ISSN-0039-2502

Journal of the Association of Lunar & Planetary Observers

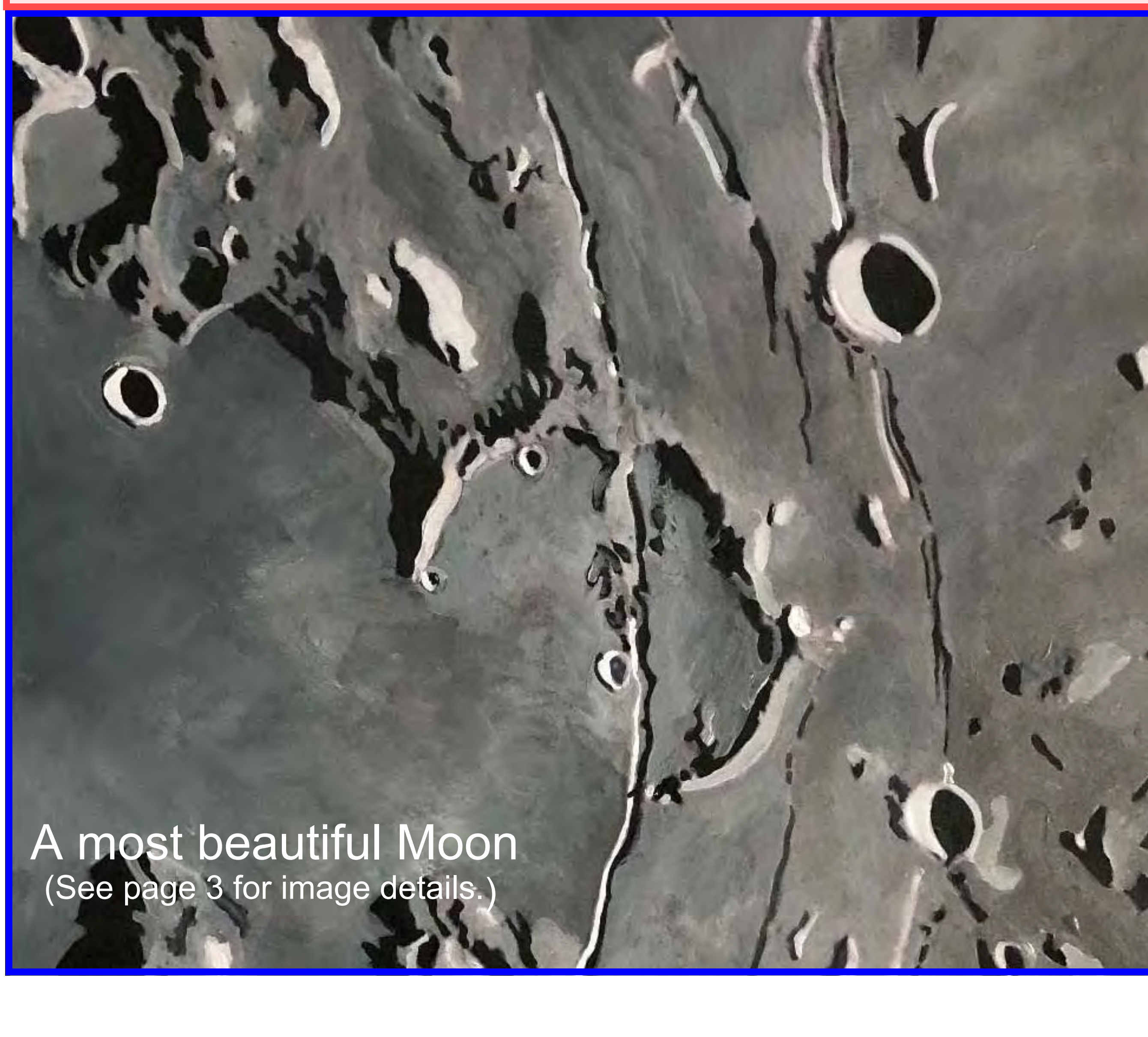
The Strolling Astronomer

Volume 63, Number 3 Summer 2021

Now in Portable Document Format (PDF) for Macintosh and PC-compatible computers

Online and in COLOR at http://www.alpo-astronomy.org

Founded in 1947



A most beautiful Moon

(See page 3 for image details.)

Journal of the Association of Lunar & Planetary Observers

The Strolling Astronomer

Shawn Dilles, Editor

Volume 63, No.3, Summer 2021
This issue published in May 2021 for distribution in both portable document format (pdf) and hardcopy format. Hard copy printing and distribution by Sheridan Press.

This publication is the official journal of the Association of Lunar & Planetary Observers (the ALPO).

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

For membership or general information about the ALPO, contact:

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

E-mail to: *matt.will@alpo-astronomy.org*

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

Founded in 1947

Inside the ALPO

Point of View: A Perfect Storm Will Inspire the Next Generation of Amateur Observers 2
News of General Interest 3
Our Cover: Rima Hippalus and Its Neighborhood 3
ALPO 2021 Conference: Final Call for Papers & Keynote Speaker Announcement 3
Reminder About Contact Changes 6
Search Continues for Jupiter Section Lead Coordinator 6
Hardcopy JALPO Issues Still Available 6
ALPO Staff Update 6
Book Review Ideas Needed 6
Call for JALPO Papers 6
ALPO Interest Section Reports 7
ALPO Observing Section Reports 10
Notable Deaths 29
Letters 31
Errata 31

Papers & Presentations

On Establishing an ALPO Radio Astronomy Section 32
2021: A Good Year for Viewing the Perseid Meteor Shower 34
A Report on Carrington Rotations 2236 and 2237 37
ALPO Observations of Venus During the 2016-2017 Eastern (Evening) Apparition 44
Lunar Domes Near the Craters Luther, Hall and Posidonius 55
Some Considerations About Visual Observation of Wrinkle Ridges On The Moon 67
ALPO Observations of Jupiter During the 2017-2018 Apparition 71
ALPO Observations of the Remote Planets in 2019-2020 87

ALPO Resources

Board of Directors 93
Publications Section 93
Interest Sections 93
Observing Sections 93
ALPO Publications 94
The Monograph Series 94
ALPO Observing Section Publications 95
Back Issues of *The Strolling Astronomer* 96

Inside the ALPO
Member, section and activity news

Association of Lunar & Planetary Observers (ALPO)

Founded by Walter H. Haas, 1947

Board of Directors

Executive Director (Chair); Julius L. Benton, Jr.
Associate Executive Director; Carl Hergenrother
Member of the Board; Sanjay Limaye
Member of the Board; Ken Poshedly
Member of the Board; Timothy J. Robertson
Member of the Board; Richard W. Schmude, Jr.
Member of the Board & Secretary/Treasurer; Matthew Will

Primary Interest Section & Observing Section Staff

(See full listing in *ALPO Resources*)
Publications: Ken Poshedly
Online Section: Larry Owens
Outreach Section:
Lunar& Planetary Training, Timothy J. Robertson
YouTube Channel & Podcasts, Timothy J. Robertson
Youth Activities, Pamela Shivak
Eclipse Section: Keith Spring
Mercury & Venus Transit Section: Keith Spring
Meteors Section: Robert D. Lunsford
Meteorites Section: Dolores Hill
Comets Section: Carl Hergenrother
Solar Section: Rik Hill
Mercury Section: Frank Melillo
Venus Section: Julius L. Benton, Jr.
Mercury/Venus Transit Section: Keith Spring
Lunar Section:
Lunar Topographical Studies & Selected Areas Program; David Teske
Lunar Meteoritic Impact Search; Brian Cudnik
Lunar Transient Phenomena; Anthony Cook
Lunar Domes Studies Program, Raffaello Lena
Mars Section: Roger Venable
Minor Planets Section: Frederick Pilcher
Jupiter Section: (Open)
Saturn Section: Julius L. Benton, Jr.
Remote Planets Section: Richard W. Schmude, Jr.
Exoplanets Section: Jerry Hubbell

Point of View:
A Perfect Storm Will Inspire the Next Generation of Amateur Observers

By Shawn Dilles, editor, Journal of the ALPO

When amateur and professional astronomers that I have met, read about and heard describe what led them to the field of astronomy, I often hear similar responses. Many have been supported or encouraged by a parent or teacher, but when it comes to the “wonder and amazement”, many cite the frenetic early days of the space program, Carl Sagan, and/or the television show *Star Trek*. These three formed a "perfect storm" that inspired and encouraged several generations into astronomy, engineering and related fields.

The "Space Race" – especially the Apollo lunar landings – played a significant role in getting me personally interested in space, and ultimately hooked on amateur observing. For some of our younger members, it is likely that later NASA exploration provided some spark of excitement and inspiration at a formative stage on their path. Who can forget the Viking Landers on Mars, flyby missions to the outer planets, the Rosetta mission to Comet 69P, the New Horizons flyby of Pluto and beyond...or the amazing images delivered by the (repaired) Hubble Telescope?

Today, the seeds are sprouting among some of the millions who have watched robotic rovers expand our efforts to explore Mars. The Perseverance landing and recent Ingenuity flights on Mars – humanity's first powered flight on another world – are breathtaking. And I cannot fail to add Elon Musk to the list for helping to make space more accessible and for many...cool again!

A new perfect storm is brewing that will accelerate interest in astronomy and related fields over the coming five years and beyond. Three separate programs are already underway, each with the potential to revolutionize our understanding of the solar system and of humanity's place in it. ALPO is the perfect place for interested observers to learn, contribute and connect with mentors and peers around the world.

First is the James Webb Space Telescope (JWST), which has the potential to shed new light on the earliest stages in the evolution of the universe. This is a goal of epic proportions and recalls the myth of Icarus, who learned how to fly in order to explore the heavens first-hand. (Ultimately, Icarus failed by flying too close to the Sun, which melted the wax that held his feathered wings together, resulting in his falling from the sky and into the sea. Hopefully the JWST will have a better fate!)

JWST will explore exoplanet systems and protoplanet formation. In our own solar system it is expected to significantly increase our inventory of asteroids, comets, and trans-Neptunian objects. It is an ideal tool to hunt for the postulated Planet 9. The JWST is not the Hubble, but it is designed for awe-inspiring science.

See “A Perfect Storm Will Inspire” on page 4.

Inside the ALPO
Member, section and activity news

News of General Interest

Our Cover: Rima Hippalus and its Neighborhood

In this most striking acrylic artwork done on 8 x 10 1/2" paper by Daniel Marcus, Plainville, Vermont, USA, we see a network of striking concentric arcuate rilles on the eastern shore of Mare Humorum.

Daniel describes the scene as "a beautiful and fascinating area of the lunar landscape, ever-changing as the light moves across the surface."

He adds, "These graben rilles run roughly 200km northeast to southwest. Rille I cuts across the floor of the flooded Imbrium-age crater Hippalus. Rille III passes to the west of Campanus. Promontorium Kelvin is a jumbled mass of low peaks and craters, attached to Rupes Kelvin by a narrow mountain ridge. The breached and flooded crater Lowry lies to the northwest."

Based on observations of the 8-day Moon, using an 8" Meade LX90 SCT, 154x and 227x.

ALPO 2021 Conference: Final Call for Papers & Keynote Speaker Announcement

By Tim Robertson & Ken Poshedly, ALPO Conference coordinators

Overview

Due to the continuing nearly worldwide quarantining caused by the Covid-19 pandemic, the 2021 Conference of the ALPO will be held online on Friday and Saturday, August 13 and 14. (This is to prevent a scheduling conflict with the

Keynote Speaker: Damian Peach

The Assn of Lunar & Planetary Observers is proud to feature Damian A. Peach, FRAS, as the keynote speaker for our 2021 annual conference.

Damian is a British amateur astronomer, astrophotographer, lecturer and author best known for his photographs of a wide variety of astronomical objects. His career in the field spans nearly 30 years.

Damian's passion for astronomy first began in 1988 and was inspired by books in his school library. He joined the British Astronomical Association (BAA) in 1996 and since then, has contributed large amounts of observations to the various observing sections and also written and co-authored many papers in the organizations journal. He was awarded the organizations prestigious Merlin Medal in 2006. That same year, he was also awarded the Walter H. Haas Observer's Award by the Assn of Lunar & Planetary Observers (the ALPO) for his contributions to that organization.

Damian has provided astronomical images for magazines and books throughout his career. His images have been featured in Astronomy magazine, Sky & Telescope magazine, Astronomy Now & The Sky at Night. He has also authored articles on astrophotography for these magazines. Damian has also co-authored several professional scientific papers on planetary astronomy, especially regarding work on Mars and Jupiter. He was one of only a few amateur astronomers to have work featured as part of the national Explorers of the Universe exhibition at the Royal Albert Hall in 2007. His work has also appeared at the Edinburgh Science Festival and The Royal Greenwich Observatory.

Damian's work has also been used by NASA and ESA to illustrate what ground-based telescopes can achieve in photographing the planets, and the support they can provide to professional space probe missions.

In 2011, Damian was crowned overall winner of the Royal Greenwich Observatory Astrophotographer of the Year competition, and was a prize winning finalist in 2012 - 2018. He also won first place in the National Science Foundation's Comet ISON photo competition for his image of that comet which was used by the media worldwide during the comet's close approach to the Sun.

Damian has also appeared on BBC television in the UK. He first appeared on the BBC's All Night Star Party program in 2003 where he imaged Mars live for the program from the Roque de los Muchachos Observatory, La Palma in the Canary Islands. Following that, he made many appearances as a guest on the BBC's Sky at Night astronomy program hosted by Sir Patrick Moore. He has also appeared on BBC news and The Discovery Channel. Damian has also conducted many public talks to both amateur and professional organizations over the past 20 years. In 2015, he was made Honorary President of Adur Astronomical Society in the UK.

In 2017, Damian formed part of a small team of observers who used the famous Pic du Midi Observatory 1.06m (42 in.) telescope to obtain some of the most detailed-ever, ground-based images of Jupiter and Saturn. The same year, asteroid 27632 was re-named Damianpeach by the International Astronomical Union (IAU) for his contributions to amateur astronomy. In 2018, he was elected to the board of the Aster Academy scientific committee and also awarded the Astronomical League's prestigious Peltier Award again for his contributions to astronomy.

Inside the ALPO
Member, section and activity news

2021 Astronomical League Convention (ALCON 2021) which will be held in Albuquerque, NM, on August 4 thru 7, 2021.)

The ALPO conference times will be:

- Friday from 1 p.m. to 5 p.m. Eastern Time (10 a.m. to 2 p.m. Pacific Time)
- Saturday from 1 p.m. to 6 p.m. Eastern Time (10 a.m. to 3 p.m. Pacific Time).

The ALPO Conference is free and open to all via two different streaming methods:

- The free online conferencing software application, Zoom.
- On the ALPO YouTube channel at *https://www.youtube.com/channel/UCEmixiL-d5k2Fx27Ijfk41A*

Those who plan to present astronomy papers or presentations must (1) already be members of the ALPO, (2) use Zoom, and (3) have it already installed on their computer prior to the conference dates. Zoom is free and available at *https://zoom.us/*

Those who have not yet joined the ALPO may do so online, so as to qualify to present their work at this conference. Digital ALPO memberships start at only $18 a year. To join online, go to *http://www.astroleague.org/store/index.php?main_page=product_info&cPath=10&products_id=39*, then scroll to the bottom of that page, select your membership type, click on "Add to Cart" and proceed from there.

There will be different Zoom meeting hyperlinks to access the conference each of the two days of the conference. Both links will be posted on social media and e-mailed to those who wish to receive it that way on Thursday, August 12, 2021. The Zoom virtual (online) "meeting room" will open 15 minutes prior to the beginning of each day's activities.

Those individuals wishing to attend via Zoom should contact Tim Robertson at *cometman@cometman.net* as soon as possible.

A Perfect Storm Will Inspire

(Continued from page 2)

Next up is the planned 10-year observing mission by the U.S. National Science Foundation's Vera C. Rubin Observatory in Chile. This telescope is unlike any other and will pioneer the new field of "time-domain astronomy". In general, the larger a telescope becomes, the smaller the portion of sky it can observe. The Rubin telescope mirrors are shaped in a way that will allow it to see the entire southern sky every four days. It will capture its images on the largest digital sensor known to exist – a 3.2-gigapixel camera. The telescope will measure the intensity and position of light from all of the objects that it detects and send millions of alert messages to astronomers around the world detailing changes that occurred since the last observation. Within the solar system, the Rubin Observatory's unprecedented power of discovery will be a giant leap forward. It will measure the properties of 10 to 100 times more objects than are currently tracked and provide information on light intensity, color, and orbits.

The alerts will almost certainly shift the way we look at the night sky to a new awareness of how dynamic the universe truly is. Scientists interested in novae, variable stars, comets and asteroids will be the first impacted. We may never think about the night sky the same way again, as the field of "time-domain astronomy' becomes quickly established and grows. The role of amateur observers will also continue to grow and evolve, as it has with Pro-Am cooperation with asteroids and exoplanets. The explosive growth of new discoveries will overwhelm professional astronomers, who will not be able to keep up the pace of discoveries.

Humankind's return to the Moon and quest to reach Mars will have the broadest impact. No one under the age of 50 has lived through the excitement of a manned landing on the Moon, but they will soon get a chance to do so. The NASA Artemis program and the Lunar Gateway will extend humanity's reach from low Earth Orbit to near-Lunar orbit, making lunar exploration and sample return much more routine. Young adults today have every reason to expect that we will continue on to Mars, increasing robotic exploration during every ~2 year launch window until humans finally land there. In the same way that Apollo turned our heads to the skies, Artemis and our ambitious reach for Mars will surely inspire the current and next generation.

ALPO stands ready to welcome, encourage, train and mentor the next generation of amateur observers; to accept and use their contributions, and to continue developing new Pro-Am collaborative partnerships as the next era of exploration unfolds. ALPO is made up of individuals with a shared set of interests, and all of us should be alert to the opportunities presented to encourage new observers to join and grow with us.

What inspired you to begin observing? Drop me a short note. If I get enough responses we will publish them in a future column.

For more information these sites are a good place to start.

JWST: *https://www.nasa.gov/mission_pages/webb/main/index.html*

Observer's Notebook Podcast on JWST: *https://soundcloud.com/observersnotebook*

Vera C. Rubin Observatory: *www.lsst.org*

Artemis: *https://www.nasa.gov/specials/artemis/*

Inside the ALPO
Member, section and activity news

Conference Agenda
The conference will consist of initial welcoming remarks and general announcements at the beginning each day, followed by papers and research findings on astronomy-related topics presented by ALPO members.

Following a break after the last astronomy talk on Saturday will be presentations of the Walter Haas Observing Award, the Peggy Haas Service Award and the Michael D. Reynolds Astronomy Award. The last one is brand new and was presented to Ms. Pranvera Hyseni several months ago in recognition for her work over the past several years to advance the public's awareness and appreciation of astronomy.

A keynote speaker will then follow the awards presentations on Saturday. The selection of a keynote speaker is in progress and the final decision will be announced in the summer issue of this Journal (JALPO63-3).

Presentation Guidelines
All presentations should be no more than 15 minutes in length; the preferred method is 12 minutes for the presentation itself plus 3 minutes for follow-up questions. The preferred format is Microsoft PowerPoint.

Send all PowerPoint files of the presentations to Tim Robertson at cometman@cometman.net .

Suggested Topics
Participants are encouraged to present research papers and experience reports concerning various aspects of Earth-based observational astronomy including the following.

- New or ongoing observing programs and studies, specifically, how those programs were designed, implemented and continue to function.
- Results of personal or group studies of solar system or extra-solar system bodies.
- New or ongoing activities involving astronomical instrumentation, construction or improvement.
- Challenges faced by Earth-based observers such as changing interest levels, deteriorating observing conditions brought about by possible global warming, etc.

Inside the ALPO
Member, section and activity news

Information about paper presentations, the keynote speaker and other conference data will be published in this Journal and online as details are learned.

Reminder About Contact Changes

E-mail addresses may come and go, phone numbers may get dropped and people may move from one location to another, but without informing key people and services of these changes, this creates a "failure to communicate" in providing/receiving those services.

Please inform the ALPO of changes in your contact information as soon as they occur. It takes only a few minutes via e-mail to do so and should be directed to the Membership Secretary, Matt Will at *matt.will@alpo-astronomy.org*.

This applies to both our membership and our volunteer staff.

For members, not informing the ALPO about e-mail address changes means missing out on announcements concerning the release of the next *Journal* and other important, time-sensitive news about your ALPO. For members receiving the hard copy *Journal*, it may not necessarily be forwarded to you through your vacated, formal postal address.

For our volunteer staff, such up-to-date contact information such as a current e-mail and postal addresses are crucial for members and observers seeking out staff for the first time for guidance in their programs. Secondary contact information such as phone numbers (which are NOT posted on the website or *Journal*) helps our managing staff in ensuring contact when e-mail won't suffice.

Please take the time to review your current contact information and check to see that the "ALPO Resources" pages in this *Journal* are correct, as well as on the ALPO website.

Search Continues for Jupiter Section Lead Coordinator

Interested individuals should contact the ALPO executive director for more information.

Hardcopy JALPO Issues Still Available

Please note that for those who still wish to add to their library of hardcopy ALPO Journals, we still have a healthy number of various issues left, some dating back to 1962. One oft overlooked thing about these early Journals is that they pre-date the age of satellite exploration of the Moon, the Sun, the planets and comets. Thus, the observing reports are full of the enthusiasm that comes with knowing that we were not competing with high tech gadgets already orbiting these celestial bodies.

And while the photos in those pages are crude when compared to the CCD and webcam images of today, the text captions that accompany them express how much work went into trying to squeeze out every little detail, no matter how grainy.

Please check the list of available issues in the back of this Journal to see what might suit your own interests.

ALPO Staff Update

Note that Bill Dembowski, an assistant coordinator in our Lunar Topographical Studies Program, has a new e-mail address, *zone-vx@comcast.net*

Contact information and much more can be found in the *ALPO Resources* section later in this Journal.

Book Review Ideas Needed

Bob Garfinkle, our book review editor, states that it's been quite awhile that since he's received suggestions for an astronomy book review.

Surely there have been such books published over the past year or so. And it is Bob himself, who authored the highly prized three-volume "Luna Cognita" (available from Amazon at *https://www.amazon.com/Luna-Cognita-Comprehensive-Observers-Handbook/dp/1493916637*).

Bob can be reached via e-mail at *ragarf@earthlink.net*

Call for JALPO Papers

The ALPO encourages its members to submit written works (with images, if possible) for publication in this Journal.

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.

Inside the ALPO
Member, section and activity news

ALPO Interest Section Reports

ALPO Online Section

Report by Jim Tomney, acting assistant section coordinator
jim@tomney.com

The ALPO website (*http://alpo-astronomy.org*) was up and available for the first quarter of 2021 (Jan-Mar) with no reported issues. During that time approximately 37K visits were made to the website, down about 7% from the prior quarter.

With Saturn & Jupiter lost in the Sun's glare and Mars well under 10 arc-seconds in size, it makes sense that the most accessed parts of the site were Solar, Lunar, Comets, and Meteor landing pages. Thanks to Jeff Beish's input, we made multiple updates in January to the Mars section pages, removing dead links and correcting others.

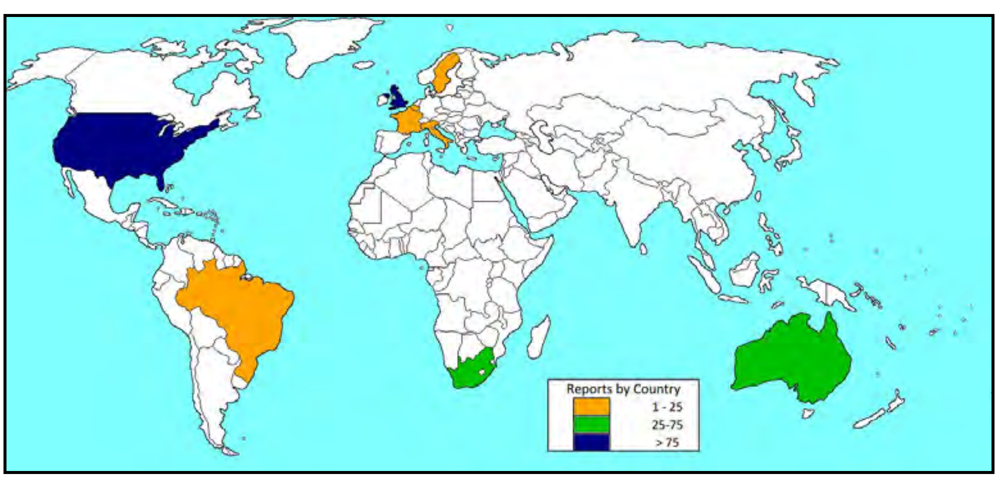
This quarter saw a total of 882 sketches and images of the Sun and major planets uploaded to the ALPO gallery. We are fortunate to have contributors submitting their work from across the globe, as noted in the accompanying map on the next page.

We encourage everyone to continue to submit their observations for inclusion in the ALPO gallery by sending them to the appropriate e-mail address listed on the website's Gallery Submission Guidelines page (*http://www.alpo-astronomy.org/alpo/?page_id=952*). A crucial aspect of the guideline is for the file name to contain the UT date and time of the observation, since it is cumbersome and error-prone to locate that value by examining the image.

We are continuing to look at the website in terms of quality, seeking to do things such as correcting / removing links and outdated content. Section coordinators should let us know of any corrections or changes needed for their portion of the website. If any section coordinator needs an ID for your section's blog, contact Larry Owens at *Larry.Owens@alpo-astronomy.org*.

If you'd like to offer any comments or feedback about the site please reach out to the ALPO Online Section coordinators using the contact information found at *http://www.alpo-astronomy.org/alpo/?page_id=179*.

Follow us on Twitter, "friend" us on FaceBook or join us on MySpace.



Outreach Section

Lunar & Planetary Training Program

Report by Tim Robertson, program coordinator
cometman@cometman.net

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

The ALPO Lunar & Planetary Training Program is a two-step program, and there is no time requirement for completing the steps. I have seen that those students who 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.

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

The course of instruction for the Training Program is two-tiered:

- The first tier is the "Basic Level" and includes reading the *ALPO Novice Observers Handbook* and mastering the fundamentals of observing. These fundamentals include

Inside the ALPO
Member, section and activity news

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

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

For more information on the ALPO Training Program, contact Tim Robertson at 195 Tierra Rejada Rd #148, Simi Valley CA, 93065; e-mail to cometman@cometman.net

YouTube & 'Observers Notebook' Podcasts

Report by Tim Robertson, program coordinator
cometman@cometman.net

The Observers Notebook podcast continues to go strong. I have recorded over 121 podcasts with various members of the ALPO, mostly section coordinators to highlight the programs within each section. The length of a typical podcast averages around 30 minutes. The longest podcast thus far is over 1 hour and 30 minutes. We can record longer, since there is no time limit – our hosting service has unlimited space available for podcasts.

It takes a great amount of time and money to make and produce the podcast, and thus far, it has been done with the help of service called "Patreon." We currently have 12 supporters - two of whom are NOT even members of the ALPO!

We have two generous Patreon supporters who each donate $35 a month to the podcast, and are, thus, producers of the podcast and who also receive one-year membership to the ALPO! Thanks to Steve Siedentop and Michael Moyer for their generous support of the Observers Notebook podcasts.

You, too, 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 $10, you receive a copy of the *Novice Observers Handbook*, and for $35 a month, you receive producer credits on the podcast plus a year's membership to the ALPO. You can help us out by going to the link below:

https://www.patreon.com/ObserversNotebook

Podcasts are released around the 1st and 15th of every month, and if you subscribe to it via iTunes, it will automatically be downloaded to your device.

Our podcasts are also used to get the word out on any breaking astronomy news or events happening in the night sky. Therefore, let me know if you have any breaking news that you want out announced.

If you have a topic that you want covered in the podcast, please drop me a note; I am also looking for member profile pieces where we get to know the members of the ALPO.

Here are a few Observer's Notebook statistics you might be interested in:

- Number of downloads as of April 20, 2021: 49,000+
- Number of Subscribers (all formats): 285+
- Average of number daily downloads (last month): 100
- iTunes rating: 5 Stars!
- Locations of most downloads: USA, UK, Russian Federation, Canada and Australia.

Check out some of our latest podcasts:

- Tim Robertson talks to Dr. Jonathan Gardner, Deputy Senior Project Scientist for the James Webb Space Telescope.
- Tim Robertson talks to Publications Section coordinator and former editor of the JALPO Ken Poshedly. Ken gives us a brief history of the Journal and what's in the latest issue.

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

https://soundcloud.com/observersnotebook

The Observers Notebook is also on Facebook:

https://www.facebook.com/groups/ObserversNotebook/

Remember that the ALPO also has a *YouTube* channel continues to include instructional videos, lectures. We used it

Inside the ALPO
Member, section and activity news

to livestream the ALPO 2020 Conference held last fall. Check it out and subscribe to the channel!

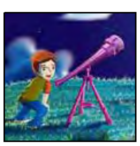
https://www.youtube.com/channel/UCEmixiL-d5k2Fx27Ijfk41A?

December 2020 was an interesting month for the *Observers Notebook* podcast. On 4 December, I posted an image on our Facebook page of the progression of the planetary conjunction between Jupiter and Saturn. On that date, the *Observers Notebook* Facebook page had just 110 members. That one image, however, was shared over 3,000 times, with over 237,000 people seeing the post.

Thanks for listening! For more information about the ALPO Lunar & Planetary Training Program or the *Observers Notebook* podcasts, contact Tim Robertson at195 Tierra Rejada Rd #148, Simi Valley CA, 93065; e-mail to cometman@cometman.net

Youth Activities Program

Report by Pamela Shivak, program coordinator
pamelashivak@yahoo.com



The goal of ALPO's Youth Activities Program is to encourage children and young adults alike to take an interest in astronomy, space, STEM and outreach. We plan to achieve this goal by forming an alliance with astronomy clubs, and other STEM and educational entities. It is our hope that with an ardent and ongoing effort formed with these organizations we can come up with fun and creative ways to get youths involved with any or all aspects of space and science while educating them in the process.

With your help and contributions, I feel we can achieve this goal as the ALPO Youth Program continues to grow with the support, cooperation and commitment of others.

While many popular star parties across the country are still slow to roll out their opening for 2021, some planetariums and public outreach events are beginning to happen! That's an exciting sign of things to come.

Meanwhile, here's a small sampling of online resources I've shared on the ALPO Youth Program Facebook group as they relate to space exploration, STEM

education and preserving our dark skies. I humbly urge you to visit the ALPO Youth Program web page and contribute or share what's there!

- February 18, 2021, brought us the excitement of NASA's Perseverance rover successfully landing on Mars and beginning its robotic exploration of the Red Planet!
- The International Space Station 2021 calendar is online now!

Download the 8 mb pdf file that highlights our orbiting lab at https://go.nasa.gov/3op0xvv

- NASA at Home -- For Kids and Families! https://www.nasa.gov/nasa-at-home-for-kids-and-families

I myself will be promoting "International SUNday", which I founded in 2014 and will be celebrated on the 20 June 2021 summer solstice (that is, the first day of summer). "International SUNday" is a worldwide celebration of the Sun and the solstice, which can be enjoyed either virtually or at a safe public or private event. Get on board! Join the group, plan an event and post a link back to your page on the "International SUNday" Facebook group. For details about "International SUNday", see the link:

https://www.facebook.com/groups/IntlSUNday/

Visit us at https://www.facebook.com/groups/ALPOYOUTHPROGRAM/

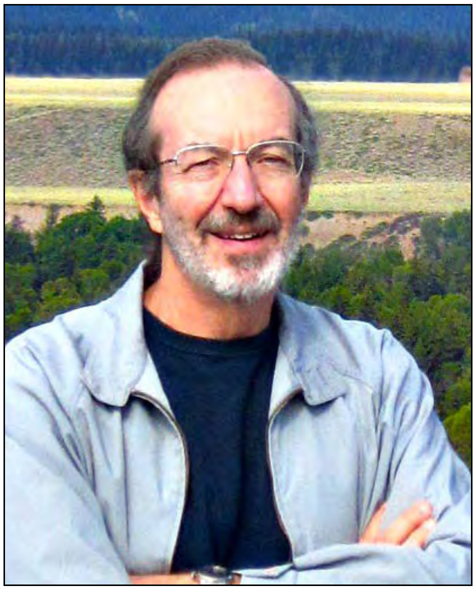
Publications Section

Report by Ken Poshedly, section coordinator
ken.poshedly@alpo-astronomy.org

We are proud to announce that longtime ALPO member and Mars Section coordinator Roger Venable has been named acting assistant coordinator/scientific advisor for the Publications Section by ALPO Executive Director Julius Benton.

Roger has been a stargazer for 61 years, and a member of the Assn of Lunar and Planetary Observers for 34 years. He has participated in many of the ALPO observing programs and has been coordinator of the ALPO Mars Section since 2007. He is also active in the International Occultation Timing Assn (IOTA) and has been its vice president since 2013.

Inside the ALPO
Member, section and activity news



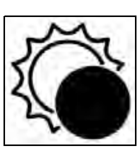
New Acting Assistant Coordinator/ Scientific Advisor Roger Venable.

Roger regularly lectures and writes about Mars and about observing occultations. With his wife Anna, he also enjoys deep sky observing and dabbles in astro-imaging. He currently has 15 telescopes, each with a different, specialized purpose. Roger recently retired from 43 years of practicing medicine.

ALPO Observing Section Reports

Eclipse Section

Report by Keith Spring, section coordinator
star.man13@hotmail.com



On Friday November 19, 2021, the entirety of the United States will experience a partial lunar eclipse from 6:02:09 UT to 12:03:38 UT. This partial eclipse will have an umbral magnitude of 0.9742, only a hair's breadth away from being a total lunar eclipse! The maximum eclipse will occur at the following local times; 1:02:53 a.m. PDT, 2:02:53 a.m. MDT, 3:02:53 a.m. CDT and 4:02:53 a.m. EDT.

Besides the November 19 event, please note the following:

- 2021 Jun 10; **Annular Solar Eclipse**; Visible from Canada, Russia; Partial in North America, Europe, North Asia
- 2021 Dec 4; **Total Solar Eclipse**; Duration 1 minute, 54 seconds; Visible from Antarctica.

The total lunar eclipse of May 26, 2021, will have concluded by the time you see this, and the ALPO Eclipse Section hopes you had a productive viewing event.

Inside the ALPO
Member, section and activity news

For consideration of publication in the next Eclipse Section report in this ALPO Journal, be sure to send your observation reports as soon as possible via e-mail to eclipse@alpo-astronomy.org or via regular mail to Keith Spring, 2173 John Hart Circle, Orange Park, FL 32073.

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

Mercury / Venus Transit Section

Report by Keith Spring, section coordinator
star.man13@hotmail.com

Past Transits

This section is still accepting reports for the November 11, 2019 Mercury Transit for archival. Please send your reports via eclipse@alpo-astronomy.org or regular mail to the contact information in the *ALPO Resources* section of this Journal.

Future Mercury Transits

- November 12-13, 2032 - Visible from Europe, much of Asia, Australia, Africa, South/some coastal areas of East North America, South America, Pacific, Atlantic, Indian Ocean and Antarctica.
- November 6-7, 2039 - Europe, much of Asia, Australia, Africa, much of South America, Pacific, Atlantic, Indian Ocean and Antarctica.
- May 7-8, 2049 - Europe, Asia, Africa, North America, South America, Pacific, Atlantic, Indian Ocean, Arctic, Antarctica.

Future Venus Transits

- December 10-11, 2117
- December 8, 2125

Please send your reports via e-mail to eclipse@alpo-astronomy.org or regular mail to Keith Spring, 2173 John Hart Circle, Orange Park, FL 32073.

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

Meteors Section

Report by Robert Lunsford, section coordinator
lunro.imo.usa@cox.net

A pre-apparition report for the 2021 Perseid appears later in this Journal.

With the first half of the year over, meteor season for the Northern Hemisphere shifts into high gear during July. A bright Moon will spoil the major displays of late July, but the Perseids in August are perfectly timed to be seen in all their glory.

Post-Perseid activity is also spoiled by moonlight, but meteor rates will remain impressive when the Moon is out of the way during the first half of September. We hope that you will take advantage of the warm summer nights to check out the meteor activity and to share your observations with us.

For your planning purposes, here is a list of those meteor showers for this quarter (Source: American Meteor Society, https://www.amsmeteors.org/meteor-showers/meteor-shower-calendar/):

- Southern Delta Aquariids, active July 18 to August 21, 2021, peaking on July 29-30, 2021, with a 62 percent waning Gibbous Moon. Shower details - Radiant: 22:42 -16.3° - ZHR: 25 - Velocity: 25 miles/sec (medium - 40km/sec) - Suspected Parent Object: Comet 96P/Machholz.
- Alpha Capricornids, active July 7 to August 15, 2021, peaking on July 30-31, 2021, with a 52 percent waning Last Quarter Moon. Shower details - Radiant: 20:26 -9.1° - ZHR: 5 - Velocity: 14 miles/sec (slow - 22km/sec) - Parent Object: 169P/NEAT.
- Perseids, active July 14 to September 1, 2021, peaking on August 11/-12, 2021, with a 13 percent waxing Crescent Moon. Shower details - Radiant: 3:13 +58.0° - ZHR: 100 - Velocity: 37 miles/sec (fast - 59km/sec) - Parent Object: 109P/Swift-Tuttle.

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.

Meteorites Section

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

This report of the ALPO Meteorites Section summarizes new meteorite approvals and revisions from January 17, 2021 through April 16, 2021 from the Meteoritical Society's Nomenclature Committee and meteorite images received from Randy Tatum. The microscope images include the NWA 12265 eucrite-melt breccia and the NWA 11342 diogenite using polarized reflected light of cut specimens.

Inside the ALPO
Member, section and activity news

There were 420 new meteorites approved or revised this period. As of April 16, 2021, the *Meteoritical Bulletin* recognizes a total of 65,503 officially named meteorites. One noteworthy meteorite this period is the H5 Arpu Kuilpu from Australia that fell on June 2, 2019. The incoming fireball was observed by the Desert Fireball Network which recovered the 31g meteorite a month later.

Newly approved meteorites include 272 ordinary chondrites (130 H, 94 L, 32 LL, 3 H melt-brec, 8 L-melt brec, 2 L-melt rock, 1 LL6-melt brec, 2 LL(L); 1 chondrite-ungr; 1 EL6; 27 carbonaceous chondrites (1 C3-ungr, 8 CK, 3 CM2, 3 CO, 9 CV3; 3 CR2); 12 R chondrites; 2 aubrites; 5 mesosiderites; 1 IAB-MG iron; 2 IIIAB irons; 5 pallasites; 31 HEDs (3 Howardites, 18 Eucrites, 10 Diogenites); 3 lodranites; 28 ureilites; 8 Winonaites; 11 Lunar; 9 Martian; 1 stony; 1 relict iron.

More information and official details on particular meteorites can be found at: *https://www.lpi.usra.edu/meteor/metbull.php*

Visit the ALPO Meteorites Section online at *www.alpo-astronomy.org/meteorite/* for a very detailed explanation of all facets of meteorite studies.

Table of Ephemerides for Comets 4P/Faye, 6P/d'Arrest, 8P/Tuttle 15P/Finlay, 67P/Churyumov-Gerasimenko and C/2021 A1 (Leonard

Date	R.A.	Decl.	r (au)	d (au)	Elong (deg)	Mag	Const	Max El 40N	Max El 40S
4P/Faye									
2021 Jul 01	01 57.6	+13 47	1.769	1.899	66M	12.1	Ari	23	32
2021 Jul 11	02 24.2	+15 24	1.731	1.795	69M	11.8	Ari	28	31
2021 Jul 21	02 51.6	+16 47	1.698	1.696	72M	11.5	Ari	33	30
2021 Jul 31	03 19.6	+17 52	1.670	1.604	75M	11.2	Ari	39	30
2021 Aug 10	03 47.8	+18 35	1.648	1.519	78M	11.0	Tau	44	29
2021 Aug 20	04 15.8	+18 56	1.632	1.440	81M	10.8	Tau	49	29
2021 Aug 30	04 43.3	+18 53	1.622	1.366	84M	10.6	Tau	53	29
2021 Sep 09	05 09.6	+18 26	1.619	1.299	88M	10.5	Tau	57	29
2021 Sep 19	05 34.2	+17 37	1.622	1.236	92M	10.4	Tau	61	30
2021 Sep 29	05 56.5	+16 30	1.631	1.178	96M	10.3	Ori	63	31
6P/d'Arrest									
2021 Jul 01	16 13.1	+14 56	1.619	0.783	127E	16.5	Her	65	35
2021 Jul 11	16 09.8	+11 53	1.563	0.763	122E	15.9	Ser	61	38
2021 Jul 21	16 10.9	+07 55	1.511	0.751	116E	15.2	Ser	55	42
2021 Jul 31	16 16.8	+03 13	1.465	0.746	111E	14.5	Ser	49	47
2021 Aug 10	16 27.8	-01 59	1.426	0.748	107E	13.7	Oph	43	52
2021 Aug 20	16 43.8	-07 29	1.395	0.757	103E	13.0	Oph	38	58
2021 Aug 30	17 04.9	-13 00	1.372	0.774	99E	12.4	Oph	32	62
2021 Sep 09	17 31.0	-18 15	1.359	0.800	96E	11.7	Oph	28	66
2021 Sep 19	18 01.6	-22 56	1.355	0.835	94E	11.2	Sgr	24	68
2021 Sep 29	18 36.3	-26 46	1.361	0.881	92E	10.7	Sgr	21	68
8P/Tuttle									
2021 Jul 01	05 24.8	+39 08	1.339	2.220	22M	12.7	Aur	4	0
2021 Jul 11	06 02.1	+35 25	1.252	2.140	21M	12.1	Aur	3	0
2021 Jul 21	06 37.9	+30 47	1.175	2.062	21M	11.4	Aur	2	0
2021 Jul 31	07 12.0	+25 14	1.110	1.989	21M	10.7	Gem	0	0
2021 Aug 10	07 45.0	+18 49	1.062	1.923	22M	10.1	Gem	0	0
2021 Aug 20	08 17.2	+11 37	1.033	1.868	24M	9.5	Cnc	0	1
2021 Aug 30	08 49.2	+03 49	1.027	1.828	26M	9.0	Hya	0	5
2021 Sep 09	09 21.5	-04 18	1.043	1.809	28M	8.7	Hya	0	9
2021 Sep 19	09 54.7	-12 25	1.081	1.814	30M	8.5	Hya	0	12
2021 Sep 29	10 29.0	-20 11	1.137	1.843	32M	8.6	Hya	0	14

Comets Section

Report by Carl Hergenrother, section coordinator
carl.hergenrother@alpo-astronomy.org

The comet highlights of the first four months of 2021 were comets C/2020 R4 (ATLAS) and C/2021 D1 (SWAN) which peaked at 8-9th and 9-10th magnitude, respectively. While not an intrinsically bright comet, C/2020 R4 passed close

Inside the ALPO
Member, section and activity news

Table of Ephemerides for Comets 4P/Faye, 6P/d'Arrest, 8P/Tuttle 15P/Finlay, 67P/Churyumov-Gerasimenko and C/2021 A1 (Leonard) (Continued)

Date	R.A.	Decl.	r (au)	d (au)	Elong (deg)	Mag	Const	Max El 40N	Max El 40S
15P/Finlay									
2021 Jul 01	02 44.7	+12 51	1.009	1.109	56M	10.9	Ari	13	0
2021 Jul 11	03 30.0	+17 22	0.993	1.148	54M	10.4	Tau	16	0
2021 Jul 21	04 14.1	+20 57	0.998	1.199	52M	10.0	Tau	20	0
2021 Jul 31	04 56.3	+23 36	1.024	1.256	52M	9.9	Tau	24	0
2021 Aug 10	05 36.0	+25 23	1.069	1.314	52M	10.0	Tau	27	0
2021 Aug 20	06 12.6	+26 25	1.129	1.368	54M	10.3	Gem	31	0
2021 Aug 30	06 45.8	+26 53	1.201	1.416	56M	10.9	Gem	35	0
2021 Sep 09	07 15.6	+26 57	1.281	1.453	59M	11.5	Gem	39	0
2021 Sep 19	07 41.7	+26 46	1.368	1.480	63M	12.2	Gem	44	0
2021 Sep 29	08 04.4	+26 27	1.458	1.495	68M	13.0	Cnc	49	0
67P/Churyumov-Gerasimenko									
2021 Jul 01	00 29.9	-01 21	1.886	1.540	92M	15.2	Cet	29	51
2021 Jul 11	00 50.2	+00 40	1.807	1.379	96M	14.8	Cet	35	49
2021 Jul 21	01 11.6	+02 48	1.730	1.226	100M	14.3	Psc	41	47
2021 Jul 31	01 34.5	+05 02	1.654	1.084	103M	13.8	Psc	47	45
2021 Aug 10	01 59.4	+07 25	1.580	0.953	106M	13.3	Psc	53	42
2021 Aug 20	02 26.6	+09 56	1.509	0.835	109M	12.7	Cet	58	40
2021 Aug 30	02 56.9	+12 37	1.443	0.730	110M	12.1	Ari	62	37
2021 Sep 09	03 30.9	+15 25	1.382	0.641	111M	11.6	Tau	65	34
2021 Sep 19	04 08.9	+18 16	1.328	0.567	112M	11.1	Tau	68	32
2021 Sep 29	04 51.0	+20 57	1.282	0.510	111M	10.5	Tau	71	29
C/2021 A1 (Leonard)									
2021 Jul 01	10 28.0	+51 35	3.091	3.614	51E	17.0	UMa	33	0
2021 Jul 11	10 28.7	+49 45	2.966	3.582	45E	16.8	UMa	28	0
2021 Jul 21	10 31.2	+47 59	2.840	3.531	40E	16.6	UMa	23	0
2021 Jul 31	10 35.1	+46 17	2.711	3.458	36E	16.4	UMa	19	0
2021 Aug 10	10 40.1	+44 40	2.580	3.361	33E	16.2	UMa	16	0
2021 Aug 20	10 46.1	+43 08	2.446	3.239	32E	15.9	UMa	12	0
2021 Aug 30	10 52.8	+41 42	2.310	3.092	32E	15.6	UMa	10	0
2021 Sep 09	11 00.2	+40 21	2.172	2.919	34M	15.3	UMa	9	0
2021 Sep 19	11 08.2	+39 05	2.031	2.719	38M	14.9	UMa	14	0
2021 Sep 29	11 16.7	+37 56	1.887	2.493	42M	14.4	UMa	20	0

to Earth at 0.46 au on April 23 after a perihelion at 1.03 au on March 1.

Though discovered in spacecraft image data, the discovery and ground-based follow-up of C/2021 D1 (SWAN) was entirely the work of amateur astronomers. Check out former ALPO Comets Section Recorder Don Machholz's podcast, *Looking Up With Don* (#61), for a nice rundown of the story behind SWAN's discovery. The podcast can be found on Don's web site at https://donmachholz.com/.

Looking forward to the months of July through September, a quintet of short-period comets become bright enough for visual observers with moderate sized telescopes. We are still watching C/2021 A1 (Leonard) develop and brighten to hopefully become a nice binocular or borderline naked eye object in December.

- 4P/Faye — In March 1841, comet 4P/Faye passed within 0.64 au of Jupiter, resulting in a drop in perihelion distance from 1.80 to 1.69 au. Perhaps as a result of the decreased perihelion, the comet became bright enough to be discovered visually by Herve Faye in November 1843 at 5-6th magnitude. The discovery apparition was abnormally bright with Faye subsequently never getting brighter than 9-10th magnitude at its best. Since discovery, its perihelion distance has been fairly stable between 1.59 and 1.75 au. This year marks the comet's 22nd observed return and is a moderately good return with perihelion on September 8 at 1.62 au and closest approach to Earth on December 5 at 0.94 au. As July begins, Faye is a morning object around 12th magnitude and should be close to a

Inside the ALPO

Member, section and activity news

maximum brightness of 10.3 by the end of September.

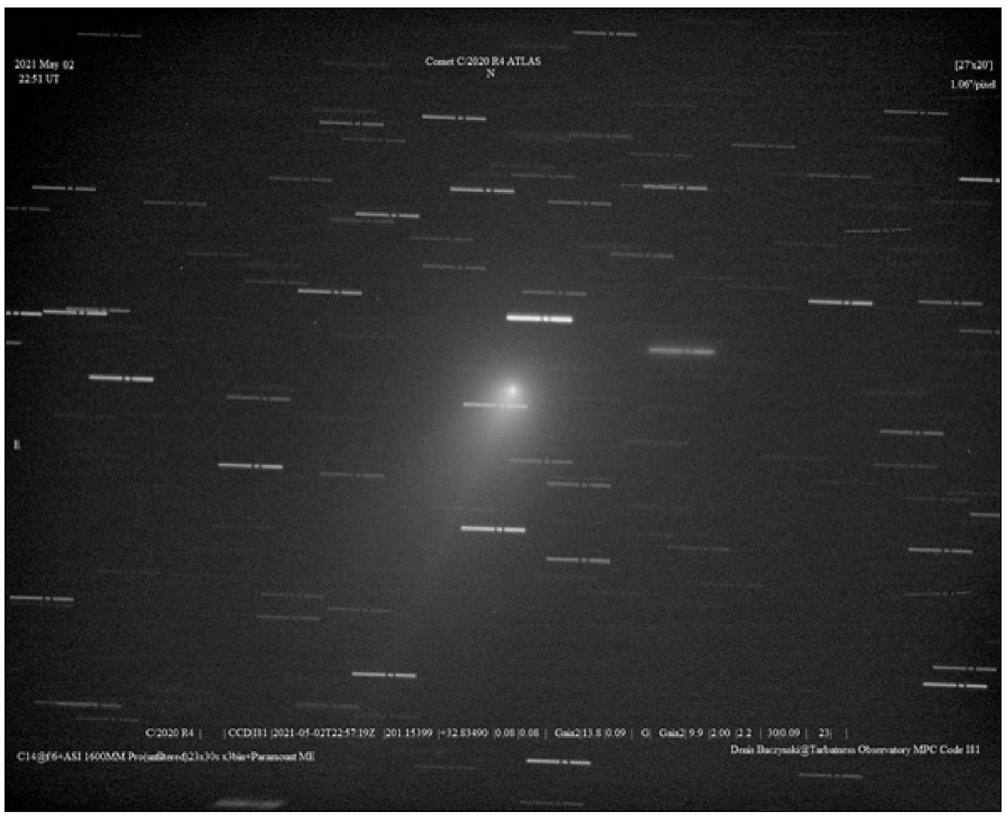
- 6P/d'Arrest — Heinrich Louis d'Arrest discovered 6P/d'Arrest visually in June 1851. d'Arrest wasn't the first person to see 6P, Phillipe la Hire having spotted the comet back in 1678. While an attempt to link 6P with the comet of 1678 was made in 1851, the linkage wasn't definitely made until 1991. Perihelion has been fairly stable between 1.03 and 1.39 au since 1678. When perihelion trends to smaller values, close approaches to Earth are possible as occurred in 1976 when d'Arrest passed 0.15 au from Earth and reached 5th magnitude.

  6P spends the July to September months as an evening object. It is a faint 16th magnitude at the start of July but quickly brightens to around magnitude 10.6 by the end of September. A peak brightness of ~9.8 should be reached in late October to early November.

- 8P/Tuttle — Pierre François André Méchain was the first discoverer of this comet in January 1790. Its periodic nature was not noticed until its re-discovery by Horace Parnell Tuttle in January 1858. With a 13.6-year period, 8P/Tuttle is making its 13th observed return having been missed in 1953 and at the four perihelion passages between the Méchain and Tuttle discoveries. Tuttle's relatively large semi-major axis of 5.7 au and inclination of 54.9° makes it a Halley-type rather than a Jupiter-family comet. It is also the parent of December's Ursid meteor shower.

  This year's return sees perihelion on August 27 at 1.03 au with a closest approach to Earth on September 12 at 1.81 au. Unfortunately, Tuttle will be located at very small elongations making it a very difficult object for northern hemispheres in early July when it will around 11-12th magnitude but only a few degrees above the horizon before the start of astronomical twilight in the morning sky. It will reappear for southern hemisphere observers in late August at 9th magnitude as it brightens to 8.5 in September.
  Tuttle's best return was in 2008, when it passed 0.25 au from Earth and brightened to 5th magnitude. That close approach allowed radar observations to resolve its 10 km (6 mile) long contact binary nucleus. In 2048, it will come even closer to Earth at 0.17 au.

- 15P/Finlay — 15P/Finlay was introduced in the last issue of this Journal. 2021 marks the 16th observed return of 15P, with a perihelion on July 13 at 0.99 au. Assuming it doesn't experience any outbursts like it did twice during its last return in 2014/2015, Finlay should start July around magnitude 10.9, brighten to 9.9 by the end of July, and then fade to 13th magnitude at the end of September. It will be a morning object, visible to both northern and southern hemisphere observers.



C/2020 R4 (ATLAS) experienced a small outburst in activity in late April. Denis Buczynski imaged the comet about a week after the outburst on 2021 May 2 with a Celestron C-14 and ASI 1600MM camera. The comet displayed a narrow tail that became visible after the late April outburst.

Inside the ALPO
Member, section and activity news

- 67P/Churyumov-Gerasimenko — Thanks to the European Space Agency's Rosetta orbiter and Philae lander, we now know more about 67P/Churyumov-Gerasimenko than any other comet. While 67P is one of eight comets visited by spacecraft, it remains the only comet to be orbited by a spacecraft with both Philae and Rosetta ultimately coming to rest on its surface. Like 8P/Tuttle, 67P is a contact binary with the largest nucleus component having dimensions of 4.1 x 3.3 x 1.8 km (2.5 x 2.1 x 1.1 miles) and the smaller component having dimensions of 2.6 x 2.3 x 1.8 km (1.6 x 1.4 x 1.1 miles).

  67P was discovered in September 1969 by astronomers from Kiev University's Astronomical Observatory working at the Alma-Ata Astrophysical Institute (in current day Kazakhstan) with a 50-cm Maksutov astrograph. Svetlana Ivanovna Gerasimenko was exposing a photographic plate for another periodic comet, 32P/Comas Solá. Nine days later, while examining the Comas Solá plate, Klim Ivanovic Churyumov found what was originally presumed to be an image of 32P, but upon further analysis was determined weeks later to be a new comet. This apparition is 67P's ninth observed return with perihelion occurring on 2021 November 2 at 1.21 au. A close approach to Earth at 0.42 au on November 12 results in the comet's best return since 1982 when it came marginally closer to Earth at 0.39 au. At that return, a peak brightness of 9th magnitude was reached. A similar brightness should occur this November and December. The comet starts July around 15th magnitude and brightens to magnitude 10.5 by the end of September. It will be a morning object visible from both hemispheres during the this period.

C/2021 A1 (Leonard) — Also introduced in the previous JALPO Journal was newly discovered long-period comet C/2021 A1 (Leonard). Catalina Sky Survey astronomer Greg Leonard discovered C/2021 A1 on 2021 January 3 with the Mount Lemmon 1.5-m reflector at 19th magnitude when it was located at a distance of 5.1 au from the Sun. It has the potential to be a nice observing object in December when it passes 0.23 au from Earth on December 12 on its way to a 2022 January 3 perihelion at 0.62 au. Current brightening trends suggest Leonard will be around 6th magnitude at the time of closest approach to Earth, but It could be even brighter. Around the time of closest approach, it will also be at a large phase angle of ~160 degrees which may result in a few additional magnitudes of brightening due to forward scattering of sunlight by dust in the coma and tail of C/Leonard. But… and there's always a “but”, the comet will be located at a small elongation of only 15 degrees at that time so a difficult object to observe.

CCD observations taken through the end of April 2021 find C/Leonard has brightened to between magnitude 17.5 and 18.0. Using a conservative 2.5n = 8 brightening rate, Leonard should start July around magnitude 17.0, and be 16.4 by August 1, 15.6 by September 1, and within range of large aperture visual observers at magnitude 14.3 by the end of September. Note, that Leonard passes through solar conjunction on September 5, but will still be visible for northern observers at that time due to a location well-north of the Sun (minimum elongation in September of 32 degrees). CCD (and hopefully visual) observers are encouraged to routinely observe C/2021 A1 as it approaches the Sun and Earth.

As always, the Comet Section is happy to receive all comet observations, whether images, drawings, magnitude estimates, and even spectra. Please send your observations via e-mail to *carl.hergenrother@alpo-astronomy.org*

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*

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

Solar Section

Report by Rik Hill, section coordinator & scientific advisor
rhill@lpl.arizona.edu

A report on Carrington Rotations 2236 and 2237 appears later in this Journal.

Solar activity is beginning to pick up a bit with a strong spike thanks to AR 2786 in CR 2237-38 (late November through early December 2020). ALPO Solar Section Assistant Coordinator Kim Hay has been doing a wonderful job noting this in her rotational reviews on our webpage. Theo Ramakers has contributed an analysis of the “ramp up” to Cycle 25 also on the webpage. Our articles on solar activity (including this issue of the Journal) examine the rotations in detail with observations citing the individual observers.

Inside the ALPO
Member, section and activity news

While we have seen a few contributing observers fall away, Section staffing remains stable and we look forward to more activity, both on the Sun and in terms of observers through the rest of 2021.

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
frankj12@aol.com

In the last Mercury Section Report, this writer stated that Mercury experienced a poor morning apparition as seen from the northern hemisphere in February and March, particularly when the planet was viewed with the naked eye during the morning twilight.

Mercury as imaged by Gregory Shanos of Longboat Key, Florida, USA, on March 14, 2021, at 12:00 UT, using a Meade 10-inch Schmidt-Cassegrain scope. North at top, West at right. CM 202°.

The ecliptic was so shallow that it was barely visible above the horizon when seen with the naked eye. On the other hand, Mercury's elongation was as far away as possible, 27 degrees west of the Sun. When it gets higher in the sky at daylight, it becomes more easily seen if you know where to look. One disadvantage of this, however, is that Mercury is south of the sun in declination. Then it doesn't matter if it is closer to the central meridian when the Sun is still in the east.

Last March, I took several good images of Mercury but never imaged this part of the surface so clearly. Also, I never thought I would be able to do it. It was still safe to observe Mercury in daylight despite it being 27 degrees west and more south of the sun. I owe thanks to nearby Jupiter, which helped me find Mercury in daylight by using setting circles. These observations will be reported in the 2021 Mercury apparitions report.

We now welcome a new ALPO member, Gregory Shanos of Longboat Key, Florida, USA (welcome!). He has become very interested in Mercury and is learning how to take images of the planet. I gave him some tips and sent him software to process his images. Mercury is indeed a very difficult planet to image, but Greg is quickly getting the hang of it. I have included one image with this report taken on March 14, 2021. It shows possibly three rayed craters in line from north to south near the center. Several days later, I captured these features in my own images. Gregory is looking forward to taking more images of Mercury as he improves his skills, and is patiently waiting for the evening apparition in May.

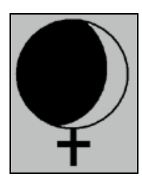
Speaking of the evening apparition, it will be over by the time you read this. But you will find Mercury in the morning sky, especially during the first half of July. It is quite favorable and easily visible to the naked eye in twilight 30 minutes before sunrise. Mercury will reach its greatest elongation on July 4 at 22 degrees west of the Sun. It will actually put on a show during most of the month. On July 15, it will reach -0.6 magnitude at a distance of 18 degrees east of the Sun. It will continue to brighten even at -1.3 magnitude the following week, but then it will inch closer to the Sun by month's end and the Superior Conjunction will occur on August 1.

If you are interested in observing Mercury don't hesitate to contact me. For current observers, please send in your observations to the Mercury Section. Visit the ALPO Mercury Section online at *www.alpo-astronomy.org/mercury*

Venus Section

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

The Venus 2016-2017 Eastern (Evening) apparition report appears later in this Journal.



Venus remains visible in the evening sky after sunset this summer. During the current, 2021-22 Eastern (Evening) apparition, Venus is passing through its waning phases (a progression from a nearly fully illuminated disk and ultimately to its 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.

Inside the ALPO
Member, section and activity news

Venus is predicted to reach theoretical dichotomy (half phase) on October 28 and then subsequently attain its greatest illuminated extent by December 7, 2021, at visual magnitude -4.8. Venus will reach Inferior Conjunction with the Sun on January 8, 2022, thereby ending the 2021-22 Eastern (Evening) apparition.

Venus is predicted to reach theoretical dichotomy (half phase) on October 28 and then subsequently attain its greatest illuminated extent by December 7, 2021 at visual magnitude -4.8. Venus will reach Inferior Conjunction with the Sun on January 8, 2022, thereby ending the 2021-22 Eastern (Evening) apparition.

For the convenience of observers, the accompanying table of Geocentric Phenomena in Universal Time (UT) pertains to the current 2020-21 Western) Morning) apparition and is included here for the convenience of interested observers.

As of the date of this report, we are awaiting recent observations of Venus to arrive for the current apparition, in the form of digital images of the planet at UV, visual, and near IR wavelengths, as well as routine drawings in integrated light (no filter) and with different color filters. Observational reports for the current 2021-22 Eastern (Evening) apparition are expected to be received regularly throughout the new apparition. Examples of the latest observations will be provided in a subsequent update.

Venus Pro-Am Activities

Regular readers of this Journal should be familiar with our continuing 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 for about nine years, from 2006 until the mission ended in 2015. It remains as one of the most successful Pro-Am efforts to date, involving ALPO Venus observers around the globe. Such observations will remain important for further study and will continue to be 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.*

Inside the ALPO
Member, section and activity news

A follow-up collaborative Pro-Am effort remains underway during the 2021-22 Eastern (Evening) Apparition in continuing support of Japan's (JAXA) *Akatsuki* mission that began full-scale observations starting back in April of 2016. The website for the *Akatsuki* mission remains active so interested and adequately equipped ALPO observers can still register and start submitting images if they have not already done so.

As always, 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 contribute their observations to the ALPO Venus Section at the same time submittals are sent to the Akatsuki mission.

Breaking recent news from the *Akatzuki* mission at the time of this report is the mission's discovery of some interesting atmospheric phenomena on Venus in the form of a giant discontinuity and disruption rapidly propagating along the middle and lower clouds of Venus that is not readily visible in the upper clouds of the planet. This atmospheric phenomenon is comparable with other planetary patterns spotted at the super-rotating upper cloud levels like the horizontal V, Y, or ψ (psi)-shaped dusky clouds that are roughly aligned along the planet's terminator typically seen in images captured UV wavelengths. A study of past observations with ground-based telescopes and data from the earlier Venus Express mission shows evidence that this is a quasi-permanent feature of the atmosphere of Venus that presumably has been missed since at least the year 1984.

While this phenomenon is very challenging to observe on the dayside upper clouds with usual UV imaging techniques, it may be that the dayside middle clouds could be marginally noticeable on images taken at visible and near-IR wavelengths). In fact, wavelengths longer than 700nm seem to be better suited for earth-based observers participating in our pro-Am efforts to see what they can accomplish with perhaps detecting the middle cloud phenomena reported by Akatsuki scientists. More on these developments will be forthcoming in a subsequent update.

We are continuing our full coordination and strong teamwork with the *Akatsuki* mission team in collection and analysis of all observations. If anyone has questions about our Pro-Am efforts, 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/ as well as in considerable detail in the author's *ALPO Venus Handbook* available free as ALPO Monograph 15 on the ALPO website. (Go to www.alpo-astronomy.org, click on the ALPO home page, lick on the *ALPO Section Galleries* link near the top-right corner of the page, click on Publication Section, click on ALPO Monographs, then click on “ALPO Monograph 15 - Venus Handbook (Revised Edition 2016)”.)

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 drawings of the planet at visual wavelengths. Regular imaging of Venus in both UV, near-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 (e.g., 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 forms 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.

Under favorable circumstances during future apparitions, 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 planet as a cooperative simultaneous observing endeavor with visual observers. Also, observers should undertake imaging of the planet at near-IR wavelengths (for instance, 1000 nm) around the dates on either side of inferior conjunction, 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 the many challenges ahead.

Inside the ALPO
Member, section and activity news

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://alpo-astronomy.org/gallery3/var/albums/Publications-Section/Observing-Section-Publications/Venus/VenusReportForm.pdf?m=1521162039

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/

Lunar Section

Lunar Topographical Studies / Selected Areas Program

Report by David Teske, program coordinator
drteske@yahoo.com

A paper on the observation of lunar "wrinkle ridges" appears later in this Journal.

The ALPO Lunar Topographic Studies Section (ALPO LTSS) received a total of 452 observations from 33 observers in 10 countries from January to March 2021. The countries represented by observers were Argentina (12), USA (11), Italy (2), Columbia (1), Uruguay (1), France (1), United Kingdom (2), Luxembourg (1), Venezuela (1) and the Dominican Republic (1).

It is most impressive to have so many high-quality lunar observations submitted from so many observers throughout the world, particularly Latin America. Thirty-one articles were published in addition to numerous commentaries on images selected in the monthly newsletter *The Lunar Observer*. The monthly newsletter *The Lunar Observer* had an average page count of 106 pages per issue during the quarter.

Throughout the quarter, *The Lunar Observer* contained a section, "By the Numbers" which looked at observer's locations and telescopes used for Moon gazing. In all three months, Schmidt-Cassegrain telescopes followed by Maksutov-Cassegrain telescopes were the most common telescope types for lunar observations. This trend in telescope type use has been consistent for many months. T*he Lunar Observer* was placed on the Cloudy Nights website and viewed an average of 231 times in each month of the quarter.

The *Focus-On* series continued under Jerry Hubbell, with the continuation of the "Lunar 100" during this quarter, based on the Lunar 100 list created by Charles Wood. The Lunar 100 observing list ranges from very easy (Lunar 100 number 1, the Moon) to very challenging (Lunar 100 number 100, Mare Marginus swirls). Every other month starting in May 2020 we have been exploring 10 of the Lunar 100 targets. In January 2021, the fifth 10 of the Lunar 100 were featured in the *Focus-On* article and March 2021 followed with the sixth 10 of the Lunar 100. An incredible response from across the globe allowed us to feature many images and drawings of these lunar subjects. As the number of the Lunar 100 gets higher, the lunar features begin to get more challenging to observe and image.

Future *Focus-On* articles will highlight observations from the Lunar 100 observing list. July 2021 will feature Lunar 100 targets 71-80 and September 2021 will feature Lunar 81-90. Articles and images of the lunar targets are due to David Teske and Alberto Anunziato by the 20th of the month prior to publication (June 20 and August 20).

The Lunar Observer also featured articles concerning lunar topographic studies, featuring familiar and not-so-familiar lunar targets. These articles ranged in sizes from 1-4 pages. During this quarter we also brought back the Lunar Topographic Studies Program of Banded Craters. Howard Eskildsen featured several of these banded craters in the quarter.

Each month *The Lunar Observer* features an in-depth article from Dr. Anthony Cook on the Lunar Geologic Change Detection Program. Other articles focus on lunar features, lunar domes and images of recent lunar topographic studies.

Electronic submissions can now be made by emailing to this coordinator. See the most recent issue of *The Lunar Observer* on the ALPO website ((http://www.alpo-astronomy.org/gallery3/index.php/Lunar) for instructions. Hard copy submissions should continue to be mailed to the coordinator at the address listed in the ALPO Resources Section of the Journal.

The lunar image gallery/archive is also now active. Wayne Bailey continues to submit archived images to the Lunar Gallery. This coordinator is now adding current lunar image submissions to the Lunar Gallery. Also, all issues of *The Lunar Observer*, including those from its beginning in 1997 as an American Lunar

Inside the ALPO
Member, section and activity news

Society publication to June 2004 when it became the newsletter of this ALPO program, are now available on the ALPO website due to hard work by Theo Ramakers. Also, in the ALPO Lunar Gallery images and reports can be found in the Lunar Dome section.

For more info, including current and archived issues of *The Lunar Observer*, go to moon.scopesandscapes.com.

Lunar Meteoritic Impacts

Report by Brian Cudnik, program coordinator
cudnik@sbcglobal.net

The ALPO LMIS Program continues to coordinate observations and activity related to the documentation of lunar meteors and the confirmation of the same. We've received no reports of observations of such phenomena since last year. Nonetheless, we will continue to encourage - even promote - the monitoring of the Moon during our monthly observing campaigns as well as during special events, when the Moon is favorably placed, such as major meteor showers and total lunar eclipses.

Please visit the ALPO Lunar Meteoritic Impact Search site online at http://alpo-astronomy.org/lunarupload/lunimpacts.htm

Lunar Transient Phenomena

Report by Dr. Anthony Cook, program coordinator
tony.cook@alpo-astronomy.org

No LTP reports have been received since the last section report. However, we continue to receive excellent repeat illumination observations that can be used to disprove some past LTP reports, but also can be used to highlight the unusual nature of LTPs.

For example, on 1882 Aug 21 UT 19:30, Arthur Stanley Williams of Brighton, England, reported to the Royal Astronomical Society's, Astronomical Register journal, that he saw a spot at least 50% brighter, and as large as Picard, near to Picard crater.

Walter Elias (AEA) in Argentina, imaged this area of the Moon under similar illumination (±0.5°) and found that Curtis crater (thought to be the location of the spot) was not especially bright or large. This illustrates the usefulness of the many repeat illumination observations that are submitted to ALPO's LTP program.

Finally, David Darling, assistant coordinator of the ALPO LTP program and past LTP coordinator for ALPO and the American Lunar Society, has kindly forwarded Winifred Cameron's LTP card collection to David Teske, coordinator of the ALPO Lunar Topographical Studies / Selected Areas Program, for storage in the Lunar Section archives. This will be very valuable for checking for typographical errors in the 1978 NASA Lunar Transient Phenomena catalog and a subsequent 2006 extension to the catalog.

General Information:

Mare Crisium as imaged by Walter Elias (AEA) on 2021 Feb 19 UT20:36 and orientated with north towards the top.See text of the LTP section report for details.

Inside the ALPO
Member, section and activity news

For repeat illumination (and a few repeat libration) observations for the coming month - these can be found on the following web site: http://users.aber.ac.uk/atc/lunar_schedule.htm . By re-observing and submitting your observations, only this way can we fully resolve past observational puzzles. To keep yourself busy on cloudy nights, why not try "Spot the Difference" between spacecraft imagery taken on different dates? This can be found on: http://users.aber.ac.uk/atc/tlp/spot_the_difference.htm . If in the unlikely event you do ever see a LTP, firstly read the LTP checklist on http://users.aber.ac.uk/atc/alpo/ltp.htm , and if this does not explain what you are seeing, please give me a call on my cell phone: +44 (0)798 505 5681 and I will alert other observers. Note when telephoning from outside the UK you must not use the (0). When phoning from within the UK please do not use the +44! Twitter LTP alerts can be accessed on https://twitter.com/lunarnaut .

Dr Anthony Cook, Department of Physics, Aberystwyth University, Penglais, Aberystwyth, Ceredigion, SY23 3BZ, Wales, United Kingdom. E-mail to atc@aber.ac.uk

Monthly summaries of the observations received as well as the best observation from each observer that can provide useful science on re-evaluation past LTP reports are published in the ALPO Lunar Section newsletter *The Lunar Observer* (http://moon.scopesandscapes.com/tlo.pdf) – often 10 or more pages per month.

We receive repeat illumination reports from astronomers across the world, most notably the UAI in Italy, the BAA in the UK, the AEA and SLA in Argentina, and LIADA members in Bolivia and Uruguay.

In the U.S., our most active ALPO contributors are Jay Albert, Rik Hill and Gary Varney.

We welcome observations from visual observers, and also astronomers with color imaging capability, who are able to record subtle natural colors on the lunar surface.

We also welcome new participants, whether they are experienced visual observers or high-resolution lunar imagers.

LTP observational alerts are given on the Twitter page: https://twitter.com/lunarnaut

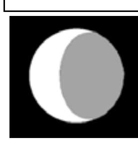
Please visit the ALPO Lunar Transient Phenomena site online at http://users.aber.ac.uk/atc/alpo/ltp.htm

Lunar Domes Studies

Report by Raffaello Lena, program coordinator
raffaello.lena@alpo-astronomy.org

A report on lunar domes Luther1, Hall1 and Posidonius1 appears later in this Journal.

W



We have received 101 images including some by Michael Barbieri, Jean Pierre Brahic, Robert Cazilhac, Maurice Collins, Howard Eskildsen, Guy Heinen, Richard Hill, Luigi Morrone, Roberto Paletta, Zlatko Pasko, Davide Pistritto, K.C. Pau, Frank Schenck, Vishal Sharma, Maximilian Teodorescu and Andrea Vannoni. Many of these images are of high resolution and of great interest for our program.

- Morrone has imaged the dome Meton 1, Marius hills volcanic complex, Reiner domes, domes in Promontorium Laplace, the domes in Gambart region and the Sommering dome.
- Eskildsen has imaged the Marius dome field catching first light of the rising Sun and under higher solar illumination angle, the Gruithuisen highland domes, Mairan T domes, Herodotus omega, Rümker volcanic complex.
- Heinen has imaged Gruithuisen highland domes, Herodotus omega, Arago domes.
- Cazilhac has submitted an image of Petavius 1 dome, Gassendi 1 dome and Capuanus domes.
- Collins has imaged the dome Piccolomini 1, Fracastorius dome, the Hortensius domes and Rümker.
- Pau has imaged the Apennine Bench formation, the dome Aristillus 1, the Valentine dome in Caucasus Mons, Hortensius domes, Hyginus 1 dome, M 24 dome which is located near the crater Brayley, domes near Messier in Mare Fecunditatis named Messier 1-5. He also imaged a prominent Kipuka east of Taruntius in Mare Fecunditatis.
- Barbieri has imaged the region around Cavendish and a swell near Wichman with rilles on the summit which is a dislocation of the soil based on LOLA DEM and WAC imagery. He has also imaged Herodotus omega dome, Marius hills volcanic complex and Mersenius P dome.
- Sharma has submitted an image of Copernicus region and part of the Sinus Aestuum volcanic region.
- Pasko has imaged Gassendi 1 dome and John Herschel crater pyroclastic deposits.

Inside the ALPO
Member, section and activity news

- Pistritto has imaged the dome Mason 1.
- Brahic has imaged Aristarchus volcanic region and Gassendi-Mare Humorum region.
- Schenck has imaged the domes near Luther crater, domes in Messier named as Messier 1-5, Aristillus 1 which is a large swell, Marius hills volcanic complex, Wollaston 1-3 domes and Herodotus omega.
- Vannoni has imaged Mare Insularum with Milichius-T.Mayer and Hortensius domes and Hansteen domes. He has also imaged the domes in Sinus Iridum termed L1, L5-L6 under different solar illumination angle, Marius hills, the dome in Kepler, the dome Encke 1 and lava flows in Mare Imbrium.

The dome Encke 1 (En1) is 180 m high, with an average slope angle of 0.62°. Furthermore, the flat appearance of En1 suggests that the rising magmas did not build up a dome through a series of flows, but that it was more likely formed by rising magma collecting in a reservoir, forming a subsurface intrusion. The dome En1 is associated with two grabens traversing its northeastern summit and the central summit, respectively. Due to its large diameter and edifice volume, the dome En1 matches the properties derived for putative intrusive dome belonging to group In1, as reported in our two articles:

http://articles.adsabs.harvard.edu/pdf/2018JALPO..60b..45L

and *https://www.hou.usra.edu/meetings/lpsc2019/pdf/1011.pdf* .

Vannoni has also imaged Agatharchides and Darney which are two well known Kipukas, high standing remnant of an earlier terrain now surrounded by lava flows, Kies 1 dome and the domes inside Pitatus crater.

Hill has imaged the Aristarcus region, where a dome is located near Herodotus, termed Herodotus omega, Gruithuisen highland domes, and Palus Putredinis region including the domes termed Putredinis 1, Aristillus 1 and Autolycus1 dome. He has also submitted an image of the volcanic region Taurus-Littrow where the Apollo 17 Lunar Module set down. All of the 22 hours of EVA (Extra Vehicular Activity) of that mission took place north of Bear Mountain between South Massif and North Massif, as they collected 110.5kg of rock samples, an all time record for any lunar sample return mission.

New telescopic images of Mare Crisium taken by Schenck and Vannoni display a connection of the suspected bump, named Cr1, with the southern ridge when the region is imaged under grazing lighting conditions. Moreover two features which look like scarps traversing the surface of Cr1 are detectable and located in direction SW and NS, respectively.

This complex bulge may have formed when magma, or volcanic gases, rose under a lava flow near the surface and inflated it. Thus, based on new acquired data described above, the most likely explanation could be that Cr1 is an inflation of the upper surface layers associated with the formation of the wrinkle ridges that cross the mare margins. This plausible explanation is described in this report:

http://www.alpo-astronomy.org/gallery3/var/albums/Lunar/Lunar-Domes/2020-Images/Observing%20Crisium%201%20%28second%20preliminary%20report%29%20Is%20an%20inflation%20of%20the%20upper%20surface%20layers%20associated%20with%20the%20formation%20of%20wrinkle%20ridges.pdf?m=1605478624

Teodorescu has imaged Kies domes, Capuanus domes, and the Marth concentric crater which is situated on the top of a low dome. He has also imaged five domes in Brayley region, well detectable in his image taken under low

Inside the ALPO
Member, section and activity news

solar illumination angle. An investigation about these domes is ongoing.

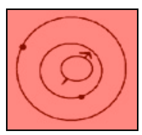
Interested observers can publish their newly acquired images using the e-mail lunar-domes@alpo-astronomy.org . Preference for the filename would be to start with the date as YYYY-MM-DD-HHMM with leading zeros where appropriate. This than could follow with the Observer's ID. This than could be followed with the name(s) of the features shown.

Images received are also shared in our Facebook group Lunar Dome Atlas Project: https://www.facebook.com/groups/814815478531774/.

Interested observers can also participate in the lunar domes program by contacting and e-mailing their observations to both Raffaello Lena, Lunar Dome Studies Program coordinator, at (raffaello.lena@alpo-astronomy.org) and Jim Phillips, assistant coordinator, at (thefamily90@gmail.com).

Mars Section

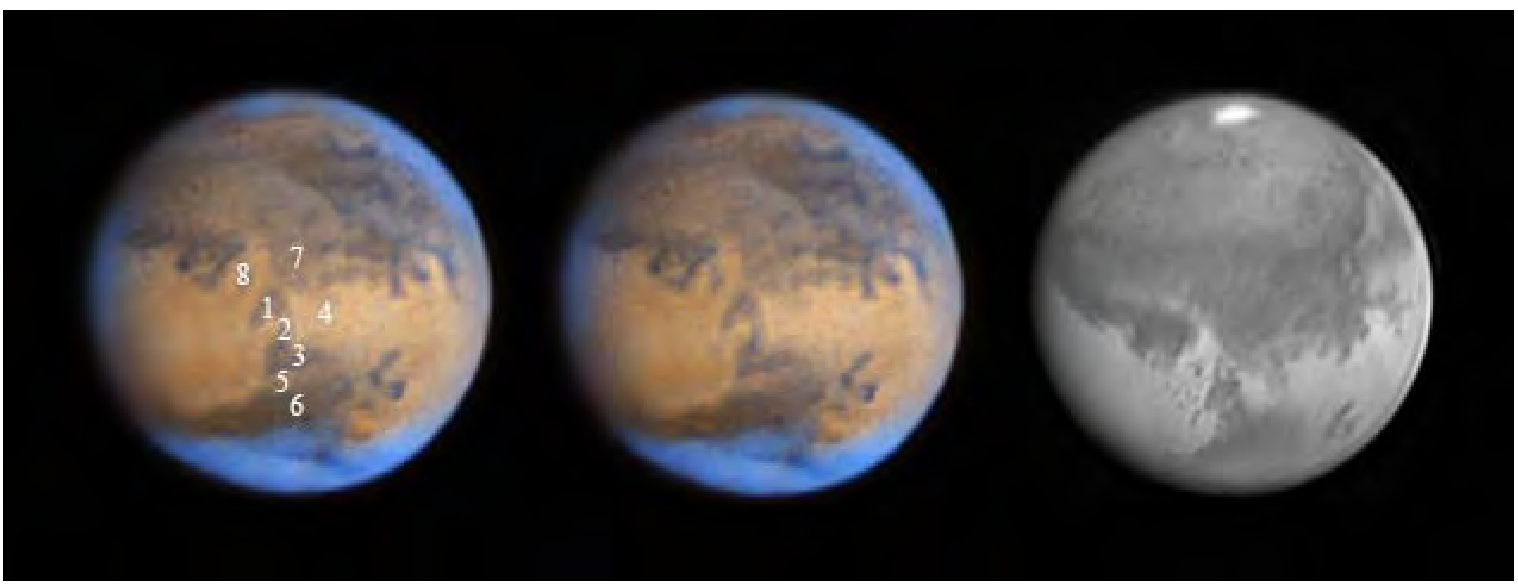
Report by Roger Venable, section coordinator
rjvmd@hughes.net



Mars on April 15, 2021, subtended only 4.95 arc seconds. Kudos to a small group of observers who have continued to observe Mars in the western sky after sundown, despite its small angular size. Paul Maxson, Martin Lewis, Frank Melillo and Michael Hood have contributed images made in April, while Paul Abel has remained active in drawing the red planet. These late observations show the South Polar Hood, the North Polar Cap, and clouds in Hellas, as well as the usual albedo features. It is clear that observers can monitor the planet for large dust storms and clouds even when it appears very small.

We'll have a preview of the 2022 apparition in this Journal in a few months. For essentially all of that apparition, the planet will have a northern declination, so it will be readily accessible to observers in Earth's Northern Hemisphere.

Students of Mars often speak of gradual changes in the shapes and extents of albedo features that occur from one apparition to another, but the specifics of these changes are seldom elucidated. The figure that accompanies this report illustrates some remarkable changes at low latitudes near meridian 20 degrees



See text of the Mars section report for explanation of these images. The left and center images are identical except for the numbers applied to the left image.
At left is an IR(G)B image made by Mikhail Abgarian, Konstantin Morozov, and Yuri Goryachko on 2007 December 5, centered on 23:40 UT, using a Maksutov telescope of 230 mm (9 in.) aperture at f/65, a monochrome CCD video camera, and IR and B filters; with seeing 7/10 and transparency 5/5. Apparent diameter 15.44 arc seconds. CM = 22°.
At right is a red light image by Mark Schmidt made on 2020 September 29 and centered on 05:08 UT, using a Schmidt-Cassegrain telescope of 356 mm (14 in.) aperture at f/16.5, a monochrome CMOS camera, and an R filter; with seeing 4-7/10 and transparency 4.

Inside the ALPO
Member, section and activity news

west longitude. Regarding the figure's three images, the left image is identical to the center one except that numbers have been added to enable the identification of certain features in the center and right images. The details about the exposures are given in the caption; note that the time interval between the center and right exposures is nearly 13 years.

Feature 1 is Oxia Palus, which shows subtle changes in shape and other detail. It is connected by feature 2 (the “canal” Indus) to feature 3 (Niliacus Lacus). Notice that in 2007, this connection was narrow but in 2020, it is broad and dark, seeming to unite features 1 and 3 into a single dark albedo marking.

Feature 4 is the “canal” Hydaspes, essentially absent in 2007 but broad and prominent in 2020. Feature 5 is Achilles Pons, prominent in 2007 but essentially absent in 2020, so that features 3 and 6 (Mare Acidalium) now appear as a single, large, dark marking. Also, notice the changes in fine detail between features 1 and 7 (Margaritifer Sinus). Feature 8 is a residue of the classical “canal” Brangaena, which, together with its immediate surroundings, has changed significantly.

Astute readers may spy other changes as they compare these images, but be advised that many of the apparent differences are due to differences of equipment, exposure and processing.

Many thanks to Mikhail Abgarian, Konstantin Morozov, and Yuri Goryachko of Minsk, Belarus, for the 2007 image, and to Mark Schmidt of Racine, Wisconsin USA, for the 2020 image.

Be sure to send your observations to *mars@alpo-astronomy.org* and to the section coordinator at *rjvmd@hughes.net*.

We invite you to join the 1,000 members of the marsobservers group of groups.io (*https://groups.io/g/marsobservers*). Observers upload their images or drawings to the photos section there, and share their thoughts about their observations.

To check the ALPO Mars image gallery on the ALPO website, first, go to *http://www.alpo-astronomy.org*, then click on the “ALPO Section Galleries” link at the upper right corner of the screen. Next click on the “Mars images and observations” icon, then click on the Mars image folder for the desired year.

Minor Planets Section

Report by Frederick Pilcher, section coordinator
pilcher35@gmail.com

Presented here are highlights published in *The Minor Planet Bulletin*, Volume 48, No. 2, 2021 April - June, which represent the recent achievements of the ALPO Minor Planets Section.

Andrew Salthouse describes how over many years he has visually observed more than 3,000 different asteroids, many of them at more than one opposition.

Brian Warner and Robert Stephens found evidence for satellites of asteroids 3865, 4503, 22056, 25465, 46818, 482505, 2013 PY6, 2020 PD1. For 3865 Lindbloom, a well-defined lightcurve shows that two bodies both corotate with the same period as that of their orbital revolution, 26.016 hours; that both are elongated with their long axes directed toward each other; and that their sizes are similar, <7.2 km and >4.6 km, respectively. For (46818) a primary rotation period of 2.77997 hours and orbital revolution period of 53.2 hours seem moderately well established. The existence of satellites of all the others is based on much weaker evidence and their existence must be regarded as tentative.

E. Diez Alonso and 16 coauthors find that 4092 Tyr is a binary with properties analogous to those of (3865). The rotations of both components are synchronous with the orbital revolution period of 16.094 hours, and the ratio of diameters is >0.45. Diez Alonso et al. also publish a spin-shape model and present a new dense lightcurve for 699 Hela.

Peter Birtwhistle has photometrically observed ten very small asteroids at very close approaches to Earth, 2018 KF1, 2020 GF2, 2020 OH3, 2020 RA6, 2020 RZ6, 2020 TP1, 2020 TD8, 2020 UQ6, 2020 VZ6, and 2020 XX3. All ten asteroids are likely smaller than 200 meters and could be observed on only one night as they passed the Earth at large angular velocity. Some of them were observed photometrically only a few hours after being discovered. All ten asteroids also have rotation periods much shorter than the centrifugal limit at which small pieces detach from the surface and move away. Their rotation periods range between 0.4167 hours for 2020 TP1 to 0.0082110 hours (29.56 seconds) for 2020 TD8. A. B. Sonka, V. Turcu, A. Nedelcu, M. Birlan, and D. Moldovan found that another Earth approacher, 2020 UA, also has superfast rotation.

Brian Warner and Robert Stephens found tumbling behavior for 2020 ST1. Tumbling occurs when the rotation axis

Inside the ALPO
Member, section and activity news

itself precesses around a second axis in space and is detected when the rotational lightcurve does not repeat, even approximately, from one rotational cycle to the next.

Brian Warner and Robert Stephens publish spin-shape models for 1063 Aquilegia, 2254 Requiem, 2346 Lilio, and 2510 Shandong, and also present new high-quality lightcurves for all of these objects.

In addition to asteroids specifically identified above, lightcurves with derived rotation periods are hereby published for 130 other asteroids as listed below:

10, 67, 74, 102, 284, 356, 424, 570, 570, 581, 589, 605, 635, 665, 693, 722, 748, 754, 791, 805, 824, 858, 866, 897, 911, 982, 1024, 1032, 1114, 1156, 1165, 1241, 1271, 1314, 1342, 1526, 1541, 1570, 1583, 1590, 1615, 1663, 1721, 1754, 1840, 2191, 2212, 2262, 2263, 2322, 2368, 2403, 2424, 2456, 2689, 2819, 2912, 920, 3001, 3048, 3063, 3133, 3578, 3600, 3709, 3781, 3793, 3955, 4103, 4493, 4625, 4717, 4729, 4995, 5111, 5445, 5802, 6701, 7753, 8078, 8190, 8256, 8823, 9144, 10115, 10221, 11894, 15010, 16559, 16834, 17312, 18418, 18640, 19120, 19755, 20498, 21082, 21088, 21182, 21242, 21787, 22393, 24038, 26568, 26858, 32772, 41331, 43028, 49125, 50713, 68130, 68359, 69230, 69274, 137311, 144411, 153201, 154302, 159402, 163902, 183230, 275714, 306517, 465749, 474179, 2000 TU28, 2002 GZ8, 2003 YJ, 2013 UX14, 2020 WU5.

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.

Newly found periods that are consistent with periods previously reported are of more value than the uninitiated may realize. Observations of asteroids at multiple oppositions widely spaced around the sky are necessary to find axes of rotation and highly accurate sidereal periods.

I congratulate the authors of all of these papers for excellent writing of the technical details of all of these projects. Their competent explanations will reward careful reading of their Minor Planet Bulletin papers. Interested readers interested are invited to download The Minor Planet Bulletin. The current issue and all back issues are available without charge on line at:

We congratulate the authors of all of these papers for excellent writing of the technical details of all of these projects. Their competent explanations will reward careful reading of their *Minor Planet Bulletin* papers.

The Minor Planet Bulletin is a refereed publication and that it is available online at "*http://www.MinorPlanet.info/MPB*

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

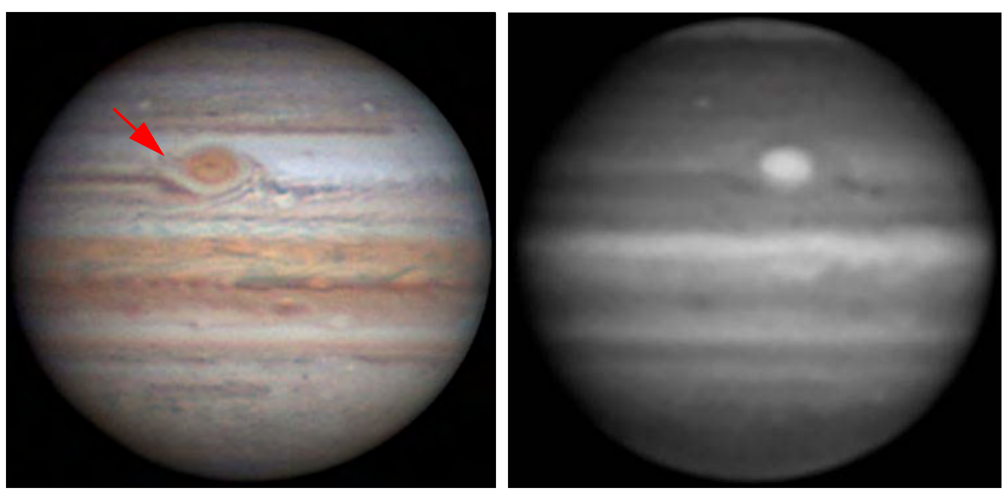
Please visit the ALPO Minor Planets Section online at *http://www.alpo-astronomy.org/minor*

Jupiter Section

Report compiled by Richard Schmude and Craig MacDougal

The Jupiter 2017-2018 apparition report appears later in this Journal.

Jupiter will be in the constellation of Aquarius in July and will be easily visible after midnight. In August, it will reach opposition and will



Images of Jupiter made by Clyde Foster on April 12, 2021, in integrated light (left) and methane-band light (right). The arrow in the left image points to an SEB oval approaching the Great Red Spot.

Inside the ALPO
Member, section and activity news

move into Capricorn. It will reach a brightness of magnitude -2.87. This is more than three times brighter than Sirius, the brightest nighttime star.

The 2020 - 2021 Jupiter apparition report has been submitted for publication in this Journal.

Jupiter has already shown some interesting activity as documented in images by Clyde Foster and included here. Note a SEBs oval moving near the Great Red Spot.

Assistant Coordinator Craig MacDougal reports that the ALPO-Jupiter io e-mail group has 37 members. To subscribe to this group send a blank e-mail (with a blank subject line) to:

ALPO-JUPITER+subscribe@groups.io

A continuing request from the ALPO Jupiter Section staff: The NASA Juno mission is currently enthusiastically accepting images of Jupiter from amateur observers. And because Juno is not primarily an imaging mission, the mission coordinators are especially interested in our (ALPO member) contributions. Please check this article for general background: *https://skyandtelescope.org/astronomy-news/observing-news/juno-pro-am-workshop-05252016/* . After sending your images to us, you're invited to also send your Jupiter images to the JunoCam homepage at: *https://www.missionjuno.swri.edu/junocam* . The JPL hopes the Juno mission will be extended for another three years past July of 2021.

Finally, this is to reminds all that the updated Jupiter manual, “Observing Jupiter in the 21st Century” is now available from the Astronomical League. Because there are several important updates in this revised version, all who observe or image Jupiter are strongly urged to obtain a copy.

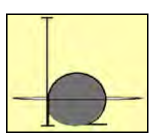
It is available at *https://store.astroleague.org/index.php?main_page=index&cPath=1*

Another reminder, all contributors are advised to send all images ONLY to *Jupiter@alpo-astronomy.org* where they will be scanned for viruses before being forwarded on to me. Those received images will also be posted in the ALPO Jupiter Images and Observations gallery.

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

Saturn Section

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



The 2021-22 apparition is now underway, with its geocentric phenomena presented in the table that accompanies this report.

As of this writing, the ALPO Saturn Section has received more than 30 individual visual observations and multi-wavelength images for the previous 2021-22 observing season. Observers have been starting to capture images this observing season in an attempt to document atmospheric phenomena in Saturn's northern hemisphere that occurred during the immediately preceding 2020-21 apparition. Included were small white spots in the EZn (northern half of the Equatorial Zone) interacting with the adjacent EB (Equatorial Band), plus sporadic small white spots in the EZs (southern half of the Equatorial Zone), as well as a curious persistent white ripple or streak midway within the EB (Equatorial Belt), as well as the previously recorded narrow white streak imaged regularly within the NEBs (North Equatorial Belt, southern component). Observers should be on the lookout for a recurrence in 2021-22 of white and dark spots the NNNTeB (North North North Temperate Belt as well as in the NPR (North Polar Region).

The aforementioned atmospheric phenomena reported in 2020-21 were often captured in images using RGB, red, and 685nm IR filters. It is extremely important for observers to continue to image Saturn with the same multi-wavelength filters to determine if the same or similar features will persist and change morphologically with time during the current 2021-22 apparition.

With the rings tilted by about +18° toward our line of sight from Earth in 2021-22, observers still have reasonably favorable opportunities to view, draw, or image the northern hemisphere of the globe and north face of the rings even though the inclination of the rings toward Earth is diminishing slowly and with Saturn's southerly declination of -18.4° for Northern hemisphere observers. Saturn will be well placed most of the night this summer, with opposition occurring on August 2, 2021.

Pro-Am cooperation actively continues during the 2021-22 apparition of Saturn, and our team of observers are routinely monitoring Saturn for atmospheric phenomena and actively sharing our results and images with the professional community. This maintains our collaborative historical efforts with the Cassini mission that started its amazing odyssey back on April 1, 2004 until the spacecraft plunged into Saturn's atmosphere on September 15, 2017. For many years to come, planetary

Inside the ALPO
Member, section and activity news

scientists will be carefully studying the vast database of images and data gleaned from the Cassini mission, including images provided during the mission by ALPO observers. Therefore, anyone around the globe 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 current observing season.

Detailed RGB image of Saturn taken by Vlamir da Silva of Guarulhos, Brazil on March, 30, 2021, at 08:13 UT using RGB filters with a 20.3 cm (8.0 in.) SCT in excellent seeing conditions. Several belts and zones of the northern hemisphere of Saturn are shown on this image, with a particularly prominent EZn (Equatorial Zone, northern half). The Sh G on R (Shadow of the Globe on the Rings is visible in this image, as well as Cassini's Division (A0 or B10) and Encke's Complex (A5). The apparent diameter of Saturn's globe in this image is 15.8" with a ring tilt of +17.4°. and CMI = 42.2°, CMII = 231.1°, CMIII = 167.4°. The apparent visual magnitude = +0.8. South is at the top of the image.

Table of Geocentric Phenomena for the 2021-22 Apparition of Saturn in Universal Time (UT)

Conjunction	2021 Jan 24^d 00^h UT
Opposition	2021 Aug 02^d 06^h UT
Conjunction	2022 Feb 04^d 00h UT
Opposition Data for August 2, 2021	
Equatorial Diameter Globe	18.5″
Polar Diameter Globe	16.3″
Major Axis of Rings	42.0″
Minor Axis of Rings	13.0″
Visual Magnitude (m_v)	+0.2
B = Declination Constellation	+18.1° +18.4° Sagittarius

Observers are also reminded that visual numerical relative intensity estimates (also known as visual photometry) remain an extremely important part of our visual observing program and are badly needed to ascertain recurring brightness variations in the belts and zones on Saturn as well as the major ring components.

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.

Also consult "ALPO Monograph 14 - Theory and Methods for Visual Observations of Saturn" available online at *http://alpo-astronomy.org/gallery3/index.php/Publications-Section/ALPO-Monographs/ALPO-Monograph-14-Theory-and-Methods-for-Visual-Observations-of-Saturn*

Observers are urged to pursue digital imaging of Saturn at the same time that others are imaging or visually monitoring the planet (i.e., simultaneous observations).

The ALPO Saturn Section thanks all observers for their dedication and perseverance in regularly submitting so many excellent reports and images in recent years. The professional community continues to solicit drawings, digital images, and supporting data from amateur observers around the world in our active ALPO Pro-Am cooperative effort.

Inside the ALPO
Member, section and activity news

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 Remote Planets apparition report for 2019-2020 appears later in this Journal.

The planets Uranus and Neptune will be visible during the early morning hours in July and August. Uranus will be in the constellation Aries and will have a declination of 16° N. This makes it a favorable target for people observing from northern latitudes. The sub-Earth latitude of Uranus will be 54° N, which will give us our best view of the North Polar Region since the mid-1950s.

Neptune will be in Aquarius and its declination will be 4° S. Neptune has not been this far north in several decades. Pluto will reach opposition during the summer. Therefore, these three objects will be well placed for observation.

The 2019 - 2020 remote planets report should be published in 2021. I will start working on the 2020 - 2021 apparition report during mid-2021. I would like to thank Jim Fox for his many brightness measurements of Uranus and Neptune.

To find any of the remote planets for telescopic observations, it is suggested that you first use a star chart which shows the position of the target, then use binoculars to find the target. Note that Sky & Telescope magazine (*http://skyandtelescope.org*) is a great source to find specific locations of sky objects.

Next, locate the target in the finder scope of your telescope. Finally, center your target in the field of view using a low-power eyepiece. You may need a dark site to locate Neptune both in binoculars and in your finder scope.

Both Uranus and Neptune have albedo features which can be imaged with a near-infrared filter. Uranus has a bright North Polar Region while Neptune may have irregular bright spots.

Finally, my usual reminder that the book *Uranus, Neptune and Pluto and How to Observe Them* 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*).

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

Exoplanets Section

Report by Jerry Hubbell
acting section coordinator
jerry.hubbell@alpo-astronomy.org

These are exciting times; some would say that we are currently in the "real" golden age of amateur astronomy. With all the high-tech equipment and instruments available to the average astronomer, doing valuable science is probably easier than it has ever been. Doing astronomy and learning about all the celestial objects is much more rewarding when you can get very "hands-on" doing your own observations, collecting and analyzing your own data.

Before going further, I want to publicly credit my daughter (Rachel Good) for her work in providing the exquisite ALPO Exoplanet Section logo shown here and which will be attached to all future reports from this ALPO section published here.

As I wrote in my previous report, the challenge in doing exoplanet observations, is that it requires us to re-examine our instruments and equipment used to acquire the necessary data, the procedures currently being used, and our analysis processes. All these need to be updated to be successful in doing transit photometry. Since this is the case, I have designed the structure of the exoplanet section to focus on these fundamental differences and needed improvements. And this is exactly what is depicted in the new exoplanet section logo.

My goal with the new ALPO Exoplanet Section is to invite all who are interested in applying any tools that you may already have in studying one of the hottest areas of amateur astronomy: observing exoplanet transits. If you already observe variable stars or asteroids and record their light-curve data, then here is one more exciting field you can use your skills and knowledge. If you are new to aperture photometry and want to learn the techniques involved in taking photometric data on any object and creating a light-curve, then the Exoplanet Section is your ticket to learning how to do that also.

Inside the ALPO
Member, section and activity news

Please contact me via e-mail if you are interested in learning these new tools, or if you are an experienced observer and citizen scientist doing photometric work, I especially want to talk to you about possibly becoming an assistant coordinator. My plans include the creation of the following groups in the Exoplanet Section: Instrumentation, Observing Program, Analysis & Modeling, Data Reporting, and Observation Training. When you contact me, be sure to indicate which groups you are interested in.

Thanks your interest, I look forward to hearing from you soon.

Notable Deaths

Derald Dean Nye (March 2, 1935 - March 26, 2021)

By Richard "Rik" Hill

With the passing of Derald Nye on March 26, 2021, at the age of 86, the ALPO lost a longtime friend and member. Derald Dean Nye was born on March 2, 1935, in Oakley, Kansas, and graduated from Oakley Consolidated High School in 1953. Following graduation, he served two years in the U.S. Army (1955 - 57) and after that attended Kansas State University, graduating in 1961 with a degree in Electrical Engineering. He loved to show off his old slide rule - complete with holster. From there Derald was hired by International Business Machines (IBM). He worked first in Oswego, New York, then Boulder, Colorado and finally in Tucson, Arizona, until he retired in August, 1991.

Derald became interested in astronomy while in high school and ground his first telescope mirror, an eight-inch, in 1964 while working for IBM at Cape Kennedy's huge Vehicle Assembly Building where he had an office in the lower bay area on the first floor (Room 1542). This was to be the first of many telescopes he made culminating in the 16-inch Newtonian/Cassegrain for the observatory at his home in Arizona.

Derald enjoyed telling the story of how in those days, he had to transport a computer from the IBM facility in Oswego to Cape Canaveral in his lap on the airplane. He knew there was an error in the electronics that could have disastrous consequences, but NASA did not want him to change a thing. In typical Derald fashion he did so anyway in transit and no one was the wiser!

Derald attended his first national meeting of the Astronomical League in 1966 in Miami, Florida, and observed his first lunar occultation while living there. This event began a lifelong love of observing occultations and eventually he formed a lifelong association with David Dunham and the International Occultation Timing Association (IOTA). Derald travelled worldwide to observe the most unusual occultations and eclipses.

Derald married Viva Little in 1962, a marriage that ended nine years later. In 1973 married Denise Blum and together they traveled to 30 solar eclipses. In that same year, Derald became the "distributor" of the *Minor Planet Bulletin* – a position he held for 37 years through 2019.

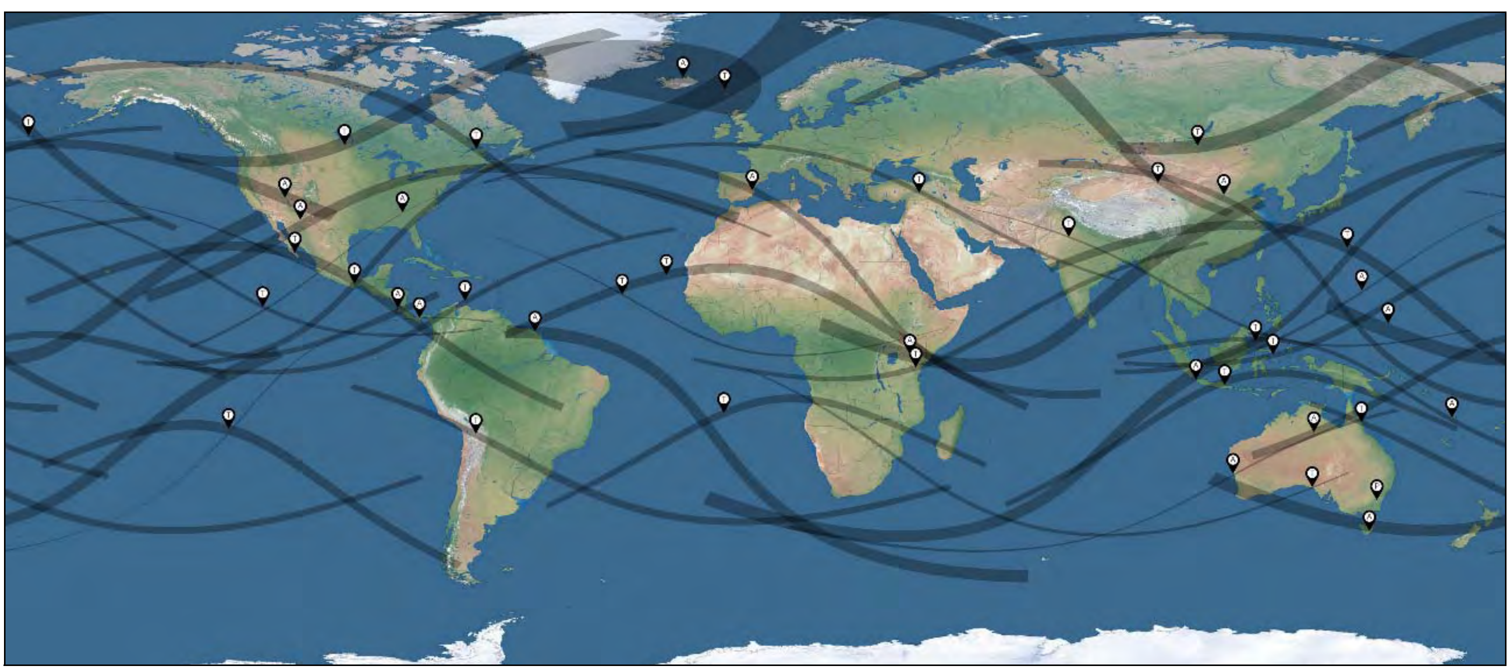
Derald had many notable experiences. On November 22, 1989 using binoculars, he timed an occultation of a 7.1-magnitude star by the minor planet (15) Eunomia on the deck of a ship on the Amazon River, the only asteroidal occultation known to have been observed from a ship. Then, on April 23, 1998, Derald and Denise observed the rare simultaneous lunar occultations of Venus and Jupiter from Ascension Island. On October 19, 2005, he timed the spectacular occultation of Regulus by (166) Rhodope from Portugal along with several other observers.

Derald liked to tell another story of when they were going to observe an eclipse from shipboard near the remote South Atlantic island of St. Helena in June, 2001. They left from Cape Town, South Africa. It was a limited number of people (20) allowed onboard for the eclipse, with many more going to St. Helena to work.

Derald and Denise Nye. (*Photo of Derald courtesy of Dean Ketelsen. Photo of Denise courtesy of Friedheim "Freddy" Dorst.*)

Inside the ALPO
Member, section and activity news

As Derald told it: "All was going smoothly (no pun intended) on the UK-Ascension-St Helena portion of the trip. On the return leg to Ascension, the daily paper published onboard the RMS was under our door as usual when I awoke. I read it with great interest when I saw the location that the ship would be at on eclipse day. It didn't take me too long to determine that the ship would be outside the path of totality! I quickly dressed and headed for the bridge. It is an "open" bridge meaning that you are welcome to go anytime you want. It so happened that the captain was on the bridge when I got there. I inquired if being advertised as an "Eclipse Cruise" meant that we would be in the path of totality (hopefully



Locations Derald Nye eclipse expeditions and their paths.

Inside the ALPO
Member, section and activity news

the center line) during the eclipse. I was told most definitely.

I then asked the Captain if the latitude and longitude that was published in the daily paper was correct. He looked at them and checked his numbers and said that was where he was told by Curnow Shipping to take us.

I told him that if we went there that I would personally sue him and Curnow Shipping and that I would most likely win the case.

This got his attention and I explained that the coordinates were outside the path of totality. The reason was very easy to explain how it happened. It seemed that Curnow Shipping had used numbers directly out of Fred Espenak's 50-year canon to get the ship to the location close to maximum duration. The problem was the "sign" on the longitude value was interpreted to be West when it was actually the East value that was used. This would put the ship north of the path and west of maximum duration.

After more discussion, the captain said that he thought something was wrong when he used "his method of calculating" where to go and had told Curnow Shipping. Curnow had replied that they had checked with "astronomers" and he was to go where they said.

About now another one of the eclipse chasers on board appeared on the bridge with the daily news in hand saying that it was wrong.

The captain said that we should come up with the new location and that is where we would go and he wasn't going to tell Curnow about the change in plan. Besides it was "shorter" for him to stay on the regular Ascension-St Helena route and intercept the eclipse path there.

To make a long story short, I got a bottle of champagne and the captain's thanks, but we were clouded out for the eclipse. Better to be in the path and clouded out than to see a partial!!"

In 1991, Derald retired from IBM, and became the full-time proprietor of his private Kirmser-Wakabayashi Observatory located at his home in Corona de Tucson, Arizona, where he had the street name changed to Observatory Drive some years earlier.

Sadly, Denise died suddenly and unexpectedly March 13, 2006, just two months after their second trip to St. Helena and four days before they were to leave for a solar eclipse in Libya. Together they were honored by longtime friend, Dr. Richard Binzel, with the naming of the Minor Planet 3685 Derdenye in 1996, a main belt asteroid that is big enough and often bright enough to be seen in amateur telescopes.

Derald observed 41 total solar eclipses, as well as more partial eclipses (see map), when he was forced by health to quit after the March 9, 2016 eclipse in Indonesia.

Derald was honored with many prestigious awards, including the 2010 Astronomical League's Peltier Award, 2017 ALPO Walter Haas Observing Award, the 2019 IOTA Laird Award and the 2020 Distinguished Service Award from the Minor Planet Bulletin.

Derald was known and beloved by many hundreds of amateur astronomers and will be greatly missed!

Letters

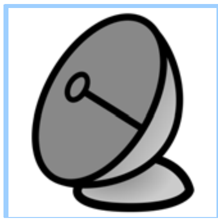
I would like to comment about my Europa eclipse timing on 2016, Dec. 15, in JALPO 63, No. 1, page 80. I had timed this disappearance at 12:24:02 UT on this date. It had been predicted at 12:22 UT by the ALPO, *Sky & Telescope* magazine and the *RASC Observer's Handbook*. I checked a copy of the form that I had sent, and it was correct. Its "dif" was given as +72 sec. in JALPO. I thought that it would have been about 2 minutes (+120 sec.). This appears to be a timing that was set aside.

- I had previously contacted Richard Schmude about it and he suggested that I contact the JALPO editor.

  Robert H. Hayes, Jr.
  Worth, Illinois 60482!

Errata

- In JALPO63-2, in a paper titled "The Mysterious History of Mapping 'Luna Incognita!'" by Richard Wilds, a telescope used by Dr. Chester Burleigh Watts in making observations of solar eclipses along with regular positional observations of stars was misstated on page 71 as a 5-inch, f/9.6 refractor. The correct focal ratio is f/96.
- In the same paper by Mr. Wilds, the correct e-mail address for Gertrude 'Trudy' E. Bell in the *References* section should be t.e.bell@ieee.org



Papers & Presentations

On Establishing an ALPO Radio Astronomy Section

By Stephen Tzikas,
ALPO Member
jlbaina@msn.com

With more and more amateur astronomers either turning to or adding radio astronomy to their repertoire, we present this proposal for your serious consideration. Please address your replies to Julius Benton, jlbaina@msn.com (regular mailing address located on page xx of this Journal).

Abstract

There are many techniques that can be employed for the observation of lunar, planetary and solar targets. One of these is radio observing. The author explores the steps necessary to create an organizational architecture of a radio observing section within the ALPO and the initial goals of such a section.

Introduction

I've been an active member of the Society of Amateur Radio Astronomers (SARA) since 2013. One of the most frequent questions I am asked by optical astronomical observers is whether it is possible to observe a particular target in radio frequencies. The simple answer is 'yes", but that it also depends on what is to be observed, how bright it is at a specific frequency and what instrument is used for the observation.

Even with that simple "yes" answer, many challenges still exist for the observer. If that observer is new to radio astronomy, then it is likely the person will not have the skill level to interpret that signal gleaned from the radio telescope, or even realize that a skill set is required to understand what that signal represents.

Even more challenging is that educational materials are fairly sparse or non-existent for the new observer, in part because radio astronomy — at least for the amateur — is a relatively new field. Moreover, the interested observer may find that he or she will need to spend a few years learning the subject in order to become competent. I don't intend to discourage anyone.

Actually, one needs to start someplace. Some types of radio observing programs can be mastered fairly quickly. The first step that ALPO members can take is to begin that process of solar, lunar and planetary observing. I have compiled a list of nine initial goals to work towards until the ALPO has a membership fluent enough in radio astronomy to expand those goals into more advanced realms of radio astronomy.

This is no easy task. However, if successful, a time may come when the progress made can be codified into an ALPO Radio Astronomy Section. The fruition of that may take considerable time. To that end, I will be writing a series of radio astronomy articles to generate ALPO interest.

Goals

Let's start with some simple goals of a proposed ALPO Radio Astronomy Section. These goals focus on member education, simple observations with available instrumentation and the development of the citizen-science field of radio astronomy. Specifically, these goals are:

1. Develop an infrastructure of radio astronomy observing in the ALPO to educate amateurs on the subject.

2. Create a foundation of ALPO radio astronomy observers.

3. Explore Pro-Am opportunities.

4. Cooperate with partner organizations (SARA, BAA, AMS, PARI, ARRL and the Astronomical League).

5. Contribute to existing databases (SuperSid, Radio Jove, Radio Meteors, e-CALLISTO Radio Solar Spectrometer Network, citizen-science (for example, SETI) and others).

6. Partner with others on the creation of amateur radio astronomy databases.

7. Visualize new opportunities for amateur radio astronomers via new citizen-science, new methodologies and instrumentation, and cooperation with other organizations.

8. Add to the comparatively sparse literature for amateur radio astronomy.

9. Understand the application of radio astronomy in the wider context of its electrical engineering basis.

As these goals are realized, ALPO members can acquire the basic principles of radio astronomy that can be applied towards Solar System and exoplanet observing.

What Can Be Observed in Radio Astronomy

There are numerous targets that can be observed and studied by ALPO members. This list includes:

- the Sun
- Earth geophysics
- artificial satellites
- the Moon
- radio meteors
- Jupiter
- Uranus
- occultations by Solar System objects
- analytical considerations

Table of Various Radio Telescopes and their Uses

Telescope	Frequency	Purpose	Output	Comments
INSPIRE	0-110 KHz	Natural Radio	Software	Geophysics events
SuperSID	25.2 KHz	Ionosphere		24-hour solar
Radio Jove	20.1 MHz	Jupiter Storms		Predetermined events
Radio Meteors	55 - 78 MHz	Meteors	Live Internet	Live data for research
Scope-in-a-box	1.42 GHz	Milky Way H-Lines	Software	Also FM radio
40-foot dish		Galactic/Extra-galactic H-Line	Strip Chart	For amateur use at Greenbank, WV
20m (Skynet)	1.4-10 GHz	Remote Ops	Internet	Analytics and broad targets
IBT	12.2-12.7 GHz	Sun/Satellites	Analog	Demonstrations
RASDR	3KHz-30GHz	“Universal”	Software	Pilot

- Masers (OH/IR stars that could have an exoplanet)
- SETI (which assumes an exoplanet)

The matrix presented here outlines some of the more popular possibilities among radio astronomy observers. Many of these are “kits” that are in the same price range as affordable optical telescopes.

The Sun is fairly well represented by a blackbody model. While the peak frequency of the Sun is in the yellow visible light range, it also emits at many other frequencies, including radio frequencies. The Sun is a strong radio source due to its relatively close distance. Hence, many radio telescopes made for hydrogen line detection or satellite reception can also detect solar emissions at those specific frequencies.

Some Initial Knowledge

Besides having some targets and appropriate instrumentation as outlined in the matrix, education is also required. Some radio telescopes are fairly specific to one type of target and the required knowledge level can be acquired fairly quickly.

It is when more powerful radio telescopes are employed with broad band capabilities that special skills sets are required to understand what the signals are and how to manipulate the raw data for analytical purposes.

Radio astronomy signals are very weak, and modern technology adds interference. This interference can be from laptops, WiFi, mobile phones, satellites, GPS devices, lawn mowers, electric fences and many other sources. Our environments are full of radio noise. It is always best to start with a simple telescope, learn some principles and then build upon them with other acquired radio telescopes and instrumentation. Strong intermittent signals, even if not near the frequency of interest, can overwhelm sensitive front ends and cause gain compression which mimics noise coming and going.

Airplane traffic can generate radar reflections and other signals near the hydrogen line. GPS, Iridium and XM/Sirius satellites generate more watts per square foot onto the Earth than most other satellites, hence their hand-held receivers work well with small antennas. Such noise needs to be recognized and filtered if possible.

Onward

In future articles, I will discuss some of the resources available to new radio astronomy observers as well as a more detailed look at specific observing targets.

Accessing the Skynet 20m Radio Observation Archive

While there are many different types of radio astronomy data displays created by amateurs and professional organizations, one excellent type of radio astronomy observation data is that provided by *Skynet*, a remote and robotic 20m radio dish located at the Green Bank Observatory in West Virginia.

1. To view a large assortment of radio observations go to: *https://www.gb.nrao.edu/20m/*
2. Click link for “Log of 20m results”.
3. See the chronological log of observations and open them one at a time.
4. For Sun, Moon or planetary observations, look for those descriptors in the observation names.
5. Explore the hyperlinks in each observation for continuum and spectra data, data file descriptions, ascii files, and the various processed data views shown for the observation.

The quality of the observations will vary, depending on whether the observer is a beginner or a professional.

To fully understand the observation, some knowledge of radio astronomy is required to distinguish good from poor observations and interpret what is displayed.

Explore the entire 20m website, including the documentation information that is stored for reference and educational purposes.

Papers & Presentations

2021: A Good Year for Viewing the Perseid Meteor Shower

Robert Lunsford, coordinator, ALPO Meteors Section
lunro.imo.usa@cox.net

The Perseids are the most popular meteor shower as it peaks during mid-August when the summer nights are warm and comfortable for stargazing. These meteors have been observed for nearly 2,000 years and were often referred to as the "Tears of St. Lawrence", whose feast day coincided with the maximum of this display. These meteors are produced by debris shed by Comet 109P Swift-Tuttle, which last passed through the inner solar system in 1992. This debris is often influenced by Jupiter, whose gravity alters a section of the debris so that it passes closer to the Earth in certain years. This last occurred in 2016 and is predicted to repeat again in 2028. When this occurs, maximum hourly meteor rates can increase several times over normal activity.

These meteors first become visible in mid-July, when the apparent source of these meteors (the "radiant") is located in the northern constellation of Cassiopeia. Rates at this time are only a couple per hour at most as the Earth is just beginning to graze the outer fringes of the debris field. But hourly rates increase slowly through the remainder of July and the first week of August. As the second week of August arrives, rates increase more steeply and reach a maximum on the night of August 11/12. By this time, the Perseid radiant has moved into Perseus, near the famous "Double Cluster" (which is comprised of both NGC 869 and NGC 884). At maximum, the average Perseid display will produce 60 meteors per hour as seen from dark sky locations with no Moon present. Luckily, this year the Moon will be a waxing crescent which will set during the evening hours before the Perseid radiant rises high in the sky. As maximum activity passes, rates will begin to fall at a rate of 50 percent per night until just a trickle of activity remains in late August.

Figure 1. This composite photograph was created by Heather M. Wendelboe on the night of August 15/16, 2020, from Jelm, Wyoming, USA, using a Nikon D750 camera equipped with a Irix Blackstone 15mm f/2.4 lens at f/2.8. Exposure was 15 seconds, ISO 6400.

To best see these meteors in 2021, wait until the Moon has set, which should be around 10 p.m. from most locations. You can then start watching, but the Perseid radiant will still be located low in the northeastern sky. At this time of night, most of the meteors will be obscured by the horizon, so little activity will be seen. It is better to wait as late as possible so that the radiant lies farther above the horizon. The radiant is best placed highest above the horizon during the last dark hour prior to dawn. Most observers watch far earlier than this and have never seen the Perseids at maximum strength.

When watching closer to midnight with the radiant lower in the sky, it would be best to view toward the northeast and watch the meteors shoot upward from low in the sky. As the night progresses, you can look further away from the radiant as by then, the Perseid meteors will be visible in all areas of the sky. No matter which direction you face, you can easily distinguish Perseid meteors as they will all come from the constellation of Perseus. If you maintain a constant field of view, you will notice that Perseid meteors are all parallel to each other and will possess the same velocity. They will present differing lengths depending on their brightness. Not all meteors you see will be Perseids because as each hour passes, you will also see a dozen random meteors not belonging to any known source. There are also other minor meteor showers active at this time that produce only one or two meteors each hour. These other meteors will be easily noticeable as they will have different paths and velocities than the Perseids.

The Perseids are also known for colorful meteors and fireballs, which are meteors larger than the normal pebble-size meteoroid that produce bright meteors with "smoke trails" that last several seconds. Most of the bright Perseids that this coordinator sees are orange, but other observers see yellow and blue Perseids, too.

If you have a camera capable of taking time exposures, then you can try to capture a photograph of a Perseid meteor. An exposure longer than a few minutes will show the stars as trails, moving in the same direction. A meteor will appear as a streak of varying brightness crossing the star trails. Astrophotographers often use motorized camera mounts that follow the sky. This eliminates the star trails and creates a more appealing photograph with just meteors streaking through the frame.

Those who wish to contribute to our knowledge of meteor showers such as the Perseids are invited to record data on each meteor they see. We ask that serious observers record data for at least an hour in order to provide a suitable amount of data. What is needed is your location, time of observations and sky conditions. Each meteor should be classified as Perseid or sporadic. Data forms are available from the ALPO Meteors Section coordinator along with explanations on how to use the form.

Meteor observing is an enjoyable project that requires nothing more than a good pair of eyes. It's a great way to get acquainted with the night sky as you wait for each meteor to appear. Even youngsters can enjoy nature's fireworks as these silent "shooting stars" streak through the night sky, much to their delight.

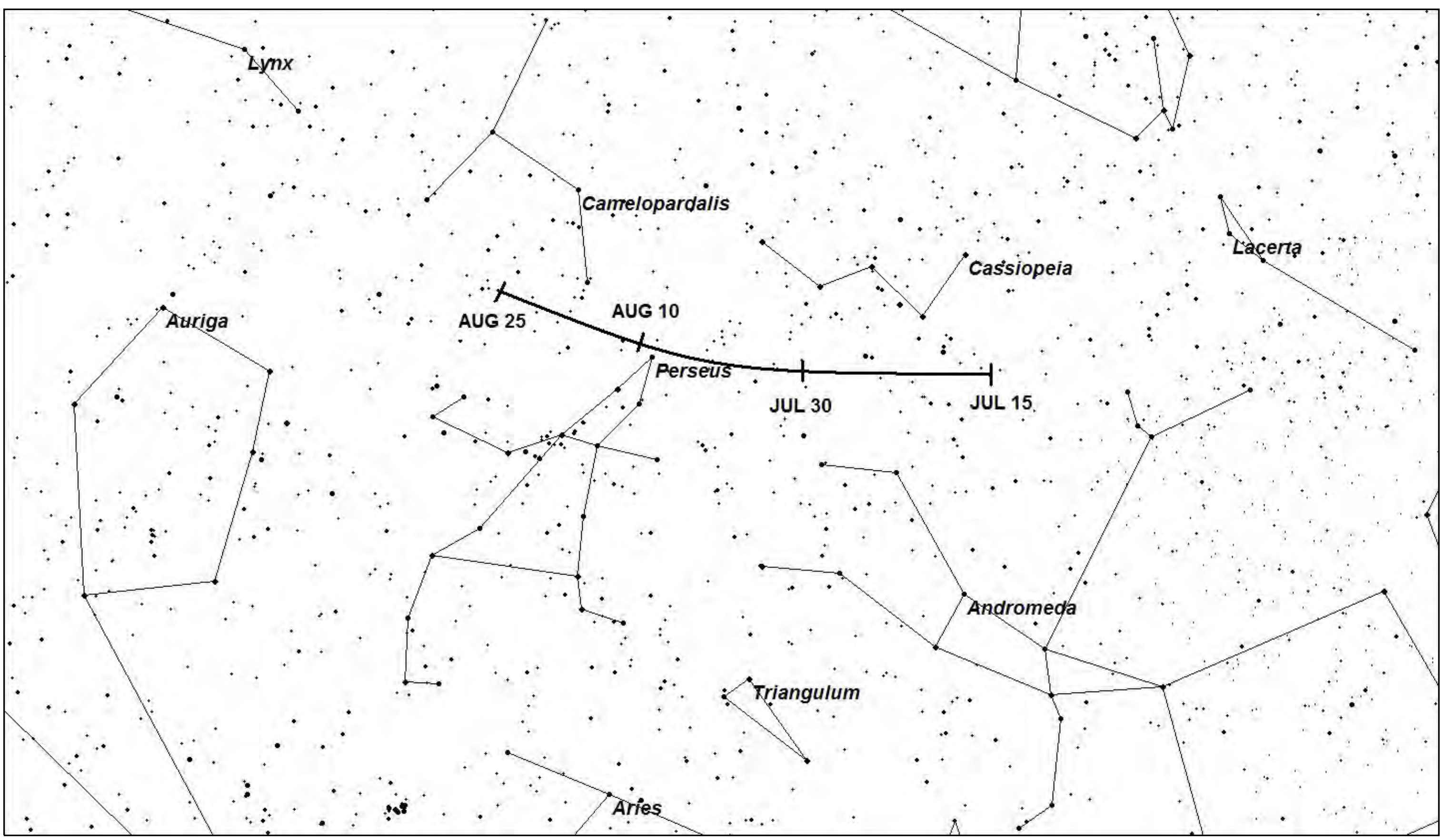


Figure 2. The Perseid radiant actually travels from Cassiopeia through Perseus and ends in Camelopardalis during the month and a half that these meteors are active. The chart that accompanies this article is provided courtesy of Carina Software.

VISUAL METEOR OBSERVING FORM

DATE: ____ (year) ____ (month)____ (day) Begin ____ h____ m End _____ h_____ m (____)

LOCATION: Long.=_______________ W. Lat.=________________N. Elevation =__________m

OBSERVER:____________________________PLACE:______________________________________

LIMITING MAGNITUDE: _____@____:____ _____@____:____ _____@____:____ ______@_____:____

_______@____:____ _______@____:____ _______@____:____ _______@___:___ ______@____:___

PERCENT CLOUDY: ____% @ ____:____ ____% @ ____:___ ____% @ ____:___ ____% @ ____:____

DIRECTION FACING & ALTITUDE : _______@____:____ _______@____:___ _______@____:____

BREAKS:____

COMMENTS:____

TIME (UT)	MAG	TYPE	DURATION	LENGTH	VELOCITY	DCV	R. DIST.	ALTITUDE	PLOT	REMARKS

Papers & Presentations:

A Report on Carrington Rotations 2236 and 2237 (2020 10 05.0125 UT to 2020 11 28.6139 UT)

By Richard (Rik) Hill,
Coordinator & Scientific Advisor,
ALPO Solar Section
rhill@lpl.arizona.edu

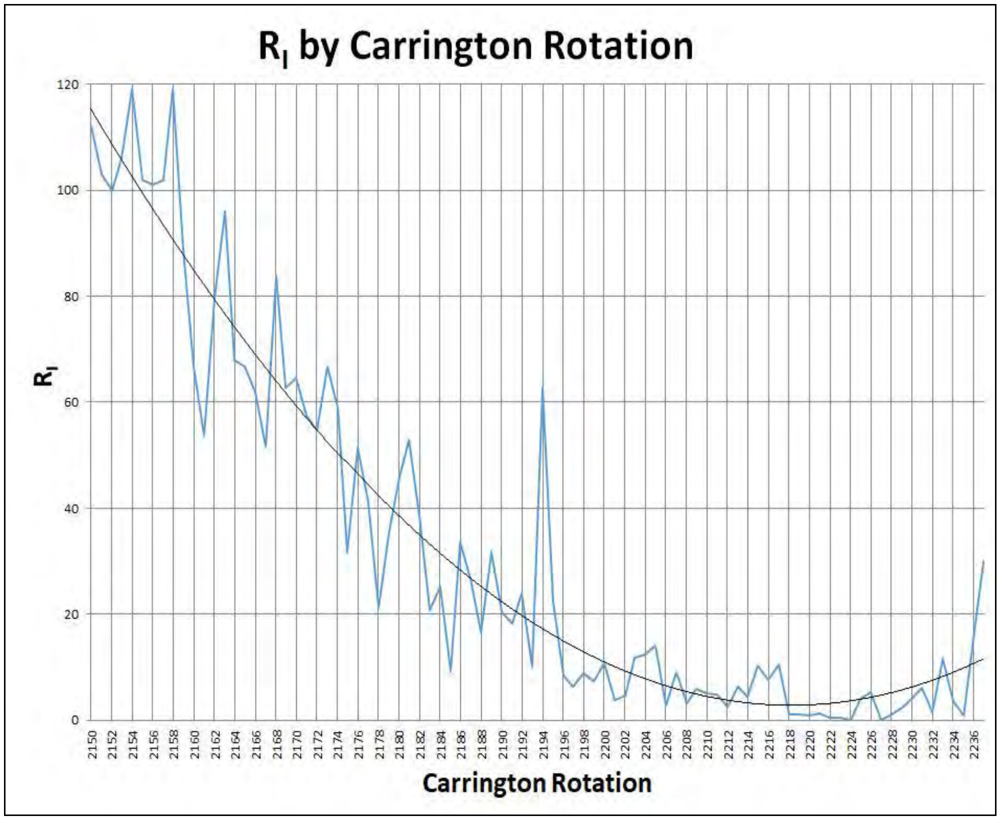
Overview

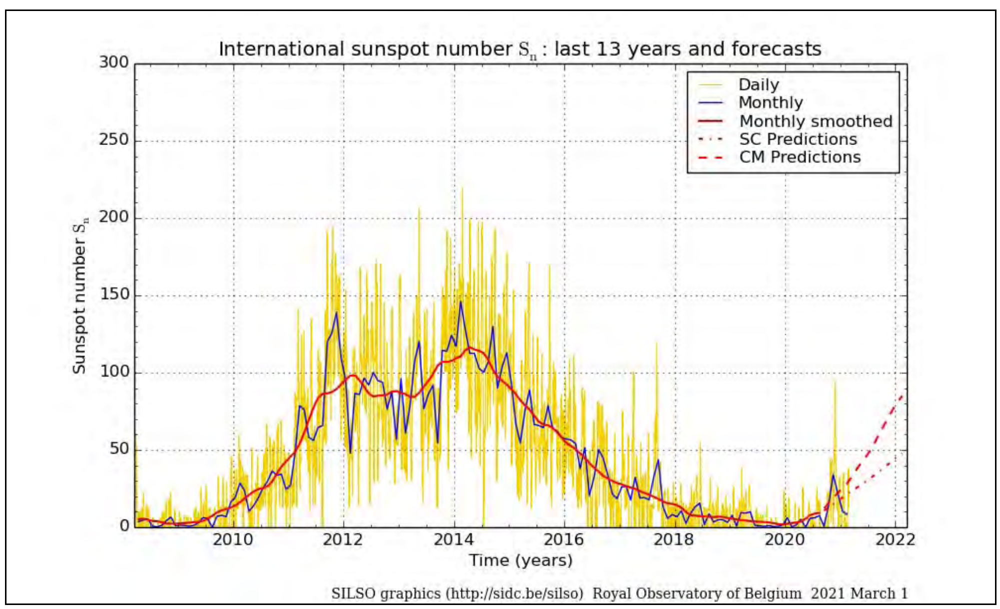
> *To our hard-copy readers: This paper can be viewed in full-color in the online (pdf) version of this Journal.*

Solar activity is starting to increase a little (**Plot 1a**). However, there are several dominant predictions for the *rate* of increase. One forecasts a rapid increase while the other predicts a much slower rise to maximum (**Plot 1b**). Maximum daily R_I was 84 in CR 2237 on 11/28, the last day of the rotation. The largest region was AR 2781, that became an Eki group of 475mils (mag-class beta-gamma) on 11/7. Active Region 2786 was even larger. It was detected at the end of CR 2237 and will be covered in the next report. There were 5 days of zero spots with most occurring in CR 2236.

Readers are encouraged to review the section on Terms and Abbreviations used in this report, as there have been some changes. For example, instead of repeating "millionths of the Sun's visible disk", the standard accepted unit of measurement, it will now be simply abbreviated "mils".

Observers contributing to this report, their modes of observing and equipment are summarized in the accompanying table. It will be used as a reference throughout this report rather than repeating this information on every image or mention.





Terms and Abbreviations

Readers are encouraged to return here as needed for definitions of any unfamiliar terms and abbreviations.

AR = Active Regions, that is, areas which include all activity in all wavelengths for that area of the Sun as designated by NOAA; only the last four digits of the full identification number is used here.

CaK = Calcium K-line observations.

CM = Central Meridian of the visible disk.

CR = Carrington Rotations.

faculae = bright regions of the Sun's photosphere seen most easily near the Sun's edge.

groups = visible light or "white light" sunspots associated with an Active Region.

H-a = hydrogen-alpha observations.

"leader" and "follower" = "east" and "west" on the Sun; using 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 all images is with north up and celestial west to the right.

mils = abbreviation for "millionths of the Sun's visible disk".

Na-D = Sodium-D observations.

Naked-eye sunspots = those spots visible on the Sun without amplification but through proper and safe solar filtration; never look at the Sun, however briefly, without such filtration even at sunrise/sunset.

NOAA = National Oceanic and Atmospheric Administration.

N, S, E and W = north, south, east, west.

plage = a luminous area in the Sun's chromosphere that appears in the vicinity of an active region.

w-l = abbreviation for "white light observations".

****

Statistics compiled by this author have their origin in the finalized daily International Sunspot Number data published by the World Data Center - Solar Index and Long Term Solar Observations (WDC-SILSO) at the Royal Observatory of Belgium. All times used here are Coordinated Universal Time and dates are reckoned from that and will be expressed numerically with month/day (for example, "9/6" and "10/23"). Carrington Rotation commencement dates are obtained from the table listed on the ALPO Solar Section web page at:

http://www.alpo-astronomy.org/solarblog/?page_id=3423

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 formerly of NOAA (McIntosh 1981, 1989) and detailed in an article in the Journal of the ALPO, Volume 33 (Hill 1989). This description is also included in an online article on white-light flare observation located at:

http://www.alpo-astronomy.org/solarblog/?page_id=200

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 unless specifically 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. The archives can be accessed by going to www.alpo-astronomy.org, then clicking on the ALPO Section Galleries link near the top-right corner of the page, then clicking on "Solar Observations Archive". You can also access the archives directly through this link: http://alpo-astronomy.org/gallery3/index.php/Solar-Observations-Archive .

Table of Contributors to This Report

Observer	Location	Telescope (aperture, type)	Camera	Mode	Format
Paul Andrew	Dover, Kent, UK	152mm RFR	ZWO ASI 290	H-a	Digital
Tony Broxton	Launceston, Cornwall, UK	127mm SCT	N/A	w-l	Drawings
Vlamir da Silva	Sao Palo, Brazil	40mm H-a PST	DMK21AU04.AS	H-a	Digital
Howard Eskildsen	Ocala, FL, USA	80mm RFR	DMK41AF02	w-l wedge	Digital Images
Guilherme Grassmann	Curitiba, Brazil	60mm RFR	Lumenera Skynyx 2.0	H-a	
Richard Hill	Tuscon, AZ USA	90mm MCT	Skyris 445M	w-l	
Monty Leventhal	Sydney, New South Wales, Australia	250mm SCT	N/A	w-l / H-a	Drawings
			Canon Rebel T3i EOS	H-a	I
Tom Mangelsdorf	Wasilla, AK, USA	120mm RFR	N/A	w-l	Drawings
Frank Mellilo	Holtsville, NY, USA	200mm SCT	DMK21AU03AS	H-a	Digital Images
Theo Ramakers	Oxford, GA, USA	80mm RFR	ZWO ASI174MM		
		279mm SCT	DMK41AU02AS	w-l	
		40mm H-a PST	DMK21AU03AS	H-a	
		40mm CaK PST		CaK	
Randy Tatum	Bon Air, VA, USA	180mm RFR	DFK31AU	w-l / pentaprism	
David Teske	Louisville, MS, USA	60mm RFR	N/A	w-l / H-a	Drawings
		100mm RFR	ZWO-ASI120mm	H-a	Digital Images
David Tyler	Buckinghamshire, UK	178mm RFR	ZWO ASI 120	w-l	
		90mm RFR	ZWO ASI 120	H-a	
Geert Vandenbulcke	Koksijde, Belgium	80mm RFR	ZWO ASI 290		
Christian Viladrich	Nattages, France	300mm RFN	Basler 1920-155	w-l	

Telescope types: Refractor (RFR), Newtonian Reflector (RFN), Schmidt Cassegran (SCT), Personal Solar Telescope (PST), Maksutov-Cassegrain (MCT)
Mode Types: White Light (w-l), Hydrogen Alpha Filter (H-a), Calcium Potassium Filter (CaK)

Carrington Rotation 2236

Dates: 2020 10 05.0125 to 2020 11 01.3056
Avg. R_I = 16.5
High R_I = 44 (10/27)
Low R_I = 0 (12 days)
(see plot on next page)

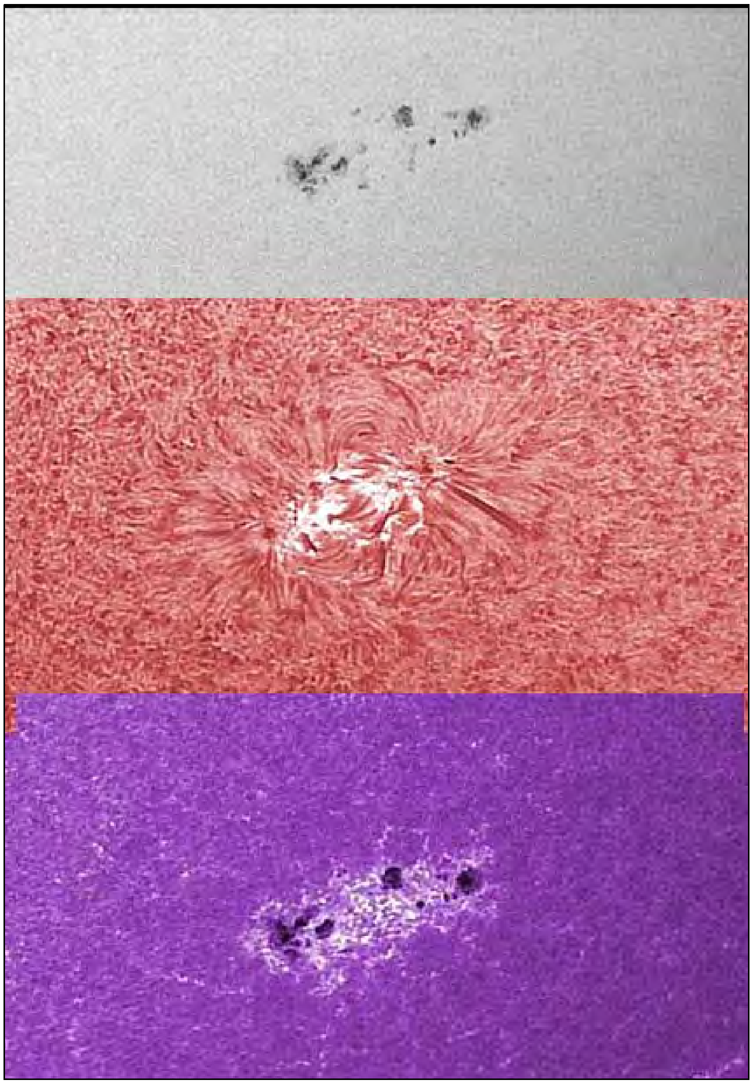
Activity slowly increased throughout this rotation from zero to an R_I of just over 40 at the end. There were four days of zero spots, all at the beginning of the rotation and six active regions during this rotation (ARs 2774-2779).

The largest region of this rotation was AR 2778 which rapidly formed on the CM (S20 lat.) on 10/26 and was fully formed by the next day as seen in a w-l/H-a/CaK montage of Eskildsen images taken at 14:32, 14:26 and 14:26 UT respectively, when the region was determined to be a Dai group of 140 mils (**Figure 1**). Another montage of Eskildsen w-l images shows the region from 10/26 through 10/30 as it developed to Eko on 10/29 and Eao on 10/30 (mag-class Beta on both days) (**Figure 2**). This montage also shows the rapid development of AR 2779 to the north. A two-pane image by Hill on 10/30 in w-l and broadband CaK shows the filigree of faculae that was evident as this region (and AR 2779) approached the limb (**Figure 3**). Melillo captured H-a and w-l images of AR 2778 on the limb (**Figure 4**). The region was now Hax of 100 mils.

Carrington Rotation 2237

Dates: 2020 11 01.3056 to 2020 11 28.6139
Avg. R_I = 30
High R_I = 84 (11/28)
Low R_I = 0 (11/16)
(see plot on next page)

This rotation was the peak of this two-rotation reporting period and the peak activity was the end of this rotation and the beginning of the next rotation with AR 2786 which will be detailed in the next report. There was only one day of zero spots which we have not seen since AR 2195. For this rotation, the largest region was AR 2781, which was officially designated on 11/3 (S23 lat.). Teske observed the region on 11/2, the day before it was officially designated in a composite w-l/H-a drawing at 20:04



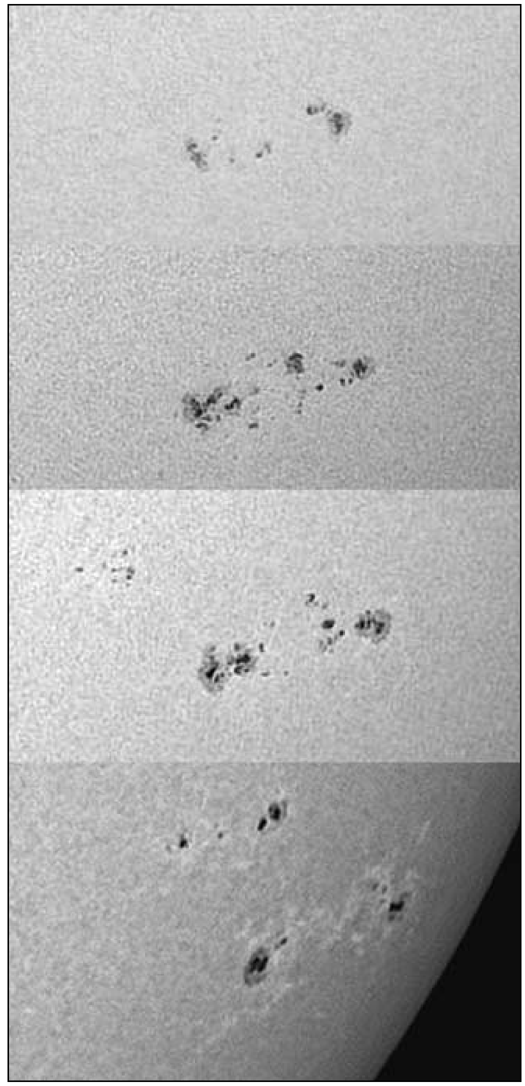
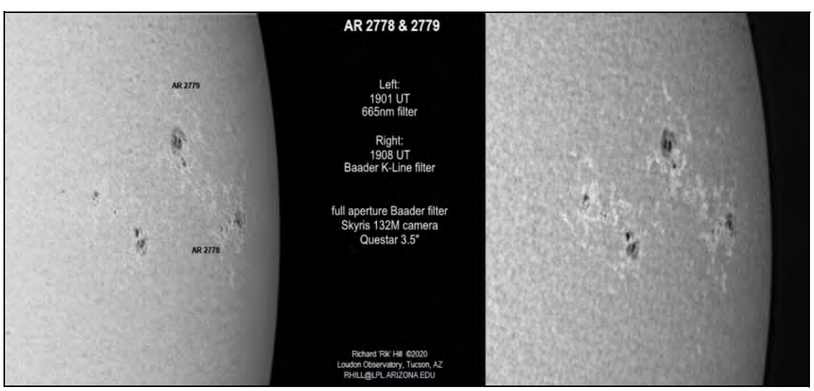


Figure 1 (above left). A three-pane view of AR 2778 by Eskildsen on 10/27. Upper pane is w-l at 14:32 UT, middle is H-a at 14:26 UT and lower is CaK at 14:28 UT.

Figure 2 (above right). A w-l synoptic montage showing the evolution of AR 2778 by Eskildsen on four days. Top: 10/26 at 17:21 UT, second down: 10/27 at 14:32 UT, third down: 10/28 at 14:48 UT, and bottom is 10/30 at 14:21 UT.



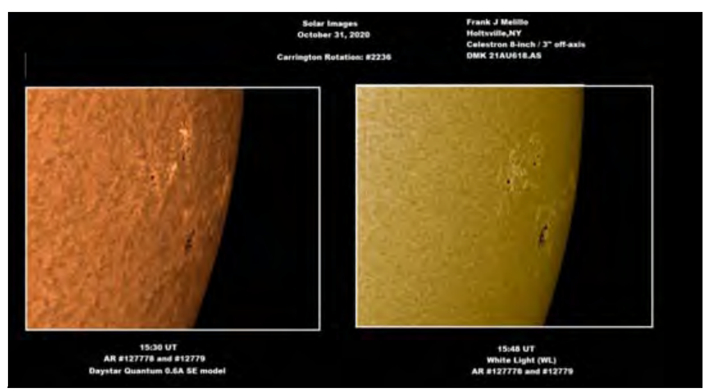


Figure 3 (above left). A two-frame composite of AR 2778 and 2779 by Hill on 10/30 in w-l (left) at 19:01 UT and broadband Baader CaK (right) at 19:08 UT.

Figure 4 (above right). A two-frame set of AR 2778 & 2779 by Melillo on 10/31 in H-a (left) at 15:30 UT and w-l (right) at 15:48 UT.

UT. Hill imaged it in w-l and CaK broadband the next day at 18:49 and 18:51 UT respectively (**Figure 5**). Faculae could be seen well north and south of a region that already showed clear leader and follower spots with a class of Cso (mag-class Beta) and an area of 150 mils.

On 11/4, Ramakers gave us the first three-color look at the region (**Figure 6**). Here in the upper w-l pane at 14:45 UT, we see a round, radially symmetrical leader spot followed by complex collection of spots, some with and some without penumbra and bits of free penumbrae all in a mass of faculae. This was even more pronounced in the lower CaK pane at 15:00 UT, while in the H-a middle pane at 14:52 UT it was all buried in a bright plage. It was now Ehi with an area over three times greater of 410 mils. This increase in class and area was more likely due to the region moving away from the limb.

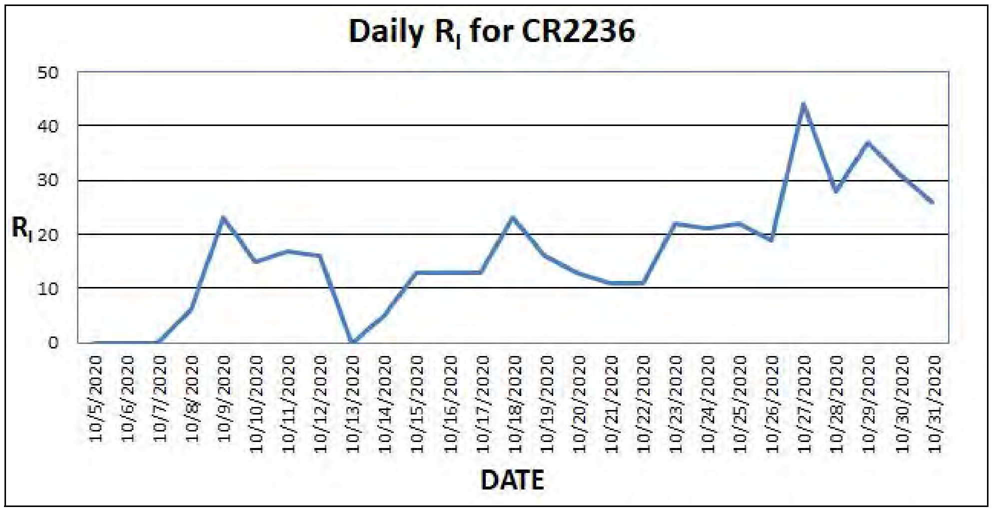
It grew a little more by 11/5, when the area was 450 mils but the class dropped to Dki (mag-class still Beta). Melillo shows it well in a two-pane w-l and H-a image at 17:04 and 17:10 UT respectively, taken on that day (**Figure 7**). The follower spot collection was aligned N-S with some of the small spots with rudimentary penumbra clustering between the leader and follower. A link of bright plage running up the leading side of the follower spots was where all the flaring activity was taking place this day.

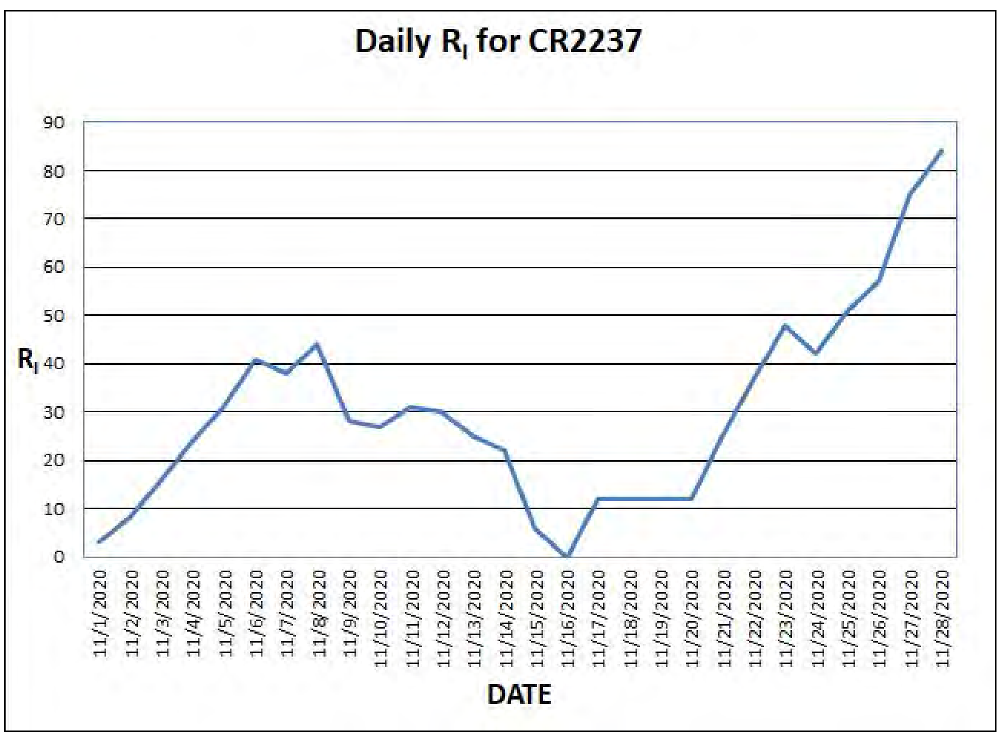
Eskildsen imaged AR 2781 in three colors on 11/6 when the region was classed as Eki (mag-class Beta-Gamma) and area 475mils (**Figure 8**). We can see that the collection of spots and fragmentary and rudimentary penumbrae that had broken off the leading side of the follower spot were now consolidating in the middle of the sunspot group. This leading edge of the follower spot can be seen, particularly in H-a, to be the area of greatest activity in this region. On this day, there were two energetic events from this region, all around 07:00-08:00 UT, but no reports were received of them.

The region showed a dramatic decrease in area on 11/7 but was still Esi (mag-class reduced to Beta). Tatum caught the region in w-l and H-a at 15:11 UT and 15:30 UT respectively (**Figure 9**). In the upper w-l image, he shows the follower spot to be a little smaller with the central collection breaking down fairly rapidly. The leader spot is still a round spot with radially symmetrical well-organized penumbra. In H-a we see the plage greatly reduced in intensity but still hugging the leading side of the follower spot.

The region showed definite signs of breaking down on 11/8 in a w-l image by Andrew at 09:45 UT. The class was still Ehi but the area was now 250 mils (**Figure 10**). The leader was about the same but the follower was reduced in area with penumbra starting to break down and the spots in the middle were less in number. This dissolution and consolidation was even more apparent on 11/9 as seen in a Ramakers w-l image at 16:32 UT where the middle spots are now seen to be moving to merge with the S end of the follower spot collection (**Figure 11**). The class was now Esi and area 230 mils.

Our next observation was on 11/11, when there was remarkable change. The middle





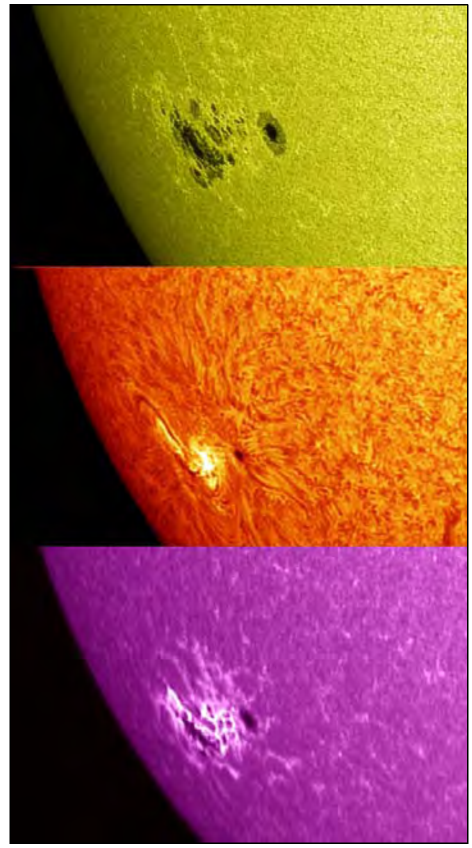
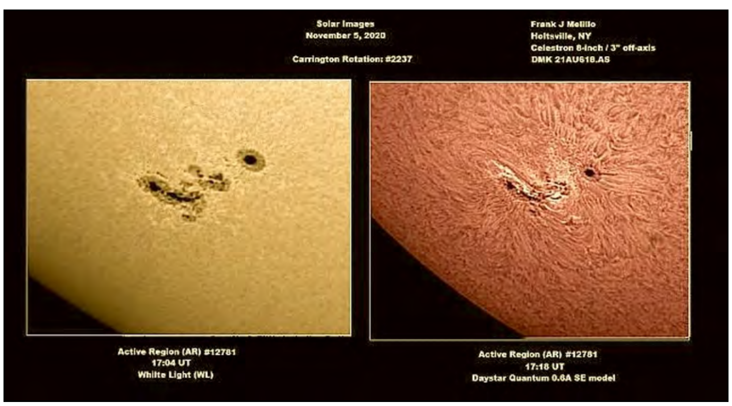
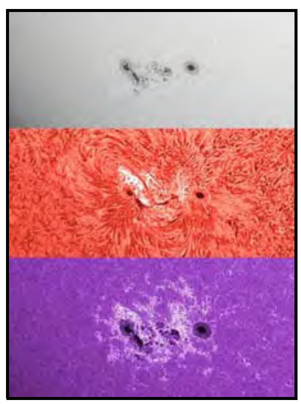


Figure 5 (above left). A composite of observations of AR 2781. Top is a combined w-l/H-a pre-designation drawing by Teske on 11/2 at 20:04 UT. Below is a two-frame view of AR 2781 by Hill on 11/3; w-l (left) at 18:49 UT and Baader broadband CaK (right) at 18:51 UT.

Figure 6 (above right). A three-pane view of AR 2781 by Ramakers on 11/4. Upper pane is w-l 14:45 UT, middle is H-a at 14:52 UT and lower is CaK at 15:00 UT.





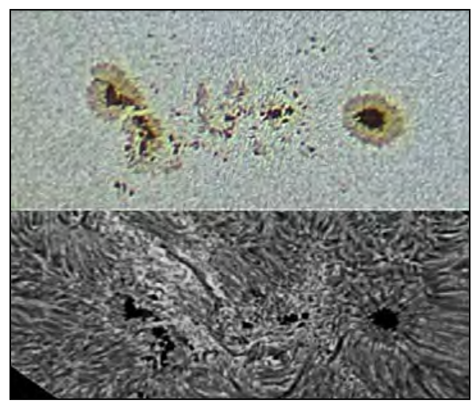
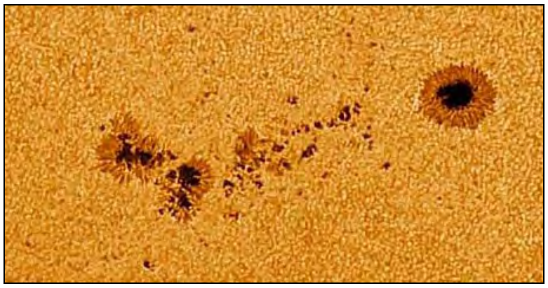
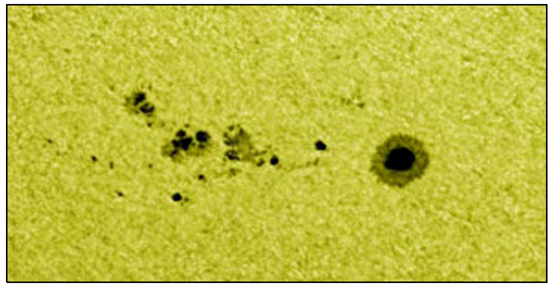


Figure 7 (above left). A two-frame set of AR 2781 by Melillo on 11/5 in w-l (left) at 17:04 UT and H-a (right) at 17:10 UT.

Figure 8 (above center). A three-pane view of AR 2781 by Eskildsen on 11/6. Upper pane is w-l 15:43 UT, middle is H-a at 15:31 UT and lower is CaK at 15:38 UT.

Figure 9 (above right). AR 2781 as seen by Tatum in two colors; above w-l at 15:11 UT and below H-a at 15:30 UT.





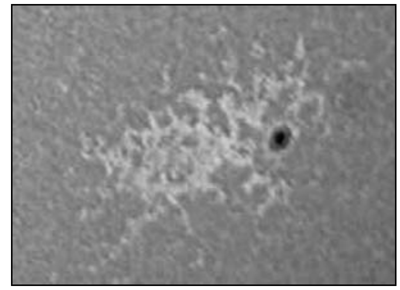


Figure 10 (above left). A w-l image of AR 2781 by Andrew on 11/8 at 09:45 UT.

Figure 11 (above center). A w-l image of AR 2781 by Ramakers on 11/9 at 16:32 UT.

Figure 12 (above right). A CaK image of AR 2781 on 11/11 at 11:33 UT by Grassmann.

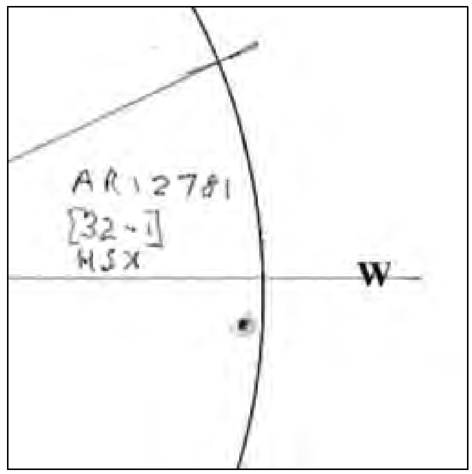


Figure 13 (left). A w-l image of AR 2781 on 11/12 at 12:46 UT by Vandenbulcke.

Figure 14 (right). Another w-l/H-a drawing of AR 2781 on 11/14 at 21:25 UT by Leventhal.

and follower spots were essentially gone. In a Grassmann CaK image at 11:33 UT, we just see a large plage following the very round leader spot. The class was Cso with an area of 100 mils (**Figure 12**). A day later, it was the leader by itself and the class had been reduced to Hsx of only 80 mils as shown by Vandenbulcke in a w-l image at 12:46 UT (**Figure 13**). Leventhal got the last look at AR 2781 as it was on the limb on 11/14 at 21:25 UT in one of his composite w-l/H-a drawings (**Figure 14**).

Conclusion

Activity is clearly picking up from a year ago as demonstrated by AR 2781. This will become more evident in the next report with observations of several other large regions including one naked- eye region. However, at the time of this writing (April 2021), activity has quieted to levels of the last reporting period so it remains to be seen if the spike at the interface of CR 2237/2238 is a true increase or an anomalous uptick in activity. These kinds of determinations are made through the diligent work of observers like you, so I encourage all to be vigilant and make use of Sunny Skies!

For more information go to: *http://www.alpo-astronomy.org/member/ALPO_Standard_Memberships.html*

References

Hill, R.E., (1989) “A Three-Dimensional Sunspot Classification System” *Journal of the Assn of Lunar & Planetary Observers*, Vol. 33, p. 10.*http://www.alpo-astronomy.org/gallery3/var/albums/Publications-Section/ALPO-Journals/DJALPO-Volume-33/DJALPO%20Vol_%2033%20Nos_%201-3%20January%201989.pdf?m=1578431360*

Hill, R. E. (2021) "A Report on Carrington Rotations 2226 through 2230", *Journal of the Assn of Lunar & Planetary Observers*, Vol. 63, No. 1, p. 52.

Hill, R. E. (2021B) "A Report on Carrington Rotations 2231 through 2235", *Journal of the Assn of Lunar & Planetary Observers*, Vol. 63, No. 2, pp. 35-44.

McIntosh, Patrick S., (1981) “The Physics Of Sunspots”. Sacramento Peak National Observatory, Sunspot, NM; L.E. Cram and J.H.Thomas (eds.), p.7. *https://ui.adsabs.harvard.edu/abs/1981phss.conf.....C/abstract*

McIntosh, Patrick S., (1989) “The Classification of Sunspot Groups” *Solar Physics*, Vol. 125, Feb. 1990, pp. 251-267. *http://adsabs.harvard.edu/abs/1990SoPh..125..251M*

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/*

Papers & Presentations

ALPO Observations of Venus During the 2016-2017 Eastern (Evening) 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

Twelve observers from France, Germany, Italy, United Kingdom, and United States provided 108 combined observations consisting of digital images and visual observations (drawings and descriptive reports) to the ALPO Venus Section during the 2016-17 Eastern (Evening) Apparition. This report provides a synopsis of the results of all 108 observations submitted. Types of telescopes and accessories used in making the observations, as well as sources of data, are noted. 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 atmospheric features on Venus, including cusps, cusp-caps, and cusp-bands, all seen or suspected at visual wavelengths in integrated light and with color filters, as well as images captured at visual, ultraviolet (UV), and infrared (IR) wavelengths. Terminator irregularities and the apparent phase phenomena, plus results from continued monitoring of the dark hemisphere of Venus for the enigmatic Ashen Light and imaging of dark side thermal emission in the infrared (IR) are discussed. As noted in the report, the 2016-17 Eastern (Evening) Apparition ended on March 24, 2017. Unfortunately, the 2016-17 apparition was poorly observed compared with more recent apparitions.

Introduction

The ALPO Venus Section received 108 observations for the 2016-17 Eastern (Evening) Apparition, comprised of visual drawings, descriptive reports, and digital images from 12 observers residing in France, Germany, Italy, United Kingdom and United States. Geocentric phenomena in Universal Time (UT) for this 2016-17 observing season are given in Table 1, while Figure 1 presents 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 telescope types used.

Observational coverage of Venus during this apparition was comparatively poor. Only a few individuals began their observations of the planet following superior conjunction on June 6, 2016, thus there was an unfortunate gap in observational coverage between early June 2016 and the third week of August 2016. Contributions by observers covered the period beginning August 23, 2016 through March 24, 2017 with 84.3% of the total contributions for the 2016-17 Eastern (Evening) Apparition of Venus, During the apparition, Venus passed through its waning phases (a progression from fully illuminated through crescentic phases) when observers witnessed the leading hemisphere of Venus at the time of sunset on Earth. The ALPO Venus Section encourages observers to plan ahead and attempt systematic observations for more thorough coverage of Venus as early as possible in any given apparition starting right after conjunction up to as close to the next conjunction as feasible.

Figure 2 shows the distribution of observers and contributed observations

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

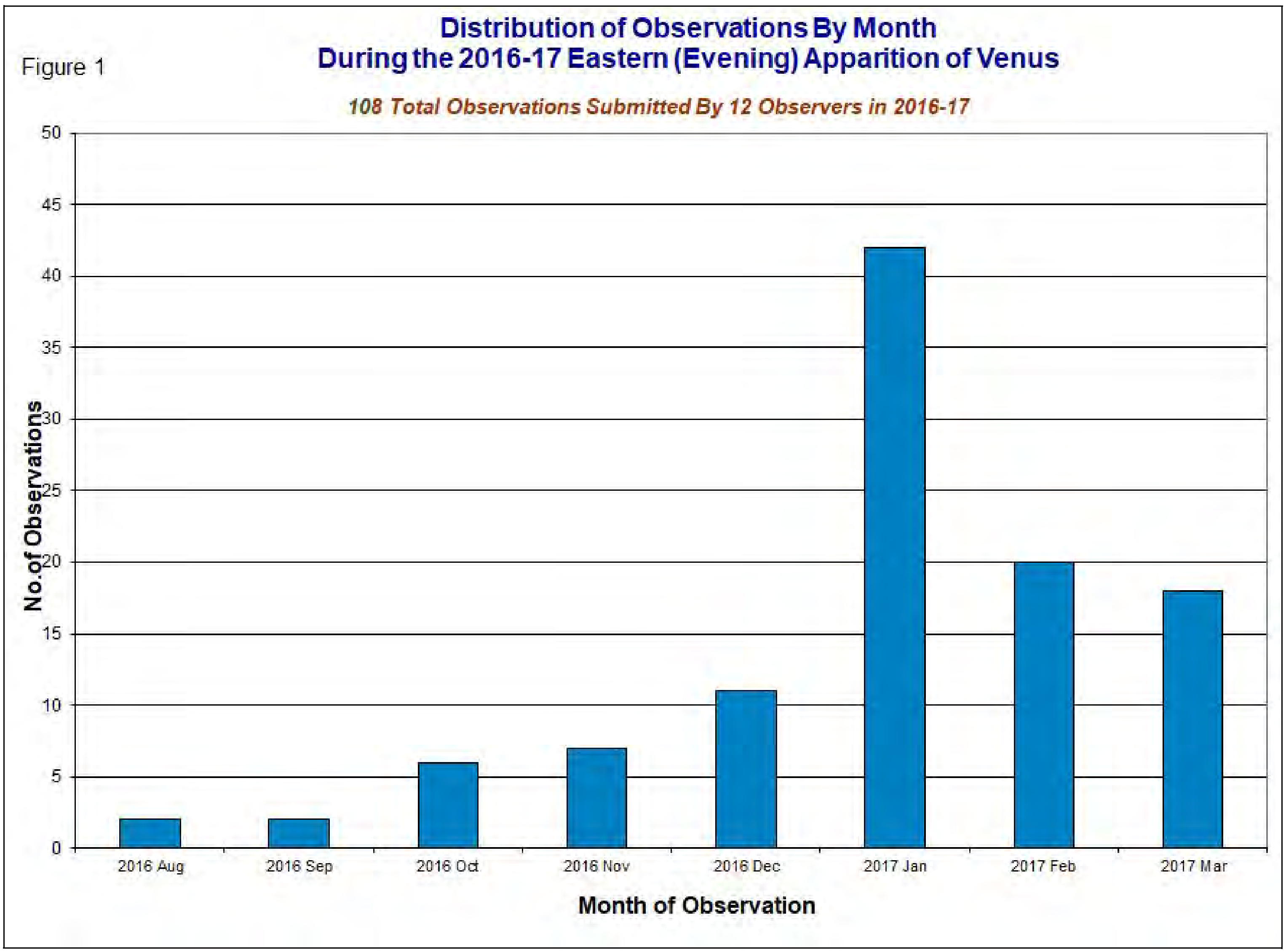
IAU directions are used in all instances.

by nation of origin for this apparition, with 36.4% of the participants in our programs located in the United States accounting for 25.0% of the total observations. Continued international cooperation was good this observing season, with 63.6% of the observers residing outside the United States furnishing 75% of the overall observations. The ALPO Venus Section highly encourages continued global teamwork by observers in the future.

The types of telescopes used to observe and image Venus are shown in Figure 3. All observations were made with telescopes ranging from 9.0 cm (3.5 in.) up to 41.0 cm (16.0 in.) in aperture, and 97.2% were made with telescopes 15.2 cm (6.0 in.). During the 2016-17 Eastern (Evening) Apparition of Venus, the frequency of use of classical designs (that is, refractors and Newtonian reflectors) was 25.0%, while utilization of catadioptrics (Schmidt-Cassegrains, Dall-Kirkhams, and Maksutov-Cassegrains) was 75.0%. All observations this apparition were performed under

Table 1. Geocentric Phenomena in Universal Time (UT) for the 2016-17 Eastern (Evening) Apparition of Venus

Superior Conjunction	2016 Jun 6^d 08^h 00^mUT
Initial Observation	Aug 23^d 14^h 27^mUT
Greatest Elongation East	2017 Jan 12^d 13^h 00^mUT (47.0°)
Dichotomy (predicted)	Jan 14.56^d
Greatest Illuminated Extent	Feb 17^d 07^h 00^mUT (m_v = −4.7)
Final Observation	Mar 24^d 11^h50^mUT
Inferior Conjunction	Mar 25^d 10^h00^mUT
Apparent Diameter (observed range): 10.7" (2016 Aug 23) ↔ 59.8" (2017 Mar 24)	
Phase Coefficient, ***k*** (observed range): 0.932 (2016 Aug 23) ↔ 0.011 (2017 Mar 24)	



daylight or twilight conditions, generally because more experienced Venus observers recognize that viewing the planet during twilight or in full daylight substantially reduces the excessive glare associated with the planet. Also, viewing or imaging Venus when it is higher in the sky substantially cuts down on the detrimental effects of atmospheric dispersion and image distortion prevalent near the horizon.

The ALPO Venus Section is most grateful for the efforts of the 12 observers who made this report possible by sending in their drawings, descriptive reports and digital images of Venus in 2016-17. Readers who wish to observe Venus in coming apparitions are urged to join the ALPO and start participating in our programs. Due to its dazzling brightness, Venus is easy to find in the twilight or night sky, and can sometimes be spotted in broad daylight if one knows where to look under clear skies. When near greatest elongation from the Sun, Venus can be almost 15 times brighter than Sirius, and from a dark, Moonless observing site, the planet can even cast shadows.

Table 2. ALPO Observing Participants in the 2016-17 Eastern (Evening) Apparition of Venus

Observer and Observing Site	No. Obs.	Telescope(s) Used*
Arditti, David, Edgeware, Middlesex, UK	1	35.6 cm (14.0 in) SCT
Benton, Julius L., Wilmington Island, GA, USA	1 2	8.0 cm (3.1 in) MAK 12.7 cm (5.0 in) MAK
Boudreau, John, Saugus, MA, USA	1	28.0 cm (11.0 in) SCT
Braga, Raffaello, Milan, Italy	15	21.0 cm (8.3 in) DAL
Gasparri, Deniele, Perugia, Italy	2	23.5 cm (9.25 in) SCT
Guidi, Marco, San Pietro Polesine, Italy	1	23.6 cm (9.3 in) NEW
Hill, Rik, Tucson, AZ, USA	12	20.3 cm (8.0 in) MAK
Legrande, Michel, Le Baule- Escoublac, France	1 19	21.0 cm (8.3in) NEW 41.0 cm (16.0 in) NEW
Maxson. Paul, Phoenix, AZ, USA	8	25.4 cm (10.2 in) DAL
Melillo, Frank J., Holtsville, NY, USA	15	220.3 cm (8.0 in) SCT
Niechoy, Detlev, Göttingen, Germany	24	20.3 cm (8.0 in) SCT
Pellier, Christophe, Bruz, France	6	25.4 cm (10.0 in) NEW
Total No. of Observers	***12***	
Total No. of Observations	***108***	
*SCT = Schmidt-Cassegrain, MAK = Maksutov, NEW = Newtonian, DAL = Dall-Kirkham		

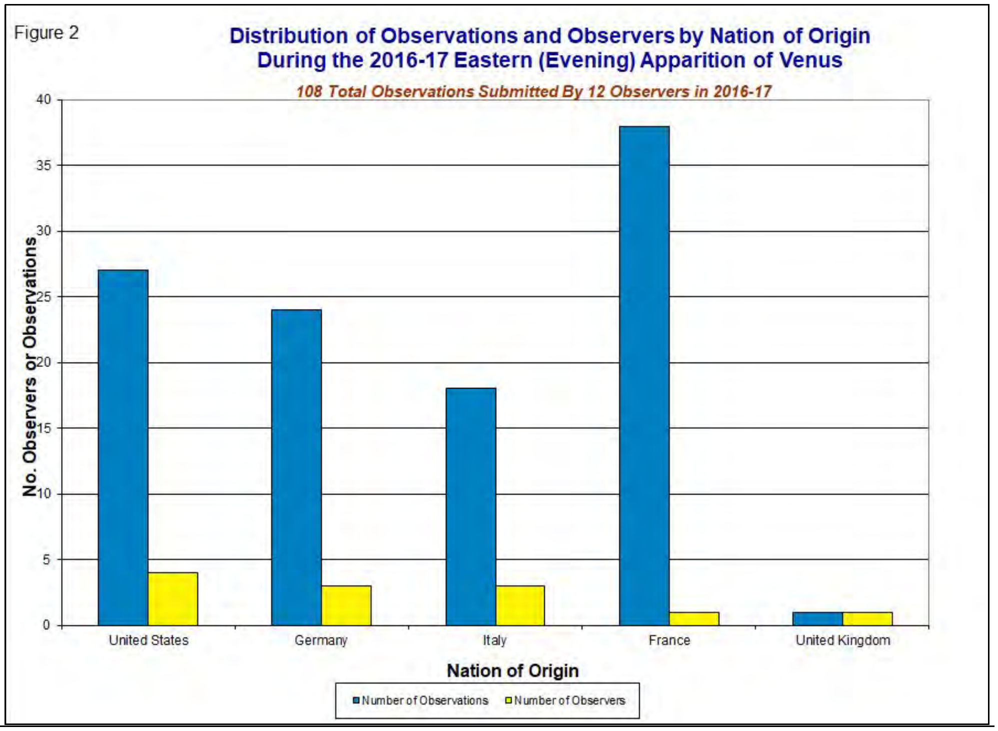
Observations of Atmospheric Details on Venus

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. This publication can be downloaded from the ALPO web site at http://alpo-astronomy.org/gallery3/index.php/Publications-Section/ALPO-Monographs/ALPO-Monograph-15-Venus-Handbook-Revised-Edition-2016 as a pdf file. 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 regularly 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 categories of atmospheric activity reported on Venus during this apparition.

Represented in the photo-visual data for this apparition were all of the long-

Figure 2



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 as references at the end of 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 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 worthwhile interpretations.

The dusky markings of Venus' atmosphere are always a challenge to detect using normal visual observing methods, and this familiar characteristic of the planet is mostly independent of the experience of the observer. When color filters and variable-density polarizers are systematically employed, views of cloud phenomena on Venus at visual wavelengths can be considerably improved. Without neglecting routine visual work that includes making drawings at the eyepiece and filling out vital information on standardized observing forms, the ALPO Venus Section urges observers to try digital imaging of Venus at UV and IR wavelengths. The morphology of features captured at UV and IR wavelengths can appear quite different from visual impressions, particularly atmospheric radial dusky patterns (in the UV) and the appearance of the dark hemisphere (in IR). Similarities do occasionally occur, however, 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 with digital imagers at different wavelengths.

Figure 4 illustrates that in 11.7% of the observations submitted this apparition the bright disc of Venus was considered as being completely devoid of atmospheric features. When dusky features were seen or suspected or imaged, the "Banded Dusky Markings" were reported 12.9% of the time, "Amorphous Dusky Markings" in 22.6%, and "Irregular Dusky Markings" (9.7%) [refer to illustrations 001 through 009]. The "Radial Dusky Markings" comprised 6.5% of the reports, to include horizontal V, Y, or ? (psi) shaped dusky clouds that are frequently aligned along the planet's equator [refer to illustrations 010 through

Figure 3

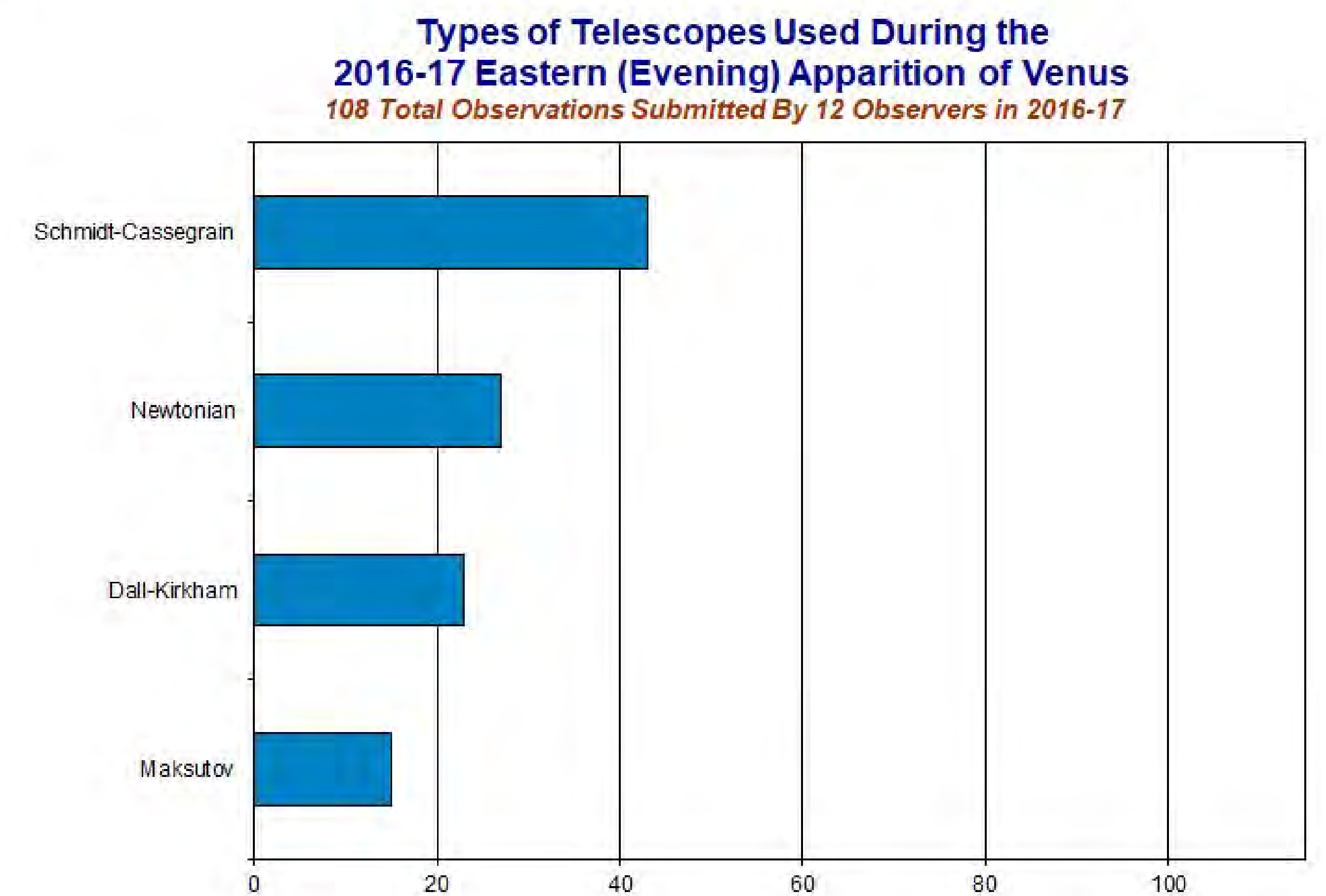


Figure 4

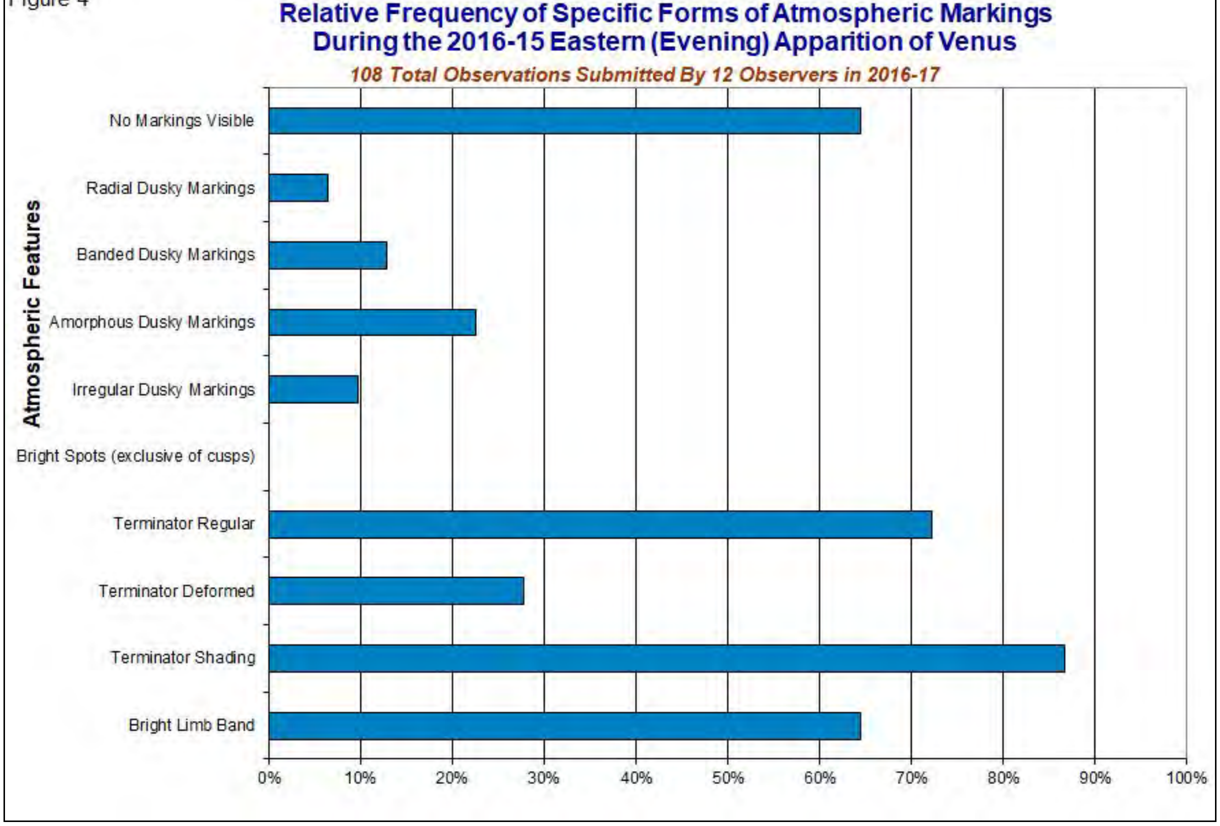
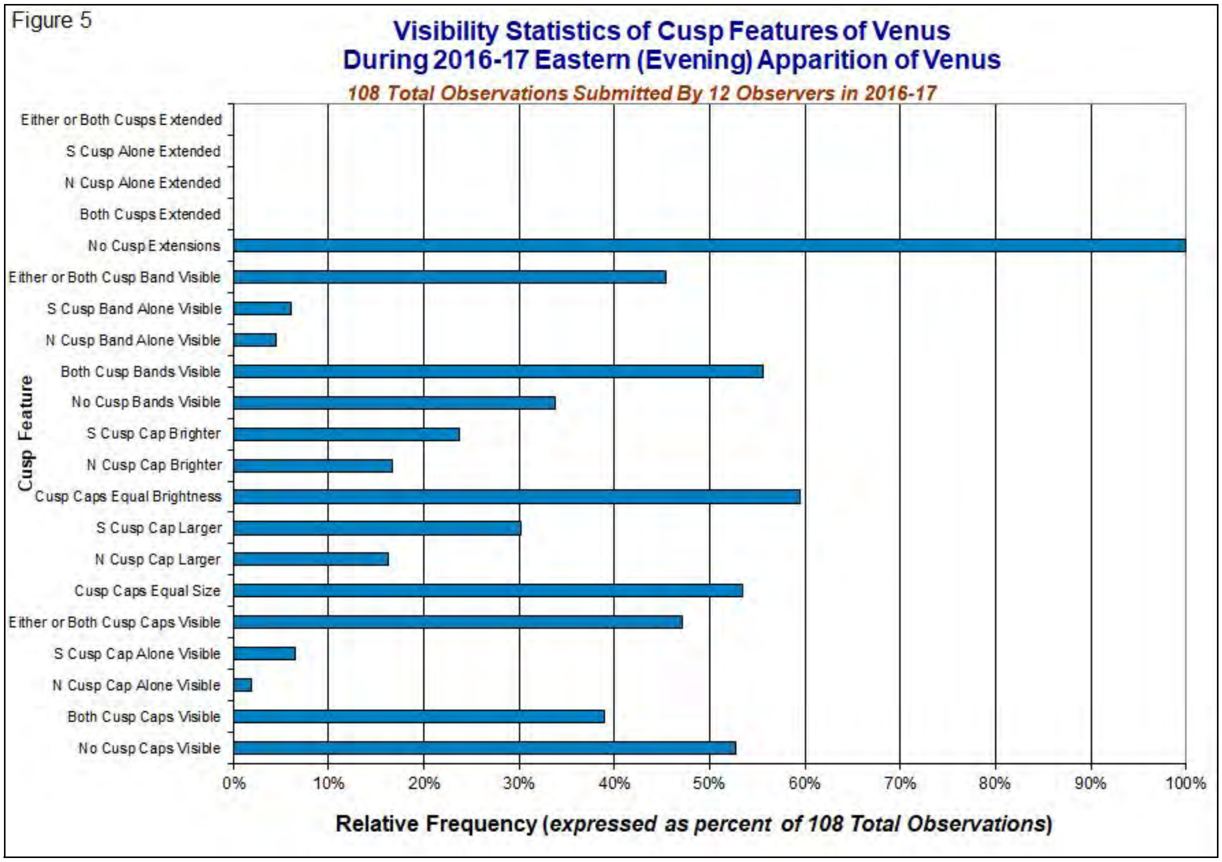


Figure 5



013]. The latter are typically only revealed in UV images. Terminator shading was reported in 86.7% of the observations, as shown in Figure 4. Terminator shading usually extended from one cusp of Venus to the other, and the dusky shading was progressively lighter in tone (higher intensity) from the region of the terminator toward the bright planetary limb as seen in drawings and digital images [refer to illustrations 005, 006, 013 and 014]. The mean numerical relative intensity for all of the dusky features on Venus this apparition averaged about 8.6. 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 3.6 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 not reported in the submitted visual observations and images. When visual observers detect such bright areas, it is an ordinary practice to denote them on drawings by using dotted lines to surround them.

Throughout 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.

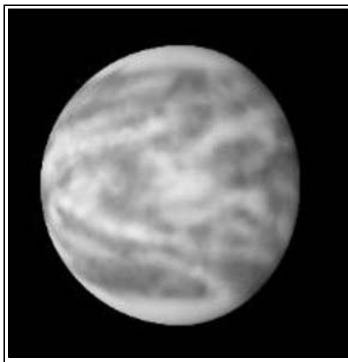
The Bright Limb Band

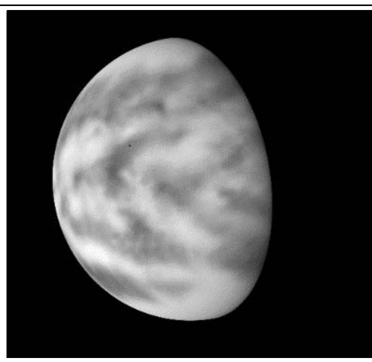
Figure 4 illustrates that 64.6% of the submitted observations during this apparition referred to a conspicuous "Bright Limb Band" on the illuminated hemisphere of Venus. When the Bright Limb Band was visible or imaged, it appeared as a continuous, brilliant arc running from cusp to cusp 54.6% of the time, and interrupted or only marginally visible along the limb of Venus in 45.4% of the time. The Bright Limb Band was more likely to be incomplete in UV images than those captured at visual wavelengths or as depicted on submitted drawings. The mean numerical intensity of the Bright Limb Band was 9.8, seemingly a bit more obvious when color filters or variable-density polarizers were used. This very bright feature was described by visual observers and imaged as well this apparition [refer to illustrations 003, 005, 006, 007, 013 and 015].

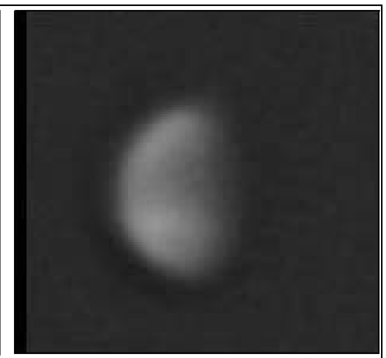
Terminator Irregularities

The terminator is the geometric curve that separates the brilliant sunlit and dark hemispheres of Venus. A deformed or asymmetric terminator was reported in

***General Caption Note for Illustrations 1-24**. 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.*







All illustrations from left to right: **Illustration 001.** 2016 August 25, 17:48 UT. Drawing by Michel Legrand. 41.0 cm (16.0 in.) NEW at 366X and W80A (light blue) filter. Seeing 5.0 (interpolated), Transparency 3.0. Phase (k) = 0.927, Apparent Diameter = 10.8”. Drawing shows the gibbous disk of Venus with banded, amorphous, and irregular dusky cloud features. S is at the top of the drawing.

Illustration 002. 2016 October 27, 15:27 UT Drawing by Michel Legrand. 41.0 cm (16.0 in.) NEW at 366X and W80A (light blue) filter. Seeing 6.0 (interpolated), Transparency 4.0. Phase (k) = 0.789, Apparent Diameter = 13.8”. Drawing shows the gibbous disk of Venus with amorphous and irregular dusky cloud features. North and South Cusp caps and cusp bands are visible. S is at the top of the drawing.

Illustration 003. 2016 October 31, 15:54 UT. UV image by Michel Legrand. 41.0 cm (16.0 in.) NEW. Seeing 6.0 (interpolated), Transparency 4.0. Phase (k) = 0.779, Apparent Diameter = 14.1”. Image of the gibbous disk of Venus depicting banded, amorphous, and irregular dusky atmospheric features, as well as the bright limb band running from cusp to cusp. S is at the top of the drawing.

Illustration 004. 2016 November 16, 2016 21:08 UT. UV image by Frank Melillo. 25.4 cm (10.0 in.) SCT. Seeing 3.5, Transparency (not specified). Phase (k) = 0.732, Apparent Diameter = 15.5”. Banded and Banded and amorphous dusky markings are noticeable. S is at the top of the image.

27.8% of the observations. Amorphous, banded and irregular dusky atmospheric markings frequently 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 occasionally take the form of bulges, while darker markings may appear as wispy hollows [refer to illustrations 008, 014 and 016].

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 63.5% of the time and in brightness in 59.5% of the observations. Also, there were several instances when the southern and northern cusp-caps were larger and brighter than each other. Both cusp-caps were visible in 60.9% 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 38.0% of the observations when cusp-caps were visible. When seen, the cusp-bands displayed a mean relative intensity of about 7.5 (see *Figure 5*) [Refer to *illustrations 2, 10 and 11*].

Cusp Extensions

In 95.5% 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*). As Venus entered its crescent phases later in the observing season and leading up to the time of Inferior Conjunction on March 25, 2017, there were no instances when visual observers suspected cusp extensions, but observers are still encouraged to try to record such features using digital imagers in upcoming apparitions.

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 $\boldsymbol{k}$ = 0.500, and the phase angle, $\boldsymbol{i}$, between the Sun and the Earth as seen from Venus equals 90°.

Theoretical dichotomy was predicted for January 14.56d 2017. However, there were no dichotomy observations reported during the 2016-17 Eastern (Evening) Apparition of Venus.



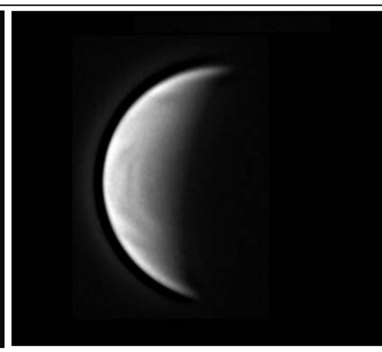
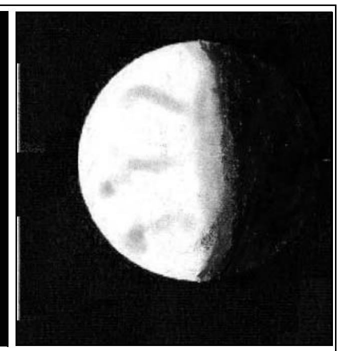



Illustration 005. 2016 December 30, 15:40 UT. UV image by Raffaello Braga. 21.0 cm (8.3 in.) DAL with W47 (violet) filter. Seeing (not specified), Transparency (not specified). Phase (k) = 0.572, Apparent Diameter = 21.6". Along with terminator shading, banded dusky markings are clearly visible in this image including the bright limb band. S is at the top of the image.

Illustration 006. 2017 January 03, 16:20 UT. UV image by Raffaello Braga. 21.0 cm (8.3 in.) DAL with W47 (violet) filter. Seeing (not specified), Transparency (not specified). Phase (k) = 0.554, Apparent Diameter = 22.4". Along with terminator shading, banded and irregular dusky features are visible in this image including the bright limb band. S is at the top of the image.

Illustration 007. 2017 February 5, 00:21 UT. UV image by Paul Maxson. 25.4 cm (10.0 in.) DAL. Seeing (not specified), Transparency (not specified). Phase (k) = .369, Apparent Diameter = 32.9". Amorphous and irregular dusky markings appear in this image. S is at the top of the image.

Illustration 008. 2017 January 19, 817:12 UT. Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 82X in IL (Integrated Light) and W25 (red) filter. Seeing 3.0, Transparency 3.0. Phase (k) = 0.0.472, Apparent Diameter = 26.7". Irregular dusky markings are mostly visible in this drawing. The terminator appears slightly deformed along its overall extent fromcusp to cusp, S is at the top of the drawing.

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. There were no reported observations of the Ashen Light during 2016-17. Venus observers are encouraged to monitor the dark side of Venus using digital imagers to try to capture any illumination that may be present on the planet, ideally as part of a cooperative simultaneous observing endeavor with visual observers.

There were no instances when the dark hemisphere of Venus allegedly appeared darker than the background sky during the 2016-2017 Eastern (Evening) Apparition, a phenomenon that is likely nothing more than a spurious contrast effect.

Dark Hemisphere Thermal Emission at IR Wavelengths

Since the instrumentation and methodology are not really complicated, the ALPO Venus Section encourages observers to pursue systematic imaging of the planet in the near-IR at about 1000nm. At these wavelengths the hot surface of the planet becomes quite apparent and occasionally mottling shows up in such images, attributable to the presence of cooler dark higher-elevation terrain and warmer bright lower surface areas. There were no images submitted during 2014-15 of the dark side thermal emission.

Simultaneous Observations

Since the instrumentation and methodology are not really complicated, the ALPO Venus Section encourages observers to pursue systematic imaging of the planet in the near-IR at about 1,000nm. At these wavelengths, the hot surface of the planet becomes quite apparent. Occasionally mottling shows up in such images, attributable to the presence of cooler dark higher-elevation terrain and warmer bright lower surface areas in the IR. Although several observers during the 2016-17 apparition made good attempts to clearly image the hot surface of the dark hemisphere, the first image unambiguously showing the dark hemisphere thermal emission was received from Frank Melillo captured on February 27, 2017 at 03:40 UT [*Illustration 017*]. David Arditti supplied an image using a 1,000nm IR filter on March 2, 2017 at 18:36 UT in which

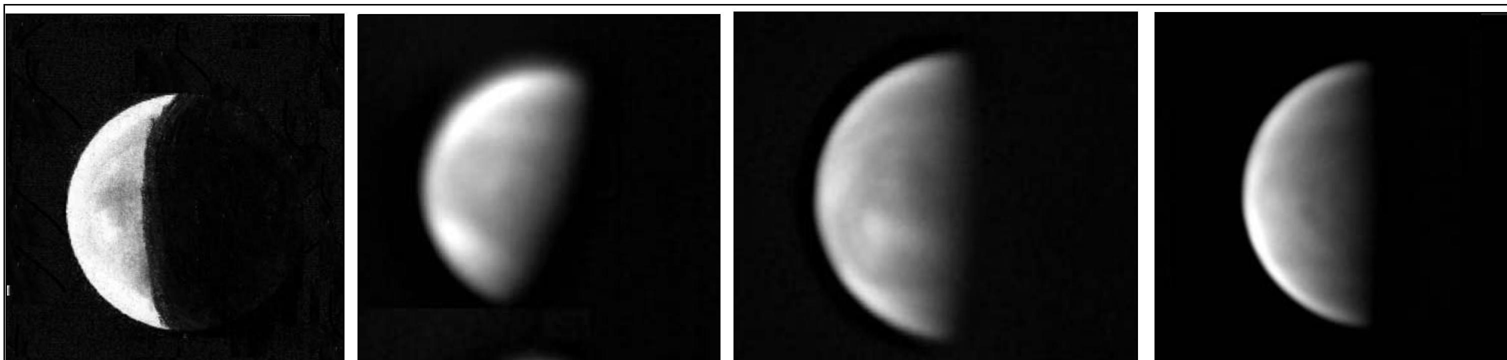


Illustration 009. 2017 February 2, 17:46 UT. Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 82X in IL (Integrated Light) and W25 (red) filter. Seeing 3.0, Transparency 3.0. Phase (k) = 0.0.385, Apparent Diameter = 31.8”. Irregular dusky markings are mostly visible in this drawing. Amorphous dusky markings are apparent inn this sketch. S is at the top of the drawing.

Illustration 010. 2016 December 6, 16:27 UT. UV image by Michel Legrand. 41.0 cm (16.0 in.) NEW. Seeing 6.0 (interpolated), Transparency 4.0. Phase (k) = 0.667, Apparent Diameter = 17.7”. Characteristic of images at UV wavelengths roughly horizontal V, Y, or ψ (psi) shaped dusky cloud features in the atmosphere of Venus are obvious. S is at the top of the image.

Illustration 011. 2016 December 31, 15:08 UT. UV image by UV image by Raffaello Braga. 21.0 cm (8.3 in.) DAL with Ca-K 395nm filter. Seeing (not specified), Transparency (not specified). Phase (k) = 0.568, Apparent Diameter = 21.8”. Somewhat horizontal V, Y, or ψ (psi) shaped dusky cloud features are seen. S is at the top of the image.

Illustration 012. 2017 January 03, 17:20 UT. Digital image by Christophe Pellier. 25.4 cm (10.0 in.) NEW. Using a W47 (violet) filter. Seeing (not specified), Transparency (not specified). Phase (k) = 0.554, Apparent Diameter = 22.4”. Roughly horizontal V, Y, or ψ (psi) shaped dusky cloud features in the atmosphere of Venus are obvious. S is at the top of the image.

the dark hemisphere thermal illumination is easily discernable. Dark patches seem to correspond to Beta and Phoebe Regio on Venus; lower warmer regions in the image correspond to where the thermal signal would be expected to be at its brightest [*illustration 018*]. On March 5, 2017 at 23:45 UT, Frank Melillo furnished another 1,000nm IR image apparently showing the Beta Regio surface feature [*illustration 019*]. He also followed up with four similar 1,000nm IR images on March 8, 2017 at 23:30 UT, March 9, 2017 at 23:30 UT, and March 10, 2017 at 23:20 UT, and March 12, 2017 at 23:15 UT [*illustrations 020, 021, 022 and 023* respectively]. At 23:34 UT on March 12, 2017, John Boudreau provided an excellent 1,000nm IR image showing dark and lighter features on the otherwise dark hemisphere, which constitutes a simultaneous observation with that of Frank Melillo [*illustration 024*]. Readers should compare the aforementioned two images.

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 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. Drawings of Venus in Integrated Light and with color filters of known transmission made while the VEX mission was in progress are also sought after. These collective data are important for further study and will continue to be analyzed for several years to come in support of this endeavor.

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

A follow-up Pro-Am effort is now underway with Japan's (JAXA) *Akatsuki* mission that began full-scale observations back in April 2016. The initial mission was successfully completed in 2018, but was extended until the end of 2020. The website for the *Akatsuki* mission is "live" and interested and adequately equipped ALPO observers can register and still submit images. 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

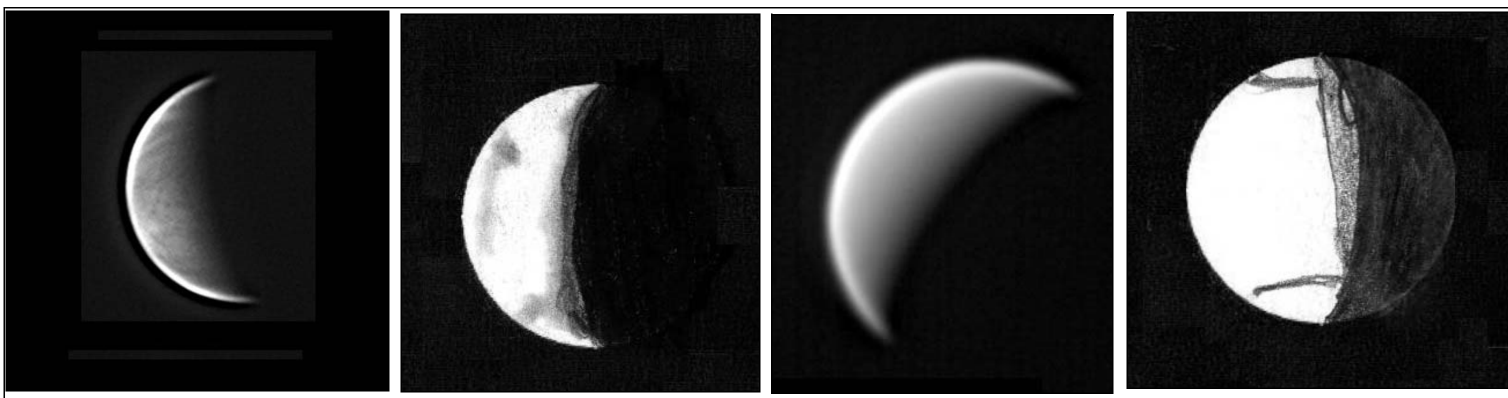


Illustration 013. 2017 February 3, 00:21 UT. UV image by Paul Maxson. 25.4 cm (10.0 in.) DAL. Seeing (not specified), Transparency (not specified). Phase (k) = 0.383. Apparent Diameter = 32.0”. In addition to the bright limb band, characteristic of images at UV wavelengths nearly horizontal V, Y, or ψ (psi) shaped dusky cloud features in the atmosphere of Venus are detected. S is at the top of the image.

Illustration 014. 2017 February 02, 17:25 UT. Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 163X in Integrated Light (no filter) and a W25 (red) filter. Seeing 4.0 (interpolated), Transparency (not specified). Phase (k) = 0.385, Apparent Diameter = 31.8”. Drawing shows obvious terminator shading and slight irregularities near the N cusp. S is at the top of the drawing.

Illustration 015. 2017 February 08, 17:23 UT. UV image by Michel Legrand. 41.0 cm (16.0 in.) NEW. Seeing (not specified), Transparency (not specified). Phase (k) = 0.342. Apparent Diameter = 34.6”. Image of the waning crescent of Venus depicting the bright limb band extending from cusp to cusp. S is at the top of the image.

Illustration 016. 2017 January 01, 18:27 UT Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 225X in Integrated Light (no filter). Seeing 4.5 (interpolated), Transparency (not specified). Phase (k) = 0.563, Apparent Diameter = 22.0”. This drawing clearly depicts both cusp caps and cusp bands. S is at the top of the drawing.

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 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/

Conclusions

Analysis of ALPO observations of Venus during the 2016-17 Eastern (Evening) Apparition showed that vague shadings on the disc of the planet were regularly apparent to most visual observers who systematically used standardized filter techniques to help see the notoriously elusive atmospheric features. It is usually very difficult to be certain visually what is genuine and what is purely illusory at visual wavelengths in the atmosphere of Venus. Greater confidence in visual results is gained as more simultaneous observations are received, and well-executed drawings remain a vital part of our overall program. Careful visual work and regular digital imaging of Venus at visual, near-UV, and near-IR wavelengths help enhance the opportunity for confirmation of highly elusive atmospheric phenomena through comparative analysis. 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. Active international cooperation by individuals making regular systematic, simultaneous observations of Venus is our main objective, including visual work and digital imaging, and our efforts as part of the aforementioned on-going and future Pro-Am cooperatives. The ALPO Venus Section encourages interested readers to join us in our many projects and challenges in the coming years.

References

Benton, Julius L., Jr., (2002). *An Introduction to Observing Venus*. Savannah, GA: Review Publishing Co. Available from the author at jlbaina@msn.com

------, (2019), *The Venus Handbook*. Available from the author at jlbaina@msn.com or download from http://www.alpo-astronomy.org/gallery3/var/albums/Publications-Section/ALPO-Monographs/ALPO%20Monograph%2015%20-%20Venus%20Handbook%20%28Revised%20Edition%202016%29.pdf?m=1584481954

------, (2015), "ALPO Observations of Venus During the 2010 Eastern (Evening) Apparition of Venus." *Journal of the Association of Lunar and Planetary Observers*, Vol. 57, No. 2: 22-33. http://alpo-astronomy.org/gallery3/var/albums/Publications-Section/ALPO-Journals/DJALPO-2015/DJALPO57-2-Spring2015.pdf?m=1521160812

------, (2015), "ALPO Observations of Venus During the 2009-2010 Western (Morning) Apparition of Venus." *Journal of the Association of Lunar and Planetary Observers*, Vol. 57, No. 3: 19-32. http://alpo-astronomy.org/gallery3/var/albums/Publications-Section/ALPO-Journals/DJALPO-2015/JALPO57-3-Summer2015.pdf?m=1521160812

------, (2016), "ALPO Observations of Venus During the 2011-12 Eastern (Evening) Apparition of Venus." *Journal of the Association of Lunar and Planetary Observers*, Vol. 58, No. 3: 38-55. http://alpo-astronomy.org/gallery3/var/albums/Publications-Section/ALPO-Journals/DJALPO-2016/DJALPO58-3-Summer2016.pdf?m=1529263025

------, (2017), "ALPO Observations of Venus During the 2012-13 Western (Morning) Apparition of Venus." *Journal of the Assn of Lunar & Planetary Observers, Vol. 59, No. 1* (Winter), 36-47. http://alpo-astronomy.org/gallery3/var/albums/Publications-Section/ALPO-Journals/DJALPO-2017/DJALPO59-1-Winter2017.pdf?m=1529265904

------, (2017), "ALPO Observations of Venus During the 2013-14 Eastern (Evening) Apparition of Venus." *Journal of the Association of Lunar and Planetary Observers*, Vol. 59, No. 3: 52-63. http://alpo-astronomy.org/gallery3/var/albums/Publications-Section/ALPO-Journals/DJALPO-2017/DJALPO59-3-Summer-2017.pdf?m=1529266084

------, (2018), "ALPO Observations of Venus During the 2014 Western (Morning) Apparition of Venus." *Journal of the Association of Lunar and Planetary Observers*, Vol. 60, No. 3: 41-51. http://alpo-astronomy.org/gallery3/var/albums/Publications-Section/ALPO-Journals/DJALPO-2018/JALPO60-3-Summer-2018.pdf?m=1545337354

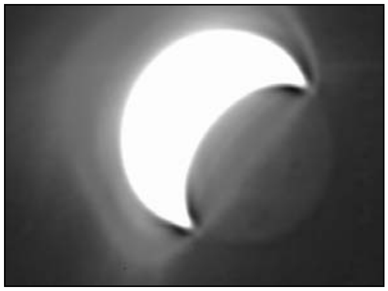
------, (2020), "ALPO Observations of Venus During the 2014-15 Eastern (Evening) Apparition of Venus." Journal of the Assn of Lunar and Planetary Observers, Vol. 62, No. 2: pp. 33-44. http://alpo-astronomy.org/gallery3/index.php/Publications-Section/ALPO-Journals/DJALPO-Volume-62-2020/JALPO62-2-Spring-2020http://alpo-astronomy.org/gallery3/index.php/Publications-Section/ALPO-Journals/DJALPO-Volume-62-2020/JALPO62-2-Spring-2020

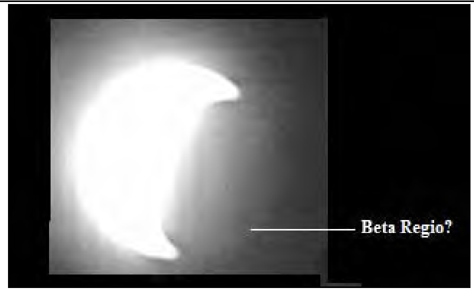
------, (2020), "ALPO Observations of Venus During the 2015-16 Western (Morning) Apparition of Venus." Journal of the Assn of Lunar and Planetary Observers, Vol. 62 No. 4: pp. 45-56. (*Not yet available online.*)

de Pater, Imke and Lissauer, Jack J., (2013). Fundamental Planetary Science. New York: Cambridge University Press. http://www.amazon.com/Fundamental -Planetary-Science-Chemistry-Habitability/dp/052161855X

Hunten, D.M., et al, eds. (1983). "*Venus.*" Tucson: University of Arizona Press. http://www.uapress.arizona.edu/BOOKS/bid222.htm

United States Naval Observatory. The Astronomical Almanac. Washington: U.S. Government Printing Office. (Annual Publication; the 2015 and 2016 editions, which were published in late 2014 and 2015, respectively, were used for this report. https://www.amazon.com/s?k=astronomical+almanac+2015&ref=nb_sb_noss





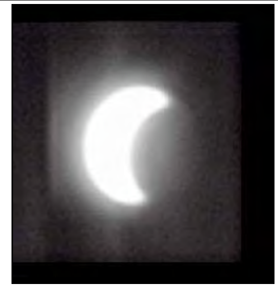
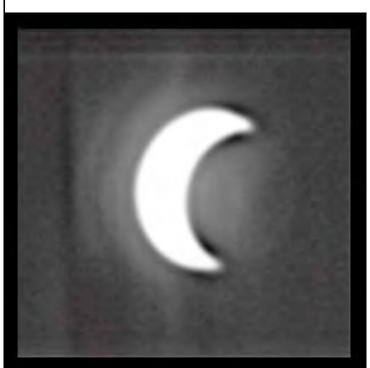


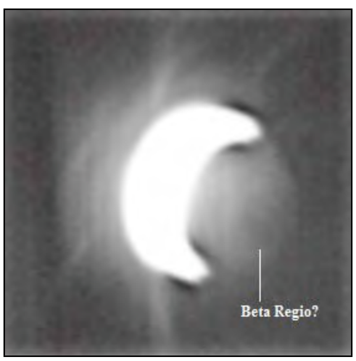
Illustration 017 2017 February 27, 03:40 UT. 1,000nm IR image by Frank Melillo. 25.4 cm (10.0 in.) SCT. Seeing 5.0, Transparency (not specified). Phase (k) = 0.186. Apparent Diameter = 46.0”.The thermal emission from the dark hemisphere was captured in this image. S is at the top of the image.

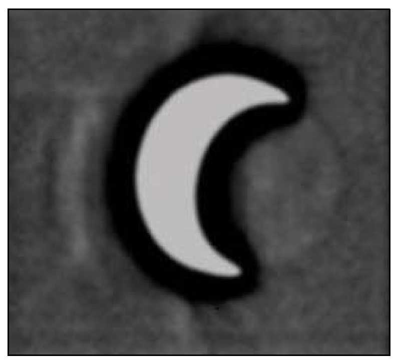
Illustration 018. 2017 March 02, 18:36 UT. 1,000nm IR image by David Arditti using a 35.6 cm (14.0in.) SCT. Seeing (not specified), Transparency (not specified). Phase (k) = 0.152, Apparent Diameter = 48.6”. Image clearly shows the warm emission from the dark hemisphere of Venus. Topographic features can be discerned in the image (see discussion in the text of this report). S is at the top of the image.

Illustration 019. 2017 March 05, 23:45 UT. 1,000nm IR image by Frank Melillo. 25.4 cm (10.0 in.) SCT. Seeing 5.0, Transparency (not specified). Phase (k) = 0.122, Apparent Diameter = 50.9”. Image shows the thermal emission from the dark hemisphere of Venus. Topographic feature Beta Regio is allegedly visible in the image (see discussion in the text of this report). S is at the top of the image

Illustration 020. 2017 March 08, 23:30 UT. 1,000nm IR image by Frank Melillo. 25.4 cm (10.0 in.) SCT. Seeing 3.0. Transparency (not specified). Phase (k) = 0.096, Apparent Diameter = 53.1”. Image shows the thermal emission from the dark hemisphere of Venus in poor seeing. S is at the top of the image.







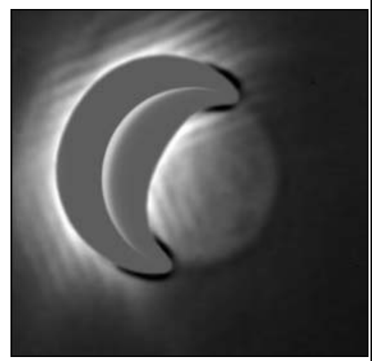


Illustration 021. 2017 March 09, 23:30 UT. 1,000nm IR image by Frank Melillo. 25.4 cm (10.0 in.) SCT. Seeing 3.0. Transparency (not specified). Phase (k) = 0.087, Apparent Diameter = 53.8”. Another nice image displaying the thermal emission from the dark hemisphere of Venus in poor seeing. S is at the top of the image.

Illustration 022. 2017 March 10, 23:20 UT. 1,000nm IR image by Frank Melillo. 25.4 cm (10.0 in.) SCT. Seeing 3.0. Transparency (not specified). Phase (k) = 0.087, Apparent Diameter = 53.8”. Superb image showing the thermal emission from the dark hemisphere of Venus in poor seeing. Topographic feature Beta Regio is allegedly visible in the image (see discussion in the text of this report). S is at the top of the image.

Illustration 023. 2017 March 12, 23:15, UT. 1,000nm IR image by Frank Melillo. 25.4 cm (10.0 in.) SCT. Seeing 5.0. Transparency (not specified). Phase (k) = 0.063, Apparent Diameter = 55.7”. Another nice image displaying the thermal emission from the dark hemisphere of Venus in poor seeing. A few topographic features are presumably detected on the warm surface of Venus. S is at the top of the image. This is essentially a simultaneous image with that of John Boudreau on the same date.

Illustration 024. 2017 March 12, 23:34 UT. Excellent 1,000nm IR image by John Boudreau. 28.0 cm (11.0 in.) SCT. Seeing 4.0 (not specified), Transparency (not specified). Phase (k) = 0.063, Apparent Diameter = 55.7”. The image shows the thermal emission from the dark hemisphere of Venus and what appears to be topographic features on the hot surface of the planet. S is at the top of the image. This is essentially a simultaneous image with that of Frank Melillo on the same date.

Papers & Presentations

Lunar Domes Near the Craters Luther, Hall and Posidonius

By Raffaello Lena, coordinator ALPO Lunar Domes Program,
raffaello.lena@alpo-astronomy.org
Jim Phillips, assistant coordinator ALPO Lunar Domes Program,
thefamily90@gmail.com

Abstract

In this study, we characterize three lunar domes using ground-based telescope CCD images, Lunar Reconnaissance Orbiter Wide Area Camera (LROC WAC) images, Clementine multispectral data, Chandrayaan-1 Moon Mineralogy Mapper (M3) and the LROC WAC-based GLD100 Digital Terrain Map (DTM). The dome Luther1 is located at 24.89º E and 33.39º N, with a diameter of 7.5 km ± 0.3 km, height of 80 ± 10 m, yielding an average flank slope of 1.1° ± 0.1°. The dome Hall1, located to the north of crater Hall, lies at coordinates 35.69 º E and 35.12° N, with a base diameter of 8.0 km ± 0.3 km and height of 50 m ± 5 m yielding an average flank slope of 0.80° ± 0.1°. These domes are not reported in the USGS I-705 map by Scott and in the USGS I-841 map by Grolier. Based on the morphometric properties, we infer the physical conditions under which the domes were formed (lava viscosity, effusion rate, magma rise speed) as well as the geometries of the feeder dikes. The third dome, Posidonius1, is located at 28.26° E and 32.02° N, with a diameter of 8.0 x 11.2 km ± 0.3 km, height of 74 ± 10 m, yielding an average flank slope of 0.8° ± 0.08°. Our data suggest that the most probable formation mechanism of Posidonius1 is a shallow magmatic intrusion.

Introduction

Lunar volcanism is a fundamental process in the geological and thermal evolution of the Moon. Early studies have used geological, petrological and remote sensing data to define and characterize deposits and features associated with lunar volcanism (Head, 1976) and to model the ascent and eruption of lunar magma (Wilson and Head, 1981). Lunar domes are the best evidence that volcanic activity occurred on the Moon (Lena et al., 2013).

The current study describes two lunar domes, of *Imbrian* age, located near the craters Luther and Hall (which we name Luth1 and Hall1). Furthermore we identify, based on terrestrial telescopic images, a shallow domical structure, first proposed by French et al. (2015). Posidonius is a floor-fractured crater (FFC), originated as a result of magmatic intrusion. The occurrence of small-scale graben in an arcuate pattern that follows the crest of a local topographic high in Posidonius, suggesting formation by uplift from a magmatic intrusion associated with FFC formation, has been recently described by French et al. (2015). Our telescopic observations and images confirm the presence of a dome in Posidonius, which we named Posidonius1 (Pos1).

Online Readers

Please send comments, questions, observing reports of your own, etc., to the authors by left-clicking your mouse on either of the e-mail addresses under the bylines on this page in blue text.

Also left-click on any hyperlinks in blue text within the text of this paper for additional information.

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

IAU directions are used in all instances.

Table of Observers and Number of Analyzed Images and Drawings Obtained for This Study

Observers	Images	Telescope
H. Eskildsen (USA)	3	Schmidt-Cassegrain (235 mm)
G. Heinen (Luxembourg)	2	Schmidt-Cassegrain (235 mm)
J. Phillips (USA)	2	Maksutov 254 mm
F. Schenck (Germany)	4	Schmidt-Cassegrain (355 mm)
M. Teodorescu (Romania)	3	Newtonian Reflector (355 mm)
C. Viladrich (France)	2	Schmidt-Cassegrain (355 mm)
C. Zannelli (Italy)	1	Dall-Kirkham (508 mm)

The morphometric characteristics of the three domes have been examined by making use of a combined photoclinometry and "shape from shading" approach (Lena et al., 2013) using LRO WAC imagery and the Lunar Orbiter Laser Altimeter Digital Elevation Model (LOLA DEM) data set. In the LRO WAC imagery, the examined domes are not as prominent as in the ground-based telescope images taken under lower solar illumination angles. As a consequence ground-based images obtained using telescopes and cameras like those commonly used by well-equipped amateur astronomers are of great value for the study and analysis of lunar domes. It once again shows that with modern imaging technology, there is still a chance for amateurs to discover and study elusive features on the moon, like the low-profile domes we examined.

Ground-Based Observations and LRO WAC Imagery

For the current study we have analyzed 17 telescopic images made by Zannelli,

Lunar Dome Classification System

Effusive Domes

Class A domes are small and shallow and formed by high-TiO_2 lavas of low viscosity, erupting at high effusion rates over very short periods of time, resulting in edifices of low volume.

Class B domes consist of lavas of intermediate to high viscosity and moderate TiO_2 content, erupting at low to intermediate effusion rates. If the effusion process continues over a long period of time, steep flank slopes and high volumes may occur (class B_1), while short periods of effusion result in shallower edifices of lower volume (class B_2).

Class C domes are formed out of low-TiO_2 (class C_1) or high-TiO_2 (class C_2) lavas building up edifices of large diameter but shallow flank slope. These at shapes are due to low lava viscosities and high effusion rates.

Class D comprises the very complex, shallow but large and voluminous edifices Arago α and ß, which were most probably formed during several subsequent effusion stages, while classes A-E describe simple, likely monogenetic effusive domes.

Class E domes represent the smallest volcanic edifices formed by effusive mechanisms (diameter < 6 km). In analogy to class B, the class E domes are subdivided into subclasses E_1 and E_2, denoting the steep-sided flank slope larger than 2° and the shallow edifices of this class, respectively.

Class G comprises the highland domes, which have highland-like spectral signatures and high flank slopes of 5°–15°, represented by Gruithuisen and Maairan highland domes.

Class H is represented by the non-monogenetic Marius domes, subdivided into three different classes. Small domes of less than 5 km diameter belong to subclass H_1. The irregular shapes of domes of subclass H_2 with more than 5 km diameter and flank slopes below 5° indicate a formation during several effusive episodes. Domes of subclass H_3 have diameters comparable to those of monogenetic class B_1 domes, but their flank slopes are all steeper than 5° and reach values of up to 9°.

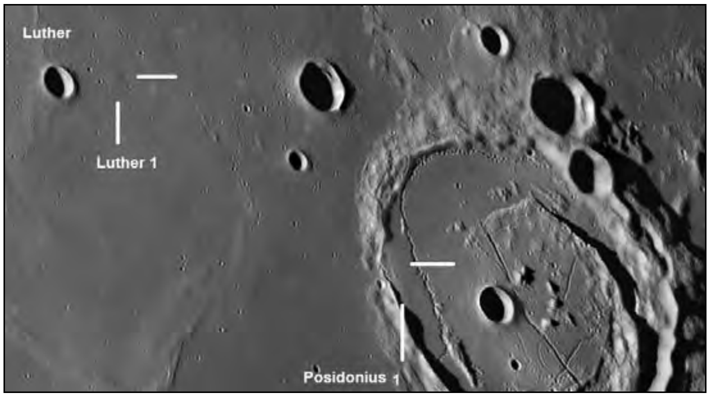
Putative Intrusive Domes

Lunar domes with very low flank slopes differ considerably from the more typical lunar effusive domes. Some of these domes are exceptionally large, and many of them are associated with faults or linear rilles of presumably tensional origin, while they do not show summit pits. A reliable discriminative criterion is the circularity of the dome outline: these domes are elongated and with low slopes (< 0.9°). The putative intrusive domes have circularity values below 0.8, while the circularity is always higher than 0.9 for the effusive domes having flank slopes below 0.9° and displaying effusive vents.

Class In1 comprises large domes with diameters above 25 km and flank slopes of 0.2°–0.6° and have linear o curvilinear rilles traversing the summit.

Class In2 is made up by smaller and slightly steeper domes with diameters of 10-15 km and flank slopes between 0.4° and 0.9°.

Class In3 comprises low domes with diameters of 13-20 km and flank slopes below 0.3°.



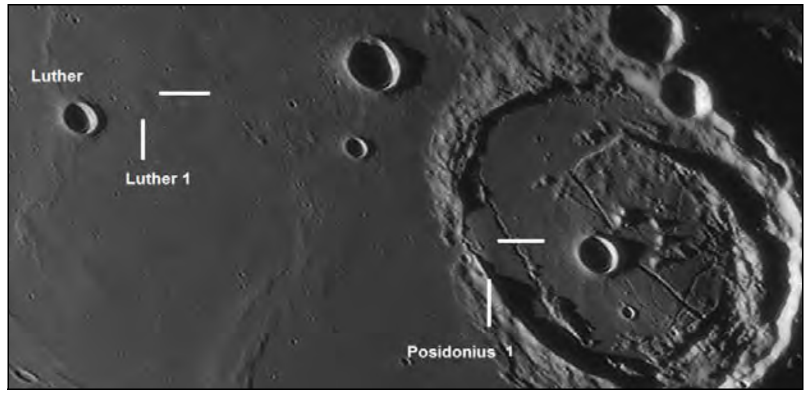
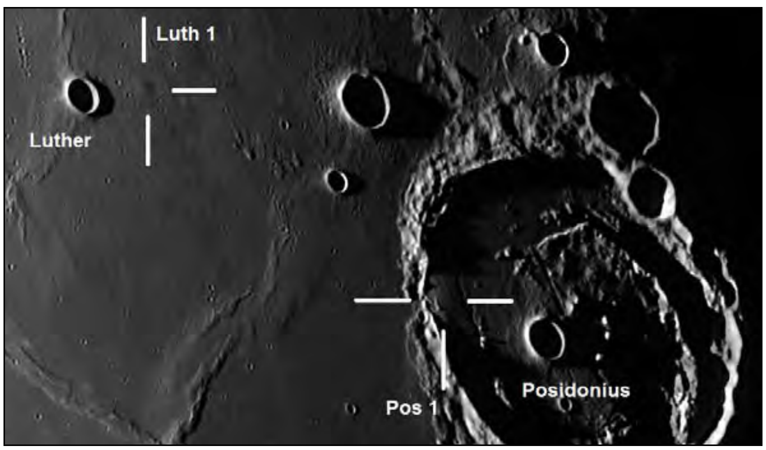


Figure 1. Image made on October 18, 2019 at 00:21 UT by Zannelli using a DK 508 mm telescope. Crop of the original image. The domes Luther1 (Luth1) and Posidonius1 (Pos1) are marked with white lines.

Figure 2. Image made on October 10, 2017 at 04:02 UT by Teodorescu using a 355 mm Newtonian. Crop of the original image. The domes Luther1 (Luth1) and Posidonius1 (Pos1) are marked with white lines.



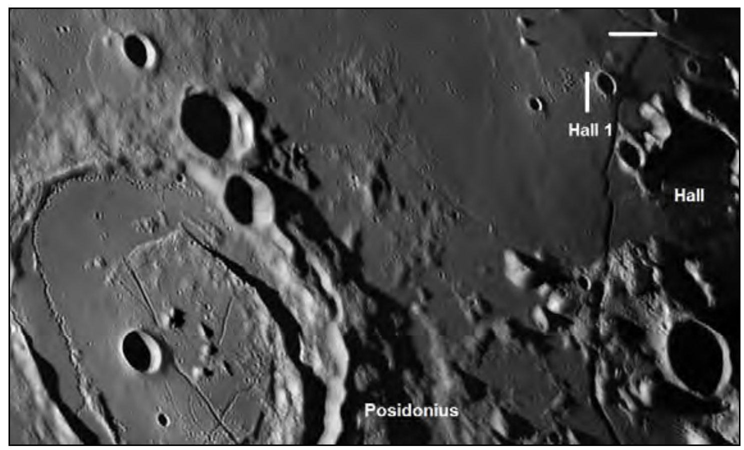


Figure 3. CCD image made on September 19, 2019 at 02:11 UT by Viladrich using a 355 mm Schmidt Cassegrain. Crop of the original image. The domes Luther1 (Luth1) and Posidonius1 (Pos1) are marked with white lines.

Figure 4. Image made with a DK 508 mm telescope on October 18, 2019 at 00:21 UT by Zannelli. Crop of the original image. The dome Hall1, located to the north of the crater Hall, is marked with white lines.

Teodorescu, Viladrich, Phillips, Schenck, Heinen and Eskildsen (**Table 1**).

The region near the crater Luther, located to northwest of Posidonius, is shown in **Figure 1**. The image was taken on October 18, 2019 at 00:21 UT by Zannelli using a DK 20" telescope with aperture of 508 mm f/14. For image acquisition a GS3-U32356M-C camera was employed.

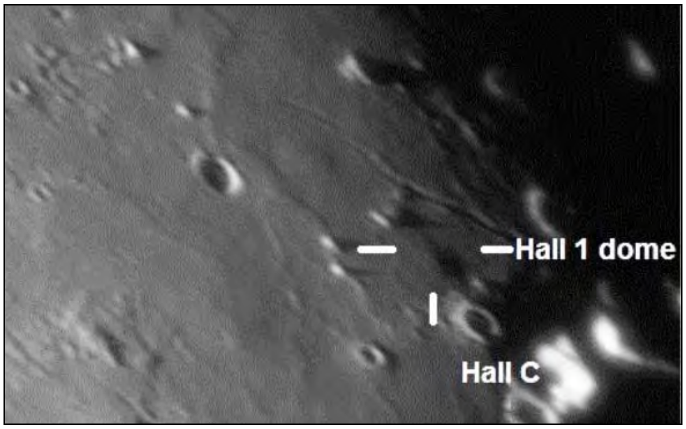
Another image of the domes Luther1 and Posidonius1 was made by Teodorescu on October 10, 2017 at 04:02 UT using a 355 mm Newtonian telescope and ASI 174MM camera (**Figure 2**).

Luther1 and Posidonius1 were imaged under lower solar illumination angle by Viladrich on September 19, 2019 at 02:11 UT using a 355 mm Schmidt Cassegrain telescope (**Figure 3**).

Figure 4 displays the dome Hall1. The image was taken on October 18, 2019 at 00:21 UT by Zannelli.

Figure 5 shows an image of Hall1 taken with a strongly oblique solar illumination angle. The image was made by Phillips on December 16, 2019 at 06:25 UT with a 254 mm Cassegrain telescope. In this image Hall1 displays the shadow cast on the lunar regolith. Based on this image the height is derived using the shadow measurement method and thus confirming indirectly the results obtained using shape from shading (SfS) method described below.

Additional images of the domes examined in this work are shown in **figures 20 through 23** at the end of this report.



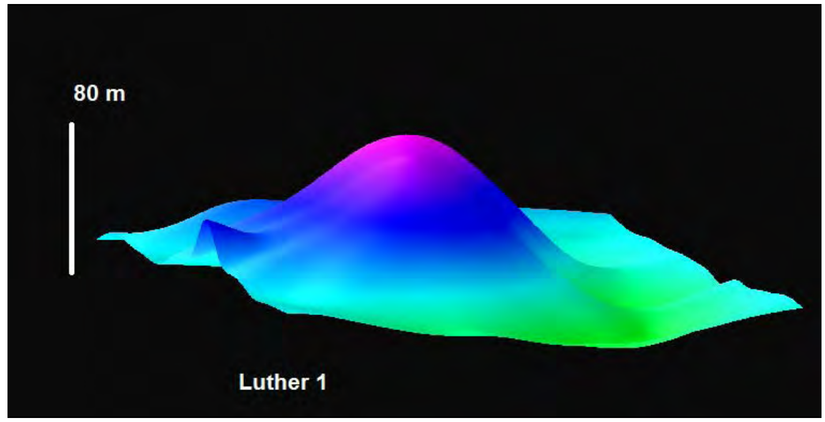


Figure 5. Image made on December 16, 2019 at 06:25 UT by Phillips using a 254 mm Maksutov. The dome Hall1, located to the north of the crater Hall, is marked with white lines. The domical shape of Hall1 is apparent in this image taken under grazing solar illumination angle.

Figure 6. 3D reconstruction of Luther1 based on terrestrial telescopic image of Figure 1 by photoclinometry and SfS analysis. The vertical axis is 30 times exaggerated.

Morphometric Properties

Digital Elevation Map Based on Telescopic Imagery and LOLA DEM

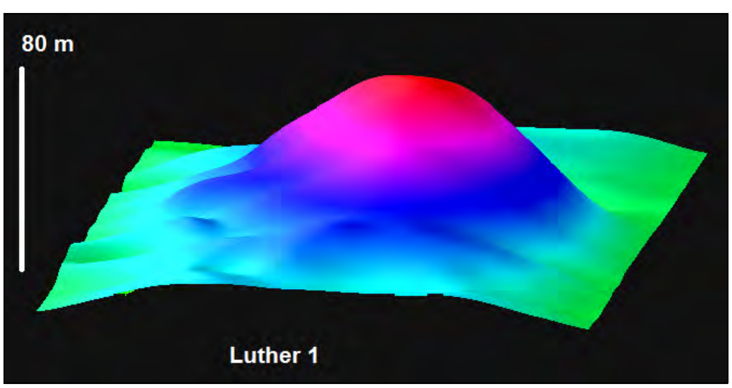
Generating an elevation map of a part of the lunar surface requires its three-dimensional (3D) reconstruction. A well-known image-based method for 3D surface reconstruction is shape from shading (SfS). This technique makes use of the fact that surface parts inclined towards the light source appear brighter than surface parts inclined away from it. The SfS approach aims to derive the orientation of the surface at each image location by using a model of the reflectance properties of the surface and knowledge about the illumination conditions, finally leading to an elevation value for each image pixel (Horn, 1989; Lena et al., 2013).

The height *h* of a dome is obtained by measuring the altitude difference in the reconstructed 3D profile between the dome summit and the surrounding surface, considering the curvature of the lunar surface. The average flank slope was determined according to:

slope = arctan $2h/D$

with "D" the diameter in km. The uncertainty results in a relative standard error of the dome height *h* of ±10 percent, which is independent of the height value itself. The dome diameter "D" can be measured at an accuracy of ± 5 percent. The 3D reconstruction of the dome Luther1 is shown in **figures 6 through 7**, while **Figure 8** depicts the 3D reconstruction of Hall1.

The cross sectional profile in E-W direction of Posidonius1 is shown in **Figure 9**.



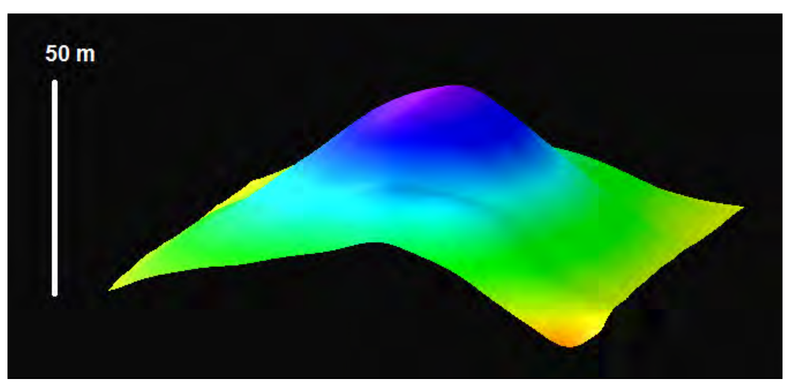


Figure 7. 3D reconstruction of Luther1 based on terrestrial telescopic image of Figure 2 by photoclinometry and SfS analysis. The vertical axis is 30 times exaggerated.

Figure 8. 3D reconstruction of Hall1 based on terrestrial telescopic image of Figure 4 by photoclinometry and SfS analysis. The vertical axis is 40 times exaggerated.

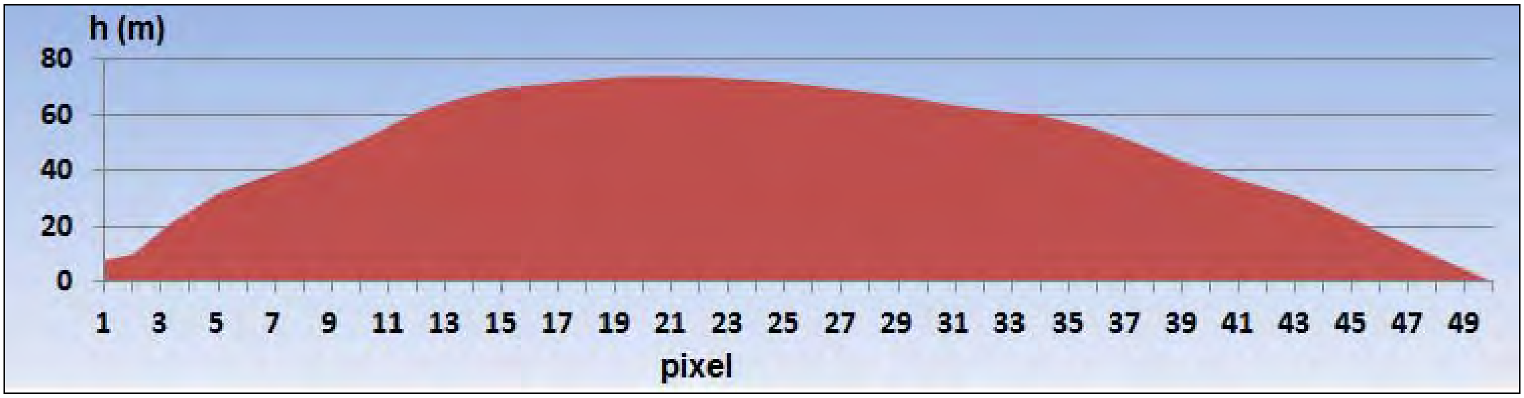


Figure 9. Cross-sectional profile of the shallow domical structure Posidonius1 described in the text, obtained using the combined photoclinometry and SfS method on the image shown in Figure 2 and regarding the central region of the feature excluding the hills located on the summit. The vertical axis is 40 times exaggerated.

The height of Hall1 was also computed from **Figure 5**, made by Phillips, using the shadow length method according using the equation

$h = l \tan \alpha$

where "*l*" is the shadow length, corrected for foreshortening and measured in km, and "tan α" the tangent of the solar altitude. This measurement was performed using LTVT software package by Mosher and Bondo (2006). Accordingly, a height of 45 m ± 5 m was obtained, in agreement with the derived result based on SfS (50 m ± 5 m).

We have also used the *ACT-REACT Quick Map* tool with the LOLA DEM dataset to obtain the cross-sectional profiles for the examined domes (**figures 10 through 12**). Note the agreement of the measurements carried out on our telescopic images and the LOLA DEM.

Comparison Between the Three-Dimensional Reconstructions Obtained From Ground-based Telescope and LROC Images

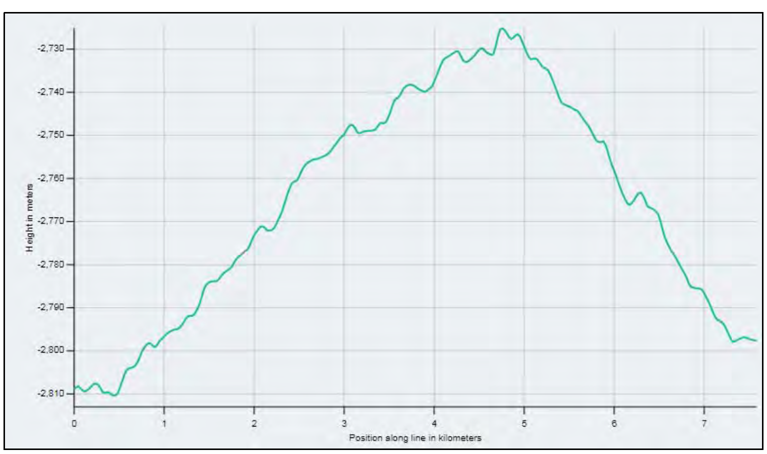
The images presented in **figures 1 through 5** highlight the continuing relevance of ground-based telescopic images. It is unlikely that these domes would have been as quickly recognized or their geological features subsequently characterized, without the images contributed by ground-based observers. These domes are not at all prominent on LROC WAC images. In fact, the corresponding 3D reconstructions based on GLD 100 dataset (**figures 13 through 15**) provide unsatisfactory results when compared to the 3D reconstructions obtained from telescopic images (**figures 6 through 8**).

Results and Discussion

Domes Luther1 and Hall1

Mode of Formation and Classification

The dome termed Luther1 is located at 24.89° E and 33.39° N, with a diameter of 7.5 km ± 0.3 km. The height is 80 ± 10 m, yielding an average flank slope of 1.1° ± 0.1°. The dome edifice volume is



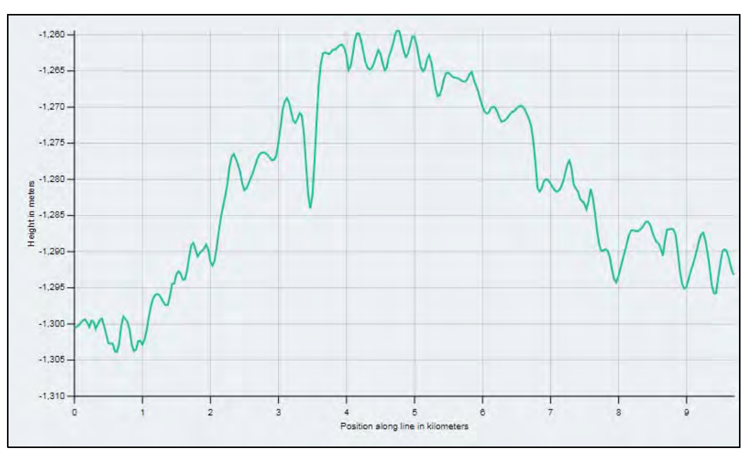
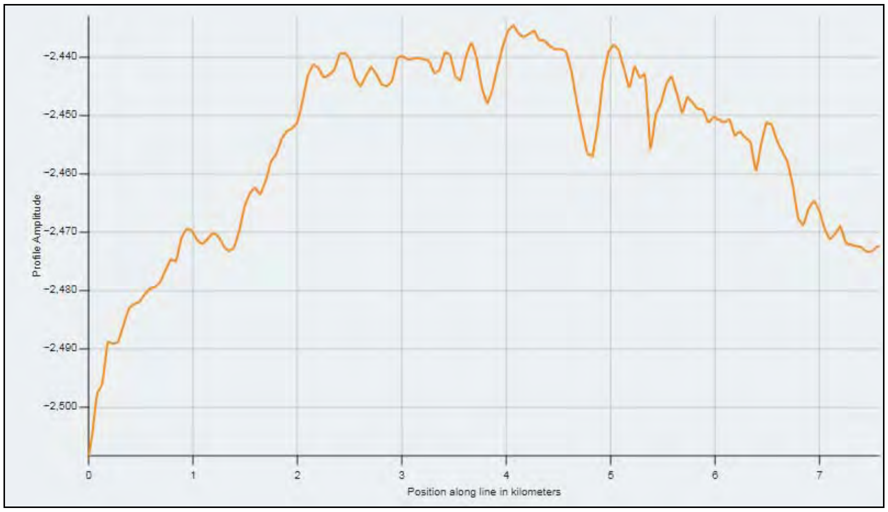


Figure 10. LRO WAC-derived surface elevation plot of Luther1 in East-West direction based on LOLA DEM.

Figure 11. LRO WAC-derived surface elevation plot in East-West direction of Hall1 based on LOLA DEM.



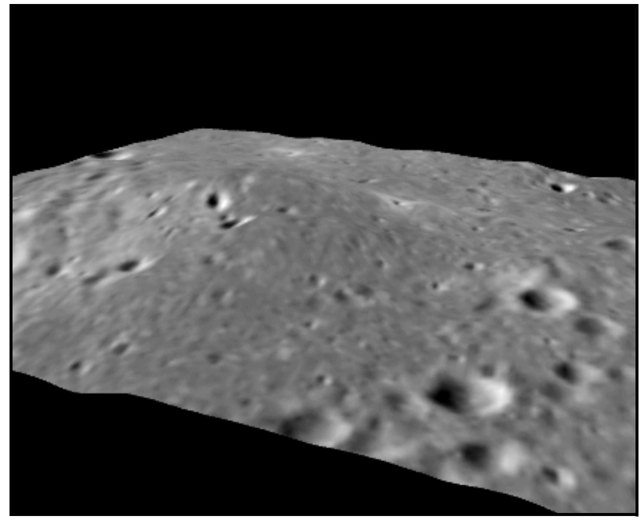
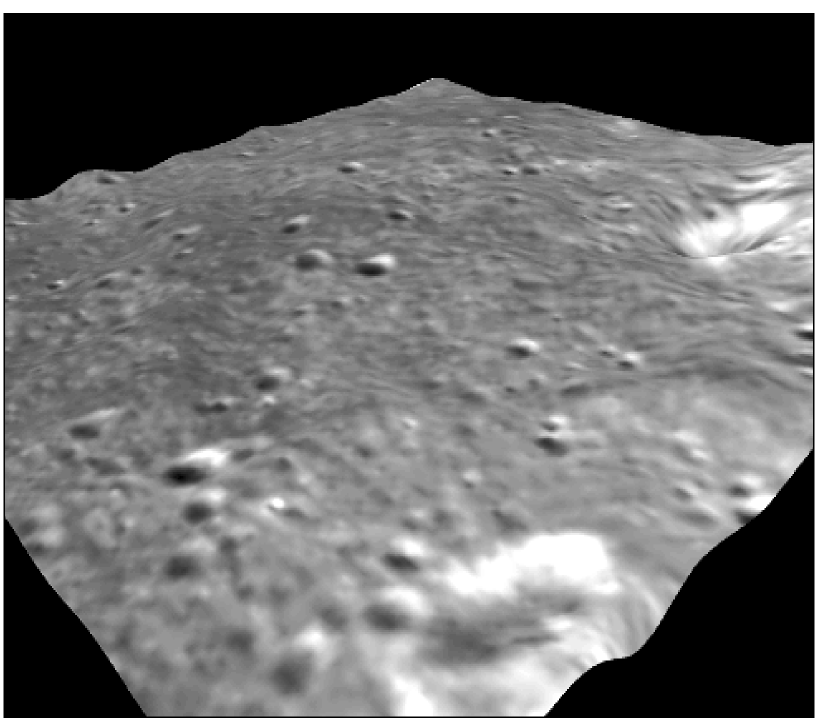


Figure 12. Topographic profile of the dome Posidonius1 (Pos1) using LOLA DEM. Elevation data for the hills and lobate scarps was not used for computing the overall flat surface of Pos1.

Figure 13. Luther1 3D reconstruction based on GLD100 dataset.

determined to be 1.9 km³ assuming a parabolic shape. The rheologic model (Lena et al., 2013; Wilson & Head, 2003) yields an effusion rate of 180 $m^3 s^{-1}$ and a lava viscosity of 9.5 x 10^4 Pa s (Pascal seconds). It formed over a period of time of 0.4 years. The Clementine UVVIS spectral data indicate a low TiO_2 content with a color ratio R_{415}/R_{750} = 0.6028. According to the classification scheme for lunar domes (Lena et al., 2013), Luther1 belongs to class C_2.

In the revised catalogue of lunar domes by Kapral and Garfinkle (2005), a dome described as "unverified" is reported at coordinates close to our data "24.83° E and 33.30° N", but with a diameter of 8.0 km and a height of 366 m (slope angle of 7°). Our measurements clearly indicate a different height, now determined to only 80 m. This effusive



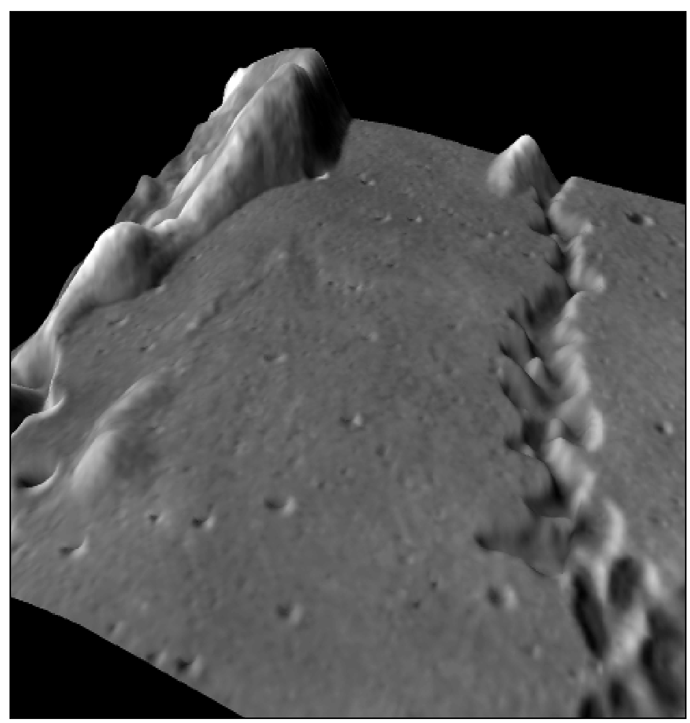


Figure 14. Hall1 3D reconstruction based on GLD100 dataset.

Figure 15. Posidonius1, 3D reconstruction based on GLD100 dataset.

dome is not reported in the USGS I-705 map by Scott (1972)

The dome Hall1, located to the north of the crater Hall, lies at coordinates 35.69° E and 35.12° N with a base diameter of 8.0 km ± 0.3 km. The height is 50 m ± 5 m, yielding an average flank slope of 0.80° ± 0.1°. The edifice volume is determined to 1.2 km^3. The rheologic model (Lena et al., 2013; Wilson & Head, 2003) yields an effusion rate of 290 $m^3 s^{-1}$ and lava viscosity of 1.2 x 10^4 Pa s. It formed over a period of time of 0.14 years. The Clementine UVVIS spectral data reveal a color ratio of R_{415}/R_{750} = 0.5591, indicating a low TiO_2 content. According to the classification scheme for lunar domes (Lena et al., 2013), the dome Hall1 belongs to class C_2 with a tendency towards class C_1.

In the revised catalogue of lunar domes by Kapral and Garfinkle (2005) a dome described as "unverified" is reported at coordinates "35.60° E and 35.02° N" without any data regarding diameter, height or slope. This dome is not reported in the USGS I-841 map by Grolier (1974).

Both domes lie in a region mapped as *Im2* unit in the 2013 renovation of the I-703 Wilhelms Geologic Map of the near side of the Moon, (Fortezzo and Hare, 2013), which denotes *Upper Imbrian* mare material (3.2-3.75 billion years ago). Thus Luth1 and Hall1 represent mare domes of *Imbrian* age. We have also used the *ACT-REACT Quick Map* tool to access to the mare age units. In the corresponding map of the Luther region, each polygon includes the unit name and crater size-frequency distributions model age (Hiesinger et al., 2011). For Luther1, the model ages indicates an age of 3.40 billion years ago. No data are available for Hall1 but, presumably, it has similar age of Luther1, based on a rough crater count.

The identification of possible source vents is inconclusive and is suggested as candidates on the basis of subdued morphology of some features. However, many effusive lunar domes do not display any signatures of a summit vent when their associated conduits are plugged by the ascending lava (Lena et al., 2013).

Three rheologic groups of effusive lunar mare domes differ from each other by their rheologic properties and associated dike dimensions, where the basic discriminative parameter is the lava viscosity (Lena e al., 2013).

- The first group, R_1, is characterized by lava viscosities of 10^4 -10^6 Pa s, magma rise speeds of 10^{-5}-10^{-3} m s^1, dike widths around 10-30 m, and dike lengths between about 30 and 200 km.
- Rheologic group R_2 is characterized by low lava viscosities between 10^2 and 10^4 Pa s, fast magma ascent (U > 10^{-3} m s^{-1}), narrow (W = 1-4 m) and short (L = 7-20 km) feeder dikes.
- The third group, R_3, is made up of domes which formed from highly viscous lavas of 10^6-10^8 Pa s, ascending at very low speeds of 10^{-6} - 10^{-5} m s^{-1} through broad dikes of several tens to 200 m width and 100-200 km length.

Dome Luther1 was formed from lava ascending at speed of 1.5x10^{-4} m s^{-1} through a dike 16 m width and 70 km length. Dome Hall1 was formed from

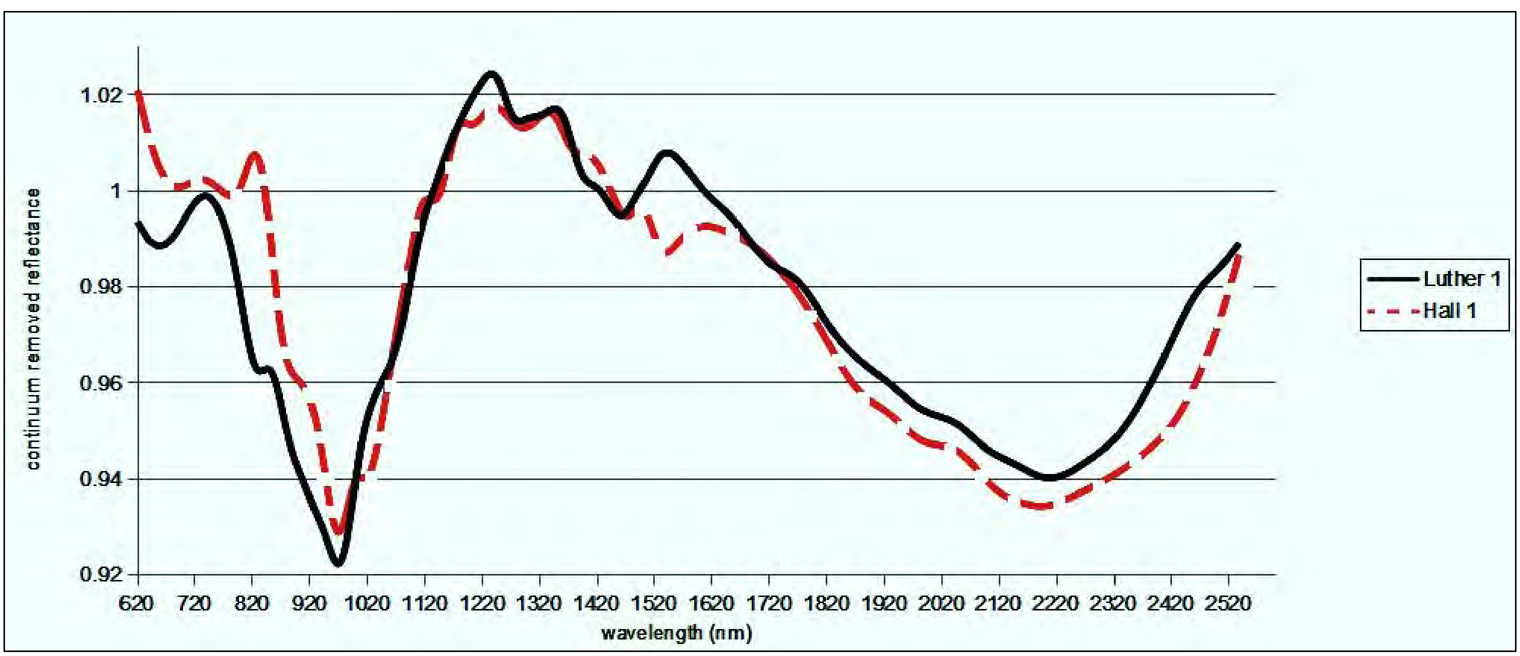


Figure 16. Chandrayaan-1 Moon Mineralogy Mapper, spectral analysis.

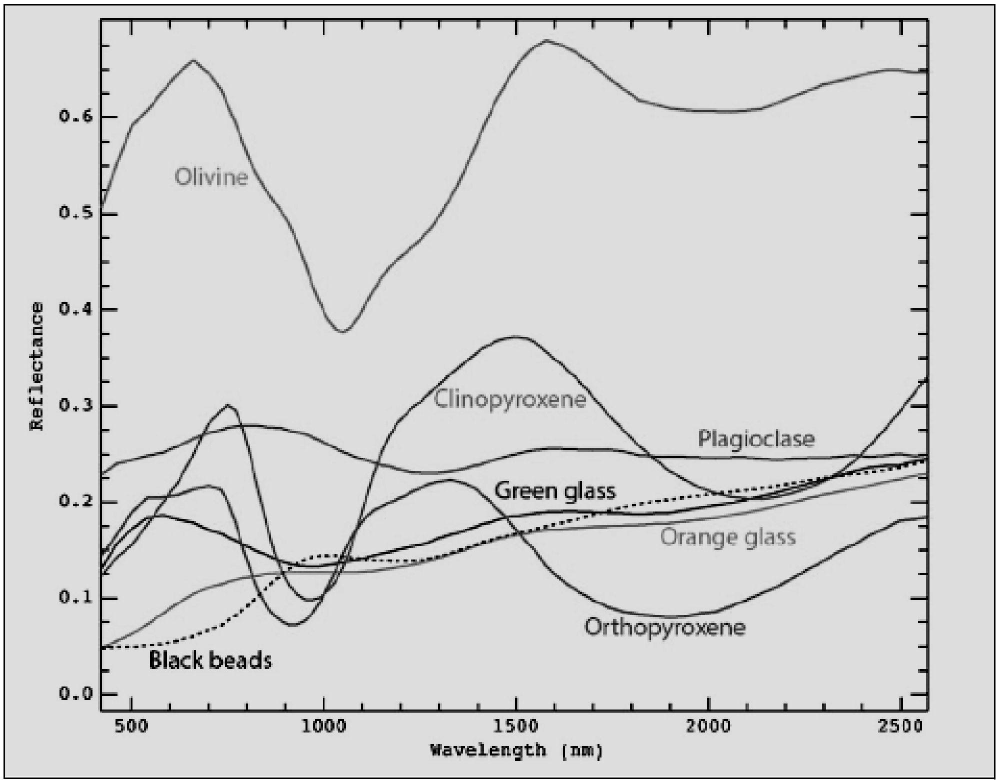


Figure 17. Spectral properties of major lunar minerals, including volcanic glasses.

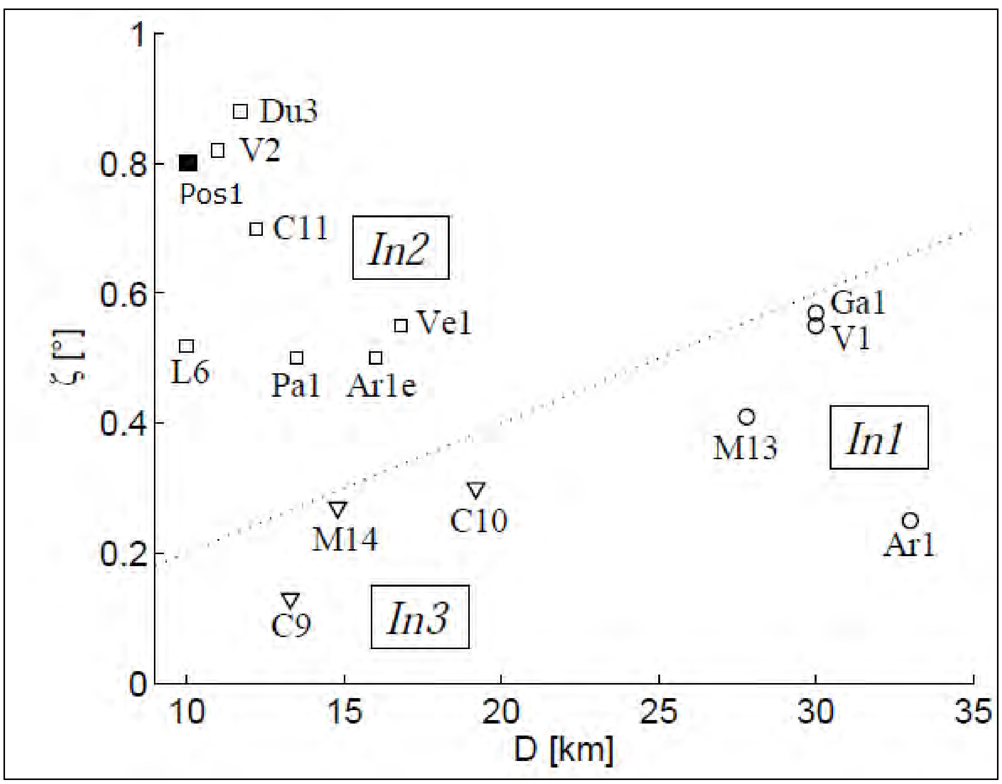


Figure 18. Diameter vs. flank slope diagram illustrating the three established morphometric classes of lunar intrusive domes. Circles, squares, and triangles denote the domes of the classes In1, In2 and In3, respectively. Posidonius1 (Pos1) is shown as a black square in the upper left.

lava ascending at speed of 8.3×10^{-4} m s^{-1} through a dike 10 m width and 37 km length. Thus these two domes belong to rheologic group R_1.

Spectral Analysis

The Lunar Reconnaissance Orbiter's (LRO) Diviner Lunar Radiometer Experiment (spatial resolution of 950 m/pixel) produces thermal emissivity data, and provides compositional information from three wavelengths centered at 7.00, 8.25, and 8.55 µm that are used to characterize the Christiansen Feature (CF), which is directly sensitive to silicate mineralogy and the bulk SiO_2 content. The major minerals of lunar soils - plagioclase, pyroxene, and olivine - have different ranges of CF values (Greenhagen, 2010). The feldspar and high silicic material, including quartz, silica-rich glass, and alkali and ternary feldspars, are characterized by CF values of 7.8-7.3 µm. In cases where olivine is abundant the CF values is >8.7 µm (Greenhagen, 2010). We used the ACT-React Quick Map to infer the CF map derived from Diviner.

Analyses of the Diviner CF map for the domes reveals that they do not display the short wavelength CF position characterizes silica-rich lithologies like the Gruithuisen domes. The average CF position of Luther1 and Hall1 domes is 8.35 ± 0.05 µm; this value is not different from the average CF position of the typical basaltic *maria*, which is 8.30-8.40 µm. Hence, the examined domes are not enriched in silica relative to the surrounding mare units and display a classic basaltic composition.

TiO_2 and FeO contents of the domes are estimated utilizing the Selene Multiband Imager (MI) data. MI is a high-resolution multispectral imaging instrument (Lemelin et al., 2016). It has five visible (VIS) bands (415 nm, 750 nm, 900 nm, 950 nm, and 1,000 nm) and four near-infrared bands (1,000 nm, 1,050 nm, 1,250 nm, and 1,550 nm). The VIS bands of MI have the same center

Figure 19. NAC imagery. Small scale grabens on the crater floor of Posidonius and in the region of the dome Posidonius1.

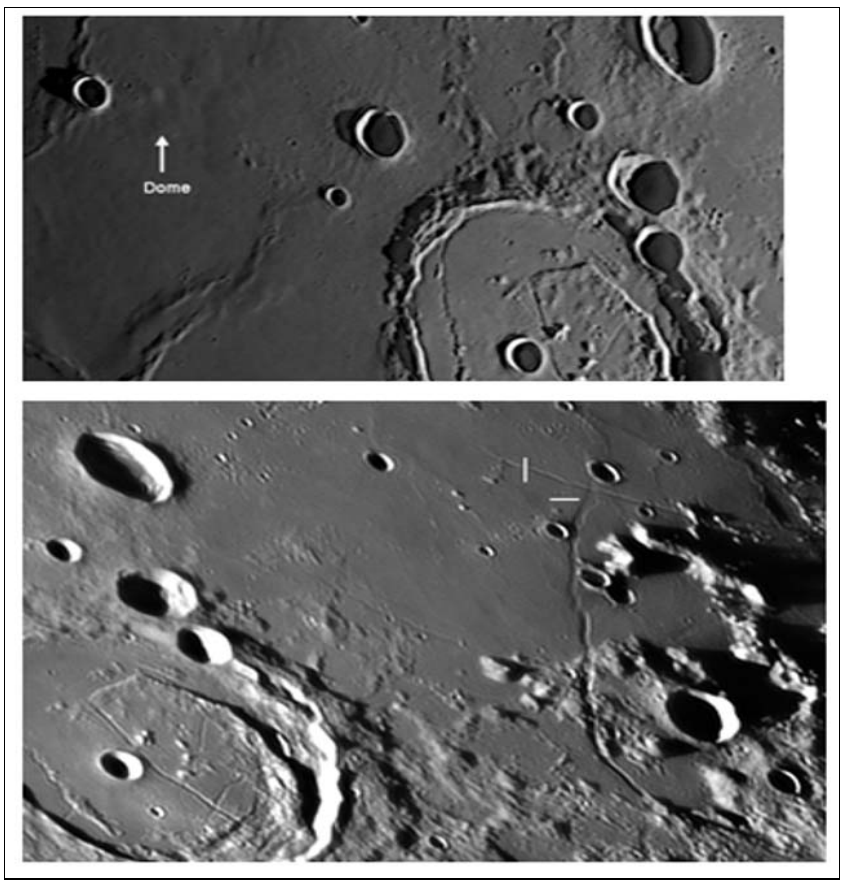


Figure 20. Images of the domes Luther1 (top, Schenck with 355 mm Schmidt Cassegrain) and Hall1 (bottom, Eskildsen using a 235 mm Schmidt Cassegrain).

wavelengths as those of the Clementine UV/VIS camera but have much higher spatial resolution (20 m/pixel) (Kodama et al., 2010).

The TiO_2 content of Luth1 and Hall1 is determined to be 1.1 wt%. The FeO content of the domes amounts to 15.0 wt% for Luth1 and 14.7 wt% for Hall1. Similar values for TiO_2 and FeO content are obtained in nearby mare units.

Composition

We obtained the spectral data using Chandrayaan-1 Moon Mineralogy Mapper (M^3), an imaging reflectance spectrometer that can detect 85 channels between 460 and 3,000 nm. Data have been obtained through the M^3 calibration pipeline to produce reflectance with photometric and geometric corrections using image set taken during the optical period OP2C1. A continuum removal method that enhances the features in the 1,000 nm absorption band and more accurately shows the position of the band centre has been used. We fit a straight line between 750 and 1,500 nm to remove the continuum.

The spectra (**Figure 16**) display a narrow trough around 1,000 nm with a minimum wavelength at 975 nm and an absorption band at 2,130 nm for Hall1 and 2,160 nm for Luth1, corresponding to a typical high-Ca pyroxene signature (Besse et al., 2014), indicating a basaltic composition.

The spectral properties of major lunar minerals, including volcanic glasses, are shown in **Figure 17**. These minerals exhibit absorption bands that differ by their shape and position along the spectral domain. Pyroxenes (orthopyroxenes and clinopyroxenes) have two absorption bands, one centered near 1,000 nm and another near 2,000 nm.

The Pyroxene is the major mafic mineral of basalt. According to the FeO and TiO_2 content (~15 wt% and ~1.1 wt% in average, respectively), we can infer that the main rock type of the examined domes is low-Ti basalt.

Dome Posidonius1

Mode of formation and classification

Using the LROC GLD100 dataset, French et al. (2015) identify a domical feature, located near the western rim of Posidonius. If an igneous intrusion occurred near the western rim of Posidonius, as proposed by French et al. (2015), a slightly elevated terrain should be detected as an up-bowing of the regolith, which we have confirmed using earth-based telescopic images taken under oblique solar illumination angles.

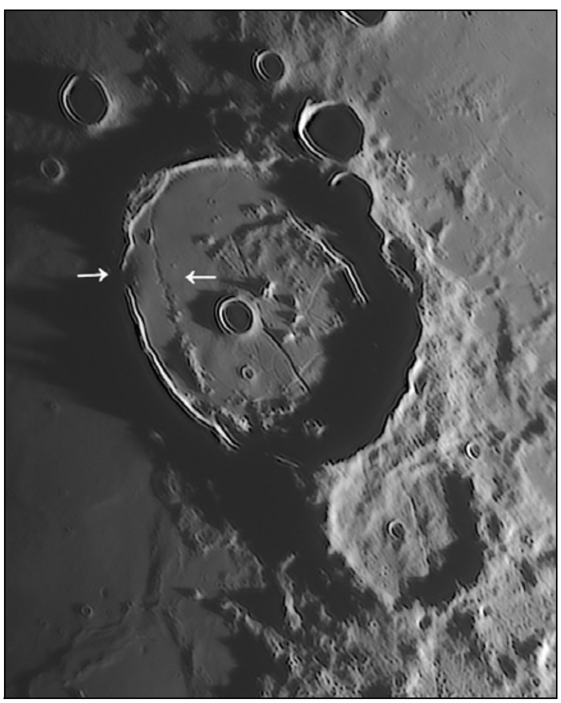
Pos1 is located at 28.26° E and 32.02° N. The height measured on the terrestrial image of **Figure 2** is 74 ± 10 m, its diameter measures 8.0 x 11.2 km, resulting in an average flank slope of 0.8° ± 0.08°. In the LOLA DEM, the elevation difference between the centre of Pos1 and the surrounding surface corresponds to 65 ± 10 m (**Figure 12**), which is in agreement with the terrestrial image-based photoclinometry and shape from shading analysis. Assuming a parabolic dome shape the edifice volume corresponds to about 2.2 km^3. It has an elongated shape with circularity (minor axis/major axis) of 0.72.

A reliable discriminative criterion in the dome classification is the circularity of the dome outline: the putative intrusive domes are elongated and with low slopes (< 0.9°).

- Class In1 comprises large domes with diameters above 25 km and flank slopes of 0.2°–0.6° and have linear or curvilinear rilles traversing the summit.
- Class In2 is made up by smaller and slightly steeper domes with diameters of 10–15 km and flank slopes between 0.4° and 0.9°.
- Class In3 comprises low domes with diameters of 13-20 km and flank slopes below 0.3°.

Figure 18 displays the diameter vs. flank slope diagram illustrating these three established morphometric classes of lunar intrusive domes (Lena et al., 2013; Wöhler & Lena, 2009). The dome Pos1 matches the properties derived for putative intrusive dome belonging to class In2 and according to French et al. (2015) an origin due to a subsurface intrusion of a magmatic body is most plausible.

The laccolith model by Kerr and Pollard (1988) has been used to estimate the geophysical parameters, especially the intrusion depth and the magma pressure, which would result from the observed morphometric properties. As introduced by Lena et al. (2013) and Wöhler & Lena (2009) intrusive domes of class In1 are characterized by uppermost basaltic layer thicknesses larger than about 0.3-0.6 km, intrusion depths of 2.3–3.5 km and magma pressures between 18 and 29 MPa. For the smaller and steeper domes of class In2, the uppermost basaltic layer is typically only 0.1-0.2 km thick, the magma intruded to shallow depths between 0.4 and 1.0 km while the inferred magma pressures range from 3 to 8 MPa. Class In3 domes are characterized by thicknesses of the



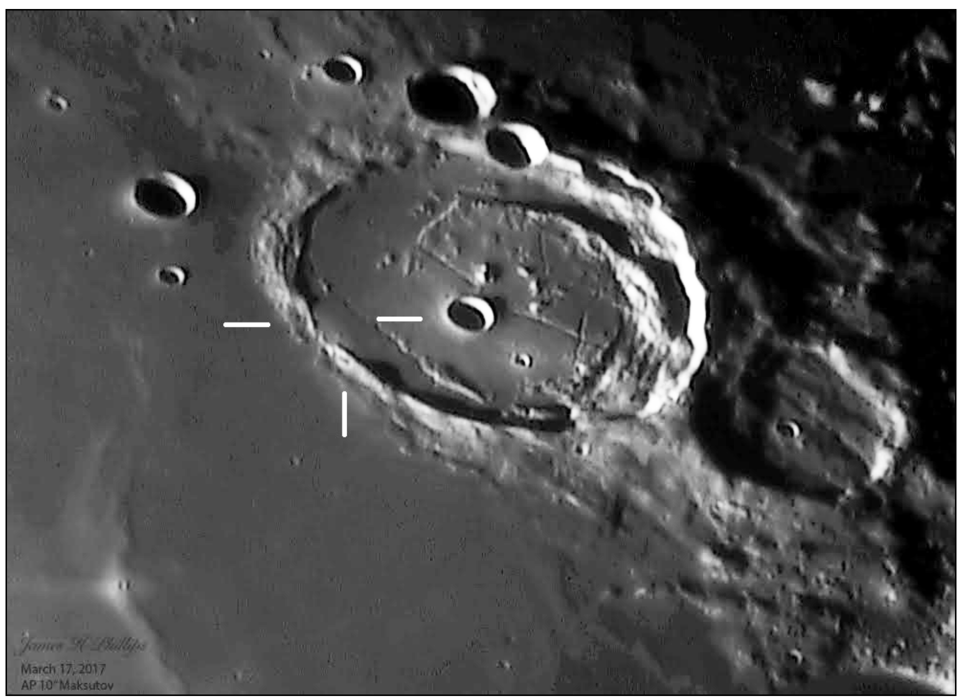


Figure 21. Image of Posidonius1 using a 355 mm Schmidt-Cassegrain (Schenk).

Figure 22. Image of Posidonius1 using a 254 mm Maksutov (Phillips).

uppermost basaltic layer of 0.4-1.2 km, intrusion depths of 1.8–2.7 km and magma pressures of 15–23 MPa.

The laccolith model applied to Posidonius1 yields intrusion depth of 0.36 km, uppermost basaltic layer thicknesses of 0.205 km and maximum magma pressure in the laccolith of 2.7 MPa, thus consistent with an igneous intrusion in the range of class In2 domes and indicating that laccolith formation proceeded until the stage characterized by flexure of the overburden.

The dome also displays small non-volcanic hills on the surface, which are characterized by heights of less than a hundred meters, suggesting that the dome formed around pre-existing non-volcanic hills. A hill in the centre of the laccolith, or also laterally, should reduce the tensional stress resulting from the strong bending of the overburden due to the steeper flank slope of Pos1 if compared with the large In1 domes, and thus preventing deep fracturing (which would be detectable as large graben in terrestrial telescopic images) and subsequent eruption of the pressurized magma.

The up-bowing of the soil, detected in the telescopic images, confirms the assumption reported by French et al. (2015) that an igneous intrusion occurred in this region.

The presence of small-scale grabens (detectable only on NAC imagery) is a characteristic signature trace of the laccolith-forming intrusion of pressurized magma between rock layers of the lunar crust (**Figure 19**). The laccolith model yields an uppermost basaltic layer thicknesses of 205 m, in accordance with the 190 m reported by French et al. (2015) for the small graben groups in Posidonius.

These small-scale grabens exhibit crisp morphology and are not superposed by craters, thus indicating younger age if compared with the age of Posidonius (*Upper Imbrian* age 3.2-3.75 billion years ago). These observations show that Posidonius has been the focus of volcanic activity over a considerable period of time, with an initial intrusive FFC phase followed by a much later and unconnected intrusive phase that produced the uplift discussed above. Effusive surface activity is represented by the mare like units which erupted onto the western floor, and the sinuous rille where a turbulent lava flow eroded down through this unit to produce the tortuous channel visible today.

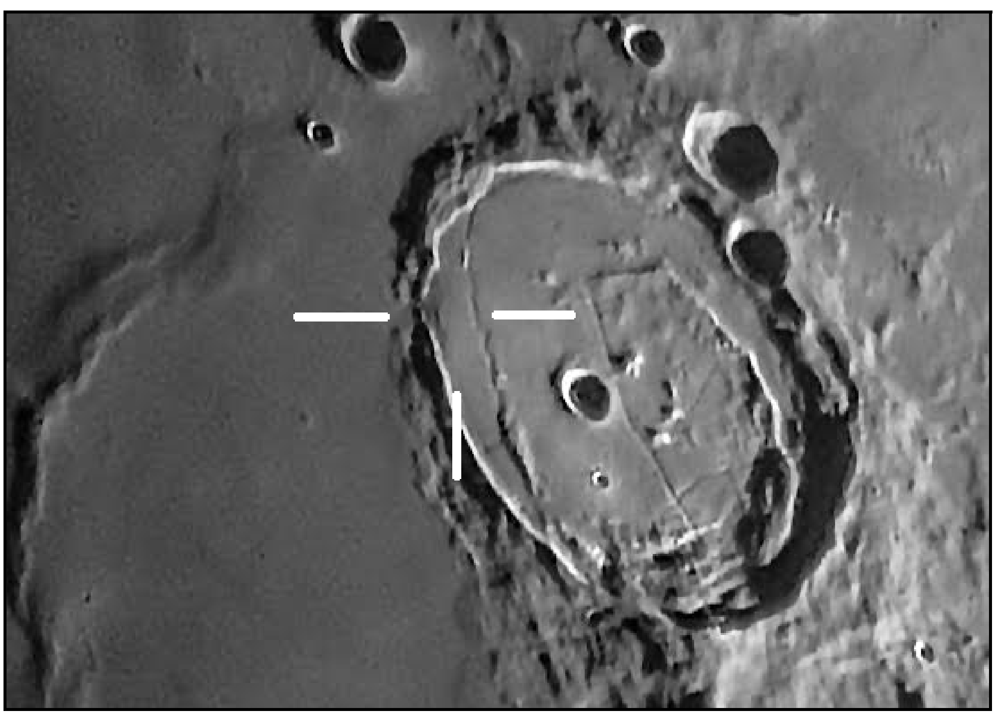


Figure 23. Image of Posidonius1 using a 235 mm Schmidt-Cassegrain (Heinen).

Spectral analysis and composition

The CF position of Pos1 is 8.20 ± 0.05 µm indicating a basaltic composition with admixed highland component due to ejecta contamination from the youngest Posidonius A impact crater. The M^3 spectrum of Pos1 displays a typical high-Ca pyroxene signature with a minimum wavelength at 985 nm and an absorption band at 2,170 nm. According to the FeO and TiO_2 content (~14 wt% and ~1.1 wt% in average, respectively), we can infer that the main rock type of the examined intrusive dome is low-Ti basalt.

Summary and Conclusion

In this study, we have examined a complex lunar volcanic region composed of two effusive lunar domes which we named Luther1 and Hall1. Factors governing the morphological development of volcanic edifices are interrelated, including the viscosity of the erupted material, its temperature, its composition, the duration of the eruption process, the eruption rate and the number of repeated eruptions from the vent. The viscosity of the magma depends on its temperature and composition. Thus, the steeper domes represent the result of cooler, more viscous lavas with high crystalline content. On the Earth, low and flat edifices such as the large Icelandic shield volcanoes, are formed by basaltic lavas, while more viscous andesitic and rhyolitic lavas with higher silica content tend to build up steep volcanic edifices (Lena et al., 2013). Because of the low silica and alumina content and high iron and titanium content, the lunar basalt lavas had a higher temperature, lower viscosity, and higher density than terrestrial basalt lavas. Temperature has a strong influence on viscosity: as temperature increases, viscosity decreases - an effect particularly evident in the lava flows. Based on morphometric and spectral data Luther1 belongs to class C_2 in the classification scheme for lunar domes, while Hall1 belongs to class C_2 with a tendency towards class C_1.

Relying on ground-based high-resolution telescopic imagery acquired under a variety of illumination conditions (**figures 1 through 5 and 20 through 23**), we have examined the morphometric characteristics of the domical structure situated in Posidonius (Posidonius1). The up-bowing of the soil detected in the telescopic images confirms the assumption reported by French et al. (2015) that an igneous intrusion occurred in this region forming Posidonius1. The laccolith model applied to Posidonius1 is consistent with an igneous intrusion in the range of class In2 domes and indicating that laccolith formation proceeded until the stage characterized by flexure of the overburden.

References

Besse, S., J. M. Sunshine, and L. R. Gaddis (2014), "Volcanic glass signatures in spectroscopic survey of newly proposed lunar pyroclastic deposits." *Journal of Geophysical Research: Planets,* Vol. 119, doi:10.1002/2013JE004537. Abstract available at: *https://ui.adsabs.harvard.edu/abs/2014JGRE..119..355B/abstract*

Fortezzo, C. M. and Hare, T. M. (2013). "Completed Digital Renovation of the 1:5,000,000 Lunar Geologic Map Series." LPSC XLIV Abstract #2114. Available at: *https://astropedia.astrogeology.usgs.gov/download/Moon/Geology/Ancillary/LunarGeologic_Renovation_Fortezzo_LPSC2013.pdf*

French, R. A., Bina, C. R, Robinson, M. S., Watters, T. R. (2015). "Small-scale lunar graben: distribution, dimensions", and formation processes. *Icarus*, Vol. 252 pp. 95–106. Available at: h*ttps://doi.org/10.1016/j.icarus.2014.12.031*

Greenhagen, B.T., Lucey, P. G., Wyatt, M.B., Glotch, T. D., Allen,C.C., Arnold, J. A., Bandfield, J. L., Bowles, N. E., Donaldson Hanna, K. L., Hayne, P. O., Song, E., Thomas, I. R., Paige, D. A., (2010). "Global Silicate Mineralogy of the Moon from the Diviner Lunar Radiometer." *Science*, Vol. 329, pp. 1507-1509. doi: 10.1126/science.1192196. Abstract available at: *https://ui.adsabs.harvard.edu/abs/2010Sci...329.1507G/abstract*

Grolier, M. J. (1974). USGS Lunar Map I-841. See: *https://www.lpi.usra.edu/resources/mapcatalog/usgs/I841/72dpi.jpg.*

Head, J. W., "Lunar volcanism in space and time", (1976). R*eviews of Geophysics and Space Physics*, Vol. 14, pp. 265-300. See also: *https://www.lpi.usra.edu/meetings/lro2009/pdf/6024.pdf*

Hiesinger, H., Head III, J. W., Wolf, U., Jaumann, R., Neukum, G. (2011) "Ages and stratigraphy of lunar mare basalts: A synthesis", *Geological Society of America Special Papers* 477, 1-51. *doi:10.1130/2011.2477(01)*

Horn, B. K. P., (1989). "Height and Gradient from Shading." MIT technical report 1105A. *http://people.csail.mit.edu/people/bkph/AIM/AIM-1105A-TEX.pdf*

Kapral, C., Garfinkle, R., 2005: GLR *Lunar Dome Catalog*. Available at: *http://digilander.libero.it/glrgroup/kapralcatalog.pdf*

Kerr, A.D., Pollard, D.D., (1998). "Toward more realistic formulations for the analysis of laccoliths". *Journal of Structural Geology*, Vol. 20 No. 12, pp. 1783–1793. Abstract available at: *https://www.sciencedirect.com/science/article/abs/pii/S0191814198000716?via%3Dihub*

Kodama, S., et al. (2010), "Characterization of Multiband Imager aboard SELENE", *Space Science Review*, 154(1–4), 79–102, doi:10.1007/s11214-010-9661-z

Lemelin, M., Lucey, P.G., L.R. Gaddis, T. Hare, and M. Ohtake (2016). Global map products from the Kaguya Multiband Imager at 512 ppd: Minerals, FeO and OMAT. 47th LPSC, abs. #2994. *http://www.hou.usra.edu/meetings/lpsc2016/pdf/2994.pdf*

Lena, R., Wöhler, C., Phillips, J., Chiocchetta, M.T. (2013). *Lunar Domes: Properties and Formation Processes*, Springer Praxis Books. https://www.springer.com/gp/book/9788847026360

Mosher, J., & Bondo, H., 2006. *Lunar Terminator Visualization Tool (LTVT)*. See: *https://github.com/fermigas/ltvt/wiki*

Scholten, F., Oberst, J., Matz, K.-D., Roatsch, T., Wählisch, M., Speyerer, E.J., Robinson, M.S., (2012). "GLD100: the near-global lunar 100 m raster DTM from LROC WAC stereo image data." *Journal of Geophysical Research: Planets*, Vol. 117(E00H17). Available at: *https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2011JE003926*

Schott, D., H., (1972). "Geologic map of the Eudoxus Quadrangle of the Moon" (USGS I-705, LAC-26). Available at: *https://www.lpi.usra.edu/resources/mapcatalog/usgs/I705/72dpi.jpg*

Wilson, L. and J. W. Head, (1981). "Ascent and eruption of basaltic magma on the Earth and Moon", *Journal of Geophysical Research*, Vol. 86, pp. 2971-3001. Abstract available at: *https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/JB086iB04p02971*

Wöhler, C., Lena, R., (2009). Lunar intrusive domes: Morphometric analysis and laccolith modelling, Icarus, Vol. 204, No. 2, 2009, pp. 381-398. *https://doi.org/10.1016/j.icarus.2009.07.031*

Papers & Presentations

Some Considerations About Visual Observation of Wrinkle Ridges On The Moon

Alberto Anunziato,
acting assistant coordinator,
ALPO Lunar Topographical Studies Program
albertoanunziato@yahoo.com.ar

For me, the typical lunar observing night always begins with observing the lunar features suggested by the *Lunar Observing Schedule* of the British Astronomical Assn's "Lunar Geological Change Detection Program." Then, the walk through the main attractions of the evening begins.

Generally I go to visit "the land of long shadows," that is, the areas of the terminator in which the highlights and shadows appear sharply defined, as in an expressionist film noir: the maria. The first reason is aesthetic, as Thomas Elger said: "Most observers will agree with Schmidt, that observations and drawings of objects on the somber depressed plains of the Moon are easier and pleasanter to make than on the dazzling highlands, and that the lunar "sea" is to the working selenographer like an oasis in the desert to the traveller — a relief in this case, however, not to an exhausted body, but to a weary eye" (Elger, 1895). In that landscape, tiny mountain ranges stand out under a rising Sun. As for the wrinkle ridges, also known as "dorsa," Elger notes that "at this stage of illumination, they are strikingly beautiful in a good telescope, reminding one of the ripple-marks left by the tide on a soft sandy beach" (ibid. P. 7).

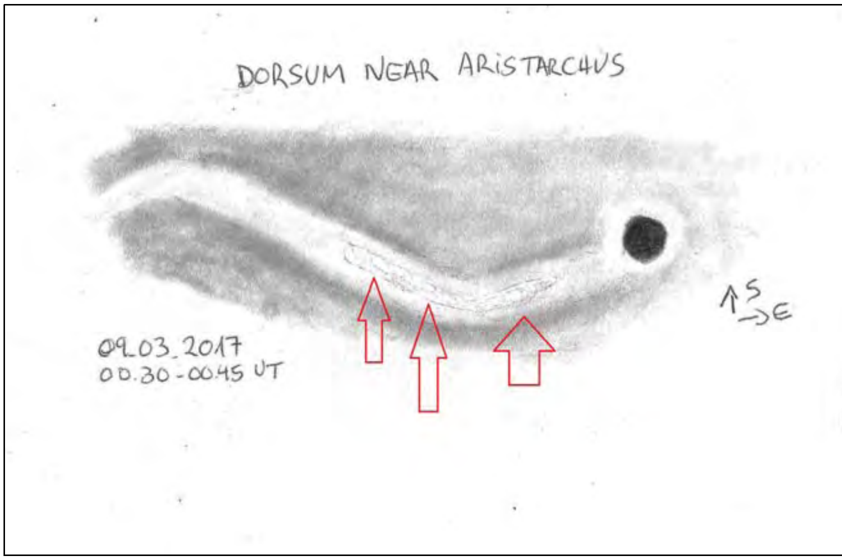
Wrinkle ridges are common features on the Moon, Mercury, Venus, Mars and our planet. What would wrinkle ridges look like from the surface of the Moon? On Earth, features that are morphologically similar to wrinkle ridges on the Moon and Mars occur where thrust faults have broken the surface (Plescia and Golombek, 1986), such as the 37km-long fault scarp produced by the 1968 Meckering earthquake in Australia, or the Tien Shan thrust fault in Kazakhstan (**Figure 1**). Elger believed that the most similar-looking landscape on our planet is that of the mounds known as "kames" in Scotland and "eskers" in Ireland, alluvial deposits of glacial origin (Elger, 1895). On the Moon, they have an average width of 3.70 km. and an average height of 300 meters (Yue et al., 2015).

In addition to the aesthetic pleasure of observing features that are "very evanescent, gradually disappearing as the Sun rises higher in the lunar firmament, and ultimately leaving nothing to indicate their presence beyond here and there a ghostly streak or vein of a somewhat lighter hue than that of the neighboring surface" (as Elger says, page 7), the observation of wrinkle ridges offers a series of details that cannot be found in atlases or even in images obtained in lunar orbit with frontal light.

Wrinkle ridges do not have much prominence in photographic atlases and generally few details are observed in their images. Even in the Lunar 100 list of observable features, we find only one — Serpentine Ridge, Lunar 33. Beyond aesthetic pleasure, another reason to visually observe wrinkle ridges is that we can perceive with a small telescope

Figure 1. The Tien Shan thrust fault in Kazakhstan is morphologically similar to lunar wrinkle ridges. (*Photo credit: Christoph Gruetzner*).

(always near the terminator) details of structure that are not found, for example, in the *Virtual Moon Atlas* or Antonin Rükl's *Atlas of the Moon*. In the sketches, I register everything I see as far as possible, since the hand that draws is more clumsy than the eye that observes. But I experienced an annoying feeling whenever I drew structures or details that I could not find in atlases or books. It was only after reading a wonderful work (*The Modern Moon: A Personal View* by Charles Wood, 2003) that I was freed from this feeling. "One of the ironies of lunar observing is that a homemade 6-inch reflector is capable of revealing much of the detail that can be photographed through the largest telescopes on Earth.... Your brain can discard the periods of fuzzy seeing and concentrate on the fleeting moments of



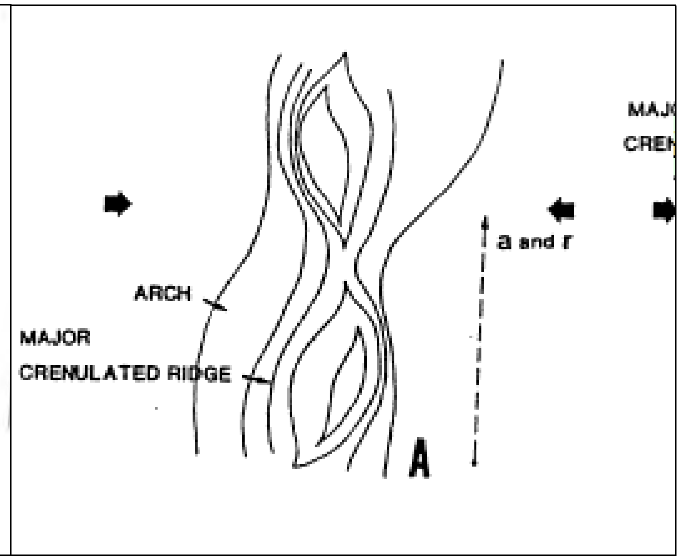
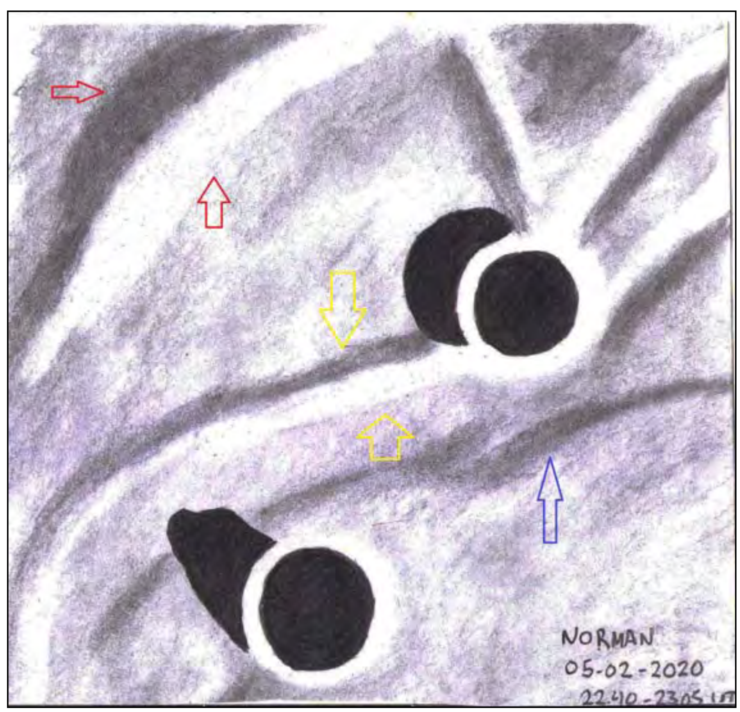


Image 1. (Above left) Dorsum near Aristarchus. Date and time of observation: Sept. 03, 2017, 00:30 to 00.45 UT. All images (except Figure 1) by Alberto Anunziato, of Paraná, Argentina, using a 105 mm. Maksutov-Cassegrain (Meade EX 105), magnification 154x.

Image 2. (Above right) Schematic morphologic map of a typical lunar wrinkle ridge showing the arch and crenulated ridge components (From: Aubele, 1989, Figure 1).

Image 3. (Below left) Luther. Date and time of observation: May 02, 2017, 01:30 to 02.00 UT.

Image 4. (Below right) Norman and Euclides C. Date and time of observation: April 28, 2020, 22.40 to 23.05 UT.



sharp viewing", says Wood (page XIV), which applies especially to maria: "The surfaces of lunar maria are typically so flat that you have to look closely to see any relief. But because the Moon lacks any significant atmosphere to dim and diffuse the Sun's rays, every small crater rim and hillock casts a long black shadow when the Sun is low. This 'shadow magnification' permits viewing many fine details that provide information unavailable from studies of mare surfaces under higher illumination… with 'shadow magnification', you can see vertical features only 25 to 50 meters high because they cast shadows thousands of meters long! Cruise the terminator with high magnification, and if the seeing is steady, you will be rewarded with details unknown to scientists who study only Lunar Orbiter photographs that are compromised by their relatively higher Sun angles (Wood, 2003, p. 42).

Image 5. Euclides D. Date and time of observation: May 31, 2020, 22.20 to 22.45 UT.

Charles Wood gave me confidence that I was recording details of wrinkle ridges that I couldn't find in the available images, thanks to shadow magnification. It was also in *The Modern Moon*, where, for the first time, I found an explanation for the differences in brightness and shadows that I observed in the wrinkle ridges.

The most interesting example of visual observation that distinguishes between arch and crest is a wrinkle ridge near Aristarchus (**Image 1**), in an area with numerous concentric wrinkle ridges. This sketch was forgotten in my observation diary, probably because I did not accurately indicate the crater that intersects the wrinkle ridge; it was the last observation of the night and I probably had some urgent reason (such as a 'biobreak') that prevented me from completing a full record. The wrinkle ridges near Aristarchus are spectacular and in this example, we can see how the crest appears brighter and very similar to the drawing that accompanies Aubele's text (**Image 2**).

In the drawing of a wrinkle ridge that intersects Luther crater (**Image 3**), we can also see two brighter areas that would be the crest on the arch. Another interesting drawing is one of the many ridges in the vicinity of Norman and Euclid C (**Image 4**); the red arrows indicate an elevation in the center of the illuminated area that is reflected in the shadow that projects what would be the crest of the ridge.

Distinguishing the two components of a wrinkle ridge with a small telescope is not easy, and we may be able to observe only the crests that rise well above the arch.

The most prominent feature that we can observe in a wrinkle ridge that gives us an idea of its height is the shadow they cast. Says Wood: "Although not very high (100 to 300 meters), ridge crests are often sufficiently steep that they cast shadows, and their sunward-facing slopes are brighter than those with gentler arches" (Wood, 2003 p. 44).

Let's look at some examples. In Image 4, we see (yellow arrows) the most classic shadow and brightness distribution from which we may infer the existence of a steep ridge that casts shadows and a steep slope that strongly reflects sunlight. But the blue arrow shows us a ridge whose presence we can only infer by the shadow it casts (without bright areas). From it we can deduce that it is high and with a less steep slope than the ridge indicated by the red arrows. Sometimes on the same ridge, there is a segment that casts shadow and another segment that does not (**Image 5**, yellow arrow). Both segments are bright, which indicate that the segment that casts shadows is higher.

In summary, ridges are visually presented with the following combinations:

- Ridges that cast shadows only.
- Ridges that shine without casting a shadow.
- Ridges that are distinguishable both by their brightness and by the shadow they cast.

We can relate shadow to height, and brightness with a steeper slope (ibid.).

Finally, Wood provides us with another important piece of information to evaluate our visual observations: "Ridge crests are usually sinuous and sometimes migrate from one side of the swell to the middle or even the other side" (ibid., p. 44). With a small telescope like my Meade EX 105mm. Maksutov-Cassegrain, it is very difficult to distinguish arch from crest because both components are usually seen integrated. But from this Charles Wood data, the observations can be interpreted to distinguish changes in orientation of the ridge crest on the same arch and not confuse them with different separate segments. This applies with **Image 4**, in which the red arrows indicate two bright areas on both sides of the shadow in what could be a bifurcation in two segments of the crest or the beginning of a migration of the crest moving to the other coast of a wide arc.

Having acquired theoretical information on the morphology of wrinkle ridges, and having revisited visual observations of them near the terminator, we are now prepared to make much more detailed and useful interpretations of wrinkle ridge observations to the extent that the aperture of the telescope allows. Once we learn to interpret the shadow and brightness associated with lunar features, they become more easily recognizable to our "educated eye", although the danger of observing with confirmation bias increases.

It is curious that wrinkle ridges were observed for the first time in the early 1890s (according to Yue) or in the late 18th century by Schröter (according to Elger) yet today we can observe what Hevelius (among others) failed to observe.

It is possible to optimize the visual observations of wrinkle ridges in order to refine the morphological data on its structure, such as by adding indications of brightness using the Elger scale or planning the observation by preparing a template with the ridge plot. This allows the observer to focus the observation time in specifying details, similar to how the observations were made in the USAF Lunar Mapping Lunar Program for the Apollo Program.

Once observers understand the morphology of ridges, and how they can be visually captured through a telescope, they can concentrate on recording specific generic indicators: Are there shadows? How dark are they? In what direction? Are there differences in brightness in the illuminated areas? Is the crest visible at the top? Is there a change in direction of the crest?

Wrinkle ridges are very beautiful to behold and their visual observation with small telescopes, reinforced with some knowledge of their morphology, can be very rewarding.

References

Aubele, J.C. (1989), "Morphologic components and patterns in wrinkle ridges: kinematic implications; MEVTV Workshop on Tectonic Features on Mars," p. 13-15. *http://adsabs.harvard.edu/full/1989tfm..conf...13A*

Elger, Thomas G. (1895), *The Moon*, George Philip & son, London. *https://archive.org/details/moonfulldescript00elgerich*

Legrand, Christian and Chevalley, P. (2000). *Virtual Moon Atlas 7.0*. *https://www.ap-i.net/avl/en/start*

Plescia J.B. and Golombek, M. (1986), "Origin of planetary wrinkle ridges from terrestrial analogs," *GSA Bulletin*, 97 (11): 1289-1299. *https://pubs.geoscienceworld.org/gsa/gsabulletin/article-abstract/97/11/1289/203106/Origin-of-planetary-wrinkle-ridges-based-on-the*

Rukl, Antonin (1992), *Atlas of the Moon*, Kalmbach Publishing, pp. 224. *https://www.amazon.com/Astronomy-Atlas-Moon-Antonin-Rukl/dp/0913135178/ref=sr_1_1?dchild=1&keywords=atlas+of+the+moon+rukl&qid=1615839848&s=books&sr=1-1*

Wood, Charles A. (2003), *The Modern Moon. A Personal View*, Sky & Telescope, Cambridge. *https://www.amazon.com/Modern-Moon-Personal-View/dp/0933346999*

Yue, Z.,W. Li, K. Di, Z. Liu, and J. Liu (2015), "Global mapping and analysis of lunar wrinkle ridges," *Journal of Geophysical Research: Planets*, 120, pp. 978-994, doi:10.1002/2014JE004777.

Papers & Presentations

ALPO Observations of Jupiter During the 2017-2018 Apparition

By: Richard W. Schmude, Jr.,
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

Thirty nine observers from six different continents submitted drawings and images of Jupiter during the apparition. A few of the highlights include a possible seasonal change of the methane-bright south polar hood over the last two decades, an image of Io transiting Jupiter that shows surface features observed in the 1940s, the presentation of low-resolution spectra of four different areas on Jupiter, a discussion of important developments in the context of 2017-2018 Jupiter reports on the BAA website, and a summary of brightness measurements of Jupiter.

Introduction

The characteristics of Jupiter for the 2017-2018 apparition are given in **Table 1**. Those who submitted observations, images or measurements of Jupiter either to the writer or to the ALPO website are included in **Table 2**. There were 891 images in the 2017-2018 Jupiter folder as of Mar. 18, 2020. They may be examined by using this link: *http://www.alpo-astronomy.org/gallery3/index.php/Jupiter-Images-and-Observations/Apparition-2018*.

This paper follows certain conventions. The planetographic (or zenographic) latitude is always used. Latitudes and longitudes were measured from images using the software application WinJUPOS (Hahn, 2019). West refers to the direction of increasing longitude. The three longitude systems are described in (Rogers, 1995). The Greek letter λ, followed by a subscript Roman numeral describes the longitude system and value. For example, $\lambda_{II} = 57°$ W means a System II longitude of 57° W. All dates and times are in Universal Time (UT). Unless stated otherwise, all data are based on visible or near infrared (wavelengths up to 1.0 micrometer) light images. All methane band images were made in light with a wavelength near 0.89 µm. In all cases, the drift rate is for the center of the feature. All dates, except where noted, are for the current apparition and, hence, years are not included. Normal belt abbreviations are used such as NEB = North Equatorial Belt (see **Table 3**). The north and south edges of a belt will have a small “n” or “s” following the abbreviation. For example the north edge of the North Equatorial Belt is the “NEBn”.

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

Disk Appearance

Figure 1 illustrates the visible-light appearance of Jupiter during 2017-2018. **Figure 2** shows two close-up images of Jupiter made by the JUNO spacecraft and **Figure 3** shows Jupiter's appearance in methane band light.

Almost 400 light intensity estimates of Jupiter's main features submitted by Cudnik and Sweetman were examined. These were made on the scale of 0 = black to 10 = white. Mean light

Table 1. Characteristics of the 2017-2018 Apparition of Jupiter[a]

First conjunction date	Oct. 26, 2017
Opposition date	May 9, 2018
Second conjunction date	Nov. 26, 2018
Brightness at opposition (stellar magnitudes)	-2.5
Equatorial angular diameter at opposition	43.8 arc-seconds
Right Ascension at opposition	15h 04m
Declination at opposition	16.0° S

[a] Data are from the Astronomical Almanac (2016, 2017)

Table 2. Individuals Submitting Observations During the 2017-2018 Apparition of Jupiter

Name, location (type of observation)*	Name, location (type of observation)	Name, location (type of observation)
D. Arditti, UK (I)	R. Hill, USA (I)	C. Pellier, France (I, S)
T. Barry, Australia (I)	M. Hood, USA (I)	M. Phillips, USA (I)
D. Breit, USA (I)	W. Jaeschke, USA (I)	J. Rogers, UK (U)
J. Carels, Belgium (I)	D. Jones, Australia (I)	R. Schmude, Jr., USA (PP)
F. Carvalho, Brazil (I)	M. Kardasis, Greece (I)	A. Soares, Brazil (I)
G. Carvalho, Brazil (I)	S. Kowollik, Germany (I)	M. Sweetman, USA (D, DN, I)
M. Collins, New Zealand (I)	P. Maxson, USA (I)	R. Taggart, USA (I)
B. Cudnik, USA (D, I, TT)	J. Melka, USA (I)	C. Triana, Columbia (I)
V. da Silva, Jr., Brazil (I)	P. Miles, Australia (I)	D. Tyler, UK (I)
M. Delcroix[a], France (I)	E. Morales-Rivera, USA (I)	S. Tzikas, USA (I)
C. Foster, South Africa (I)	G. Orton, USA (I)	G. Walker, USA (I)
C. Go, Philippines (I)	A. Pace, Malta (I)	A. Wesley, Australia (I)
P. Gorczynski, USA (I)	D. Peach, UK (I)	C. Zannelli, Italy (I)
Key: D = drawing, DN = descriptive notes, I = image, Pol = polarization, PP = photoelectric photometry, S = spectral data, TT = transit time, U = Jupiter update NOTE: [a]Assisted by F. Colos & E. Kraaikamp.		

intensities and standard deviations are summarized in **Table 4**. Statistically significant changes since April 2017, at the 95% confidence level, include the NTB becoming brighter and the EZn, EB and EZs becoming darker (Schmude 2021).

Table 5 summarizes belt latitudes measured in visible light. Statistically, significant changes include the northward shift of the SEBs, and the southward shifts of the SEBn, NEBn, NTBs and NTBn.

Table 6 summarizes belt latitudes measured in methane band light. Statistically significant changes include the northward shift of the SPCn and SEBs along with the southward shift of the SEBn, NEBn and NTBn.

Region I: The Great Red Spot (GRS)

Figures 4A-4B and 4D-4H show the appearance of the GRS in visible light. As in the previous apparition, the GRS underwent a few changes. Firstly, its shape changed. The GRS has a flatter appearance in **Figure 4B** than in **Figure 4G**. Secondly, its major axis (the longest axis in an ellipse) has different orientations in **figures 4D and 4H**. Thirdly, white streaks are visible on the GRS (see **figures 4A, 4D and 4G**). A new change, not seen previously, is that the central dark bar changed. Figure 4E shows a possible white center in that bar and **Figure 4F** shows a dark central arc instead of a bar.

As in the previous apparition, the GRS was brighter than any other feature in methane band light (see **figures 3B, 3E, 3F and 3H**). There were not as many bright extensions from the GRS as in the previous apparition. As in the previous apparition, the GRS had dark curved streaks (see **Figure 4C**).

A few observers submitted reports on visual observations of the GRS made through the telescope. For example, Sweetman reports the GRS had a bright rust red color on May 19, a bright orange color on June 5 and a "very red" color on August 5. He reports it had a dark border on its south-proceeding edge on May 24, June 5 and July 9. Cudnik reports the center of the GRS crossed the central meridian at 2:02 UT on June 9, 2018. The mean light intensity of the GRS was 3.7. This is near the value in 2016-2017.

The software application *WinJUPOS* (Hahn, 2019) was used in measuring the longitude and latitude of the GRS. The System II longitudes are plotted in **Figure 5A**. The mean drift rate for this feature is 1.3°/30 days for the apparition. Rogers (2018c) reports the GRS drift rate changed in April. The writer measured System II drift rates of 1.5°/30 days and 1.1°/30 days for Nov. 29 - Mar. 31 and Apr. 1 - Aug. 19, respectively. Therefore, the data are consistent with the results in Rogers (2018c). Between April 24 and May 24, λ_{II} = 289.3° W for the GRS with a standard deviation of 1.0°. These values are based on 17 measurements. The mean GRS latitude, for the apparition is 22.6° S with a standard deviation of 0.60°. The latitude of the GRS may have shifted after April 1. The mean latitude for Nov. 29 - Mar. 31 is 22.4° S while the corresponding value for April 1 - Aug. 19 is 22.7° S. There is evidence the GRS changes latitude (Rogers, 2008).

Region II: South Polar Region to the South

Tropical Zone

Figure 2B shows an excellent view of the SPR taken by the JUNO spacecraft. This region appears bluish. Melka (2020) reports a blue South Polar Belt in color images of Jupiter. The reported blue

Table 3. 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

[a] The word “Jet” replaces the word “Jetstream” in some cases.

color is consistent with this image.

The SPR had a mean light intensity of 5.8 compared to 6.0 for the NPR. This difference is statistically significant at the 95% confidence level. How did the SPR and NPR light intensity compare in other wavelengths of light? The SPR was brighter than the NPR in methane band light (see **Figure 3**). In ultraviolet and blue light, the SPR was darker than the NPR but in near infrared light, both regions had nearly the same light intensity. Sweetman reports the SPR has a brown tone on May 6. He also reports this area as being dark on several dates between May 24 and June 12.

Table 4. Mean Visible Light Intensities of Jovian Features for the 2017-2018 Apparition

Feature	Intensity	Standard Deviation	Number
NPR	6.0	0.40	43
NTB	6.6	0.74	27
NTrZ	7.7	0.35	42
NEB	3.4	0.34	42
EZn	7.9	0.73	40
EB	6.9	0.74	26
EZs	7.8	0.70	43
SEB	3.6	0.50	42
STrZ	9.7	0.46	42
GRS	3.7	0.52	17
STB	5.5	1.20	28
SPR	5.8	0.47	43

Table 5. Planetographic Latitudes of Belts on Jupiter Based on Images Made in Visible Wavelengths in May 2018[a]

Feature	South Edge	North Edge
South Polar Belt (SPB)	67.8° S (1.4°, 18)	64.4° S (1.0°, 18)
South Equatorial Belt (SEB)	20.2° S (1.1°, 18)	8.2° S (0.7°, 18)
Equatorial Band (EB)	3.6° S (0.7°, 18)	1.2° S (0.8°, 18)
North Equatorial Belt (NEB)	8.2° N (1.2°, 18)	18.6° N (2.3°, 18)
North Temperate Belt (NTB)	23.3° N (0.7°, 18)	30.2° N (0.9°, 18)
North North Temperate Belt (NNTB)	33.8° N (1.0°, 18)	38.5° N (2.2°, 18)

[a] Standard deviations are in parentheses followed by the number of measurements.

Table 6. Planetographic Latitudes of Belts on Jupiter Based on Methane-band Images Made at a Wavelength Near 0.889 m in May 2018[a]

Feature	South Edge	North Edge
South Polar Cap (SPCn)	–	66.8° S (1.0°, 17)
South Equatorial Belt	19.9° S (0.8°, 17)	6.7° S (0.8°, 18)
North Equatorial Belt	8.7° N (1.5°, 18)	17.6° N (1.6°, 18)
North Temperate Belt	24.6° N (0.5°, 18)	30.4° N (1.3°, 17)
North North Temperate Belt	35.2° N (1.6°, 15)	38.2° N (1.9, 15)

[a] Standard deviations are in parentheses followed by the number of measurements.

During the 2009-2010 apparition, this writer examined to determine if the methane-bright South Polar Hood (SPH) changes with Jupiter's seasons (Schmude, 2011). There seemed to be a seasonal correlation with the hood being smallest in 2006 when Jupiter's southern hemisphere was near summer solstice. Almost ten years later, this writer has revisited this question. The measured latitudes of the northern edge of the methane-bright SPH are plotted against the sub-solar latitude. The results are shown in **Figure 6**. The correlation coefficient is statistically significant at the 95% confidence level (Larson & Farber, 2006).

The area between the SPR and the SEB underwent changes. For example, on Dec. 28 (**Figure 1B**), there were two distinct zones at 22-35° S and 47-53° S and two distinct belts at 35-47° S and 53-56° S. The southerly zone grew thinner by March 2 (**Figure 1D**). The other one had grown less distinct as a result of a dark feature following Oval BA (see **Figure 1G**).

A dark feature following Oval BA developed in January; it is visible in **Figure 1G**. Rogers (2018a-c) states that it went from being the “STB Ghost” to an STB fragment followed by a “South-following tail.” **Figures 4M and 4N** show the growth of this feature between Jan. 22 (25° long) and Mar. 2 (59° long). Cudnik drew part of it on Mar. 31 and assigned it a light intensity value of 5.5.

This is near the mean light intensity value of the SPR, but not as dark as the NEB. He also drew the proceeding portion of this feature on Mar. 23 and assigned it a light intensity value of 6.0. **Figure 3D** shows a methane-bright tilted bright streak at the same position as the gray area following Oval BA. This is evidence that part of this feature extended to high altitudes.

Figures 4I thru 4N show images of Oval BA. In Feb. and Mar., it had an inner orange ring. Six measurements of this ring were made between Feb. 18 and Mar. 31. The mean dimensions are shown in **Table 7** and are similar to those in the previous two apparitions. This writer was unable to locate images taken after Mar. 31 showing the orange ring. It appears to have become less distinct (see **Figure 4L**). A portion of the orange ring was faint in near-infrared light (see **Figure 4I**).

Table 7: Dimensions of the Orange Ring in Oval BA for the Current and Previous Two Apparitions[a]

Apparition	Outer Dimension		Inner Dimension	
	East-West	North-South	East-West	North-South
2015-2016	5.5° (0.61°, 13)	4.5° (0.36°, 14)	2.5° (0.36°, 13)	1.9° (0.44°, 14)
2016-2017	6.2° (1.00°, 11)	4.8° (0.53°, 11)	3.1° (0.56°, 11)	2.4° (0.42°, 11)
2017-2018	6.0° (0.74°, 6)	4.8° (0.33°, 6)	3.4° (0.15°, 6)	2.4° (0.33°, 6)

[a] The standard deviation and number of measurements are in parentheses.

Table 8: Brightness Measurements of Jupiter During the 2017-2018 Apparition

Date 2018	α (degrees)	Measured Magnitude	Comp. Star	Date 2018	α (degrees)	Measured Magnitude	Comp. Star
Jan. 20.480	9.8	H = –1.68	α-Lyr	Apr. 20.325		H = –	α-Lyr
Jan. 20.497	9.8	J = –2.19	“	Apr. 21.148	3.6	H = –2.11	“
Mar. 3.347	9.9	V = –2.15	γ-Lib	Apr. 21.159	3.6	J = –2.75	“
Mar. 3.361	9.9	V = –2.17	“	Apr. 21.173	3.6	H = –2.18	“
Mar. 3.405	9.9	V = –2.14	“	Apr. 21.184	3.6	J = –2.74	“
Mar. 3.419	9.9	V = –2.11	“	Jun. 5.118	5.3	H = –2.29	“
Mar. 9.336	9.5	H = –1.97	α-Lyr	Jun. 5.132	5.3	J = –2.72	“
Mar. 9.350	9.5	J = –2.51	“	Jun. 25.253	8.3	H = –2.12	α-Boo
Mar. 13.323	9.2	V = –2.24	γ-Lib	Jun. 25.270	8.3	J = –2.61	“
Mar. 13.338	9.2	V = –2.23	“	Jul. 10.068	9.8	H = –2.00	α-Lyr
Mar. 13.351	9.2	V = –2.23	“	Jul. 10.093	9.8	J = –2.54	“
Mar. 23.271	8.1	V = –2.32	“	Jul. 26.072	10.7	J = –2.44	“
Mar. 23.285	8.1	V = –2.29	“	Jul. 26.085	10.7	H = –1.89	“
Mar. 23.300	8.1	V = –2.28	“	Aug. 5.078	10.8	J = –2.30	“
Mar. 23.314	8.1	V = –2.27	“	Aug. 5.095	10.8	H = –1.82	“
Apr. 17.164	4.3	V = –2.41	“	Aug. 26.086	10.3	J = –2.12	“
Apr. 17.178	4.3	V = –2.45	“	Aug. 26.102	10.3	H = –1.61	“
Apr. 17.192	4.3	V = –2.49	“	Sept. 12.039	8.5	J = –1.98	“

The middle frame of **Figure 5B** shows the System II longitudes of Oval BA. Its mean drift rate for the apparition is -12°/30 days. This is similar to the results of Rogers (2018a) and in the previous apparition (Schmude, 2021). It accelerated eastwards a little in May. Rogers (2018d) reports a drift rate of -13.8°/30 days for May to July. He also reports a Juno image showing the centers of oval BA and the GRS about 9° apart on Dec. 28. Based on this image and the drift rates of these features after opposition, they transited each other around Dec. 2, 2018. This is a time difference of 760 days from the previous transit date of November 2, 2016.

The mean latitude of Oval BA, for the apparition, is 33.4° S with a standard deviation of 0.63°. This is based on 35 measurements. The latitude is similar to those in the two previous apparitions. (Schmude, 2020, 2021). Rogers (2018d) reports Oval BA accelerated in May and, hence, this writer examined latitudes before and after May 1 and computed mean latitudes of 33.2° S (Dec. 20 - Apr. 24) and 33.6° S (May 6 - Oct. 6) for this feature. The difference is not quite statistically significant at the 95% confidence level.

Region III: South Equatorial Belt (SEB)

Figure 1 shows the appearance of the SEB in visible light and **Figure 3** shows its appearance in methane band light. It had nearly the same light intensity value as in the previous apparition. (Schmude, 2021). One change the SEB underwent was it grew thinner in visible light. In the previous apparition, it spanned 14.8° of latitude (Schmude, 2021) whereas in the current one, it only spanned 12°. The

SEB also grew thinner in methane band light (Schmude, 2021).

The SEBs had a large festoon on it (see **figures 1B and 1C**). This was apparently the preceding edge of a new South Tropical Disturbance, abbreviated as STropD, (Rogers, 2018d). It was not visible in August, 2017 but it was on Dec. 12. The top graph in **Figure 7** shows its System II longitude between Dec. 9 and Feb. 26. Its mean drift rate is -11°/30 days. The bottom frame shows additional longitudes measured in March. Apparently, the festoon halted its eastern advancement once it approached the GRS (see **figures 1M thru 1P**). The festoon center was 4° of longitude from the western edge of the GRS on March 8 and 18. It was unrecognizable in a March 28 image by Wesley.

The lengths of the STropD in degrees of System II longitude are Dec. 12.1 (20), Dec. 28.1 (16), Jan. 10.8 (20), Jan. 27.4 (23) and Feb. 3.4 (30). Its initial size is consistent with that of a similar feature in the early 20th century (see **Figure 10.45** of Rogers (1995).

Rogers (1995) reviews previous STropD events that occurred between 1889 and 1971. He points out the STropD reformed as it passed the GRS on nine occasions between 1902 and 1938. For the next 33 years though, it did not reform on the other side of the GRS. It also did not reform on the other side of the GRS in 2018. How can this be? One possibility is that the GRS has undergone changes since the early 20th century. One of these is its decreasing size.

Sweetman made several notes on the SEB from his telescopic studies. On June 10, he reports the SEB had a brownish color. On several occasions, he reports the SEB as having a dark southern edge. This is confirmed in **Figure 1**. On August 5, and 20, he notes the SEB as not being dark except along its southern edge. The mean SEB light intensity of August, however, is almost the same as its mean value for the apparition.

Region IV: Equatorial Zone (EZ)

Figure 1 shows the appearance of the EZ in visible light. One may see that it grew darker in Apr. The EZ has a darker appearance in **figures 1F thru 1I** than in **figures 1A thru 1E**. Longtime visual observer, Sweetman, notes the EZ as being dark on several occasions between May 6 and Aug. 20. On Aug. 5, he writes “The EZ looks amazingly dark, about equal to the NPR.” The mean light intensity values for the EZn and EZs between Dec and Apr. 30 are 8.7 and 8.4, respectively. The corresponding values for May 1 - Oct. 7 are both 7.7. The light intensity for the previous apparition is 9.0 for both the EZn and EZs. Therefore, the EZ was probably near its normal intensity through early 2018 but darkened afterwards.

Figure 1J shows the appearance of the EZ in blue light. It looks even darker than in integrated light. This suggests that haze causing the EZ darkening has a reddish hue. This is consistent with the orange color reported by Rogers (2018d, 2020).

Figure 3 shows the appearance of the EZ in methane band light. There does not appear to be much darkening. Therefore, the EZ darkening in mid-2018 happened at lower altitudes.

The visible light appearance of the EB is shown in **figures 1G and 1H** and its mean latitudes are given in **Table 5**. The latitudes are similar to those reported for 1967-1977 (Rogers, 1995, 2018c). On June 7, Sweetman reports the EZ as having a “thin belt” and on July 1, he reports several sections of the EB are visible.

Region V: North Equatorial Belt (NEB)

The mean light intensity of the NEB is close to that in 2016-2017 (Schmude 2021). The NEB width, however, dropped. In visible wavelengths, the NEB had a width of 10.4° in latitude in May 2018, compared to 12.8° in Apr. 2017. In methane band light, the corresponding widths are 8.9° and 12°. Sweetman states the NEB had nearly the same width as the SEB on May 19, Jun. 12 and Jul. 1.

Figures 1D and 1G show gaps (or waves) in the northern portion of the NEB. Similar gaps are present in **figures 3A thru 3D**. Rogers (2018c, d) reports similar features as well.

Sweetman reports the NEB had a brown color on May 19 and Jun. 10. On several occasions, he describes it as having

Table 9: Summary of J and H Brightness Measurements Since the 2013-2014 Apparition[a]

Apparition	J filter			H filter		
	$J(1, \alpha)$	St. Dev.	n	$H(1, \alpha)$	St. Dev.	n
2013-2014	–9.54	0.026	18	–9.07	0.025	18
2014-2015	–9.61	0.033	41	–9.09	0.028	39
2015-2016	–9.58	0.027	18	–9.08	0.028	17
2016-2017	–9.57	0.042	14	–9.07	0.041	16
2017-2018	–9.61	0.056	12	–9.10	0.059	10

[a]The JPH Horizons ephemeris was the source of the Jupiter-Sun and Jupiter-Earth distances.

irregularities. He reports an NEB barge as having a red-orange color on Jun. 10.

Region VI: North Tropical Zone to the North Polar Region (NPR)

The NTrZ had a higher light intensity (7.7) than in 2016-2017 (Schmude 2021). The change may be due to it getting wider as a result of the NTB becoming narrower.

Figure 1 shows how the NTB changed. In **figures 1A thru 1C**, it appears as a broad belt with a hint of a central white band. **Figures 1D thru 1I** show a fainter NTB with a central white zone. **Figures 1K and 1L** show it even fainter. Sweetman notes the NTB was faint during May. During Jun. and Jul., he usually reports it as either being faint, visible as a fragment or not visible at all. The light intensity measurements, however, show little change between Dec and Oct. In methane band images, the NTB appears to have grown fainter during the apparition (see **Figure 3**).

Figure 1 shows the visible light appearance of the NNTB. It extended from 33.8° N to 38.5° N in May. These latitudes are a bit south of the mean 1950-1991 latitudes of 35.8° N to 39.1° N (Rogers, 1995). Sweetman describes it as thin (May 24, Jun. 7) or as a segment (Aug. 1, 5). On Jun. 11, however, he describes it as "dark and wide". Rogers (2018d) reports the NNTB as being moderately dark and having a variable width. This in consistent with **Figure 1**.

Figures 6B thru 6E show images of the patchy methane-bright North Polar Hood. The arrows point to some of the bright patches. This area was not as bright as the corresponding area near the South Pole. It will be interesting to see if the appearance of the North Polar Hood changes with Jupiter's seasons.

The Satellite Io

Peek (1981) and Rogers (1995) report that albedo features on a Galilean satellite are easiest to see when it is transiting Jupiter. Therefore, this writer searched for an image of Io transiting Jupiter because it has active volcanoes and, hence, is the satellite most likely to undergo albedo changes. This writer found a superb image made by Peach on May 8 (see **Figure 8)**. Io is enlarged in the image on the right. It has a faint albedo feature extending from the dark South Polar Region down to the equator. This feature is near 180° W (Dollfus, 1961). It was drawn in 1941-1945 and in 1966 (Dollfus, 1961), (Rogers, 1995). It is also in Lyot's map of Io (Dollfus, 1961). In addition to this, the dark polar caps are visible in 2018 as they were decades earlier. Therefore, we have detected no large-scale albedo changes on Io near 180° W in these observations spanning 77 years.

Photoelectric Photometry

The writer carried out brightness measurements in filters transformed to the Johnson V system along with those in the J and H system (Table 8). Comparison star magnitudes for the J and H system are from Hendon (2002). Those for the V-system (Gamma-Libra) are from Westfall (2008) who cites Mermilliod (1991).

The V-filter measurements were corrected for extinction and color transformation described by Hall and Genet (1988). The reduced magnitudes (Shepard, 2017) for the V filter were plotted against the phase angle and fitted to a linear equation. The net result is $V(1, \alpha) = -9.42 - 0.010$ with a correlation coefficient value of $r = 0.688$. These were made before the EZ darkened.

There appears to be too much scatter to compute the small phase coefficients for the J and H filters. This is similar to the situation in the previous apparition (Schmude, 2021). Mean reduced magnitudes for the J and H filter magnitudes since the 2013-2014 apparition are summarized in **Table 9**. The values have not changed much. The mean J - H value, based on each of these five apparitions receiving an equal weight, is -0.50.

Spectra

Pellier used a *Star Analyzer 100* camera to obtain low-resolution spectra of Jupiter's STrZ, EZ, SEB and NEB on Jun. 7. He used the star Beta-Libra to correct for instrument response and atmospheric extinction. His results are shown in **Figure 9** along with two Jupiter images made on Jun. 7. The spectra show that the NEB was darker than the SEB at all visible wavelengths. A second trend is that the EZ is almost as dark as the SEB in blue and ultraviolet wavelengths. This is evident in the bottom left image in **Figure 9**.

Acknowledgements

The writer would like to thank Gordon State College for a Faculty Development Grant in 2014. This enabled him to purchase an SSP-4 photometer. He is also grateful to Theo Ramakers for archiving the Jupiter images for 2017-2018 on the ALPO website.

References

ALPO Japan Latest Jupiter website at *http://alpo-j.sakura.ne.jp/indexE.htm*

Astronomical Almanac for the Year 2017, U. S. Govt. Printing Office, Washington DC. *https://bookstore.gpo.gov/products/sku/008-054-00254-4*

Astronomical Almanac for the Year 2018, U. S. Govt. Printing Office, Washington DC. *https://bookfullreaders.com/read/astronomical-almanac-for-the-year-2018/*

Dollfus, A. “Visual and Photographic Studies of Planets at the Pic du Midi” in Planets and Satellites (G. P. Kuiper and B. M. Middlehurst, eds.) pp. 534-571, plate 40, 1961.

Hahn, G. A. (2019) see *http://jupos.privat.t-online.de/index.ht*

Hall, D. S., Genet, R. M. “Photoelectric Photometry of Variable Stars, Second, Revised and Expanded Edition, Willmann-Bell, Inc. Richmond, VA, 1988. *www.alibris.com/Photoelectric-Photometry-of-Variable-stars-A-Practical-Guide-for-the-Smaller-Observatory-Douglas-S-Hall/book/5109450*.

Henden, A. A. “JHK Standards for Small Telescopes”. *Journal of the American Assn. of Variable Star Observers*, 31, pp. 11-20, 2002. *http://adsabs.harvard.edu/full/2002JAVSO..31...11H*

JPL Horizons at: *https://ssd.jpl.nasa.gov/horizons.cgi* .

Larson, R., Farber, B. “Elementary Statistics Picturing the World”, 3rd edition, Pearson, Upper Saddle River, NJ, 2006. (3rd edition out of print.)

Melka, J. “An Interpretation of Recently Observed Blue Features on Jupiter”, *Journal of the Assn. of Lunar & Planetary Observers*, Vol. 62, No. 2, p. 68, 2020. *http://www.alpo-astronomy.org/gallery3/index.php/Publications-Section/ALPO-Journals/DJALPO-Volume-62-2020*

Mermilliod, J. C. “Photoelectric Photometric Catalogue of Homogenous Measurements in the UBV System.” *NASA Astronomical Data Center, Selected Astronomical Catalogues, Volume 1*. (CD-ROM), 1991.

Peek, B. M. “The Planet Jupiter”, 2nd edition, Faber and Faber, London, 1981. *https://www.amazon.com/Planet-Jupiter-B-M-Peek/dp/B0000CJX4K*

Rogers, J. H. “The Giant Planet Jupiter” Cambridge University Press, Cambridge, 1995. *http://www.amazon.com/Planet-Jupiter-Practical-Astronomy-Handbooks/dp/0521410088*

Rogers, J. H. “The accelerating circulation of Jupiter’s Great Red Spot”. *Journal of the British Astronomical Assn,* 118, No. 1, pp. 14-20, 2008. *http://www.britastro.org/jupiter/JBAA-118-1_GRS-paper.pdf*

Rogers, J. H. “Jupiter in 2018: Report No. 2" (2018a). *https://britastro.org/node/12669*

Rogers, J. H. “Jupiter in 2018: Report No. 3" (2018b). *https://britastro.org/node/13272*

Rogers, J. H. “Jupiter in 2018: Report No. 5" (2018c). *https://britastro.org/node/14405*

Rogers, J. H. “Jupiter in 2018: Report No. 6" (2018d). *https://britastro.org/node/15381*

Rogers, J. H. “Jupiter in 2019 (Part I: Amateur Imaging)” *Journal of the British Astronomical Assn*., Vol. 130 No. 2, pp. 78-80, 2020.

Schmude, R. W. Jr. “ALPO Observations of Jupiter During the 2012-2013 Apparition”. *Journal of the Assn of Lunar & Planetary Observers,* Vol. 58, No. 3, pp. 60-74, 2016a. *http://alpo-astronomy.org/gallery3/var/albums/Publications-Section/ALPO-Journals/DJALPO-2016/DJALPO58-3-Summer2016.pdf?m=1529263025*

Schmude, R. W. Jr. “ALPO Observations of Jupiter During the 2013-2014 Apparition” *Journal of the Assn of Lunar & Planetary Observers,* Vol. 59, No. 2, pp. 41-60, 2017. *http://alpo-astronomy.org/gallery3/var/albums/Publications-Section/ALPO-Journals/DJALPO-2017/DJALPO59-2-Spring2017.pdf?m=1529266043*

Schmude, R. W. Jr. “ALPO Observations of Jupiter During the 2014-2015 Apparition” *Journal of the Assn of Lunar & Planetary Observers,* Vol. 60, No. 3, pp. 53-74, 2018. *http://alpo-astronomy.org/gallery3/var/albums/Publications-Section/ALPO-Journals/DJALPO-2018/JALPO60-3-Summer-2018.pdf?m=1545337354*

Schmude, R. W. Jr. “The 2015-2016 Apparition of Jupiter” *Journal of the Assn of Lunar & Planetary Observers*, Vol. 62, No. 2, pp. 55-67, (2020). *http://alpo-astronomy.org/gallery3/index.php/Publications-Section/ALPO-Journals/DJALPO-Volume-62-2020/JALPO62-2-Spring-2020*

Schmude, R. W. Jr. “The 2016-2017 Apparition of Jupiter” *Journal of the Assn of Lunar & Planetary Observers*, Vol. 63, No. 2, pp. 78-92, (2021).

Schmude, R. W. Jr. “Observing Jupiter in the 21st Century”, Second Edition. The Astronomical League: Humble Independent School District and the Insperity Observatory (2019). *https://store.astroleague.org/index.php?main_page=product_info&products_id=160*

Shepard, M. K. “Introduction to Planetary Photometry.” (Cambridge: Cambridge University Press) 2017. *https://www.amazon.com/Introduction-Planetary-Photometry-Michael-Shepard/dp/110713174X*

Westfall, J. “Photometric Catalog of Zodiacal Stars” private publication (2008) who cites Mermilliod, J. C. “Photoelectric Photometric Catalog of Homogeneous Measurements in the UBV system” NASA, Astronomical Data Center, Selected Astronomical Catalogues. Volume 1. (CD-ROM).

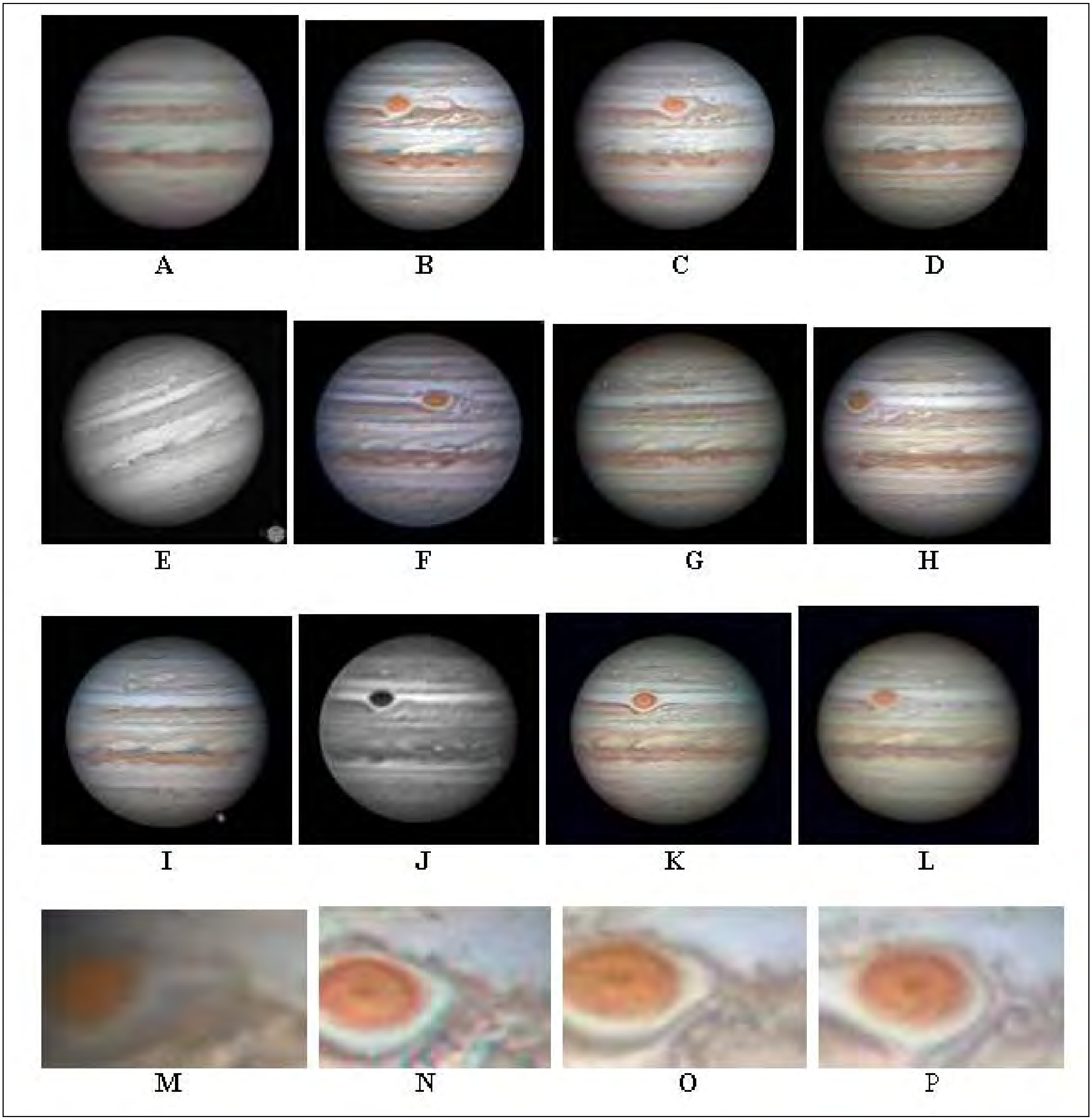


Figure 1. Images of Jupiter and of a SEBs festoon approaching the GRS. South is near the top in all images. Unless noted, all images are in visible light. **A**: Dec. 12 (2:50.3 UT) by C. Foster; **B**: Dec. 28 (2:53.3 UT) by C. Foster; **C**: Feb. 2 (2:16.1 UT) by C. Foster; **D**: Mar. 2 (9:42.1 UT) by D. Peach & the Chilescope Team; **E**: Apr. 7 (17:51.3 UT) by A. Wesley in near-infrared light; **F**: May 1 (4:33.5 UT) by M. A. Phillips; **G**: May 9 (5:54.4 UT) by M. Hood; **H**: May 28 (13:16 UT) by C. Go; **I**: Jun. 18 (17:25.5 UT) by C. Foster; **J**: Jul. 25 (20:37.4 UT) by C. Pellier in blue light; **K**: Aug. 19 (16:11.5 UT) by C. Foster; **L**: Oct. 6 (16:24 UT) by C. Foster; **M**: Jan. 27 (8:43.1 UT) by D. Peach & the Chilescope Team; **N**: Feb. 9 (2:37.4 UT) by C. Foster; **O**: Feb. 14 (2:51 UT) by C. Go; **P**: Feb. 26 (21:31 UT) by C. Go.

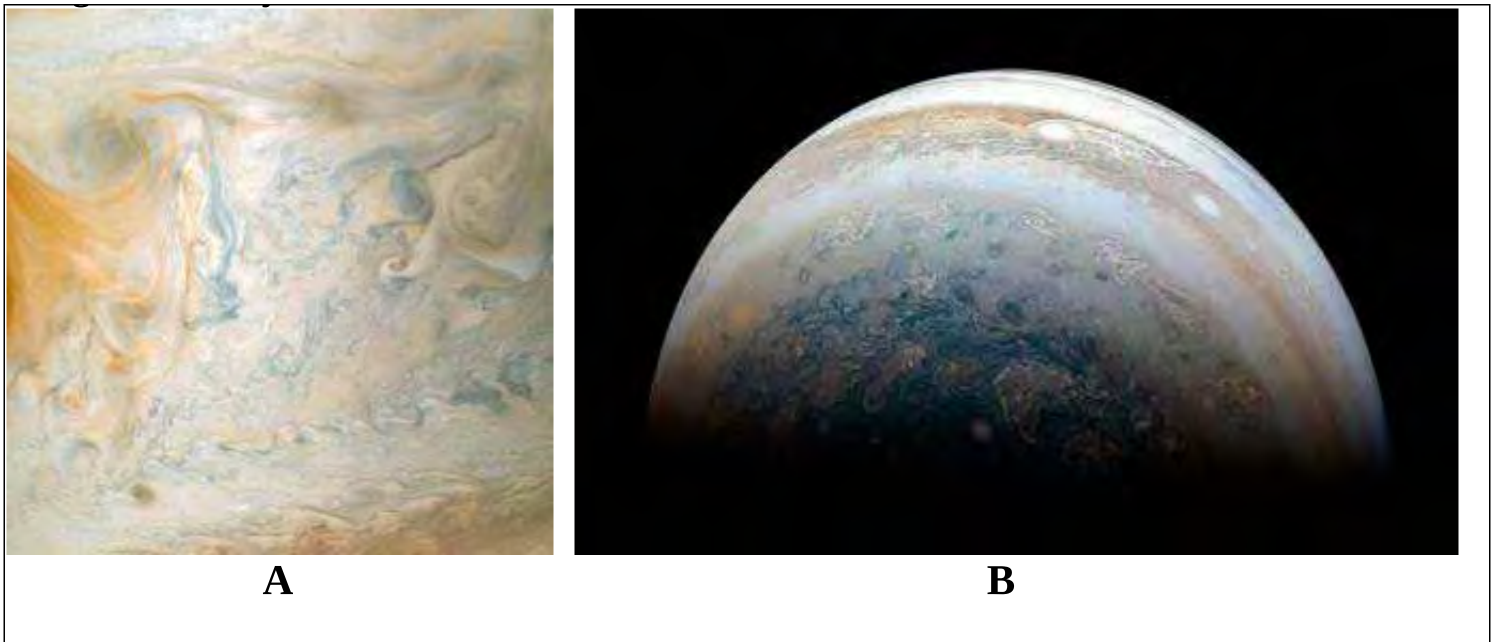


Figure 2. Two images of Jupiter made by the Juno Spacecraft. **A**: Apr. 1, 2018 (10:01 UT) showing the edge of the GRS along with other atmospheric features. Credit: Enhanced image by Kevin M. Gill (CC – BY) Based on images provided courtesy of *NASA/JPL-Caltech/SwRI/MSSS*. **B**: May 24, 2018 (6:31 UT) showing the southern hemisphere of Jupiter. The spacecraft is above 71° S. Credit: Enhanced image by Kevin M. Gill (CC-BY) based on images courtesy of *NASA/JPL-Caltech/SwRI/MSSS*.

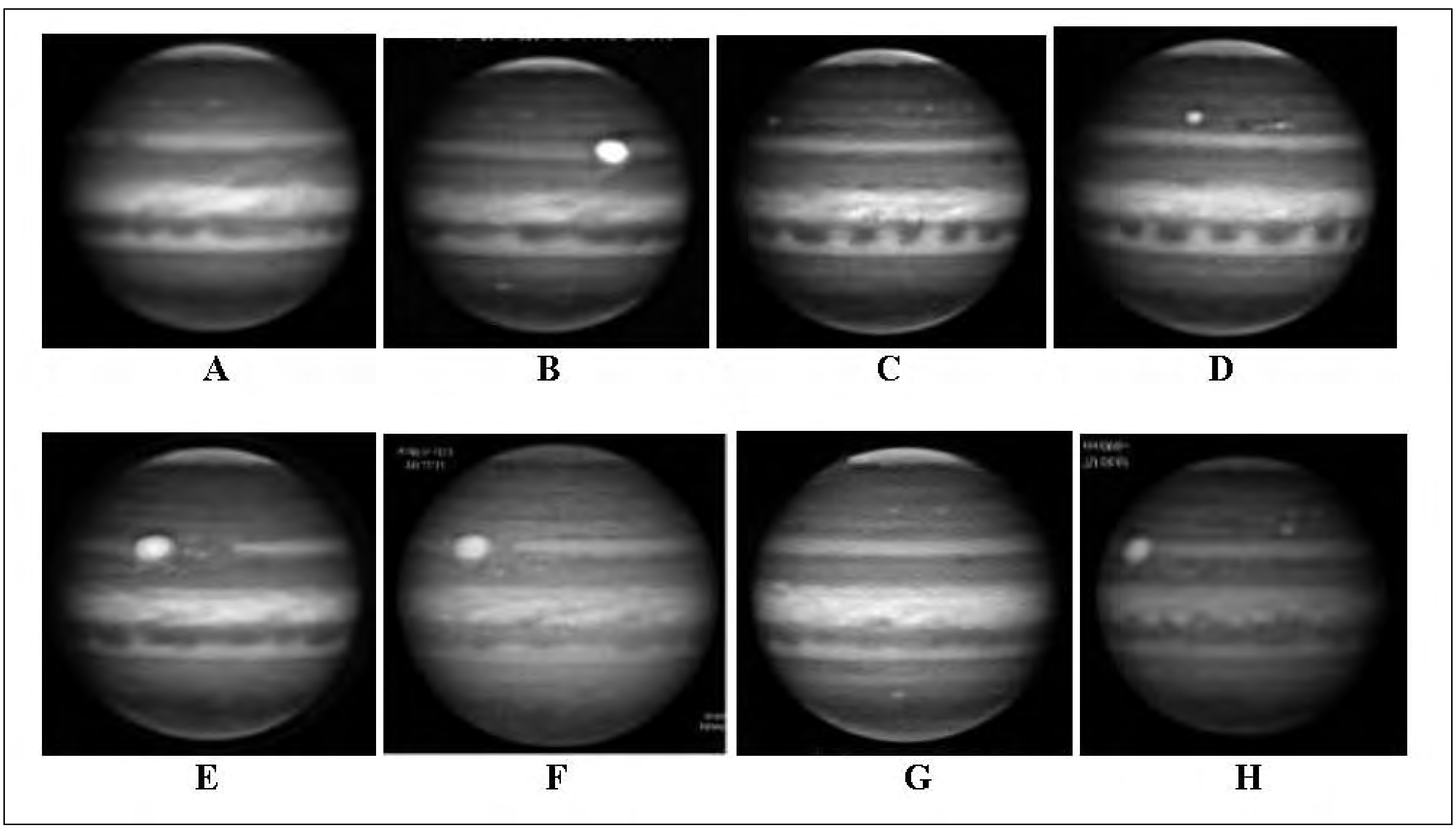


Figure 3. Images of Jupiter made in methane band light with a wavelength near 0.89 micrometers. South is near the top in all images. **A**: Dec. 24 (21:10 UT) by C. Go; **B**: Dec. 28 (21:31 UT) by C. Go; **C**: Jan. 25 (21:16 UT) by C. Go; **D**: Feb. 8 (21:29 UT) by C. Go; **E**: Mar. 28 (17:26 UT) by C. Go; **F**: May 14 (21:22 UT) M. Kardasis; **G**: Jun. 20 (12:45 UT) by C. Go; **H**: Jul. 28 (18:50 UT) by M. Kardasis.

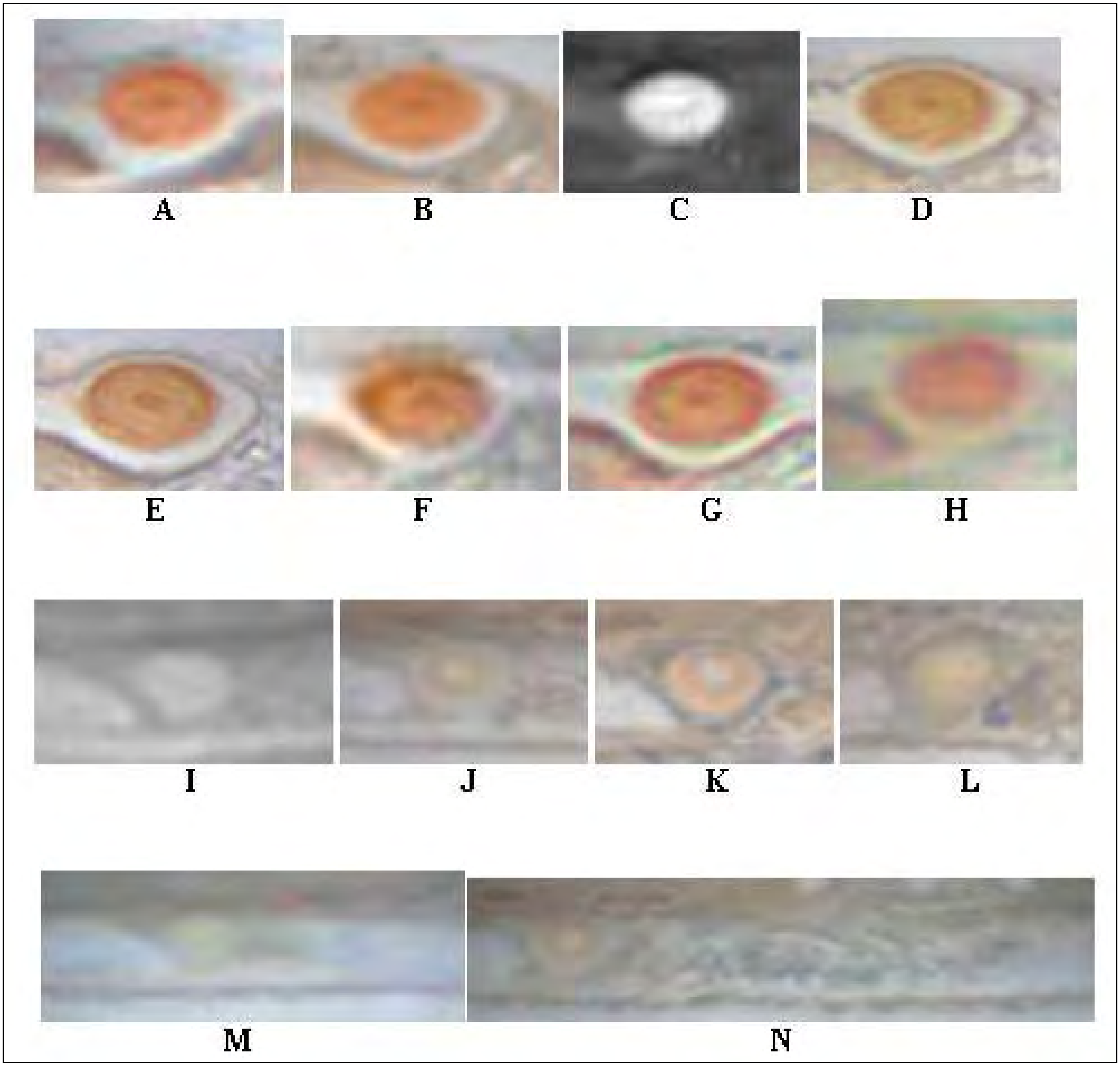


Figure 4. Images of the Great Red Spot (A-H) and Oval BA (I-N). South is at the top in all images. **A**: Dec. 28 (2:53.3 UT) by C. Foster; **B**: Feb. 17 (9:34 UT) by D. Peach & the Chilescope Team; **C**: Mar. 28 (2102 UT) by C. Go in methane band light; **D**: May 4 (2:29.4 UT) by D. Peach; **E**: May 23 (12:31.9 UT) by A. Wesley; **F**: Jul. 5 (3:11 UT) by P. Maxson; **G**: Aug. 19 (16:11.5 UT) by C. Foster; **H**: Oct. 6 (16:23.8 UT) by C. Foster; **I**: Jan. 3 (21:18 UT) in near infrared light by C. Go; **J**: Feb. 18 (9:38.3 UT) by D. Peach, M. Mihelcic & Chilescope Team; **K**: Mar. 31 (7:36.1 UT) by D. Peach & the Chilescope Team; **L**: May 7 (3:28.8 UT) by D. Peach; **M**: Jan. 22 (2:25.9 UT) by C. Foster; **N**: Mar. 2 (9:42.1 UT) by D. Peach & the Chilescope Team.

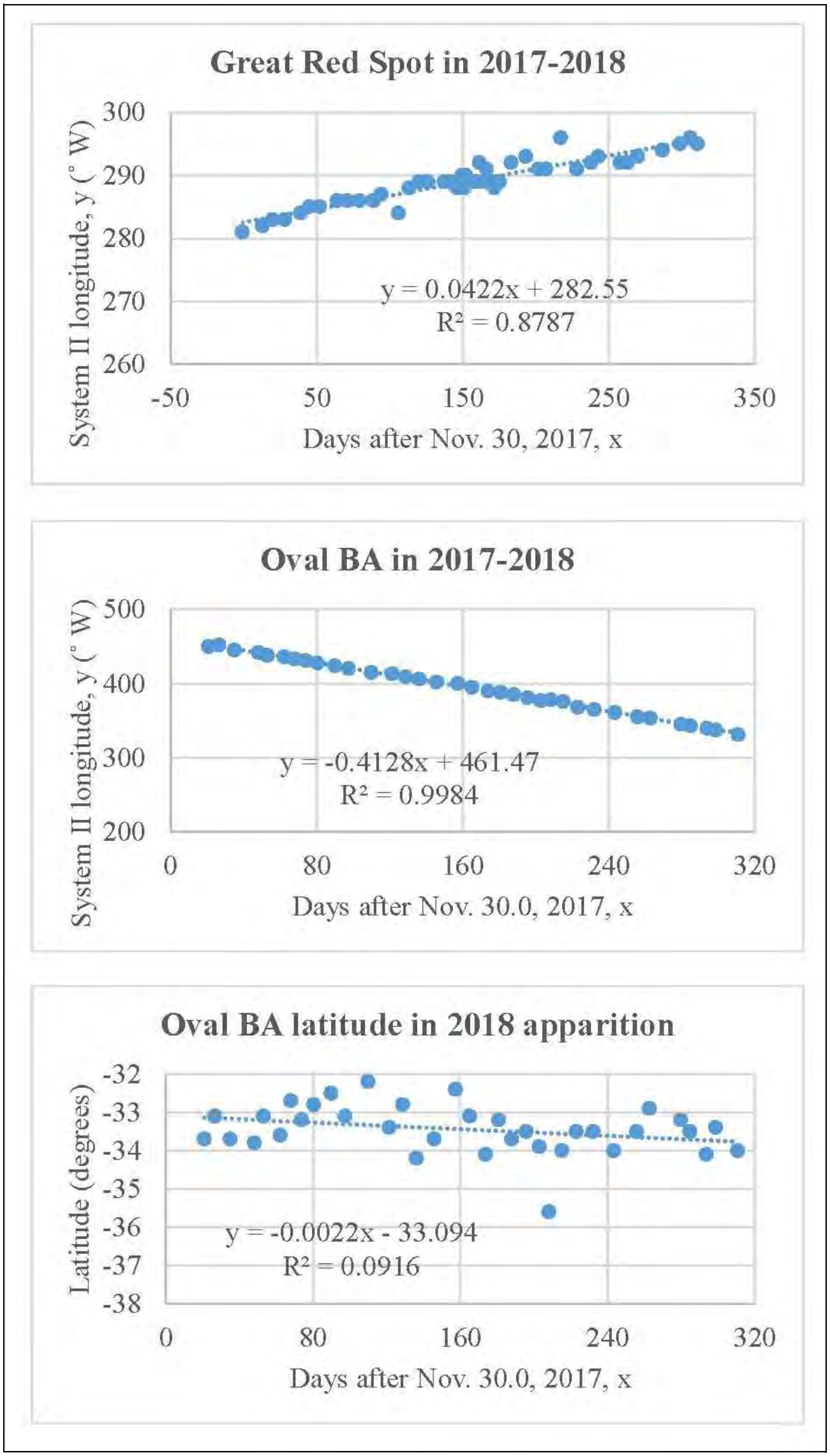


Figure 5. Top: A graph of the longitude of the Great Red Spot versus the number of days after Nov. 30.0, 2017; Middle: A graph of the longitude of the Oval BA versus the number of days after Nov. 30.0, 2017; Bottom: A graph of the latitude of Oval BA versus the number of days after Nov. 30.0, 2017.

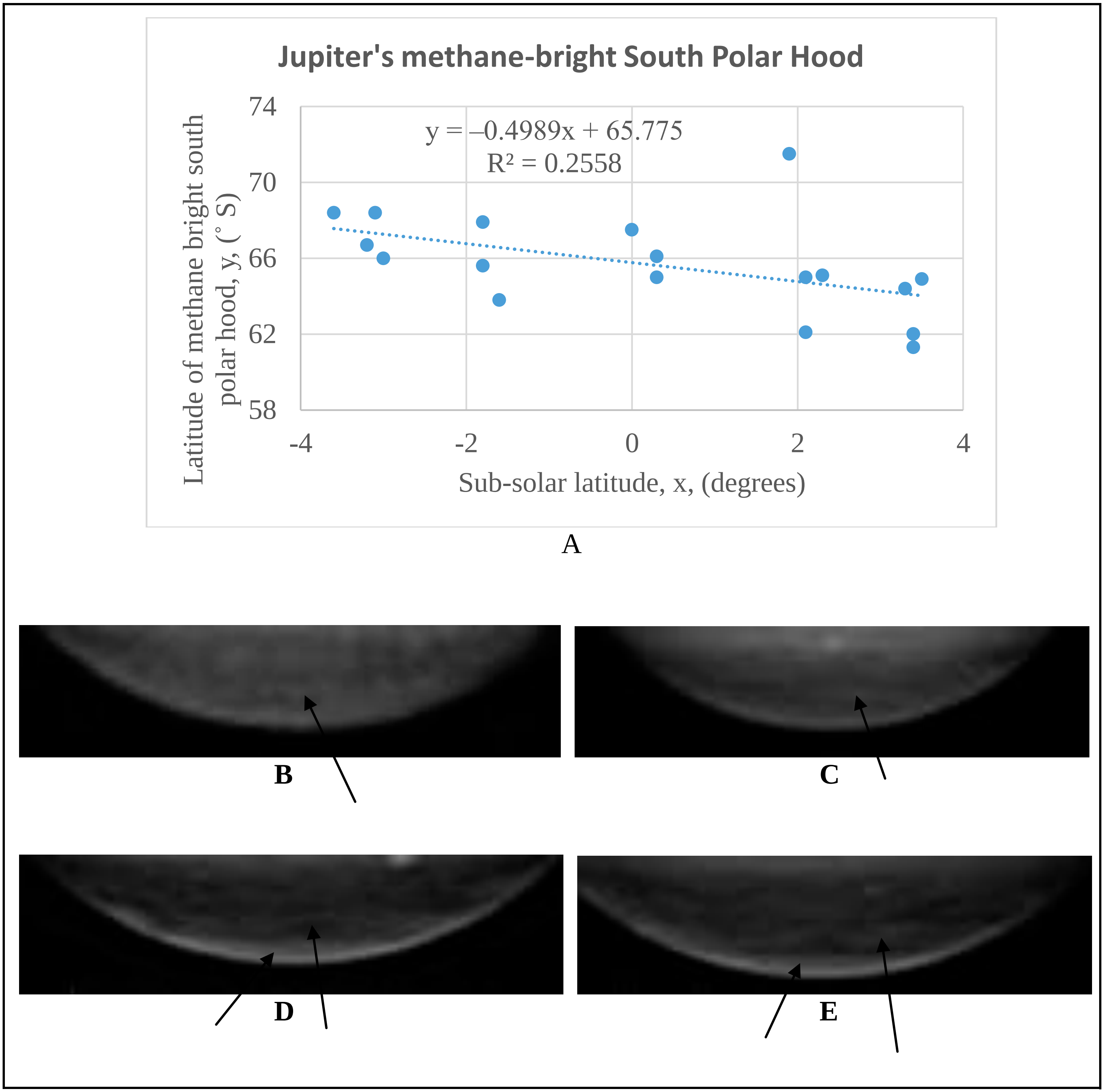
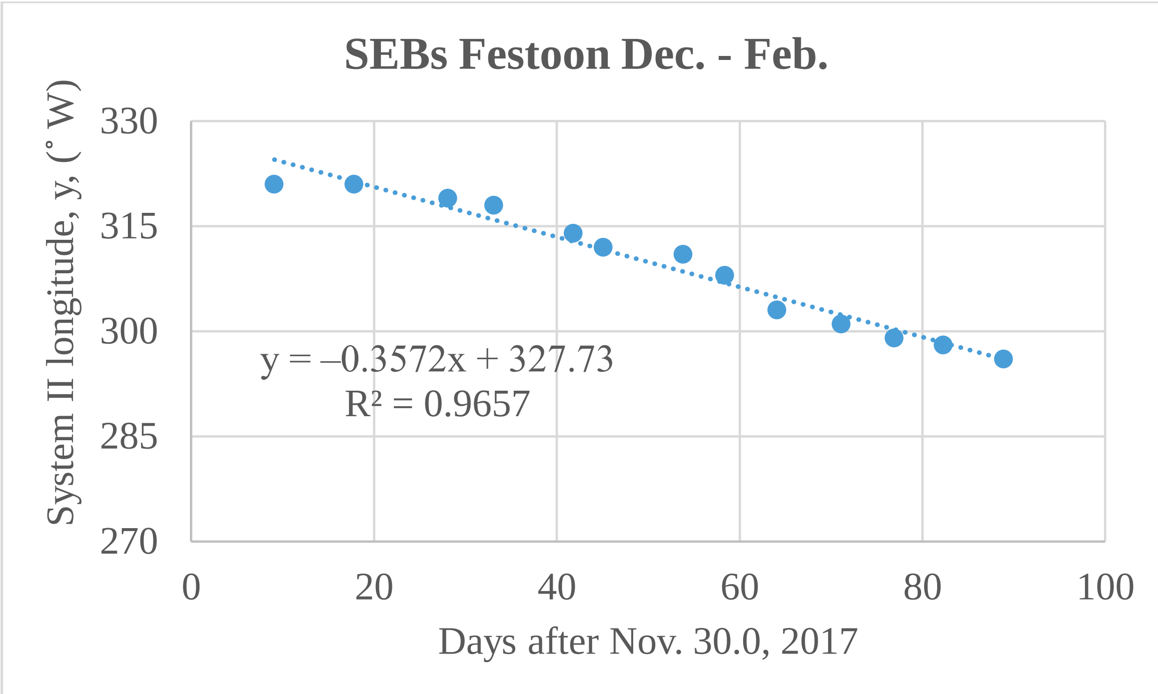


Figure 6. **A**: A plot of the latitude of the northern edge of the methane-bright South Polar Hood versus the sub-solar latitude of Jupiter. A sub-solar latitude near -4 means the southern hemisphere is near its summer solstice. The correlation coefficient is statistically significant at the 95% confidence level. Figures **B** thru **E** are methane band images of the north part of Jupiter showing the patchy methane-bright North Polar Hood (see arrows). **B**: May 10 (6:39 UT) by P. Maxson; **C**: May 14 (21:46 UT) by M. Kardasis; **D**: May 22 (13:26 UT) by C. Go; **E**: May 23 (12:52 UT) by C. Go.



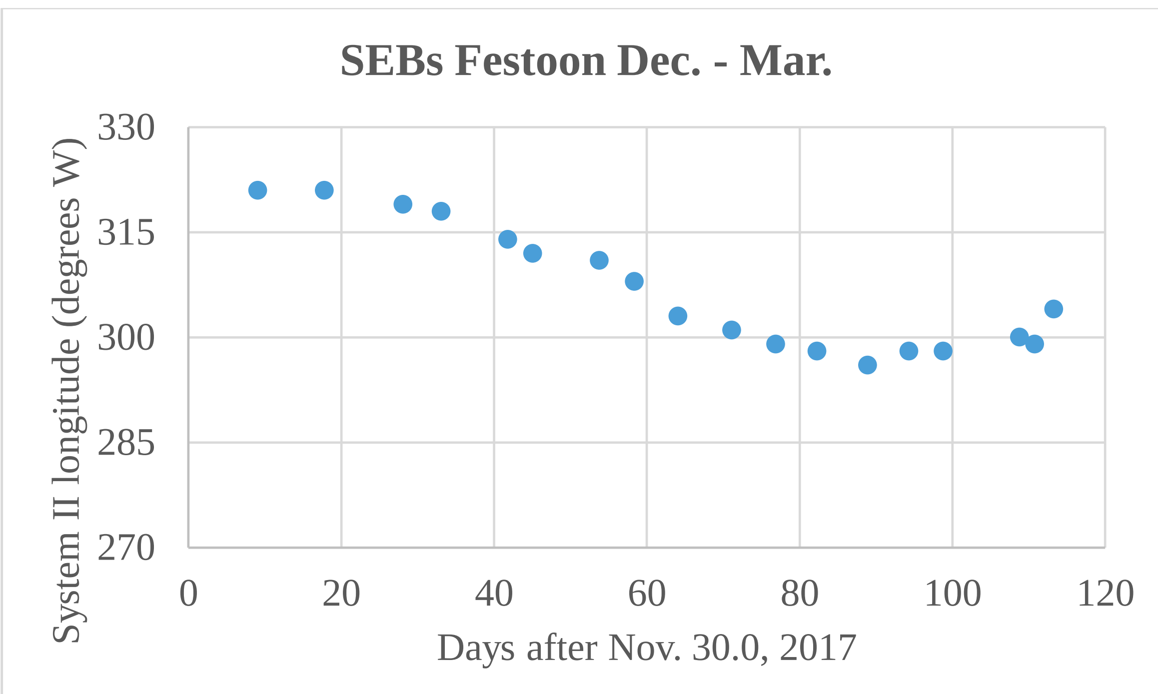


Figure 7. The top frame is a plot of System II longitude versus days after Nov. 30.0, 2017 for a festoon on the south edge of the SEB. The top frame covers the period between Dec. 9 and Feb. 26. The bottom frame shows additional longitude measured in March 2018.

Figure 8. A transit of Io across Jupiter. This RGB image was taken by Damian Peach on May 8 at 3:53.1 UT. The small insert at the lower right is a magnified view of Io and its shadow.

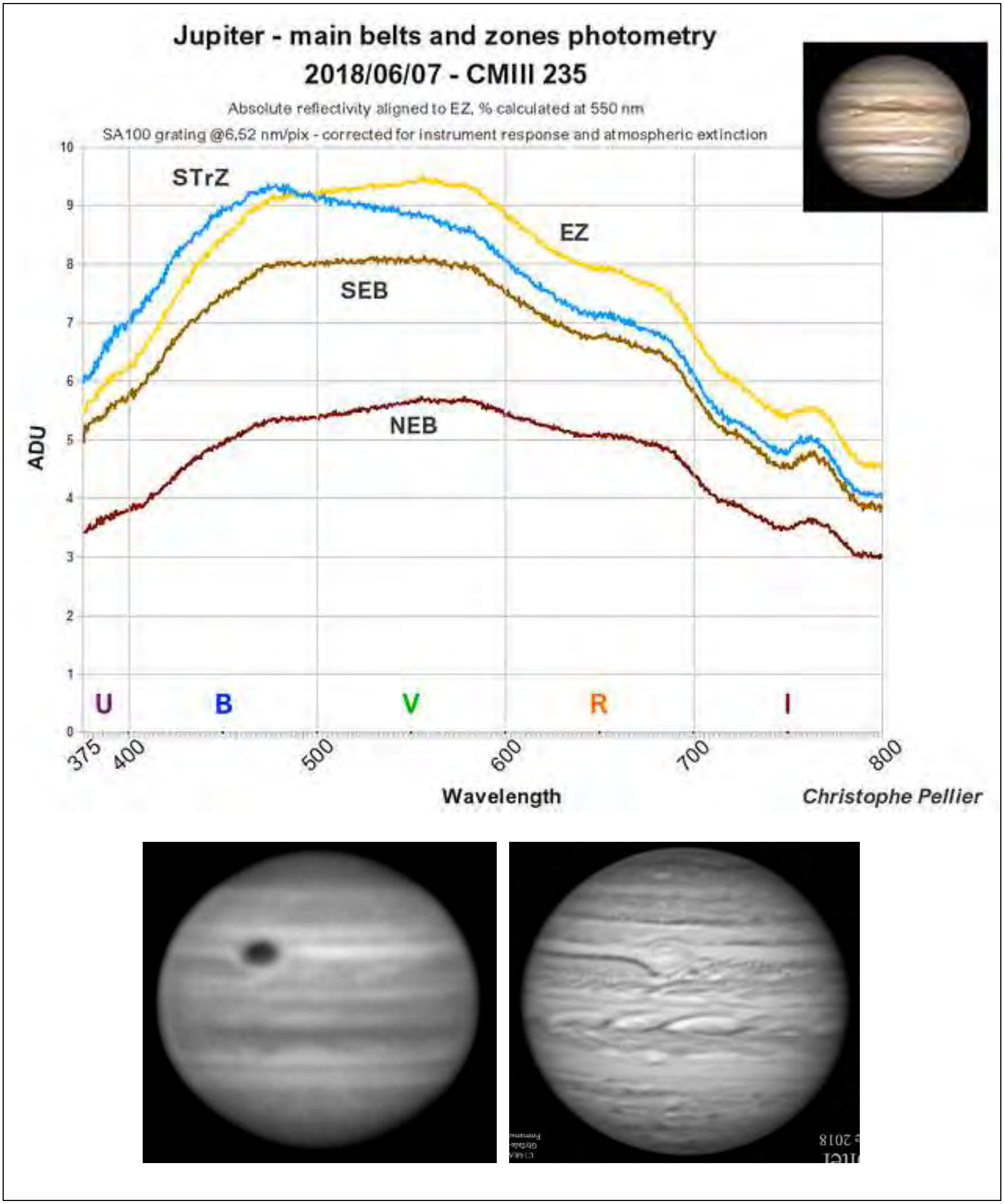


Figure 9: Spectra by C. Pellier collected on Jun. 7, 2018. Wavelength is in nanometers. Below left: Ultraviolet image of Jupiter made on Jun. 7 (2049.5 UT) by M. Kardasis; below right: Near-infrared image of Jupiter made by M. Kardasis on Jun. 7 (2022.6 UT).

Papers & Presentations

ALPO Observations of the Remote Planets in 2019-2020

By Richard Schmude, Jr.,
Coordinator, ALPO Remote Planets Section
schmude@gordonstate.edu

Abstract

Fourteen observers from five countries submitted high-quality images, spectra and brightness measurements during this apparition. This report summarizes 112 brightness measurements of Uranus and Neptune made in ultraviolet through near-infrared wavelengths. Pellier recorded spectra of both planets and reports synthetic, whole-disk U, B, V, Rc and Ic magnitudes. His U-, B-filter and V-filter values are consistent with photoelectric magnitudes. Images of both planets and the major moons of Uranus were taken using either red or near infrared filters. The appearance of each planetary disk is analyzed and relative brightness of the moons presented.

Introduction

Several individuals submitted high-quality images, spectra and brightness measurements of Uranus and Neptune during the second half of 2019 and early 2020. In 2019, the writer also compiled a review of ultraviolet brightness measurements made of Uranus between 1949 and 2018 (Schmude, 2020b). The main results, reported in that review are: there is no statistically significant relationship between the reduced U-filter brightness and either the phase angle or the sub-Earth latitude (between 0° and 45°), but that there is a statistically significant relationship between the reduced magnitude and the sunspot number.

Table 1 lists characteristics of Uranus and Neptune during their 2019-2020 apparitions. **Table 2** gives a list of individuals who submitted material during that time. There were 26 images in the 2019-2020 remote planets folder as of Jun. 30, 2020. They may be examined by clicking on "ALPO Section Galleries" and then "Remote Planets Images" and then "2019-2020" or go to: *http://www.alpo-astronomy.org/gallery3/index.php/Remote-Planets-Images.*

Table 1. Characteristics of the 2019-2020 Apparitions of Uranus and Neptune[a]

Parameter	Uranus	Neptune
First conjunction date (2019)	Apr. 22	Mar. 7
Opposition date (2019)	Oct. 28	Sep. 10
Angular diameter in arc-seconds (opposition)	3.7	2.3
Sub-Earth latitude (opposition)	47.6° N	24.6° S
Right Ascension (opposition)	2h 09m	23h 14m
Declination (opposition)	12.5° N	6.1° S
Second conjunction date (2020)	Apr. 26	Mar. 12

[a]From the *Astronomical Almanac* (2018, 2019), JPL Ephemeris and Edgar (2018)

Photoelectric Photometry

Fox, Pellier and the writer made brightness measurements of Uranus and Neptune. Fox and the writer used photoelectric photometers in making measurements, whereas Pellier computed "synthetic magnitudes" from spectra.

Table 3 summarizes the comparison and check star characteristics used in the studies by Fox and the writer. The comparison star is what is used as the standard in measuring the brightness of the target. The check star is used to see if the comparison star brightness is consistent with its reported value. Fox used three different stars (HD 12479, 19-Ari and HD 12140) as comparison stars for his Uranus measurements, and used HD 220035 as his Neptune comparison star. The writer used γ-Ari as the comparison star for his U-filter Uranus measurements and 83-Aqr and 96-Aqr as comparison stars for his U-filter Neptune measurements.

Fox and the writer used check stars for their brightness measurements and their measured values were usually close to those listed in **Table 3**. Fox used two different check stars (19-Ari and HD12479) for his Uranus measurements. The mean measured magnitudes for these are B = 7.268 (sd = 0.014) and V = 5.710 (sd = 0.014) for 19-Ari and B = 7.610 and V = 5.795 for HD 12479. In all cases, sd = standard deviation. One B-filter measurement (made on March 6, 2020) was not included for 19-Ari because its brightness value was eight standard deviations higher than the mean value of the other

All Readers

Your comments, questions, etc., about this report are appreciated. Please send them to the author's email address.

Online Readers

Left-click your mouse on:

The 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).

18 measurements. Fox used SAO 146593 as his check star for his Neptune measurements. The mean measured magnitudes for it are B = 5.630 (sd = 0.021) and V = 5.573 (sd = 0.021). The writer used α-Ari as his check star for his U-filter measurements of Uranus and the mean measured magnitude is 4.257 (sd = 0.017). He used 91-Aqr his check star for his U-filter Neptune measurements and the measured mean magnitude is U = 6.396 (sd = 0.032). The good agreement between measured and accepted magnitude values for the check stars is evidence for the reliability of measurements for both planets to within stated uncertainties.

Fox reports transformation coefficients of – 0.0499 and 0.072 for the V-filter and B-filter, respectively. The writer used a transformation coefficient of – 0.0224 for his U-filter measurements.

Tables 4 and **5** list individual brightness measurements of Uranus and Neptune, respectively. The writer corrected these measurements for atmospheric extinction and color transformation (Hall and Genet, 1988). The writer made extinction corrections, based on assumed extinction coefficients of k_V = 0.23 and k_B = 0.38 magnitudes/air mass, for Fox's measurements. Reduced magnitudes were computed using the procedure described by Shephard (2017). **Table 6** summarizes reduced magnitudes of both planets along with estimated uncertainties.

The brightness values for Uranus are near those in the previous apparition (Schmude, 2020a). The B – V color index of that planet, 0.53, is close to historical values (Schmude, 2008), (Mallama et al. 2017). Harris (1961) reports a U – B value of 0.28, which when used with his B - V and V (1, 0) values corresponds to U (1, α) = -6.35. This is close to the 2019 value.

The mean reduced magnitudes of Neptune are 0.02-0.03 magnitudes dimmer than those in the previous apparition (Schmude, 2020a). It will be interesting to see if this dimming trend continues in the 2020s. The U-B and B-V color indexes are nearly the same as in 2018-2019 (Schmude, 2020a).

Table 2. Individuals Who Submitted Images/Measurements for the 2019-2020 Remote Planets Report

Observer (Country)	Type[a]	Observer (Country)	Type[a]
D. Baratoux (France)	I	P. Maxson (USA)	I
J. Carels (Belgium)	I	F. Melillo (USA)	I
F. Colas (France)	I	L. Morrone (Italy)	I
M. Delcroix (France)	I	C. Pellier (France)	S, P
J. Fox (USA)	PP, S	R. Schmude, Jr. (USA)	PP
R. Hill (USA)	I	S. Sylla (France)	I
M. Kardasis (USA)	I	A. Wesley (Australia)	I

[a]Type of Observation: I = image, P = photometric data from spectra, PP = photoelectric photometry, S = spectra

Table 3. Comparison and Check Stars Used in Photometric Measurements of Uranus and Neptune

Star	Star Brightness in Magnitudes			Right Ascension	Declination	Source
	U-filter	B-filter	V-filter			
HD 12479	–	7.606	5.992	2h 03m	13.48° S	a
19-Ari	–	5.220	4.26	2h 13m	15.28° S	a
HD 12140	–	6.269	6.082	1h 59m	12.30° S	a
γ–Ari	3.725	3.842	3.880	13h 54m	19.29° N	b
HD 220035	–	7.255	6.170	23h 14 m	5.91° N	a
96-Aqr	5.939	5.950	5.552	23h 19m	5.12°S	b
83-Aqr	5.776	5.733	5.424	23h 05m	7.69° S	b
SAO146593	–	5.614	5.553	23h 16m	3.98° S	a
α-Ari	4.27	3.15	2.00	2h 08m	23.55° N	c
91-Aqr	6.364	5.339	4.232	23h 16m	9.09° S	b

[a]"MICA V. 2.0 USNO" from J. Fox; [b]Westfall (2008); Iriarte, B. et al. (1965). Positions are from the *Astronomical Almanac* (2019)

Spectra

Pellier submitted geometric albedo and flux spectra of Uranus and Neptune. Please see: *http://astrosurf.com/pellier/spectro_albedo.html* for more information on how the spectra were processed. **Figure 1** shows Pellier's 2019 albedo spectra of Uranus and Neptune. From the spectra, he was able to compute both "synthetic magnitudes" and geometric albedo values. These are summarized in **Table 7**. The U, B and V values of Neptune are close to those in **Table 6**, whereas his Uranus results are a bit fainter than those in **Table 6**. The albedo of Neptune is higher than that of Uranus for wavelengths below 4,000 angstroms in **Figure 1**. This is consistent with the U(1, α) values for the two planets in **Table 6**. The red and infrared magnitudes are difficult to compute because of the difficulties with transformation.

Disk Appearance

During late 2019, several individuals imaged Uranus and Neptune using telescopes as large as 1.06 meters using either red or near infrared filters. Albedo features usually show up better in these wavelengths than at the shorter ones. **Figure 2** shows selected images of Uranus and Neptune. The most obvious feature on Uranus is the bright North

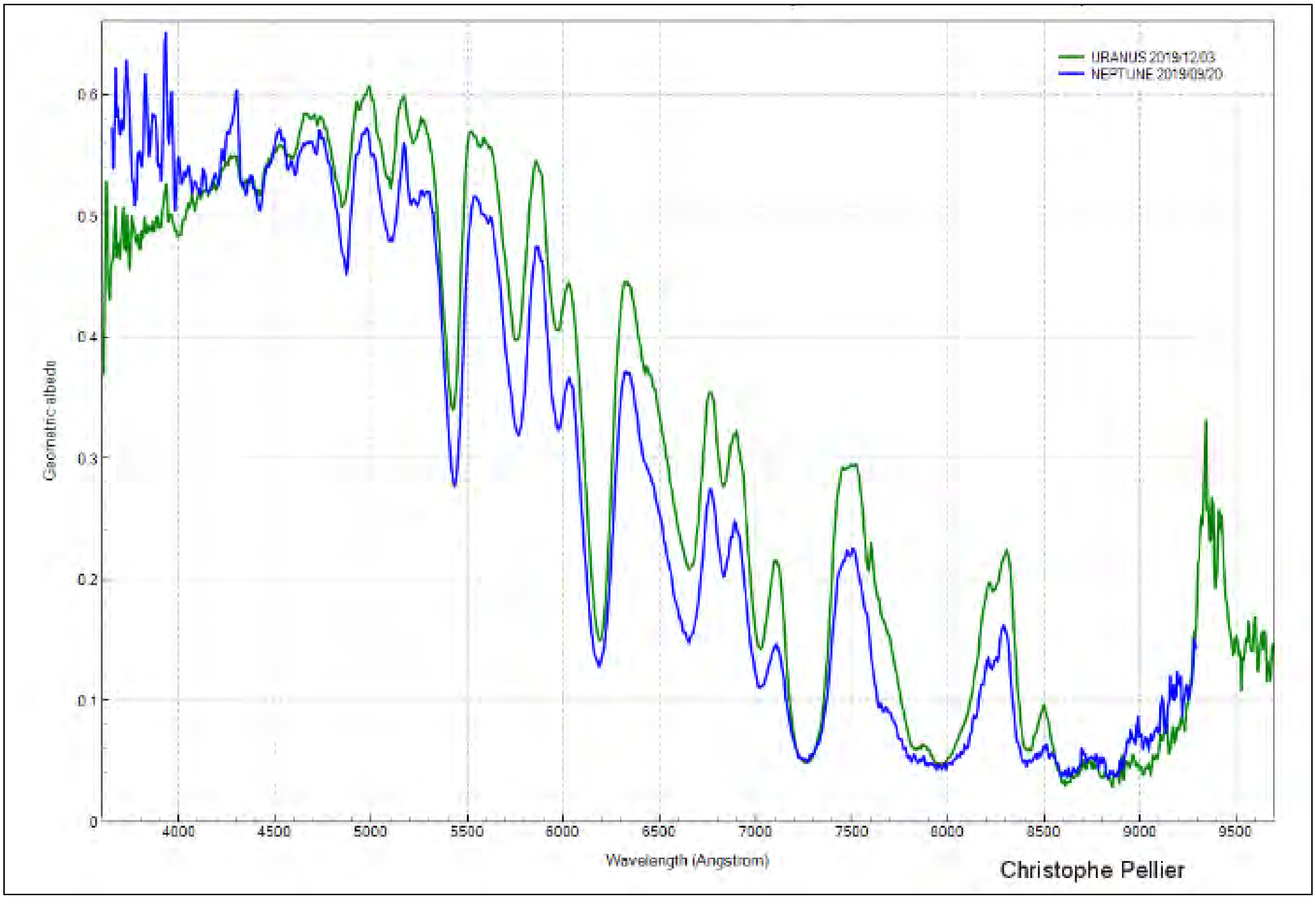
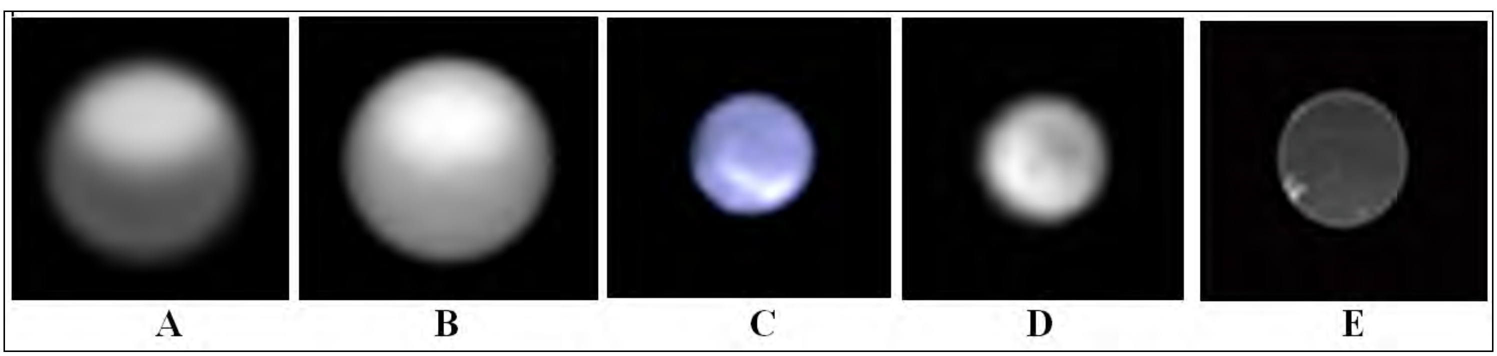


Figure 1 (above). Geometric albedo spectra of Uranus and Neptune recorded by Pellier.

Figure 2 (below). Images of Uranus (A-B) and Neptune (C-E). North is near the top in all images. **A**: Aug. 14, 2019 (4:13.5 UT) by M. Delcroix, S. Sylla, D. Baratoux and F. Colas; **B**: Oct. 26, 2019 (15:08.7 UT) by A. Wesley; **C**: Sep. 27, 2019 (12:56.6 UT) by A. Wesley; **D**: Oct. 10, 2019 (23:01.1 UT) by M. Delcroix; **E**: Sep. 28, 2019 by the Hubble Space Telescope, F763M filter; Credit: NASA/Space Science Institute/Amy Simon/Mike Wong - processing by Marc Delcroix.



Polar Hood. It extends to 46° N. This is the mean of several measurements. The writer used the formulae in Peek (1981) to compute latitudes.

Observers also noted several bright spots are on Neptune. A Hubble Space Telescope (HST) image taken on Sep. 28, 2019, (**Figure 2**) shows three large bright spots on that planet centered at +30° N; 28° S and 39° S. Delcroix imaged a spot at 21° N on Aug 14, 2019, which may have dissipated by the time the HST imaged Neptune. Delcroix also apparently imaged the spot at 39° S on Oct. 10, 2019, which matches the latitude of one of those imaged by the HST.

Satellites

Delcroix imaged the four brightest moons of Uranus using a 0.32 m telescope; he and three other co-workers (Sylla, Baratoux and Colas) used the 1.06 m telescope at Pic-du-Midi observatory to image Ariel, Umbriel and Miranda. In all cases, red and near infrared light was used. The order of brightness is Ariel = Titania > Oberon > Umbriel >> Miranda.

Acknowledgements

The writer thanks everyone who submitted remote planet measurements and images. He is also grateful to Theo Ramakers for archiving images on the ALPO website.

References

Astronomical Almanac for 2019, U.S. Govt. Printing Office, Washington DC. 628 pp., 2018. Free Kindle version available for download at *https://www.nwcbooks.com/files/ebook.php?id=dIDmLSgetRAC&item=astronomical-almanac-for-the-year-2019*

Astronomical Almanac for 2020, U.S. Govt. Printing Office, Washington DC. 628 pp., 2019. *https://www.amazon.com/Astronomical-Almanac-Government-Publishing-Office/dp/0707746000*

Edgar, J (Editor) "Observer's Handbook 2019" The Royal Astronomical Society of Canada, Toronto, 352 pp., 2018. *https://www.amazon.com/Observers-Handbook-2019-USA-Edition/dp/1927879159*

Hall, D. S. and Genet, R. M. “Photoelectric Photometry of Variable Stars”, Second revised and expanded edition, (Richmond, VA: Willmann-Bell, Inc.) 1988. *www.alibris.com/Photoelectric-Photometry-of-Variable-Stars-A-Practical-Guide-for-the-Smaller-Observatory-Douglas-S-Hall/book/5109450*

Harris, D. L. “Photometry and Colorimetry of Planets and Satellites.” In Planets and Satellites (G. P. Kuiper and B. M. Middlehurst - editors), The University of Chicago Press, Chicago, pp. 272-342, 1961. Available at: *http://articles.adsabs.harvard.edu/pdf/1961plsa.book..272H*

Iriarte, B., Johnson, H. L., Mitchell, R. I. and Wisniewski, W. K. "Five-Color Photometry of Bright Stars" Sky & Telescope, Vol. 30 (July) pp. 21-31, 1965.

JPL Horizons ephemeris at: *https://ssd.jpl.nasa.gov/horizons.cgi*

Mallama, A., Krobusek, B, Pavlov, H. “Comprehensive wide-band magnitudes and albedos for the planets, with applications to exo-planets and Planet Nine”. *Icarus* 282, pp. 19-33. *https://www.sciencedirect.com/science/article/abs/pii/S0019103516301014* Abstract at: http://dx.doi.org/10.1016/j.icarus.2016.09.023.

Peek, B. M. "The Planet Jupiter The Observer's Handbook", Faber and Faber, London, 240 pp., 1981. *https://www.amazon.com/Planet-Jupiter-Observers-Handbook/dp/0571180264*

Pellier, C., Private communication, 2019.

Schmude, R. W. Jr. “Uranus, Neptune, and Pluto and How to Observe Them” Springer Science+Business Media, LLC, New York, 2008. *https://www.springer.com/gp/book/9780387766010*

Schmude R. Jr. “ALPO Observations of the Remote Planets in 2017-2018” Journal of the Assn of Lunar & Planetary Observers, Vol. 61 (No. 1), pp. 63-68, 2019. *http://alpo-astronomy.org/gallery3/index.php/Publications-Section/ALPO-Journals/DJALPO-Volume-61-2019/JALPO61-1-Winter-2019*

Schmude, R. W. Jr. "ALPO Observations of the Remote Planets in 2018-2019" Journal of the Assn. of Lunar and Planetary Observers, Vol. 62 (No. 1), pp. 82-88, 2020a.

Schmude, R. W. Jr. "A Review of Ultraviolet Photometry of Uranus" Journal of the Assn. of Lunar and Planetary Observers, Vol. 62 (No. 3), pp. 74-80, 2020b.

Shephard, M. K. "Introduction to Planetary Photometry" Cambridge Univ. Press, Cambridge, 258 pp., 2017. *https://www.amazon.com/Introduction-Planetary-Photometry-Michael-Shepard/dp/110713174X*

Westfall, J. E. "ALPO Monograph Number 12 Photometric Catalog of Zodiacal Stars." (Westfall cites Mermilliod J.-C. (1991) "Photoelectric Photometric Catalog of Homogeneous Measurements in the UBV System" NASA, Astronomical Data Center, Selected Astronomical Catalogs. Volume 1. (CD-ROM), 2008.

Table 4. Brightness Measurements of Uranus Made During the 2019-2020 Apparition

Date (2019)	Filter	Magnitude		Comp. Star	Date (2019 or 2020)	Filter	Magnitude		Comp. Star
		X (+)	X(1, α) (–)				X (+)	X(1, α) (–)	
Sep. 22.117	U	6.614	6.269	γ-Ari	Nov. 17.196	B	6.225	6.643	b
Sep. 22.134	U	6.575	6.308		Nov. 17.196	V	5.677	7.191	
Sep. 22.151	U	6.588	6.295		Nov. 25.134	B	6.220	6.654	
Sep. 24.225	B	6.202	6.678	a	Nov. 25.134	V	5.689	7.185	
Sep. 24.225	V	5.700	7.180		Dec. 20.105	B	6.253	6.654	
Oct. 10.231	B	6.217	6.649		Dec. 20.105	V	5.725	7.184	
Oct. 10.231	V	5.675	7.191		Dec. 21.121	B	6.266	6.642	
Oct. 11.231	B	6.234	6.632	19-Ari	Dec. 21.121	V	5.725	7.183	
Oct. 11.231	V	5.684	7.182		Dec. 22.116	B	6.265	6.645	
Oct. 13.215	B	6.207	6.658		Dec. 22.116	V	5.739	7.171	
Oct. 13.215	V	5.691	7.174		Dec. 30.121	B	6.271	6.652	
Oct. 21.196	B	6.218	6.644	b	Dec. 30.121	V	5.736	7.187	
Oct. 21.196	V	5.675	7.187		Jan. 1.103	B	6.278	6.649	
Oct. 22.210	B	6.203	6.658		Jan. 1.103	V	5.735	7.192	
Oct. 22.210	V	5.666	7.195		Jan. 2.084	B	6.300	6.628	
Oct. 24.067	U	6.515	6.346	γ-Ari	Jan. 2.084	V	5.737	7.191	
Oct. 24.083	U	6.524	6.337		Jan. 6.113	B	6.290	6.645	
Oct. 24.098	U	6.467	6.394		Jan. 6.113	V	5.738	7.197	
Nov. 3.024	U	6.572	6.289		Jan. 18.105	B	6.313	6.645	
Nov. 3.040	U	6.507	6.354		Jan. 18.105	V	5.778	7.180	
Nov. 3.055	U	6.526	6.335		Jan. 19.083	B	6.343	6.617	
Nov.14.106	B	6.210	6.656	b	Jan. 19.083	V	5.789	7.171	
Nov. 14.106	V	5.677	7.189		Mar. 6.085	B	6.419	6.620	
Nov. 15.167	B	6.223	6.643		Mar. 6.085	V	5.878	7.161	
Nov. 15.167	V	5.669	7.197						

[a]HD 12479; [b]HD12140

Table 5. Brightness Measurements of Neptune Made During the 2019-2020 Apparition

Date (2019)	Filter	Magnitude		Comp. Star	Date (2019 or 2020)	Filter	Magnitude		Comp. Star
		X (+)	X(1, α) (–)				X (+)	X(1, α) (–)	
Jun. 14.325	U	8.403	6.352	96-Aqr	Oct. 13.186	V	7.710	6.990	a
Jun. 14.341	U	8.366	6.389		Oct. 21.186	B	8.118	6.588	
Jun. 14.356	U	8.348	6.407		Oct. 21.186	V	7.722	6.984	
Jun. 14.374	U	8.344	6.411		Oct. 22.171	B	8.121	6.586	
Jun. 14.387	U	8.348	6.407		Oct. 22.171	V	7.714	6.993	
Aug. 29.103	U	8.291	6.398	83-Aqr	Nov. 14.080	B	8.171	6.560	
Aug. 29.120	U	8.264	6.425		Nov. 14.080	V	7.755	6.976	
Aug. 29.138	U	8.292	6.397		Nov. 15.123	B	8.157	6.575	
Aug. 30.091	U	8.344	6.345		Nov. 15.123	V	7.728	7.004	
Aug. 30.105	U	8.309	6.380		Nov. 17.171	B	8.161	6.573	
Aug. 30.121	U	8.283	6.406		Nov. 17.171	V	7.773	6.961	
Aug. 30.136	U	8.288	6.401		Nov. 25.081	B	8.152	6.591	
Aug. 31.111	U	8.300	6.388		Nov. 25.081	V	7.751	6.992	
Aug. 31.124	U	8.278	6.410		Dec. 21.077	B	8.203	6.573	
Aug. 31.138	U	8.308	6.380		Dec. 21.077	V	7.801	6.975	
Sep. 22.058	U	8.272	6.417		Dec. 22.084	B	8.261	6.516	
Sep. 22.074	U	8.234	6.455		Dec. 22.084	V	7.819	6.958	
Sep. 22.091	U	8.295	6.394		Dec. 27.082	B	8.194	6.589	
Sep. 24.198	B	8.098	6.592	a	Dec. 27.082	V	7.791	6.992	
Sep. 24.198	V	7.712	6.978		Dec. 30.073	B	8.206	6.581	
Oct. 10.120	B	8.070	6.628		Dec. 30.073	V	7.805	6.982	
Oct. 10.120	V	7.728	6.970		Jan. 6.065	B	8.167	6.628	
Oct. 13.186	B	8.111	6.589		Jan. 6.065	V	7.801	6.994	

Table 6. Summary of Mean Normalized Magnitude Values for Uranus and Neptune (uncertainties are estimated)

Planet	U(1, α) [n]	B(1, α) [n]	V(1, α) [n]	B – V	U – B
Uranus	–6.33 ±0.03 [9]	–6.646 ± 0.02 [20]	–7.184 ±0.02 [20]	0.538	0.32
Neptune	–6.40 ±0.03 [17]	–6.58 ±0.03 [14]	–6.982 ±0.02 [14]	0.402	0.18

Table 7. Summary of "Synthetic Magnitudes" and Geometric Albedos (in parentheses) Based on the Spectra and Analysis Made by Christophe Pellier

Date	Planet	Reduced Magnitude (and Albedo) Values in Different Filters				
		U	B	V	R_c	I_c
Dec. 3, 2019	Uranus	–	–6.58 (0.55)	–7.13 (0.50)	–7.14 (0.35)	–6.41 (0.13)
Jan. 20, 2020	Uranus	–	–6.58 (0.55)	–7.14 (0.51)	–6.98 (0.32)	–6.17 (0.11)
Aug. 22, 2019	Neptune	–	–6.56 (0.55)	–6.96 (0.44)	–6.96 (0.31)	–6.25 (0.12)
Sep. 4, 2019	Neptune	–6.40 (0.55)	–6.55 (0.54)	–6.95 (0.44)	–6.92 (0.30)	–5.93 (0.09)

ALPO Resources

People, publications, etc., to help our members

Board of Directors

http://www.alpo-astronomy.org/main/board.html

- Executive Director; Julius L. Benton, Jr., Associates in Astronomy, P.O. Box 30545, Wilmington Island, Savannah, GA 31410; jlbaina@msn.com (preferred) and jbenton55@comcast.net
- Associate Executive Director; Carl Hergenrother, 4101 North Sunnywood Place, Tuscon, AZ 85749; chergen@lpl.arizona.edu
- Member of the Board; Sanjay Limaye, University of Wisconsin, Space Science and Engineering Center, Atmospheric Oceanic and Space Science Bldg. 1017, 1225 W. Dayton St., Madison, WI 53706; sanjayl@ssec.wisc.edu
- Member of the Board; Ken Poshedly, 1741 Bruckner Ct., Snellville, GA 30078-2784; ken.poshedly@alpo-astronomy.org
- Member of the Board; Timothy J. Robertson, 195 Tierra Rejada Rd., #148, Simi Valley, CA 93065; cometman@cometman.net
- Member of the Board; Richard W. Schmude, Jr., 109 Tyus St., Barnesville, GA 30204; schmude@gordonstate.edu
- Member of the Board, Secretary/Treasurer; Matthew Will, P.O. Box 13456, Springfield, IL 62791-3456; matt.will@alpo-astronomy.org

Publications Section

http://alpo-astronomy.org/gallery3/index.php/Publications-Section

- Coordinator; Ken Poshedly (ALPO-Member-Discussion e-mail group moderator & *The Strolling Astronomer* production); 1741 Bruckner Ct, Snellville, GA 30078-2784; ken.poshedly@alpo-astronomy.org
- Assistant Coordinator; (Editor, *The Strolling Astronomer)*; Shawn Dilles, 9517 Center St., Vienna, VA 22181; shawn.dilles@alpo-astronomy.org
- Acting Assistant Coordinator/Scientific Advisor; Roger J. Venable, MD, P.O. Box 117, Chester, GA 31012; rjvmd@hughes.net
- Assistant Coordinator (Book reviews, *The Strolling Astronomer*); Robert A. Garfinkle, FRAS, 32924 Monrovia St., Union City, CA 94587-5433; ragarf@earthlink.net
- Assistant Coordinator (Indexer, *The Strolling Astronomer*); Michael Mattei, 11 Coughlin Rd., Littleton, MA 01460-2108; micmatt@hughes.net

Interest Sections

Outreach Section

Lunar & Planetary Training Program

http://www.alpo-astronomy/training

- Coordinator; Timothy J. Robertson, 195 Tierra Rejada Rd., #148, Simi Valley, CA 93065; cometman@cometman.net

YouTube Channel & Podcasts

https://soundcloud.com/observersnotebook

- Coordinator; Timothy J. Robertson, 195 Tierra Rejada Rd., #148, Simi Valley, CA 93065; cometman@cometman.net

Youth Activities Program

http://www.cometman.net/youth/

- Acting Coordinator; Pam Shivak, 4225 NW 32nd St., Cape Coral, FL 33993; pamelashivak@yahoo.com

Online Section

http://www.alpo-astronomy.org/

- Coordinator (ALPO website); Larry Owens, 4225 Park Brooke Trace, Alpharetta, GA 30022; larry@ceastronomy.org
- Assistant Coordinator (ALPO social media); Steven Siedentop, 1475 Holly Lake Circle; Snellville, GA 30078; sdsiedentop@gmail.com
- Acting Assistant Coordinator; Jim Tomney, 404 Dixie Dr., Towson, MD 21204; jim@tomney.com

Observing Sections

Eclipse Section

http://www.alpo-astronomy.org/eclipseblog

- Coordinator; Keith Spring, 2173 John Hart Circle, Orange Park, FL 32073; star.man13@hotmail.com

Mercury/Venus Transit Section

http://www.alpo-astronomy.org/transit

- Coordinator; Keith Spring, 2173 John Hart Circle, Orange Park, FL 32073; star.man13@hotmail.com

Meteors Section

http://www.alpo-astronomy.org/meteor

- Coordinator; Robert D. Lunsford, 14884 Quail Valley Way, El Cajon, CA 92021-2227; lunro.imo.usa@cox.net
- Assistant Coordinator; Robin Gray, P.O. Box 547, Winnemuca, NV 89446; sevenvalleysent@yahoo.com

Meteorites Section

http://www.alpo-astronomy.org/meteorite

- Coordinator; Dolores Hill, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721; dhill@lpl.arizona.edu

Comets Section

http://www.alpo-astronomy.org/comet

- Coordinator; Carl Hergenrother, 4101 North Sunnywood Place, Tuscon, AZ 85749; chergen@lpl.arizona.edu
- Acting Assistant Coordinator; Michel Deconinck, Aquarellia Observatory, 5 rue des Aires, F83630 Artignosc-sur-Verdon, France; trialogmdc@yahoo.fr

Solar Section

http://www.alpo-astronomy.org/solar

- Coordinator & Scientific Advisor; Richard Hill, 10130 E. King Manor Dr., Tucson, AZ 85730; rhill@lpl.arizona.edu
- Assistant Coordinator; Pam Shivak, 4225 NW 32nd St., Cape Coral, FL 33993; pamelashivak@yahoo.com
- Acting Assistant Coordinator (new observers and ALPO Solar Section Online Image Archive contact; primary moderator ALPO Solar Section Yahoo email list); Kim Hay, 76 Colebrook Rd., RR #1, Yarker, Ontario, K0K 3N0 Canada; cdnspooky@gmail.com

Mercury Section

http://www.alpo-astronomy.org/Mercury

- Coordinator; Frank J. Melillo, 14 Glen-Hollow Dr., E-#16, Holtsville, NY 11742; frankj12@aol.com

ALPO Resources

People, publications, etc., to help our members

Venus Section

http://www.alpo-astronomy.org/venus

- Coordinator; Julius L. Benton, Jr., Associates in Astronomy, P.O. Box 30545, Wilmington Island, Savannah, GA 31410; jlbaina@msn.com (preferred) and jbenton55@comcast.net

Lunar Section

Lunar Topographical Studies Program

http://moon.scopesandscapes.com/ALPO_Lunar_Program.htm

Lunar Selected Areas Program

http://moon.scopesandscapes.com/alpo-sap.html

Lunar Banded Craters Program

http://moon.scopesandscapes.com/alpo-bcp.htm

- Coordinator; David Teske, 2162 Enon Rd., Louisville, MS 9501; drteske@yahoo.com
- Assistant Coordinator; Wayne Bailey, 14120 S. Mica Place, Tucson, AZ 85736; wayne.bailey@alpo-astronomy.org
- Assistant Coordinator; William Dembowski, 219 Old Bedford Pike, Windber, PA 15963; zone-vx@comcast.net
- Acting Assistant Coordinator; Alberto Anunziato, Boulevard Racedo 773, 3100-Parana-Entre Rios, Argentina albertoanunziato@yahoo.com.ar

Lunar Domes Studies Program

- Coordinator; Raffaello Lena, Cartesio 144 D, 00137 Rome, Italy; raffaello.lena@alpo-astronomy.org
- Assistant Coordinator; Jim Phillips, 101 Bull St., Charleston, SC 29401-1712; thefamily90@gmail.com

Lunar Meteoritic Impacts Search Program

http://www.alpo-astronomy.org/lunar/lunimpacts.htm

- Coordinator; Brian Cudnik, 11851 Leaf Oak Drive, Houston, TX 77065; cudnik@sbcglobal.net

Lunar Transient Phenomena Program

http://www.alpo-astronomy.org/lunar/LTP.html; also http://www.LTPresearch.org

- Coordinator; Dr. Anthony Charles Cook, Institute of Mathematical and Physical Sciences, University of Aberystwyth, Penglais, Aberystwyth, Ceredigion. SY23 3BZ, United Kingdom; tony.cook@alpo-astronomy.org
- Assistant Coordinator; David O. Darling, 416 West Wilson St., Sun Prairie, WI 53590-2114; DOD121252@aol.com

Mars Section

http://www.alpo-astronomy.org/Mars

- Coordinator; Roger J. Venable, MD, P.O. Box 117, Chester, GA 31012; rjvmd@hughes.net
- Assistant Coordinator (photometry and polarimetry); Richard W. Schmude, Jr., 109 Tyus St., Barnesville, GA 30204; schmude@gordonstate.edu
- Assistant Coordinator; Jim Melka, 14176 Trailtop Dr., Chesterfield, MO 63017; jtmelka@yahoo.com

Minor Planets Section

http://www.alpo-astronomy.org/minor

- Coordinator; Frederick Pilcher, 4438 Organ Mesa Loop, Las Cruces, NM 88011; fpilcher35@gmail.com
- Scientific Advisor: Alan W. Harris, 4750 Walnut St, Suite 205, Boulder, CO 80301; harrisaw@att.net
- Scientific Advisor; Dr. Petr Pravec, Ondrejov Observatory, Astronomical Institute, Academy of Sciences, Cz-25 165 Ondrejov, Czech Republic; ppravec@asu.cas.cz
- Asteroid Photometry Coordinator; Brian D. Warner, Center For Solar System Studies, 446 Sycamore Ave, Eaton, CO 80615; brian@MinorPlanetObserver.com

Jupiter Section

http://www.alpo-astronomy.org/jupiter

- Section Coordinator - Open
- Assistant Coordinator, Apparition Reports; Richard W. Schmude Jr., 109 Tyus St., Barnesville, GA 30204; schmude@gordonstate.edu
- Assistant Coordinator, John McAnally, 2124 Wooded Acres, Waco, TX 76710; CPAJohnM@aol.com
- Assistant Coordinator, Jupiter Section Yahoo email list; Craig MacDougal, 821 Settlers Road, Tampa, FL 33613; macdouc@verizon.net

Saturn Section

http://www.alpo-astronomy.org/saturn

- Coordinator; Julius L. Benton, Jr., Associates in Astronomy, P.O. Box 30545, Wilmington Island, Savannah, GA 31410; ; jlbaina@msn.com (preferred) and jbenton55@comcast.net

Remote Planets Section

http://www.alpo-astronomy.org/remote

Coordinator; Richard W. Schmude, Jr., 109 Tyus St., Barnesville, GA 30204; schmude@gordonstate.edu

Exoplanets Section

http://www.alpo-astronomy.org/saturn

- Acting Coordinator; Jerry Hubbell, 406 Yorktown Blvd, Locust Grove, VA 22508; jerry.hubbell@alpo-astronomy.org

****

ALPO Publications

The Monograph Series

http://www.alpo-astronomy.org/publications/Monographs page.html

Publications too lengthy for publication in *The Strolling Astronomer*. All are available ONLY online as a pdf files. NONE are available any longer in hard copy format. There is NO CHARGE for any of the ALPO monographs.

- **Monograph No. 1.** *Proceedings of the 43rd Convention of the Association of Lunar and Planetary Observers. Las Cruces, New Mexico, August 4-7, 1993. 77* pages. File size approx. 5.2 mb.
- **Monograph No. 2**. *Proceedings of the 44th Convention of the Association of Lunar and Planetary Observers. Greenville, South Carolina, June 15-18, 1994. 52* pages. File size approx. 6.0 mb.
- **Monograph No. 3**. *H.P. Wilkins 300-inch Moon Map.* 3rd Edition (1951). Available as one comprehensive file (approx. 48 megabytes) or five section files (Part 1, 11.6 megabytes; Part 2, 11.7 megabytes; Part 3, 10.2 megabytes; Part 4, 7.8 megabytes; Part 5, 6.5 mb)

ALPO Resources

People, publications, etc., to help our members

- **Monograph No. 4.** *Proceedings of the 45th Convention of the Association of Lunar and Planetary Observers. Wichita, Kansas, August 1-5, 1995.127* pages. Hard copy $17 for the United States, Canada, and Mexico. File size approx. 2.6 mb.

- **Monograph No. *5.*** *Astronomical and Physical Observations of the Axis of Rotation and the Topography of the Planet Mars. First Memoir; 1877-1878.* By Giovanni Virginio Schiaparelli, translated by William Sheehan. 59 pages. File size approx. 2.6 mb.

- **Monograph No. *6.*** *Proceedings of the 47th Convention of the Association of Lunar and Planetary Observers, Tucson, Arizona, October 19-21, 1996.20* pages. File size approx. 2.6 mb.

- **Monograph No. 7.** *Proceedings of the 48th Convention of the Association of Lunar and Planetary Observers. Las Cruces, New Mexico, June 25-29, 1997.76* pages. File size approx. 2.6 mb.

- **Monograph No. 8**. *Proceedings of the 49th Convention of the Association of Lunar and Planetary Observers. Atlanta, Georgia, July 9-11,1998.122* pages. File size approx. 2.6 mb.

- **Monograph Number 9**. *Does Anything Ever Happen on the Moon?* By Walter H. Haas. Reprint of 1942 article. 54 pages. File size approx. 2.6 mb.

- **Monograph No. 10.** *Observing and Understanding Uranus, Neptune and Pluto*. By Richard W. Schmude, Jr. 31 pages. File size approx. 2.6 mb.

- **Monograph No. 11**. *The Charte des Gebirge des Mondes* (Chart of the Mountains of the Moon) by J. F. Julius Schmidt, this monograph edited by John Westfall. Nine files including an accompanying guidebook in German. Note files sizes:
Schmidt0001.pdf, approx. 20.1 mb;
Schmidt0204.pdf, approx. 32.6 mb;
Schmidt0507.pdf, approx. 32.1 mb;
Schmidt0810.pdf, approx. 31.1 mb;
Schmidt1113.pdf, approx. 22.7 mb;
Schmidt1416.pdf, approx. 28.2 mb;
Schmidt1719.pdf, approx. 22.2 mb;
Schmidt2022.pdf, approx. 21.1 mb;
Schmidt2325.pdf, approx. 22.9 mb;
SchmidtGuide.pdf,approx. 10.2 mb

- **Monograph No. 12.** *Solar Activity from 2014 through 2016* (subtitled *An unorthodox analysis of solar activity during three years, on the way to solar minimum*) by Theo Ramakers. Documents the research done to evaluate the relationship between the Wolf number indicator used to identify solar activity in many amateur solar reports and the size of the areas which Active Regions occupy during times of high solar energy."

- **Monograph No. 13.** *A Manual for Observing the Moon: The ALPO Lunar Selected Areas Program* by Dr. Julius Benton. Second update to original 1994 edition. Intended for serious enthusiasts who want to seriously contribute to lunar science through participation in the specialized efforts of the ALPO Lunar Selected Areas Program (which now includes the Dark Haloed Craters Program (DHCP) and the Bright and Banded Craters Program (BBCP). The handbook includes fundamental methods and techniques for conducting systematic observations of specific types of lunar features, including remarks on the lasting value of current lunar visual observations by amateur astronomers with Earth-based telescopes.

- **Monograph No. 14.** *Theory and Methods for Visual Observations of Saturn* by Dr. Julius Benton. Intended for the individual who seeks to gain an understanding of the observational theory and methodology involved in pursuing a worthwhile program of observing Saturn, its ring system, and accompanying satellites. The methods and techniques presented will hopefully be instructive and helpful to the observer who wishes to produce the most useful and reliable data possible for analysis, whether one is conducting a purely visual program or utilizing digital imagers to capture images of Saturn at various wavelengths.

- **Monograph No. 15.** *A Guide for Visual Observations of the Planet Venus* by Dr. Julius Benton. Update to the original 2016 edition. Intended for the individual who seeks to gain an understanding of the observational theory and methodology involved in pursuing a worthwhile program of observing the planet Venus. This small (65-page) handbook has been written for the amateur astronomer who wants to pursue an organized program of systematic visual observations of this planet, a beautiful but exceedingly difficult object to observe.

ALPO Observing Section Publications

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

- **Solar:** *Guidelines for the Observation of White Light Solar Phenomena*, *Guidelines for the Observing Monochromatic Solar Phenomena* plus various drawing and report forms available for free as pdf file downloads at *http://www.alpo-astronomy.org solarblog*.

- **Lunar & Planetary Training Section:** *The Novice Observers Handbook* $15. An introductory text to the training program. Includes directions for recording lunar and planetary observations, useful exercises for determining observational parameters, and observing forms. Available as pdf file via e-mail or send check or money order payable to Timothy J. Robertson, 195 Tierra Rejada Rd., #148, Simi Valley, CA 93065; e-mail *cometman@cometman.net*.

- **Lunar:** (1) *The ALPO Lunar Selected Areas Program Handbook* (hardcopy, $17.50). Includes full set of observing forms. (2) *Observing forms*: Send a SASE for a hardcopy of forms. Both the Handbook and individual observing forms are available for download (as pdf files) at *moon.scopesandscapes.com/ alpo-sap.html*. Use of observing forms will ensure that all requested information is included with observations, but are not required. Various lists and forms related to other Lunar section programs are also available at *moon.scopesandscapes.com*. NOTE: Observers who wish to make copies of

ALPO Resources

People, publications, etc., to help our members

the observing forms may instead send a SASE for a copy of forms available for each program. Authorization to duplicate forms is given only for the purpose of recording and submitting observations to the ALPO lunar SAP section. Observers should make copies using high-quality paper.

- **Lunar**: *The Lunar Observer*, official newsletter of the ALPO Lunar Section, published monthly. Free at *http://moon.scopesandscapes.com/tlo.pdf* or send SASE to: Wayne Bailey, 17 Autumn Lane, Sewell, NJ 08080.

- **Venus (Benton):** Introductory information for observing Venus, the comprehensive *ALPO Venus Handbook*, as well as all observing forms and ephemerides, can be conveniently downloaded as pdf files at no cost to ALPO members and individuals interested in observing Venus as part of our regular programs at *http://www.alpo-astronomy.org/venus*.

- **Mars:** Free resources are on the ALPO website at *www.alpo-astronomy.org* . Click on "Mars Section" in the left column; then on the resulting webpage, look for links to resources in the right column including “Mars Observing Form”, and "Mars Links". Under “Mars Links”, click on "Mars Observers Cafe", and follow those links to The New “Internet Mars Observer's Handbook.”

- **Minor Planets (Derald D. Nye):** *The Minor Planet Bulletin*. Published quarterly; free at *http://www.minorplanetobserver.com/mpb/default.htm*. Paper copies available only to libraries and special institutions at $24 per year via regular mail in the U.S., Mexico and Canada, and $34 per year elsewhere (airmail only). Send check or money order payable to “Minor Planet Bulletin”, c/o Derald D. Nye, 10385 East Observatory Dr., Corona de Tucson, AZ 8564l-2309.

- **Jupiter:** *(1) Jupiter Observer’s Handbook*, from the Astronomical League Sales, temporarily out of stock. (*2*) *ALPO_Jupiter*, the ALPO Jupiter Section e-mail network; to join, send a blank e-mail to *ALPO_Jupiter-subscribe@yahoogroups.com* (3) *Jupiter Observer’s Startup Ki*t, $3 from Richard Schmude, Jupiter Section Coordinator.

- **Saturn (Benton):** Introductory information for observing Saturn, including all observing forms and ephemerides, can be conveniently downloaded as pdf files at no cost to ALPO members and individuals interested in observing Saturn as part of our regular programs at *http://www.alpo-astronomy.org/saturn*. The former *ALPO Saturn Handbook* was replaced in 2006 by *Saturn and How to Observe It* (authored by Julius L. Benton) and it can be obtained from book sellers such as *Amazon.com*.

- **Meteors:** (1) *The ALPO Guide to Watching Meteors* (pamphlet). $3 per copy (postage & handling); check/money order to Astronomical League Sales, 9201 Ward Parkway, Suite 100, Kansas City, MO 64114; phone 816-DEEP-SKY (816-333-7759); e-mail *leaguesales@astroleague.org*. (2) *The ALPO Meteors Section Newslette*r, free (except postage), published quarterly (March, June, September and December). Send stamps, check or money order for first class postage to cover desired number of issues to Robert D. Lunsford, 14884 Quail Valley Way, El Cajon, CA 92021-2227.

Back Issues of The Strolling Astronomer

Online Issues

All issues of this Journal are available for downloading via the ALPO website through Vole 61(2019).
All indexes have been posted except for volume 61 (2019) and volume 62 (2020). The missing items will be posted as soon as possible.

To download online Journals:

1. Go to alpo-astronomy.org, then click on the “ALPO Section Galleries” link near the top of the right corner.
2. Next, click on the Publications Section icon, then click on the ALPO Journals icon.
3. Choose either the folder of indexes or the desired volume of Journals according to year.
4. Finally, click on the desired Journal to view or download.

Note that the newest four issues are available for downloading only by ALPO members.

Hard-Copy Issues

Some hard-copy back issues listed below may be out of stock with no guarantee of availability. Issues are sold on a first-come, first-served basis. Back issues are $4 each, and $5 for the current issue. Discounts available on orders over $30. Contact Secretary/Treasurer Matthew Will to order hard copies (see address under “Board of Directors,”):

$4 each:
Vol. 16 (1962) Nos. 3-4
Vol. 17 (1963) Nos. 1-2
Vol. 19 (1965) Nos. 3-4
Vol. 29 (1981-83) Nos. 1-2 and 11-12
Vol. 30 (1983-84) Nos. 1-2, 7-8, 9-10
Vol. 32 (1987-88) Nos. 3-4, 10-12
Vol. 33 (1989) Nos. 10-12
Vol. 34 (1990) Nos. 1 and 3
Vol. 35 (1991) Nos. 1, 2, and 4
Vol. 36 (1992-93) Nos. 1, 2, 3, and 4
Vol. 37 (1993-94) Nos. 1, 2, 3, and 4
Vol. 38 (1994-96) Nos. 1, 2, 3, and 4
Vol. 39 (1996-97) Nos. 1, 2, 3, and 4
Vol. 40 (1998) Nos. 2 and 3
Vol. 41 (1999) Nos. 1, 2, and 3
Vol. 42 (2000) Nos. 1 and 4
Vol. 43 (2001) Nos. 1, 2, 3, and 4
Vol. 44 (2002) Nos. 1, 2, 3, and 4
Vol. 45 (2003) Nos. 1, 2, and 3
Vol. 46 (2004) Nos. 1, 2, 3, and 4
Vol. 47 (2005) Nos. 1, 2, 3, and 4
Vol. 48 (2006) Nos. 1, 2, 3, and 4
Vol. 49 (2007) Nos. 1, 2, 3, and 4
Vol. 50 (2008) Nos. 1, 2, 3, and 4
Vol. 51 (2009) Nos. 1, 2, 3, and 4
Vol. 52 (2010) Nos. 1, 2, 3, and 4
Vol. 53 (2011) Nos. 1, 2, 3, and 4
Vol. 54 (2012) Nos. 1, 2, 3, and 4
Vol. 55 (2013) Nos. 1, 2, 3 and 4
Vol. 56 (2014) Nos. 1, 2, 3 and 4
Vol. 57 (2015) Nos. 1, 2, 3 and 4
Vol. 58 (2016) Nos. 1, 2, 3 and 4
Vol. 59 (2017) Nos. 1, 2, 3 and 4
Vol. 60 (2018) Nos. 1, 2, 3 and 4
Vol. 61 (2019) Nos. 1, 2, 3 and 4
Vol. 62 (2020) Nos. 1, 2, 3 and 4
Vol. 63 (2021) Nos. 1 and 2
$5: Vol. 63 (2021) No. 2 (current issue)

THE ASSOCIATION
OF LUNAR & PLANETARY OBSERVERS (ALPO)

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

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

We have “sections” for the observation of all the types of bodies found in our Solar System. Section coordinators collect and study submitted observations, correspond with observers, encourage beginners, and contribute reports to our quarterly Journal at appropriate intervals. Each section coordinator can supply observing forms and other instructional material to assist in your telescopic work. You are encouraged to correspond with the coordinators in whose projects you are interested. Coordinators can be contacted either via e-mail (available on our website) or at their postal mail addresses listed in our Journal. Members and all interested persons are encouraged to visit our website at *http://www.alpo-astronomy.org*. Our activities are on a volunteer basis, and each member can do as much or as little as he or she wishes. Of course, the ALPO gains in stature and in importance in proportion to how much and also how well each member contributes through his or her participation.

Our work is coordinated by means of our quarterly periodical, the *Journal of the Assn. of Lunar & Planetary Observers* (known also as *The Strolling Astronomer*). Membership dues include a subscription to our Journal. Two versions of our Journal are distributed — a hardcopy (paper) version and an online (digital) version in portable document format (pdf) at considerably reduced cost.

Membership rates and terms are listed below (effective January 1, 2019).

- ..*$US18 – 4 issues of the digital Journal only; all countries, e-mail address required
- ..*$US32 – 8 issues of the digital Journal only; all countries, e-mail address required
- ..*$US45 – 4 issues of the paper Journal only; US, Mexico and Canada
- ..*$US84 – 8 issues of the paper Journal only; US, Mexico and Canada
- ..$US46 – 4 issues of the paper Journal only, all other countries
- ..$US86 – 8 issues of the paper Journal only, all other countries
- ..*$US75 – Sustaining Membership level, 4 issues of the digital and paper Journal, all countries
- ..*$US150 – Sponsoring Membership level, 4 issues of the digital and paper Journal, all countries
- ..*$US250 – Patron Membership level, 4 issues of the digital and paper Journal, all countries
- ..*$US500 – Benefactor Membership level, 4 issues of the digital and paper Journal, all countries
- ..*$US1,000 – Provider Membership level, 4 issues of the digital and paper Journal, all countries
- ..*$US2,500 – Funder Membership level, 4 issues of the digital and paper Journal, all countries
- ..*$US10,000 – Universal Membersship level, lifetime issues of the digital and paper Journal, all countries

For your convenience, you may join online via the via the Internet or by completing the form at the bottom of this page.

To join or renew online, simply left-click on this Astronomical League web page link:
http://www.astroleague.org/store/index.php?main_page=product_info&cPath=10&products_id=39

Afterwards, e-mail the ALPO membership secretary at *matt.will@alpo-astronomy.org* with your name, address, the type of membership and amount paid.

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.

Please Print:
Name____
Street Address____
____
City, State, ZIP ____
E-mail Address____
Phone Number____
Please share your observing interests with the ALPO by entering the appropriate codes on the line below.
Interest____

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)