths between 0.37 and ~0.6 µm (Optec, 1997). Images generally cover the 0.7 to 1.0 µm wavelength range.

Table 1 lists characteristics of Uranus and Neptune during their 2016-2017 apparitions. Individuals who submitted observations to Schmude or to the ALPO Japan Latest website are summarized in Table 2. I was unable to gain access to the ALPO archives at the Arkansas Sky Observatory; hence, individuals who submitted images there may not be listed in Table 2.

Table 1: Characteristics of the 2016 - 2017 Apparitions of Uranus and Neptune[a]

Parameter	Uranus	Neptune
First conjunction date	April 9, 2016	February 28, 2016
Opposition date	October 15, 2016	September 2, 2016
Angular diameter (opposition-arc seconds)	3.7	2.4
Sub-Earth latitude (opposition)	35.6° N	26.3° S
Right Ascension (opposition)	1h 24m	22h 50m
Declination (opposition)	8.2° N	8.4° S
Second conjunction date	April 14, 2017	March 2, 2017

[a]Data are from the Astronomical Almanac for the years 2016 and 2017.

Brightness Measurements: Photoelectric Photometry

Fox and Schmude measured the brightness of both Uranus and Neptune. Both individuals used the same equipment as in the previous apparition (Schmude, 2017, 62). Fox reports transformation coefficients of ε_B = 0.0745 and ε_V = -0.0501. Schmude used the same transformation as in 2014-2015 (Schmude, 2015a, 49).

Both Fox and Schmude used comparison and check stars. Their magnitudes are summarized in Table 3. The same comparison star magnitudes used in the two previous apparitions (Schmude, 2015a, 51; 2017, 62) were used here.

Tables 4 and 5 summarize brightness measurements of Uranus and Neptune, respectively. All measurements were

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corrected for atmospheric extinction and color transformation in the same way as is described in Hall and Genet (1988, 199). Any V-filter measurement made by itself was treated as if B - V = 0.53 (Uranus) and 0.41 (Neptune) for the purposes of the color transformation correction. These are the values measured in the previous apparition (Schmude, 2017, 62). Schmude used o-Psc and δ-Psc as check stars for his U and V filter measurements of Uranus and he used ι-Aqr as a check star for his U and V filter measurements of Neptune. His check star measurements were consistent with literature values except for o-Psc (U filter), where the measured brightness was 0.10 magnitudes fainter than the value in Table 3. His U filter measurement for δ-Psc was consistent with the value in Table 3. Fox used 88-Psc (Uranus) and 67-Aqr (Neptune) for his check stars. His measurements are consistent with those in Table 3.

Table 2: Contributors to the ALPO Remote Planets Section in 2016-2017

Observer (country)	Type[a]	Instrument[b]	Observer (country)	Type[a]	Instrument[b]
D. Arditti (UK)	I	0.36 m SC	F. Melillo (USA)	I	0.25 m SC
R. Bosman (The Netherlands)	I	0.36 m SC	P. Miles (Australia)	I	0.51 m RL
J. P. Cazard	I	1.06 m C	A. Osborne (USA)	I	0.07 m RR
F. Colas	I	1.06 m C	C. Pellier (USA)	I	0.25 m G
M. Delcroix (France)	I, P, V	1.06 m C	R. Schmude, Jr. (USA)	PP	0.20 m MC
J. Fox (USA)	PP	0.25 m SC	J. Sussenbach (The Netherlands)	I	0.36 m SC
V. Krumov	I	0.20 m RL	A. Wesley (Australia)	I, V	0.41 m RL

[a]Type of Observation: I = image, P = polarization, PP = photoelectric photometry, V = video

[b]Telescope type: C = Cassegrain; MC = Maksutov-Cassegrain; SC = Schmidt-Cassegrain; G = Gregorian; RL = Reflector

In addition to those individuals listed above, the following individuals submitted observations to the ALPO Japan Latest website: P. Abel (UK), T. Akutsu (Japan), R. Christensen (USA), W. K. Dimitrios (Greece), B. Estes (USA), D. Gray (UK), M. Guidi (Italy), R. Hillebrecht (Germany) M. Lewis (UK), S. Maksymowicz (France), E. Martinez (Spain), Milika-Nicholas (Australia), L. Morrone (Italy), A. Obukhov (Russia), J. J. Poupeau (France), R. Schulz (Austria), C. Sprianu (Romania), A. Vaccaro (Italy), G. Walker (USA) and K. Wildgoose (UK).

Table 3: Comparison and Check Stars Used in the 2016-2017 Apparitions of Uranus and Neptunee

Star	Star brightness in magnitudes			Right Ascension	Declination	Source for star magnitudes
	U filter	B filter	V filter			
μ-Psc	---	6.214	4.842	1h 30m	6.14° N	Mermilliod et al 2007
88-Psc	---	7.109	6.026	1h 15m	7.00° N	
ε-Psc	5.95	5.24	4.28	1h 04m	7.98° N	SIMBAD
o-Psc	5.90	5.22	4.26	1h 46m	9.24° N	
σ-Aqr	4.64	4.79	4.825	22h 31m	10.91° S	Iriarte et al. 1965 (U) & note a
ι-Aqr	3.907	4.191	4.266	22h 06m	13.87° S	Mermilliod et al. 1991 cited in Westfall (2008)
70-Aqr	---	6.47	6.19	22h 49m	10.56° S	Mermilliod et al 2007
67-Aqr	---	6.363	6.405	22h 32m	10.91° S	
δ-Psc	7.774	5.926	4.426	0h 50m	7.68° N	Mermilliod et al. 1991 cited in Westfall (2008)

[a]Jim Fox took the B and V values from SIMBAD in about 2013.

The selected photometric constants for Uranus and Neptune for 2016-2017 are summarized in Table 6. They are close to those reported in the previous apparition (Schmude, 2017, 62). Uncertainties were computed in the same way as in 2014-2015 (Schmude, 2015a, 54).

Brightness Model

The V-filter brightness of Uranus increases as the sub-Earth latitude approaches the pole (Schmude, 2015b, 15). The brightness change is reported to be 0.00084 ± 0.00004 magnitudes per degree change in the sub-Earth latitude. Lockwood and Jerzykiewicz (2006, 449) also report the brightness of Uranus in the Stromgren b (blue) and y (green) filters increase as the sub-Earth latitude approaches the south pole. They also report the change is larger for the y than the b filter.

Lockwood (1978, 86) reports a mean B filter solar phase angle coefficient of 0.0017 ± 0.0002 magnitudes/degree for Uranus. Essentially, Uranus grows brighter as the solar phase angle decreases. Lockwood and Thompson (1999, 5) also report several values of the solar phase angle coefficient for the Stromgren y filter for 1972-1989 and 1991-1996. The mean value of their y-filter results is 0.0017 magnitudes/degree. Between 1972 and 1996, the southern hemisphere of Uranus was facing the Earth and, hence, these values correspond to that hemisphere.

Because both the sub-Earth latitude and the solar phase angle affect the brightness of Uranus, Schmude decided to fit all 263 V(1,α) values of Uranus made between 2008 and early 2017 to an equation of the form:

$$V(1,\alpha) = A\alpha + Bs + C \quad (1)$$

where "V(1,a)" is the V filter magnitude when the Uranus-Earth and Uranus-Sun distances equal 1.0 astronomical Unit, "α" is the solar phase angle in degrees, "s" is the sub-Earth latitude in degrees and "A", "B" and "C" are

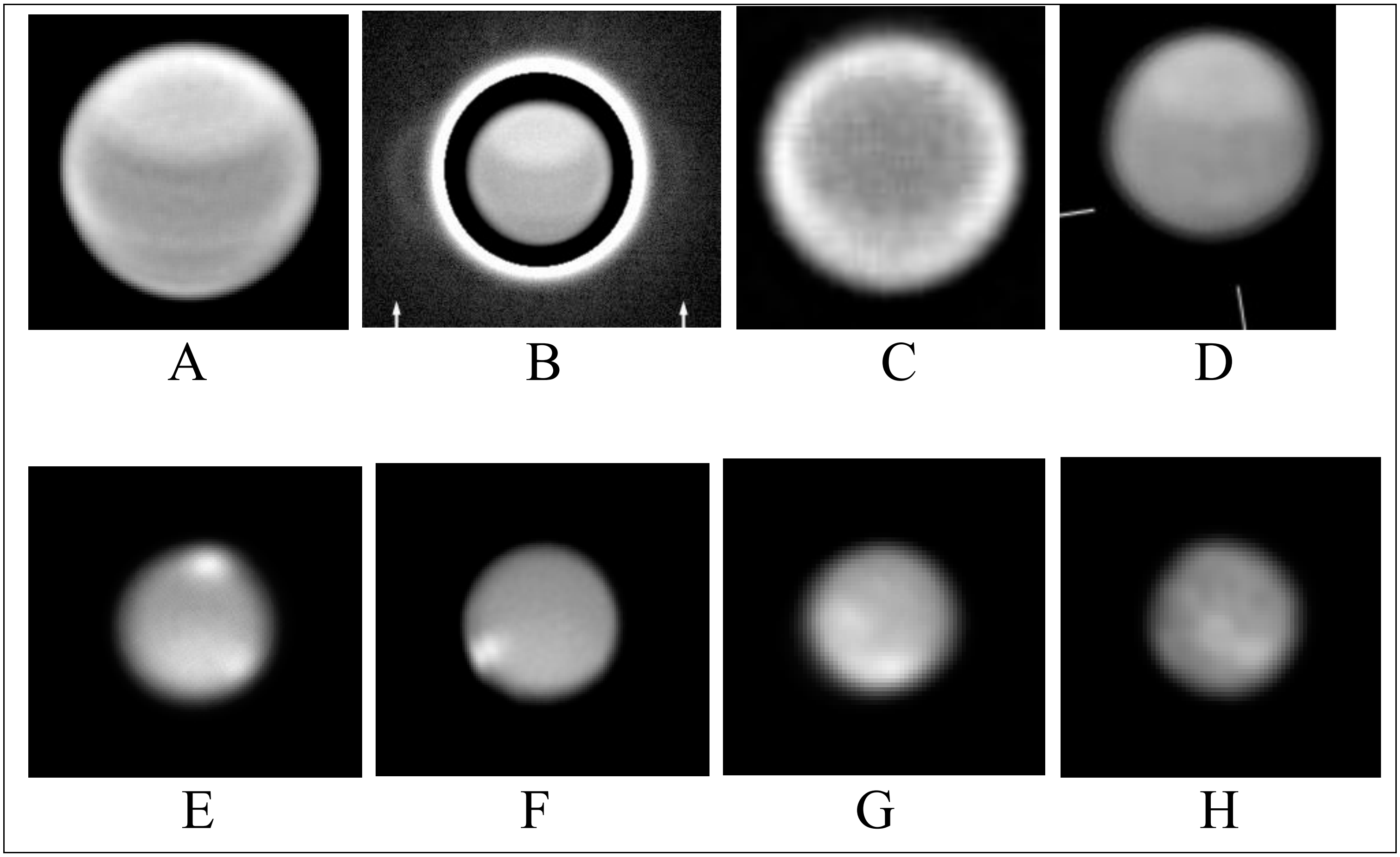

Figure 1: Images of Uranus (top row, A - D) and Neptune (bottom row E - H). North is at the top in all images. A: Aug. 8, 2016 (2:53.3 UT) by M. Delcroix, C. Pellier, J. P. Cazard and F. Colas, 1.06 m Cassegrain and “IR>685 nm” filter; B: Aug. 8, 2016 (2:33 UT) by M. Delcroix, C. Pellier, J. P. Cazard and F. Colas, 1.06 m Cassegrain and “IR>685 nm” filter; C: Aug. 8, 2016 (3:39.5 UT) by M. Delcroix, C. Pellier, J. P. Cazard and F. Colas, 1.06 m Cassegrain and methane band filter; D: Sept. 8, 2016 (23:24 UT) by J. Sussenbach, 0.36 m Schmidt-Cassegrain and Red long pass filter; E: Aug. 7, 2016 (1:10 UT) by M. Delcroix, C. Pellier, J. P. Cazard and F. Colas, 1.06 m Cassegrain and “IR>685 nm” filter; F: Aug. 7, 2016 (23:50.7 UT) by M. Delcroix, C. Pellier, J. P. Cazard and F. Colas, 1.06 m Cassegrain and “IR>685 nm” filter; G: Sept. 16, 2016 (11:03.2 UT) by A. Wesley, 0.41 m RL, R + IR filter; H: Oct. 28, 2016 (21:43.6 UT) by M. Delcroix, 0.32 m RL, R + IR filter.

constants which were determined through a multiple regression routine using Microsoft Excel. The time interval 2008 to 2017 was selected because the sub-Earth latitude was north of the equator. It was south of the equator for all measurements between 1967 and 2007. The resulting equation is:

$$V(1, \alpha) = -7.120 + 0.000292\alpha - 0.00049s \quad (2)$$

This equation is consistent with Uranus getting brighter as the solar phase angle decreases and as the sub-Earth latitude approaches the north pole. The –0.00049 has a standard error of 0.0000884 and, hence, it is smaller than the corresponding value in Schmude et al., 2015b, 1). Equation 2, however, does not cover as wide a range of s values as in (Schmude et al. 2015b, 15) and, hence, it should be considered only as a preliminary result. The standard error of estimate for all V(1,α) values fitted to equation 2 is 0.016 magnitudes, which is a slight improvement over the V(1,α) values by themselves, which is 0.017 magnitudes.

Disk Appearance

Figure 1 illustrates the appearance of Uranus and Neptune during 2016. All images were recorded in red and/or near-infrared light. In most cases, there is little or no limb darkening. In fact, the methane band image (Figure 1C) shows limb brightening. This is similar to previous apparitions (Schmude, 2014, 51; 2015a, 51), but is different from images in visible light which show limb darkening (Schmude, 2008, 192-193).

The planet Uranus had two bright areas in near-infrared light (wavelengths between ~0.7 and 1.0 microns). The bright North Polar Region had a nearly uniform appearance up to the north pole. This is different from 2011-2015 where there was a bright polar belt which extended from ~45° N to ~60° N and a darker area north of 60° N. Latitudes were measured from six high-resolution images using the same procedure as described in the previous apparition (Schmude, 2017, 64), (Peek, 1981, 49).

During late 2016, the bright North Polar Region extended down to 44° N, which is close to the corresponding value in the previous apparition. A second bright belt, which I have called the “Equatorial Belt”, had mean north and south latitudes of 12° N and 1° S. These are consistent with the

Table 4: Brightness Measurements of Uranus Made in 2016-2017

Date 2016-2017	Filter	Magnitude		Comp. Star	Date 2016-2017	Filter	Magnitude		Comp. Star
		Meas. (+)	Norm. (–)				Meas. (+)	Norm. (–)	
July 14.351	V	5.866	7.136		Oct. 19.185	B	6.285	6.603	
July 14.371	V	5.863	7.139		Oct. 21.188	V	5.733	7.155	
July 14.386	V	5.866	7.136		Oct. 21.189	B	6.284	6.604	
Sept. 23.187	V	5.731	7.165	μ-Psc	Oct. 22.197	V	5.727	7.162	
Sept. 23.188	B	6.356	6.540		Oct. 22.198	B	6.286	6.603	
Sept. 25.237	V	5.743	7.152		Oct. 26.183	V	5.752	7.138	
Sept. 25.238	B	6.31	6.578		Oct. 26.184	B	6.316	6.574	μ-Psc
Oct. 1.062	U	6.583	6.306		Oct. 27.199	V	5.747	7.143	
Oct. 1.076	U	6.621	6.270		Oct. 27.200	B	6.289	6.601	
Oct. 1.098	U	6.611	6.280		Nov. 9.103	V	5.742	7.157	
Oct. 1.110	U	6.593	6.298		Nov. 9.103	B	6.312	6.587	
Oct. 1.130	U	6.593	6.298		Nov. 15.143	V	5.760	7.144	
Oct. 1.142	U	6.608	6.283	ε-Psc	Nov. 15.144	B	6.304	6.600	
Oct. 1.158	U	6.599	6.292		Nov. 25.007	V	5.785	7.131	
Oct. 2.056	U	6.642	6.249		Nov. 25.022	V	5.791	7.125	ε-Psc
Oct. 2.072	U	6.598	6.293		Nov. 25.041	V	5.771	7.145	
Oct. 2.089	U	6.603	6.288		Dec. 20.095	V	5.834	7.121	
Oct. 2.103	U	6.622	6.269		Dec. 20.096	B	6.385	6.570	
Oct. 3.181	V	5.739	7.151		Dec. 24.106	V	5.832	7.130	
Oct. 3.181	B	6.318	6.572	μ-Psc	Dec. 24.106	B	6.387	6.575	
Oct. 5.208	V	5.747	7.142		Dec. 25.136	V	5.812	7.152	
Oct. 5.208	B	6.317	6.572		Dec. 25.137	B	6.351	6.613	
Oct. 9.057	U	6.559	6.329		Jan. 7.085	V	5.832	7.156	
Oct. 9.068	U	6.596	6.292		Jan. 7.085	B	6.378	6.606	μ-Psc
Oct. 9.083	U	6.586	6.302		Jan. 9.115	V	5.851	7.141	
Oct. 9.094	U	6.594	6.294		Jan. 9.115	B	6.415	6.577	
Oct. 9.109	U	6.599	6.289	ε-Psc	Jan. 20.102	V	5.904	7.108	
Oct. 12.066	V	5.737	7.151		Jan. 20.103	B	6.480	6.532	
Oct. 12.077	V	5.754	7.134		Feb. 6.093	V	5.944	7.098	
Oct. 12.094	V	5.746	7.142		Feb. 6.093	B	6.461	6.581	
Oct. 12.106	V	5.747	7.141		Feb. 9.090	V	5.899	7.147	
Oct. 19.184	V	5.732	7.156	μ-Psc	Feb. 9.091	B	6.468	6.578	

Table 5: Brightness Measurements of Neptune Made in 2016-2017

Date 2016-2017	Filter	Magnitude		Comp. Star	Date 2016-2017	Filter	Magnitude		Comp. Star
		Meas. (+)	Norm. (–)				Meas. (+)	Norm. (–)	
Sept. 23.161	V	7.725	6.970	70-Aqr	Oct. 27.174	V	7.734	6.988	70-Aqr
Sept. 23.161	B	8.118	6.577		Oct. 27.174	B	8.108	6.614	
Sept. 25.212	V	7.679	7.017		Oct. 29.008	U	8.267	6.456	σ-Aqr
Sept. 25.213	B	8.102	6.594		Oct. 29.022	U	8.262	6.461	
Oct. 3.156	V	7.705	6.996		Oct. 29.036	U	8.249	6.474	
Oct. 3.156	B	8.093	6.608		Oct. 29.051	U	8.218	6.505	
Oct. 5.181	V	7.712	6.990		Oct. 29.069	U	8.266[a]	6.457	
Oct. 5.181	B	8.085	6.617		Oct. 29.089	U	8.295	6.428	
Oct. 19.158	V	7.757	6.957		Nov. 5.127	U	8.318[a]	6.413	
Oct. 19.158	B	8.146	6.568		Nov. 5.141	U	8.279	6.453	
Oct. 21.163	V	7.735	6.981		Nov. 5.156	U	8.308	6.424	
Oct. 21.163	B	8.135	6.581		Nov. 5.169	U	8.329	6.403	
Oct. 22.172	V	7.713	7.004		Nov. 9.071	V	7.751	6.985	70-Aqr
Oct. 22.172	B	8.122	6.595		Nov. 9.071	B	8.145	6.591	
Oct. 26.036	V	7.754	6.966	σ-Aqr	Nov. 15.088	V	7.774	6.969	
Oct. 26.050	V	7.723	6.997		Nov. 15.089	B	8.156	6.587	
Oct. 26.065	V	7.735	6.985		Dec. 20.068	V	7.874	6.912	
Oct. 26.077	V	7.710	7.010		Dec. 20.068	B	8.242	6.544	
Oct. 26.157	V	7.731	6.990	70-Aqr	Dec. 24.074	V	7.895	6.896	
Oct. 26.157	B	8.115	6.606		Dec. 24.074	B	8.234	6.557	

[a] Large scatter

Table 6: Selected Photometric Constants of Uranus and Neptune for Their 2016-2017 Apparitions

Planet	U(1,α) [n]	B(1,α) [n]	V(1,α) [n]	B – V
Uranus	–6.290 ± 0.028 [16]	–6.582 ± 0.014 [19]	–7.141 ± 0.010 [29]	0.557 ± 0.017
Neptune	–6.447 ± 0.023 [10]	–6.588 ± 0.012 [13]	–6.977 ± 0.011 [17]	0.389 ± 0.016

corresponding latitudes in the previous apparition.

A few individuals recorded isolated bright areas on Uranus. For example, Sussenbach imaged a bright area near the equator on September 8 (Figure 1D; the lines point to it). Gray and Maksymowicz also drew similar features; however, more observations are needed to determine a drift rate. It is my hope that future observers will describe the longitude system used. The *JPL Solar System Ephemeris* will compute longitudes for Uranus and Neptune based on their magnetic fields.

Several individuals submitted images with bright albedo features on Neptune (see figures 1E - 1H). Delcroix reported a bright area on August 7 at 1:10 UT at 26.7° N and 278.3° W. He reports a similar feature 1.936 days later at 33.5° N, 270.8° W. If this is the same feature, it would have shifted 7.5° ± 7° of longitude. An uncertainty of 5° of longitude is reported for Earth-based images (Hueso et al. 2017, 97). I have computed an uncertainty of 7° by computing the square root of the sum of the squares. More than likely, it rotated three times in 1.936 days. Images over a longer period of time are needed to compute reliable drift rates. Both Obukhov and "Milika-Nichola" submitted a series of images showing a bright feature moving over a 0.5 to 2.1 hour period.

Satellites

Abel used a 0.415 m Dall-Kirkham telescope to examine Neptune and Triton. He reported a tan color for Triton on August 22, 2016. He reported a similar color for it on October 2. No relative brightness measurements of satellites were reported.

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If using the form below, please make payment by check or money order, payable (through a U.S. bank and encoded with U.S. standard banking numbers) to "ALPO" There is a 20-percent surcharge on all memberships obtained through subscription agencies or which require an invoice. Send to: ALPO Membership Secretary, P.O. Box 13456, Springfield, Illinois 62791-3456 USA.

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Interest Abbreviations
0 = Sun 1 = Mercury 2 = Venus 3 = Moon 4 = Mars 5 = Jupiter 6 = Saturn 7 = Uranus 8 = Neptune 9 = Pluto A = Asteroids C = Comets D = CCD Imaging E = Eclipses & Transits H = History I = Instruments M = Meteors & Meteorites P = Photography R = Radio Astronomy S = Computing & Astronomical Software T = Tutoring & Training Program (including Youth)