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Journal of the Association of Lunar & Planetary Observers

The Strolling Astronomer

ASSOCIATION OF LUNAR & PLANETARY OBSERVERS
ALPO
Founded in 1947

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

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

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

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http://www.alpo-astronomy.org

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Association of Lunar & Planetary Observers (ALPO)

Founded by Walter H. Haas, 1947

Point of View:
Trouble in Internet Paradise

By Ken Poshedly, Publications Section coordinator

Aren't computers and the internet wonderful? Yeah, well, they are, BUT maybe not with everything.

More and more frequently, ALPO members (and really everybody else) are receiving “spoof” messages, that is, e-mails that state they're from someone familiar to the recipient but are really not. And what's worse is that while these messages seem innocent, they instead most probably download computer malware, that is, a virus, ransomware, spyware or keylogger onto your computer.

Certainly, we all know about computer viruses and the damage they can do to your terminal, from minor annoyances such as disabling some files to “hiding” your computer's hard drive (making all of your files and programs inaccessible). Ransomware is still out there and you'll know you have it when your computer files are locked from you and you receive an e-mail directing you to deposit a huge sum of money into a specific bank account in order to free up your computer. By then, it’s too late and you are at the mercy of the criminal. Various individuals, cities and counties have been hit by ransomware attacks and either paid up or lost the locked files forever.

Spyware is pretty much just that – a hidden program that “reports back to headquarters” as to what websites you visit so you can get even more advertising. There’s nothing like being stalked online, eh? Some folks think this is cute. I don't.

Keyloggers can be personally tragic. This little ditty also “reports back to headquarters” every keystroke you use to type a message or go online, including passwords and financial information. At its extreme, your bank accounts can be emptied without your knowledge. And you have no recourse after it's done because the bank records will show that “you” logged in, entered the correct password and electronically transferred all of your money to somewhere else.

How to prevent these things? Two very important ways. First, obtain one way or the other a reputable antivirus software program and then run it frequently (at least weekly) on your computer, or set it to automatically scan your system in the “background” while you continue your work. The free versions are okay, but the antivirus programs that you pay for usually have free phone and other technical support if you get confused.

See “Trouble in Internet Paradise (from page 2)” on page 5

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News of General Interest

Our Cover: Quiet Please! (Well, Maybe Not So Much)

In 1967, the British pop band Herman's Hermits once more hit the top 10 music charts with their song, "There's A Kind of Hush (All Over the World)".

And while the subject of that song was love, surely, no one ever thought there WOULD be a real "hush" all over the world, but this one brought on by a global pandemic.

Our cover this time reminds us how solitary astronomy can be – either by choice or by decree.

Later in this issue of your Journal we present personal comments from ALPO members worldwide as to how – if at all – the orders for social distancing have affected their observing activities.

Enjoy! (But only from a distance.)

Tim Robertson, ALPO board member, and coordinator, Lunar & Planetary Training Program and "Observers Notebook" podcasts.

Organization Updates

We are pleased to publish the following announcement by ALPO Executive Director Julius Benton, effective May 1, 2020

- **Creation of an "Outreach Section"** which includes the "Lunar & Planetary Training Program" with Timothy J. Robertson as coordinator, "Podcasts" also with Tim Robertson as coordinator and a "Youth Activities Program" with Pamela Shivak as coordinator.
- **Election of Tim Robertson to the ALPO Board of Directors** to fill the vacancy created with the passing of Dr. Michael Reynolds in October 2019. Tim grew up in the San Fernando Valley, north of Los Angeles, California. His father was an engineer with Rocketdyne, which designed rocket engines for the Apollo program. Tim's interest in astronomy began one afternoon while he was climbing around in the rafters of the family garage and came across a telescope that his older brother had used. Setting it up that evening and looking at the Moon, Tim was hooked. But living in the light-polluted valley, his stargazing was limited to the Moon and planets. Plus, he enjoyed see the changes in these objects on a nightly basis. Now, years later, Tim works for NASA and has had a number of telescopes in his lifetime and still prefers observing the Moon and planets. Tim has been a member of the ALPO since the early 1970s and has been coordinator of the organization's Lunar & Planetary Training Program since the 1990s; in 2017, he started hosting the "Observers Notebook" podcast for the ALPO.
- **Appointment of Bruce Cordell as acting coordinator & scientific advisor of the ALPO Jupiter Section**. This appointment allows Richard Schmude to return to the assistant coordinator position, where he will continue to produce the Jupiter apparition reports; he had been serving as lead coordinator as well for several years following the vacancy created when the previous coordinator left for health reasons. Bruce's duties will include working with the existing ALPO Jupiter Section staff, which consists of assistant coordinators John McAnally, Craig MacDougal and Richard Schmude. Bruce's beginnings in astronomy go back to the 1960s and his Criterion RV-6 Dynascope (Newtonian reflector) which stunningly revealed a Moon that NASA was about to land on, seasonal changes on Mars, the dynamic atmosphere of Jupiter, and the nearly edge-on view of the rings of Saturn. A later very special meeting with Clyde Tombaugh when

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Bruce was 16 accelerated this process; Bruce still has a copy of our Journal, *The Strolling Astronomer*, (Vol. 19, No. 7-8) which Mr. Tombaugh autographed! A later encounter with Gerard Kuiper, founder of the Lunar and Planetary Lab, led to Bruce leaving UCLA and getting a PhD at the University of Arizona in Planetary Science. His professional career in part includes being an astronomy professor in the California State University and elsewhere. He retired in May 2018 and moved back to Tucson, Arizona, where he is building his observatory. He says: "It's a real pleasure and I'm excited to be part of the Jupiter Section where, in the long, illustrious tradition of ALPO, our current and future observers will expand the scientific conquest of the mysteries of Jupiter." Look for an expanded write-up about Jim in the summer issue of the ALPO Journal (due for release in June).

- **Appointment of Jim Tomney as acting assistant coordinator in the ALPO Online Section**. He will report to Online Section Coordinator Larry Owens in overseeing the ALPO website, especially daily updates to the home page and posting images to the section galleries. Jim started observing using a classic 60mm starter scope; later came his Criterion RV-6 Dynascope (Newtonian reflector), which he still uses to this day, some half century later and which fostered his interest in planetary observing.

  In the 1980s, Jim jumped onboard that newfangled Internet, signing up for a Prodigy account. It was there that he met Jupiter assistant coordinator Craig MacDougal and started a friendship sharing their mutual enthusiasm for observing Jupiter. It was Craig who convinced him to join ALPO, and the idea of being able to contribute observations to a body of work with potential scientific value made him a member from that point on.
  When asked about what stands out over his observing career, Jim noted, "Without a doubt one of the most spectacular events in my 50+ years of peering through that RV-6 was the Shoemaker-Levy 9 impacts on Jupiter. It was one of those rare occasions where expectations were wildly exceeded!"

  As the hobby has evolved, Jim has tried to adopt new techniques. These days he has traded in sketching at the eyepiece in favor of "lucky imaging", that is, capturing video and then stacking it to produce results that would have been impossible using film. Given the light pollution living on the outskirts of Towson University near Baltimore means the planets remain some of the best objects to enjoy from the comfort of his driveway.

  Jim made a mid-life career change into IT (information technology) about 20 years ago, and it is these skills that he hopes to bring to the ALPO website. He has hopes of improving the site incrementally (such as making the site more mobile friendly) but that may need to be tempered by technical resources. He also wants to focus on keeping the content up-to-date so that it's not only a helpful resource to our members but also an enticement for others to join ALPO. If you have feedback on the site for Jim to consider, please feel free to share your thoughts with him at *Jim@tomney.com*.

- **Besides her new duties in the "Youth Activities Program", Pamela Shivak will also continue as an assistant coordinator in the ALPO Solar Section.** Pam's "Youth Activities Program" duties include trying to

(Top) Bruce Cordell, Jupiter Section acting coordinator & scientific advisor.
(Bottom) Jim Tomney, Online Section acting assistant coordinator.

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reach a broad audience of astronomy clubs and STEM organizations and encourage them to organize astronomy or space-related activities for youths of various ages for the purpose of introducing children to the wonders of the universe and space exploration past, present and future via social media platforms such as Facebook and the internet. Pam invites all to join the "ALPO Youth Activities Program" on Facebook at *https://www.facebook.com/groups/ALPOYOUTHPROGRAM/?ref=share*

Pamela already organizes worldwide outreach events on social media like International SUNday which she founded, the Worldwide Solstice Festival and Solar Sidewalk Astronomer's SUN-day. These events mobilize hundreds of folks and astronomy clubs around the world to celebrate our life giving star, the sun and share the experience with the public. Pamela and her husband also do weekly outreach down in Southwest Florida.

Pam describes her beginnings in astronomy this way: "I became interested in astronomy while in high school, circa 1972, when I was dating the guy I would later marry, Randy Shivak. HE was interested in astronomy. So when other girls were going to high school football games with their boyfriends, I was going to astronomy club meetings with my boyfriend.

"I don't have ANY telescopes but my husband Randy has five of them. He's actually the astronomer. I'm the social media personality dedicated to promoting outreach, space and STEM.

"I got interested in the ALPO when we lived in Arizona and then became associated with Rik Hill, the ALPO Solar Section coordinator."

"As for the ALPO Solar Section, I don't remember what year it was, but Rik Hill recruited me to join the Solar Section as an assistant coordinator to do social media and the Youth Activities program. I was recommended to take over at the ALPO Youth Program Coordinator by Tim Robertson May of 2020.

Pam Shivak, Youth Activities acting program coordinator.

As a NASA/JPL Solar System Ambassador, she travels the country attending conferences and star parties giving talks on NASA's missions and does solar outreach with her husband Randy, who is a pro-am solar astronomer/imager. Pamela and her husband were both born and raised near Cleveland, Ohio. They moved to Arizona in 2012 for 6 years, but now reside in southwest Florida and are both retired.

She has presented talks titled "Living with a Star" and "Reaching out with Social Media", at RTMC Astronomy Expo, Solar Fest USA and at the ALPO conference at the University of Georgia in 2017.

Trouble in Internet Paradise (from page 2)

Secondly, NEVER open e-mails — especially attachments — from strangers or e-mails which seem "fakey". This includes notices from banks and even your internet service provider; the usual giveaway is the greeting, which starts off with "Dear valued user". Other such e-mails mis-state the company's name, such as "ATT" (which should ALWAYS be "AT&T) or use grade school grammar and incorrect punctuation. Almost all of them have "hyperlinks" in them for you to click on. Doing so takes you to a false web site where you are asked to divulge everything the sender needs to clean out your bank account.

Lately, e-mails received by me and others seem to come from ALPO Executive Director Julius Benton with a request for gift cards for donation to a veterans hospice or something similar. For one thing, Julius doesn't solicit anything from anybody. Also, the e-mail address used by the sender was not that of Julius (check the board of directors listing in the "ALPO Resources" section of your ALPO Journal for his actual e-mail address). Also, the electronic signature Julius uses is long and intricate and is never just "Julius". And the chances that if you reply to that e-mail, are any of the above occurrences could happen to you.

Just like other things in life, being a responsible computer user means being aware and not easily caught off-guard by these ruses. Be cool and responsible.

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Pamela talks to many people about the Sun and NASA's solar missions every weekend when she and her husband do day and night astronomy on the beach near their home in southwest Florida. Of special interest is the Parker Solar Probe, NASA's first mission to Touch the Sun, which Pamela saw launch from Kennedy Space Center in 2018.

The biggest event by far she participated in as a Solar System Ambassador was the Astronomy Festival on the National Mall in Washington DC which drew a crowd of thousands.

For her efforts in promoting astronomy outreach, she was awarded the Clifford W. Holmes Award at RTMC in 2016 which is presented to individuals who provide a "Major Contribution to Popularizing Astronomy". In addition, she has earned a Master level Outreach Certificate from the Astronomical League.

- **Appointment of Kim Hay as acting assistant coordinator in the ALPO Solar Section**. She had served as lead coordinator of the ALPO Solar Section, then was an assistant coordinator there before leaving several years ago to concentrate on other matters. In the short term, and with Kim already having experience with both Yahoo Groups e-mail lists and Groups.io, she will be working to transfer everything from the Yahoo Solar ALPO e-mail list to our new Solar e-mail list at Groups.io. In the long term, Kim will be a liaison for the ALPO Solar Section, joining with Pam Shivak to put the ALPO Solar Section on more social media more regularly and to recruit new members from some of the observers who continue to post excellent images on these sites. Kim first became interested in astronomy when she was a young girl on her aunt's farm under dark pristine skies of Canada and seeing her first meteor which belonged to the Perseid Meteor shower. She has since then developed her astronomy interest to include solar, meteor and radio astronomy. She has observed the Sun in white light for over 20 years using a 100 mm (4 inch) Bausch & Lomb SCT and sketches sunspots every clear day when possible. More recently, she purchased a Coronado Solar Max 60 solar telescope which she uses to observe and sketch in H-alpha. Future plans include observing the Sun in the calcium line.

Kim Hay, Solar Section acting assistant coordinator.

Aerial view of the North Georgia College in Dahlonega, Georgia.

ALPO Website Updates

The preceding organizational appointments have been incorporated into the ALPO website.

ALPO Conference News

Interested parties are hereby invited to submit papers and research posters on the astronomy-related topics of their choice for presentation at the next ALPO

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conference to be held jointly with the Georgia Regional Astronomers Meeting (GRAM) when that group meets on November 6 and 7, 2020.

This will be the second time the ALPO has participated with the GRA group, the first time being the autumn of 2017.

Like last time, the decision was made after an online discussion and vote by the ALPO board of directors.

This year's conference will be at North Georgia College in Dalton, Georgia, approximately a one-and-a-half hour drive north of downtown Atlanta. The ALPO portion of the conference will commence with the ALPO board meeting on Friday, November 6, to be followed by an informal gathering that evening with a lecture, social gathering with snacks and observing at the school's on-campus observatory.

All papers will be presented the following day, Saturday, November 7, between 9 a.m. and 5 p.m.

Also as we did in 2017, there will be an ALPO dinner on Saturday evening where the Walter Haas Observing Award and the Peggy Haas Service Award will be presented.

We have been allotted up to at least four (4) time slots for ALPO papers of no more than 15 minutes in length; the preferred method is 12 minutes for the paper presentation plus 3 minutes for follow-up questions. The preferred format is Microsoft PowerPoint.

We have also been invited to participate with wall-mounted research posters which are also commonly done at academic and professional conferences everywhere.

Participants are encouraged to submit research papers, presentations, and experience reports concerning various aspects of Earth-based observational astronomy. Suggested topics for papers and presentations include 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.

A hard-copy version of your paper should be made available for future web site publication.

More details about paper presentations and to whom they should be sent will be published in the next issue of this Journal for release in early September.

Call for JALPO Papers

The ALPO encourages its membership 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.

ALPO Interest Section Reports

ALPO Online Section

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

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

To all section coordinators: If you need an ID for your section's blog, contact Larry Owens at *larry.owens@alpo-astronomy.org*

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

Outreach Section

Lunar & Planetary Training Program

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

The ALPO Training Program currently has two 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

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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 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*

'Observers Notebook' Podcasts

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

The Observers Notebook podcast is going strong. I have recorded over 95 podcasts with various members of the ALPO, mostly section coordinators to highlight the programs within each section. The podcasts average around 30 minutes in length. The longest podcast thus far is over 1 hour and 30 minutes, but there is no time limit and the hosting service has unlimited space available for podcasts.

The most recent podcasts that are now online include, a young group of telescope makers, a "round table" discussion with several members of the ALPO, a "what's happening with Comet Atlas" discussion with ALPO Comets Section Coordinator Carl Hergenrother,

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and the new Comet SWAN, Solar Observing with Theo Ramakers.

It takes a great amount of time and money to make and produce these podcasts, and thus far it has been done with the help of a service called Patreon. We currently have ten 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, at that level they become producers of the podcast and also receive one-year membership to the ALPO! Thanks to Steve Siedentop and Michael Moyer for their generous support of the Observers Notebook.

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 and a years membership to the ALPO.

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

https://www.patreon.com/ObserversNotebook

If you have a topic that you would like to hear on the podcast, please drop me a note. I would like to have a discussion on the use of color filters for planetary observing, and another on how you plan an evening observing session. If any of you would be interested in discussing those subjects please let me know.

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

These podcasts are also used to get the word out on any breaking astronomy news or events happening in the night sky. So once more, PLEASE let me know if you have any breaking news that you want out there.

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

- Number of downloads as of April 15, 2020: 39,000+
- Number of Subscribers (all formats): 220+
- Average of number daily downloads (last 3 months): 85
- iTunes rating: 5 Stars!
- Locations of most downloads: USA, UK, Canada, Australia, Germany, and France.

You can hear the podcast on iTunes, Stitcher, iHeart Radio, Amazon Echo, and Google Play just search for *Observers Notebook*. You can also listen to them at the link below:

https://soundcloud.com/observersnotebook

The *Observers Notebook* is also on Facebook – just search for "Observers Notebook" in the search field on top.

Podcasts are released on the 1st and 15th of every month, and if you

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subscribe to it via iTunes it will automatically be downloaded to your device.

You can hear the podcast on iTunes, Stitcher, iHeart Radio, Amazon Echo, and Google Play just search for *Observers Notebook*. You can also listen to them at the link below:

https://soundcloud.com/observersnotebook

The *Observers Notebook* is also on Facebook – just search for "Observers Notebook" in the search field on top.

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

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
cometman@cometman.net

On April 21st, 2020 I was officially appointed as the ALPO Youth Activities Program Coordinator. I created the Youth Program Facebook group on April 23rd.

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

Many clubs have canceled their outreach events and star parties for 2020. My husband and I have been sequestered as well down here in Southwest Florida and every star party and conference we planned on attending were canceled.

As the world starts getting back to normal, I'll be soliciting more astronomy clubs and STEM entities to join the ALPO Youth Activities Program Facebook group.

As of this writing (in early May), I've added 56 people and groups such as STARDOM. the Space Foundation, the Emil Buehler Planetarium, the American Space Museum, Observers Notebook as well as numerous astronomy clubs.

I'm rolling them out on the group slowly so as to spread out the announcement of their joining. I also post some content daily to keep the group relevant and so it shows up in peoples timeline.

Recommendations and spreading the word of my group with your own astronomy club, STEM or outreach friends would be greatly appreciated.

Remember, "We're going to the Moon…to stay"! Be well!

ALPO Observing Section Reports

Eclipse Section

Keith Spring, acting section coordinator
star.man13@hotmail.com

Past Eclipses

We are still accepting reports for the 20-21 January 2019 total lunar eclipse, the 5 June 2020 penumbral lunar eclipse and the 21 June 2020 annular solar eclipse.

Upcoming Eclipses

I now invite everyone to submit eclipse reports for those listed below. Your reports can include photos, but most certainly should include timings, equipment details, viewing conditions, your exact locale and any other observations you may have made during the events.

- 2020 Nov 30; Penumbral Lunar Eclipse; Visible from Asia, Australia, Pacific, North America, South America
- 2020 Dec 14; Total Solar Eclipse; Duration 2 minutes, 10 seconds; Visible from Argentina, South Atlantic, Chile, South Pacific

Please send your reports 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

Keith Spring, acting section coordinator
star.man13@hotmail.com

Past Transits

This section is still accepting reports for the November 11, 2019 Mercury Transit for archival.

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*

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Meteors Section

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

The year was suppose to start with a bang as the Quadrantid meteor shower was predicted to peak over eastern North America. Unfortunately, it peaked early over western Europe and the eastern Atlantic area. By the time the radiant swung into view for North America, rates were falling precipitously. More than three months lapsed before another major meteor shower was predicted to occur.

The Lyrids peaked near 8:00 UT, which was favorable for eastern North America. Peak zenith hourly rates were near 18, but by the time the Lyrids appeared on North America's the West Coast, rates had fallen by 50 percent. So East Coast observers were better situated for both of these early year showers.

The next chance to view a major shower will be in late July, when the southern delta Aquariids peak. The Moon will be favorable for this display, as the First Quarter Moon will set by the time the radiant culminates in the southern sky.

Several weeks later, the Perseids will peak with a Last Quarter Moon in the sky. While not perfect conditions, a grand show should still be witnessed by all with clear, transparent, skies.

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 includes new meteorite approvals from two periods: Oct. 31, 2019 to December 31, 2019 and Jan. 1, 2020 to April 18, 2020 from the Meteoritical Society's Nomenclature Committee.

The *Meteoritical Bulletin* records officially recognized, classified meteorites of the world's inventory. As of April 18, 2020, it contains a total of 63,709 meteorites.

Noteworthy meteorites are 6 approved falls: Shidian (CM2) fell 2017 in Yunnan, China; Taqtaq-e Rasoul (H5) fell 2019 in Bakhtaran, Iran; Tocache (H5) fell 1998 in San Martin, Peru; Flensburg (C1-ungr) fell 2019 in Schleswig-Holstein, Germany; Zhob (H3-4) fell 2020 in Baluchistan, Pakistan; Matarka (L6) fell in 2018 Eastern Morocco; and Saint-Ouen-en-Champagne (H5) fell 1799 in Pays de la Loire, France.

There were 1,752 new meteorites approved in the last two months of 2019 and first quarter of 2020. Most are from cold and hot desert regions, particularly Antarctica and North West Africa. 437 entries corrected or updated information on already known meteorites.

Newly approved meteorites include 1,479 ordinary chondrites (840 H, 543 L, 96 LL); 2 EH; 5 EL; 4 EL-melt rocks; 71 carbonaceous chondrites (11 CK, 7 CM, 29 CO, 3 CR, 18 CV, 1 C ungr, 2 C3.00-ungr); 5 R chondrite; 22 irons; 2 acapulcoite; 1 lodranite; 1 angrite; 2 brachinite, 6 mesosiderites; 14 ureilites; 71 HEDs (4 Howardites, 54 Eucrites, 13 Diogenites,); 5 pallasites; 6 achondrites; 25 Lunar; 25 Martian; 6 winonaites.

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.

Comets Section

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

The year 2020 is developing into an exciting one for comet observers. We have already seen seven comets at 10th magnitude or brighter with six of the seven being recent discoveries. As a result, the ALPO Comets Section has been very active over the first four months of 2020.

Through the end of April, the following observers have contributed 179 magnitude measurements of 17 comets: Salvador Aguirre, Michel Deconinck, J. J. Gonzalez, Carl Hergenrother, Willian Souza and Christopher Wyatt. The Section also received 164 images and sketches of 22 comets from Andre Brossel, Denis Buczynski, John Chumack, Dan Crowson, Michel Deconinck, Carl Hergenrother, Manos Kardasis, Michel Lefèvre, John Maikner, Gianluca Masi, Frank J. Melillo, Martin Mobberley, Efrain Morales Rivera, John D. Sabia, Chris Schur, Willian Souza, Tenho Tuomi, and Myron E. Wasiuta.

The highlights of early 2020 were comets C/2019 Y4 (ATLAS) and C/2020 F8 (SWAN). C/2019 Y4 spent a few weeks being hyped in the media as the next "Comet of the Century", only to disintegrate and slowly fade in April. The comet was well-placed for northern hemisphere observers to watch its disintegration. While southern hemisphere observers missed out on C/2019 Y4, they had a front-row seat to watch the development of outburst prone C/2020 F8 (SWAN). As of the end of April, this comet has become a faint, naked-eye object at 5th magnitude. With a perihelion in late May at 0.43 au, hops were for this comet to continue to brighten throughout May.

Up to six comets have the potential of being brighter than 10th magnitude during the July-August-September quarter.

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C/2017 T2 (PANSTARRS) has been a well-placed visual target for northern observers since the end of 2019. Starting in July, southern observers will also get a chance to view the comet. Now past perihelion (T = 2020 May 04 at 1.62 au), PANSTARRS will fade from ~9th to 11th magnitude in the evening sky.

Frequent visitor 2P/Encke is making its 64th observed return since it was first seen in 1786. This year Encke is unobservable from the northern hemisphere. Southern hemisphere observers can watch it fade in the evening sky from 7th to 10th magnitude in July.

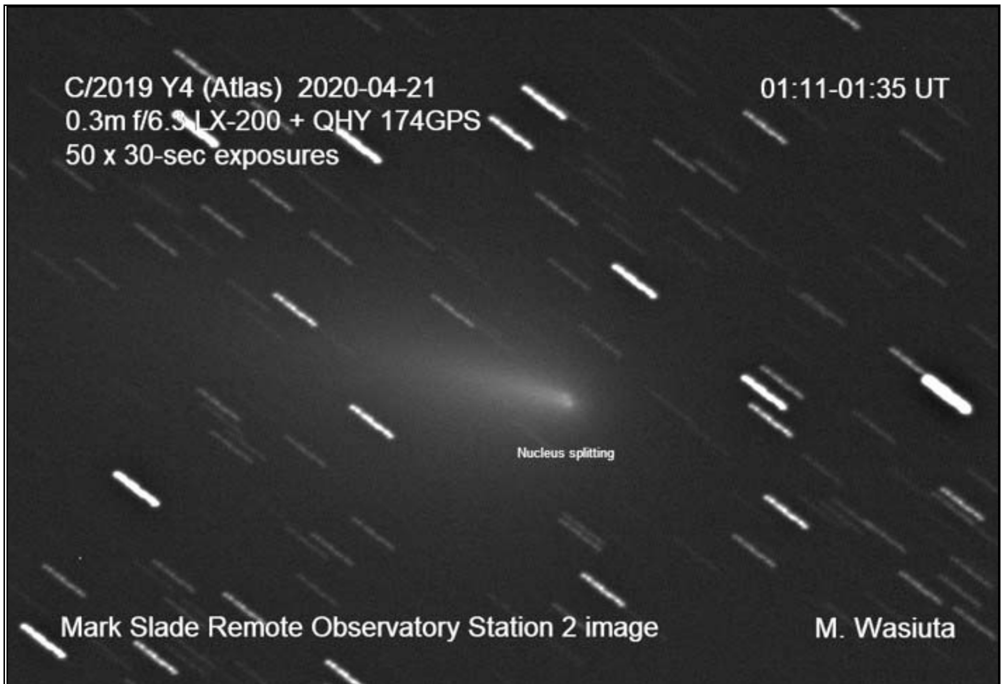
Another short-period comet, 88P/Howell, will steadily brighten from 11th to 8th magnitude. It is also an evening object but, unlike Encke, will be visible from both hemispheres.

The remaining three comets are all of the long-period variety. Predicted brightnesses for these comets is more uncertain than usual. C/2019 U6 (Lemmon) appeared to be an inactive object at discovery. The comet has since become active and rapidly brightened. At the end of April, comet Lemmon was around magnitude 9.0. Perihelion occurs on June 18 at 0.91 au when it could become as bright as 6-7th magnitude. By July the comet will still be near maximum brightness and a nice object from both hemispheres. It should fade below 10th magnitude by September.

April saw the discovery of two comets with small perihelion distances. C/2020 F3 (NEOWISE) was on the verge of brightening past magnitude 10 at the end of April. The comet appears to be intrinsically faint and there is a possibility it won't survive its July 3rd perihelion at 0.30 au. As July starts, the comet will be located too close to the Sun for most observers. It rapidly moves away from the Sun and, assuming it survived its close brush with the Sun, it could become visible from the northern hemisphere in a few days after perihelion. Southern hemisphere observers will need to wait till later in July to see C/2020 F3 again.

The predicted magnitudes in the ephemerides table are a guesstimate and may be off by many magnitudes.

After the disintegration of C/2019 Y4 (ATLAS), C/2020 F8 (SWAN) took over the mantle of brightest comet in the sky. As seems to be a trend with the current batch of new discoveries, predicting SWAN's future performance is a bit problematic. SWAN may have been in outburst at the time of discovery. Another outburst occurred at the end of April when the comet brightened to 5th magnitude and became a borderline naked-eye object. Will the outbursts produce a bright comet? Are they



(Above) Multiple fragments of the nucleus of comet C/2019 Y4 (ATLAS) are seen in an image taken on 2020 April 21 by Myron E. Wasiuta with a Meade 0.3-m, f/6.3, LX-200 SCT at the Mark Slade Remote Observatory near Fredericksburg, Virginia.

(Right) Martin Mobberley captured this image of C/2020 F8 (SWAN) taken on 2020 April 25 with an iTelescopes 0.51-m classical Dall-Kirkham, f/4.4, from Siding Spring, Australia.

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symptomatic of a possible disintegration? With perihelion having occurred on May 27 at 0.43 au, you'll have an answer to these questions by the time you are reading this. SWAN starts July close to the Sun but may become visible at 9-10th magnitude in late July though its predicted brightness may be well off.

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
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See also the paper "A Report on Carrington Rotations 2221 through 2225" later in this Journal.

This year has been one of many changes for the Solar Section.

Our first change was the loss of Rick Gossett as assistant coordinator back in December due to work pressures. He has served the ALPO Solar Section in various capacities since 2002, including starting up our e-mail list which has been busy ever since. Rick was one of those people that operated behind the scenes but without whom things don't work. You will be missed, Rick, and any time you want to come back, just ask!

The second change was the resignation of Theo Ramakers. He was key in the Section, building and then running the image gallery of over 50,000 images

Ephemerides for Comets 2P Encke, 88P Howell, C/2017 T2 (PANSTARRS), C/2019 U6 (Lemmon), C/2020 F3 (NEOWISE) and C/2020 F8 (SWAN)

Date	R.A.	Decl.	r (au)	d (au)	Elong (deg)	m1	Const	Max El 40N	Max El 40S
2P/Encke									
2020 Jul 01	08 03.8	+17 43	0.36	1.052	20	7.3	Cnc	0	1
2020 Jul 11	09 13.9	+08 19	0.52	0.816	30	7.8	Cnc	0	12
2020 Jul 21	10 29.3	-03 23	0.70	0.668	43	9.0	Sext	0	26
2020 Jul 31	11 58.0	-16 04	0.88	0.622	59	10.4	Crv	0	42
2020 Aug 10	13 30.4	-25 33	1.05	0.677	73	11.8	Hya	0	56
2020 Aug 20	14 49.9	-30 11	1.20	0.805	82	13.1	Cen	5	64
2020 Aug 30	15 51.0	-31 41	1.35	0.977	85	14.3	Lup	8	68
2020 Sep 09	16 37.0	-31 45	1.49	1.174	85	15.4	Sco	11	67
2020 Sep 19	17 13.1	-31 15	1.62	1.386	83	16.3	Sco	13	64
2020 Sep 29	17 42.8	-30 30	1.74	1.606	80	17.1	Sco	14	60
88P/Howell									
2020 Jul 01	12 55.7	-05 31	1.65	1.20	95	11.1	Vir	56	56
2020 Jul 11	13 08.4	-07 26	1.59	1.23	89	10.8	Vir	59	57
2020 Jul 21	13 24.3	-09 36	1.54	1.26	84	10.4	Vir	60	57
2020 Jul 31	13 43.2	-11 59	1.49	1.28	80	10.1	Vir	59	56
2020 Aug 10	14 05.1	-14 29	1.45	1.30	76	9.8	Vir	58	54
2020 Aug 20	14 30.0	-17 03	1.42	1.32	73	9.5	Lib	55	53
2020 Aug 30	14 57.9	-19 35	1.39	1.34	70	9.2	Lib	52	51
2020 Sep 09	15 28.9	-21 58	1.37	1.36	68	9.0	Lib	49	49
2020 Sep 19	16 02.7	-24 04	1.36	1.38	67	8.9	Sco	45	47
2020 Sep 29	16 39.0	-25 44	1.35	1.41	65	8.8	Sco	42	46
C/2017 T2 (PANSTARRS)									
2020 Jul 01	12 30.6	+41 38	1.79	1.80	73	8.8	CVn	49	8
2020 Jul 11	12 50.9	+33 56	1.85	1.89	71	9.1	CVn	44	15
2020 Jul 21	13 08.9	+26 44	1.91	2.02	69	9.3	Com	39	21
2020 Jul 31	13 25.3	+20 11	1.99	2.16	66	9.7	Com	33	25
2020 Aug 10	13 40.7	+14 17	2.06	2.32	62	10.0	Boo	28	27
2020 Aug 20	13 55.4	+09 02	2.14	2.49	58	10.3	Boo	24	27
2020 Aug 30	14 09.7	+04 21	2.23	2.67	53	10.6	Vir	20	26
2020 Sep 09	14 23.8	+00 12	2.31	2.85	48	10.9	Vir	16	23
2020 Sep 19	14 37.6	-03 29	2.40	3.04	43	11.2	Vir	12	19
2020 Sep 29	14 51.3	-06 48	2.49	3.21	37	11.5	Lib	8	14
C/2019 U6 (Lemmon)									
2020 Jul 01	10 25.4	-02 11	0.94	0.83	60	6.6	Sext	85	39
2020 Jul 11	11 34.4	+05 59	1.00	0.88	62	6.9	Leo	86	36
2020 Jul 21	12 33.1	+12 29	1.08	0.99	65	7.4	Vir	86	31
2020 Jul 31	13 21.3	+16 54	1.18	1.13	66	8.0	Com	86	28
2020 Aug 10	14 01.1	+19 40	1.29	1.29	66	8.6	Boo	86	24
2020 Aug 20	14 35.0	+21 20	1.41	1.46	66	9.1	Boo	86	21
2020 Aug 30	15 04.9	+22 16	1.53	1.63	66	9.6	Boo	85	19
2020 Sep 09	15 31.9	+22 45	1.65	1.80	65	10.1	Ser	85	16
2020 Sep 19	15 57.0	+22 57	1.78	1.97	64	10.5	Ser	84	12
2020 Sep 29	16 20.7	+23 01	1.91	2.13	63	10.9	Her	84	8

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Ephemerides for Comets 2P Encke, 88P Howell, C/2017 T2 (PANSTARRS), C/2019 U6 (Lemmon), C/2020 F3 (NEOWISE) and C/2020 F8 (SWAN)

C/2020 F3 (NEOWISE)									
2020 Jul 01	05 55.7	+26 08	0.31	1.24	10	4.4?	Tau	0	0
2020 Jul 11	06 43.8	+41 49	0.37	0.90	21	4.3?	Aur	3	0
2020 Jul 21	09 43.9	+47 13	0.58	0.70	33	5.3?	UMa	17	0
2020 Jul 31	12 22.6	+29 58	0.80	0.77	51	6.5?	Com	27	10
2020 Aug 10	13 28.0	+13 52	1.01	1.02	59	7.9?	Vir	26	26
2020 Aug 20	14 00.5	+04 09	1.21	1.33	60	9.0?	Vir	22	32
2020 Aug 30	14 21.4	-01 57	1.40	1.65	57	10.0?	Vir	18	32
2020 Sep 09	14 37.3	-06 10	1.58	1.96	52	10.7?	Vir	14	29
2020 Sep 19	14 50.8	-09 18	1.75	2.27	47	11.4?	Lib	10	25
2020 Sep 29	15 02.8	-11 45	1.91	2.55	40	11.9?	Lib	7	19
C/2020 F8 (SWAN)									
2020 Jul 01	06 16.7	+31 47	0.94	1.92	10	7.7?	Aur	0	0
2020 Jul 11	06 26.1	+28 19	1.13	2.08	14	8.5?	Aur	0	0
2020 Jul 21	06 33.5	+25 16	1.31	2.20	20	9.1?	Gem	0	0
2020 Jul 31	06 39.4	+22 30	1.48	2.29	28	9.6?	Gem	5	1
2020 Aug 10	06 43.8	+19 53	1.65	2.34	37	10.0?	Gem	12	7
2020 Aug 20	06 46.6	+17 20	1.81	2.36	46	10.3?	Gem	20	13
2020 Aug 30	06 47.5	+14 49	1.97	2.36	55	10.6?	Gem	28	19
2020 Sep 09	06 46.3	+12 16	2.13	2.34	65	10.8?	Gem	36	24
2020 Sep 19	06 42.7	+09 39	2.28	2.31	75	11.0?	Gem	44	30
2020 Sep 29	06 36.5	+06 58	2.43	2.27	86	11.2?	Mon	50	36

going back to 1979. But this was just an off-shoot to the larger job of his help in building much of the new website for the ALPO. Observers don't realize it, but when they e-mail in their observations, these must have image names that conform to a standard for the software. This means each and every image has to be individually inspected and changed to match this standard. It's a big job. Further, everyone knew him because he contacted just about everybody in the Section over the years! Those on social media see his almost daily solar images done from his home in Georgia. Recently, he had been very involved with making observations of Solar Cycle 25 sunspots and posting them on the website and I certainly hope he will continue to contribute these and his other observations in the future (as he has in the report elsewhere in this JALPO issue). He had also done some research on calculating solar activity and some of this has appeared in the pages of this Journal. Thank you Theo for all you did! It was a big help!!

The changes don't stop there. With the departure of Theo it was necessary to quickly fill his shoes as regards the Solar Gallery on the ALPO website as observations continued to be submitted. This was done with the appointment of Jim Tomney to the ALPO Online Section to work under Larry Owens. Tim's bio and background information are found elsewhere in this Journal.

We were also delighted to have Kim Hay return to the ALPO Solar Section. Kim has already done us a service by completing the change over from Yahoo Groups to Groups.io for our e-mail list that Rick Gossett was maintaining. Thanks Kim! As with Jim, her background and biographical information can be found elsewhere in this Journal.

Solar activity is at an extremely low level right now, giving everyone a chance to reorganize and giving observers a chance to prepare their equipment and techniques. Activity will be picking up and according to some predictions, very soon.

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

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

Mercury Section

Report by Frank J. Melillo, section coordinator
frankj12@aol.com

By the time you read this, Mercury will be a morning planetary object. For the entire month of July, it will be brightly visible before sunrise and will reach the greatest elongation of 20 degrees west of the Sun on July 22.

Visually, Mercury will stand almost 10 degrees above the eastern horizon about 30 minutes before sunrise. It will shine at an average magnitude of +0.3. Plus, Venus will be above Mercury about 23 degrees to the upper right. Telescopically on July 25, Mercury will be facing the exact same longitude as it did on August 10, 2019 in my image.

It will appear as a fat crescent 46% illuminated at 7.3 arc seconds in diameter. The unknown crater ray ejecta below center should be visible in good seeing conditions using a WR #25 red filter. Also, a few other white patches may be seen, but they will be much smaller.

By month's end, Mercury continues to brighten about -0.7 magnitude in Gemini near Pollux and Castor upper left. Then, it will fall into inferior conjunction with the Sun on August 17 only to reappear shortly after as an evening object once again.

The Mercury section has received some incredible images by Italian amateur Luigi Morone. On February 8, 2020, he sent in a photo of Mercury showing some

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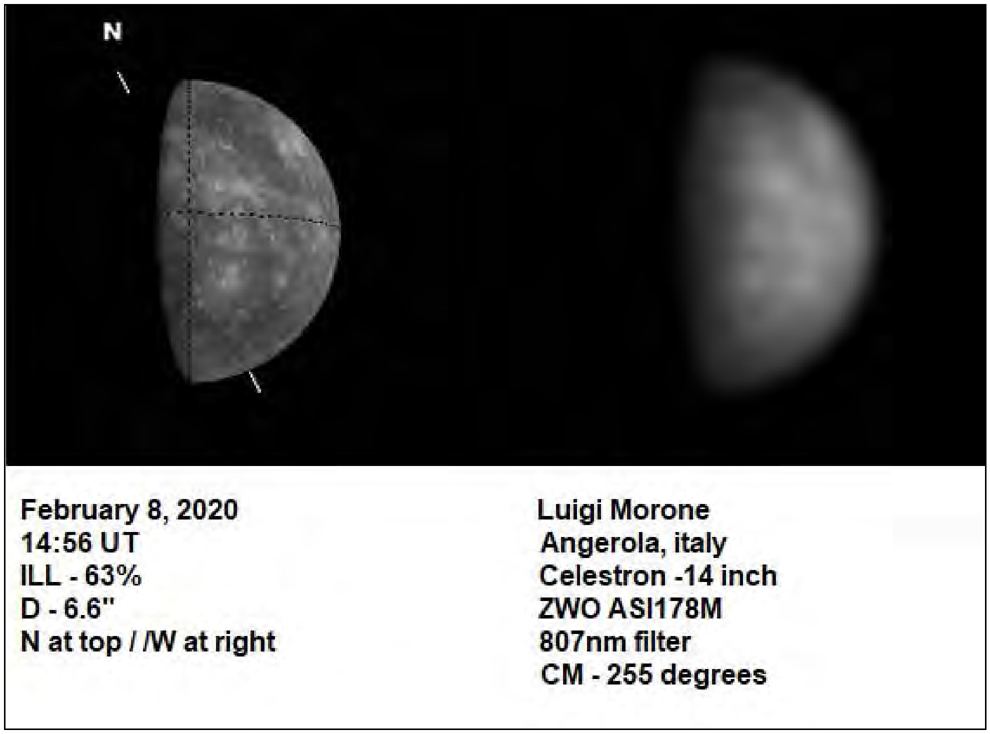
white ejecta rayed craters, which can easily compare with the *WinJUPOS Stimulate* image taken by the MESSENGER spacecraft. Plus, the large basin Colaris can easily be seen near the upper right of the sunlit limb. This is one example of how well Mercury can be imaged with a moderately sized telescope.

If you miss the morning apparition in July, take heart because Mercury will have another favorable morning apparition in November, perhaps even better! More about that in the next issue.

[We always appreciate receiving your observations, so please, send them in!

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



Mercury as imaged by Luigi Morone of Angerola, Italy. See image for details.

Venus Section

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

Venus entered into Inferior Conjunction with the Sun on June 3, 2020, thereby ending the immediately preceding 2019-20 Eastern (Evening) Apparition. During the new 2020-21 Western (Morning) Apparition, Venus is passing through its waxing phases as it shrinks in angular diameter, slowly changing from a thin crescent to a gibbous and ultimately a fully illuminated disk as it reaches Superior Conjunction on March 26, 2021.

As of the date of this report (in late April), observers had submitted well in excess of 125 observations for the previous 2019-20 Eastern (Evening) Apparition; these included digital images of the planet at UV, visual, and near IR wavelengths, as well as numerous drawings in integrated light (no filter) and with different color filters. Not all observations for the previous 2019-20 Eastern (Evening) Apparition have been received, so observers are continuing to submit their completed reports for the observing season; thus, the final number of reports for the period will not be known for quite some time until the apparition report is prepared for publication.

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.*

A follow-up collaborative Pro-Am effort remains underway this apparition in support of Japan's (JAXA) Akatsuki mission that began full-scale observations starting back in April 2016. The website for the Akatsuki mission is currently active so interested and adequately equipped ALPO observers can still register and start submitting images if they have not already done so. More information will 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.

This will enable full coordination and teamwork 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.

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

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

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

Observers are urged to attempt to make simultaneous observations by performing digital imaging of Venus at the same time and date that others are imaging or making 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 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

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 (e.g., 1,000nm) the time of inferior conjunction, whereby the hot surface of the planet becomes apparent and occasionally mottling shows up in such images attributable to cooler dark

Luigi Morrone of Agerola, Italy submitted this image of Venus using 320-380nm UV filters at 17:28 UT on March 18, 2020, using his 35.6cm (14.0 in.) SCT under good seeing conditions. The image captures horizontal V, Y, or ψ (psi)-shaped dusky clouds roughly aligned along the planet's terminator that are typically revealed in UV wavelengths as well as amorphous dusky features on the crescent disk of Venus. Both cusp caps and cusp bands are apparent in the image, as well as the bright limb band extending from cusp to cusp. The apparent diameter of Venus is 22.2", phase k=0.545 (54.5% illuminated), and visual magnitude -4.3. South is at the top of drawing.

Geocentric Phenomena of the 2019-20 Eastern (Evening) Apparition of Venus in Universal Time (UT)

Superior Conjunction	2019 Aug 14^d 00^h UT (angular diameter = 9.7″)
Greatest Elongation East	2020 Mar 24^d 00^h UT (46.1°)
Theoretical Dichotomy	2020 Mar 27.04^d UT (Venus is predicted to be exactly half phase)
Greatest Illuminated Extent	2020 Apr 28^d 00^h UT ($-4.6m_v$)
Inferior Conjunction	2020 Jun 03^d 00^h UT(angular diameter = 58.3″)

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higher-elevation terrain and warmer bright lower surface areas in the near-IR.

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, acting program coordinator
drteske@yahoo.com

See also "Lunar Nighttime Thermal Analysis" later in this Journal.

The ALPO Lunar Topographic Studies Section (ALPO LTSS) received a total of 170 observations from 30 observers in nine countries during the January-March 2020 quarter. The countries represented by observers were Argentina (12), USA (8), Spain (3), Italy (2), Columbia (1), Greece (1), Uruguay (1), New Zealand (1) and Romania (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-six articles were published in addition to numerous commentaries on images selected in the monthly newsletter *The Lunar Observer*. A total of 227 lunar images and drawings were submitted. *The Lunar Observer* was placed on the Cloudy Nights website and viewed over 200 times in each month of the quarter.

The *Focus-On* series continued under Jerry Hubbell, with craters from the ALPO Selected Areas Program. The January issue *Focus-On* article featured the craters Plato and Theophilus and the March issue *Focus-On* article featured the lunar craters Tycho (Figure 1), and Herodotus.

Lunar crater Tycho, one subject of a *Focus-On* article in the March issue of *The Lunar Observer*. Image by Victoria Gomez, AEA - Oro Verde, Entre Rios, Argentina, taken 07 February 2020, 00:26 UT; 10 inch Meade LX 200 SCT, ZWO ASI 120 MM/S camera.

Future *Focus-On* articles will highlight observations from the Lunar 100 observing list compiled by Charles Wood. The Lunar 100 observing list includes 100 targets to observe on the Moon from very easy (Lunar 100 number 1, The Moon) to very challenging (Lunar 100 number 100, Mare Marginus swirls). Every other month we'll feature 10 of the Lunar 100 targets in the *Focus-On* series. July will feature Lunar 100 targets 11-20 and September will feature Lunar 100 targets 21-30.

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

Electronic submissions can now be submitted through the ALPO website, (lunar@alpo-astronomy.org). The former method of submitting them directly to the coordinators will still work, but please DO NOT submit through both the website and directly. See the most recent issue of *The Lunar Observer* (http://moon.scopesandscapes.com/tlo.pdf) for instructions on its use. Hard copy submissions should continue to be mailed to me at the address provided in the "ALPO Resources" section of the Journal.

The lunar image gallery/archive is also now active. At the time of this writing, all images received after December 2017 are in the gallery. Wayne Bailey continues to submit archived images to the Lunar Gallery. Acting Coordinator David Teske 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 Society publication to June 2004 when it became the newsletter of this ALPO program, are now available on the ALPO

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website due to hard work by Theo Ramakers.

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

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 observations have been received since the last LTP Program report in this Journal. We continue to have success, though, in eliminating some past LTP reports via our repeat illumination program *http://users.aber.ac.uk/atc/lunar_schedule.htm*, though, interestingly, others remain unresolved.

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.

To help us to solve some past historical lunar observational puzzles, we urge all to access the *Lunar Observing Schedule*, which can be found online at:

http://users.aber.ac.uk/atc/lunar_schedule.htm

This can be especially useful in being able to eliminate a few LTP reports where the observers concerned may have mistaken natural surface color for something more unusual.

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*

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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

See also "Lunar Domes in the Milichius - Tobias Mayer Region: Dome M24" later in this Journal.

In these extraordinary times of Covid-19, when so many of our observers will be feeling anxious and isolated, it is good to know that you are part of a larger group with a common interest that can be sustained, virtually at least, throughout the present crisis.

We have received 82 images, including some by Michael Barbieri, Jean Pierre Brahic, Howard Eskildsen, Tom Glenn, Guy Heinen, Richard Hill, Raffaello Lena, Luigi Morrone, K.C. Pau, Frank Schenck and Martin Stenke.

Hill imaged the dome Mason1 and Piccolomini dome.

Schenck imaged the domes near Messier crater and the region near Hall where further suspected features are under investigation.

Glenn has imaged the dome M24 with the sunrise terminator very close to this location and a solar angle of about 1.5° above the local horizon.

Brahic submitted images of the dome Laplace 1, first identified by Teodorescu (see: *http://www.alpo-astronomy.org/lunarblog/wp-content/uploads/2019/10/dome-sinus-iridum-alpo.pdf*), the low swell named Teneriffe 1, Hortensius-Milichius domes, three domes in Kies and the Apennine Bench formation.

Morrone detected the dome named Putredinis 1 and Barbieri has imaged the Marius hills. Zannelli submitted an image of the dome Meton 1.

Heinen imaged the Gruithuisen highland domes, Kepler dome, Marius hills, Grimaldi dome, Herodotus 1 dome, Cavalerius 1 dome, Doppelmayer 1 dome (including the small dome Gassendi 1 which is bisected by a rille), Arago domes, Menelaus bisected domes, Piccolomini dome, Autolycus 1 dome, Aristillus dome, Valentine domes, Birt bisected domes, Kies 1 dome, Herodotus Omega dome, Hortensius domes, Reinhold domes and two Archytas domes.

Stenke submitted images of the Hortensius Milichius domes field and the dome Prinz 1, first identified by Pau.

Eskildsen submitted many images under different solar illumination angles of Grimaldi dome, Laplace domes, Rümker domes, Fracastorius dome, and the dome Kies 1-3 (K1-K3). The dome named K3 had been previously discovered by Phillips on December 29, 1983, with a drawing made using a 6-inch refractor; no measurements were made at the time. The dome height is now determined to be 130±15 m, while the average slope angle is 0.72°±0.1°.

He also imaged the Capuanus domes and the concentric crater Marth (which is located on a dome as well), Lansberg D domes, Piccolomini dome, domes in Cauchy-Vitruvius and northern Tranquillatitis region, Hortensius-Milichius domes field, and the Hall 1 dome.

Eskildsen also submitted a report on the Gardner megadome. The megadome appears to be approximately 112 km on the N-S sample path and 90 km W-E, with a geometric mean diameter of 100 km. The average megadome height above the surrounding surface for the N-S path is 1,366 meters and 1,206 meters for the E-W path, for a mean height of 1,286 meters. This implies an average slope of 1.5°.

Lena in previous studies has described the Gardner mega dome. Its large diameter and volume (1400 km^3) corresponds to a volcanic shield, a previously unrecognized style of lunar volcanic activity. Another typical example of these features is the volcanic complex Mons Rümker, which is situated in the north-western part of Oceanus Procellarum. With a diameter of about 65 km, it is the largest contiguous volcanic edifice on the Moon. The derived digital elevation model (DEM) of the volcanic complex Mons Rümker shows that the height of the plateau reaches about 900 m in its western and north-western part, 1,100 m in its southern part, and 650 m in its eastern and north-eastern part (yielding an average slope of 1.7°). Another volcanic shield is the Marco Polo mega dome (Marco Polo MD). I have found that the examined volcanic shields (Gardner MD, Mons Rümker and Marco Polo MD) form a separate spectral and morphometric group in the lunar domes classification scheme, which is shown on a Principal Component Analysis (PCA): thus, I extend the classification scheme and assign the recognized large volcanic shields to a new class designated "I".

Pau has imaged the dome named Wolf 1, located at longitude 7.92° W and latitude 15.27° N, with a base diameter of 9.1 ± 0.5 km. It displays protrusions on the summits, which probably are pre-existing non-volcanic hills. The height of the dome is 90 ± 10m, resulting in an average slope of 1.1° ± 0.10°. It belongs to class C_2. Pau has also imaged the Hansteen domes and a large intrusive dome in Mare Vaporum (newly named as MP2) located at longitude 0.43°E and latitude 12.38°N, with an elevation of 105 m ± 10 m and a very low slope of 0.5° ± 0.05° considering the base diameter of ~26km.

MP2 lies to the south of the Marco Polo MD complex, which has been previously studied (see https://www.hou.usra.edu/meetings/lpsc2017/pdf/1005.pdf). In the MP MD complex, the magma in the laccolith found its way to the surface in a number of vents producing either low-albedo pyroclastic deposits and/or erupting thin, low-viscosity lava flows originating some effusive domes MP1, MP3 and MP4.

In contrast, at the Marco Polo MD2 detected by Pau, only a phase of uplift

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occurred from the rise of magma that did not erupt onto the surface. These differences deserve attention and additional images are requested to identify other similar structures. Pau has also submitted an image showing a suspect feature located south of crater La Condomine S, but further images are requested to investigate it.

This author was contacted by Dr. Charles Galdies (senior lecturer with the Division of Environmental Management and Planning/Institute of Earth Systems, University of Malta) about specific topics that still need to be addressed in lunar dome studies. He sent us an article written about "Spectral and Morphometric Analysis of a Small Lunar Dome Complex Blanketed by Ejecta in Euclides-J Region". ALPO strongly encourages professional-amateur collaborations and additional professional contacts are encouraged.

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 would then be followed by the observer's ID. This would be followed by 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
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See also "Report of a Probable Comet Impact on Mars in 1973" by Jim Melka later in this Journal.

Mars's seasonal South Polar Cap (SPC) will progressively decrease in size throughout July, August, and September, and these months may be your best opportunity to witness its changes for the next 15 years.

The SPC outlier called the "Mountains of Mitchel", also known as "Novissima Thyle" and as "Novus Mons", will be visible whenever Syrtis Major is visible during these months. Like the cap itself, it will gradually diminish in size, while the shrinking cap's edge recedes from it. Look also for irregularities in the cap, including a relatively dark area at the terminator, bright spots along the northern edge, and small bright spots in the cap itself.

We have already seen several local dust storms in the Hellas and Margaritifer Sinus areas, but the season of the largest dust storms will be beginning in these months. More observers are needed, to fully document them. Remember that dust storms are bright in red light, usually as bright or slightly brighter than the "deserts" of the red planet, and they obscure the usual albedo features. You will see them change or move as you observe from night to night.

We expect to see white clouds over the Tharsis Montes and Olympus Mons late in the Martian afternoons, which often coalesce into a single W-shaped cloud. There may also be occasional, faint, equatorial cloud bands. If you are observing visually, use a blue filter to reveal the clouds most effectively.

Please join us online at *https://groups.io/g/marsobservers* and feel free to open discussions or describe your own observations on that message list. There is a large photos section there in which to store your drawings and images. It is also good to send your images directly to this section coordinator at *rjvmd@hughes.net* and directly to the ALPO web page archiver at *mars@alpo-astronomy.org*.

Finally, I extend special thanks to Clyde Foster and to Paul Maxson, who already have been observing the Red Planet for months.]

Be sure 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
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Following here are some of the highlights published in *The Minor Planet Bulletin*, Volume 47, No. 2, 2020 April-June. These represent the recent achievements of the ALPO Minor Planets Section.

Lorenzo Franco has published a spin-shape model of 33 Polyhymnia. A sidereal rotation period of 19.6089 +/- 0.0003 hours with two equally likely and therefore ambiguous positions of the rotational pole at celestial longitude and latitude 19 degrees, -65 degrees; or 185 degrees, -61 degrees, respectively. Numerical values of sidereal rotation period to four or more decimal places in hours and pole positions, the latter in many cases doubly ambiguous with two equally likely values at celestial longitudes differing by about 180 degrees, are now known for all of the first 46 asteroids to be numbered.

Robert Stephens and Brian Warner, in addition to presenting a new lightcurve of the Mars crossing asteroid (16143) 1999 XK142, also publish a spin-shape model

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for this object. They found a sidereal rotation period 6.397446 hours with a rotational pole position at celestial longitude and latitude 17 degrees and -89 degrees, respectively, that is, retrograde rotation.

A lightcurve will not repeat from one cycle to another if the asteroid is tumbling, that is, its rotational pole is precessing. For the Earth, the 25,800 year period of precession is vastly longer than the rotation period. For tumbling asteroids the rotational and precessional periods usually differ by a factor of not more than two or three, and the physics explaining the precession is completely different. Asteroids for which tumbling behavior is newly published include 2000 Herschel, (467317) QW7, and the newly discovered Earth-approacher 2019 SH6.

A satellite of an asteroid may be detected photometrically if a brief dip is observed in the rotational lightcurve as the secondary either transits or is occulted by the primary. Their combined light is reduced during these satellite events. Dual-period software can separate the two lightcurves with separate periods from the observed combined lightcurve. For 1563 Noel, a primary rotation period of 3.549 hours is well established. A very slight dip with 15.88 hour periodicity is hinted, but the dip is very shallow and may not be real.

Alternatively, if transits and occultations do not occur but the two components have different rotation periods, their rotational lightcurves can be resolved by dual-period software. For minor planet 6646 Churanta, Brian Warner and Robert Stephens report rotation periods of the two components as 5.8712 and 16.00 hours, respectively; and for (442243) 2011 MD11, 2.4753 and 21.71 hours, respectively.

For Earth-approachers moving rapidly across the sky, the viewing line of sight and the shape and even synodic period of the accompanying lightcurve can change by a large amount from night to night. Furthermore, the window of observation may be only one to a few days. Decomposition and interpretation of lightcurves becomes uncertain and ambiguous. Minor planets reported as possible binaries include (5189) 1990 UQ, (326291) 1998 HM3, (489486) 2007 GS3, and 2007 TQ24. Tumbling behavior is suggested but poorly documented in (162082) 1998 HL1 and (496817) 1989 VB.

In addition to asteroids specifically identified above, lightcurves with derived rotation periods are published for 102 other asteroids as listed below: 10, 47, 153, 190, 204, 395, 455, 495, 463, 563, 576, 587, 702, 711, 773, 774, 783, 828, 892, 1057, 1060, 1152, 1481, 1620, 1746, 1997, 2051, 2070, 2180, 2389, 2466, 2543, 2569, 2580, 2634, 2716, 2729, 2783, 2937, 3122, 3171, 3200, 3295, 3343, 3361, 3428, 3533, 3606, 3662, 3819, 4183, 4422, 4686, 4898, 5096, 5626, 5671, 6085, 6097, 6455, 7043, 7345, 7397, 8141, 8323, 9333, 10426, 18172, 24029, 26737, 36236, 48918, 51149, 65679, 66146, 71280, 88959, 99248, 99907, 100935, 137084, 137199, 138925, 141593, 153814, 162273, 243025, 297418, 310560, 333888, 339714, 481394, 503960, 2010 UH7, 2015 FO124, 2015 JD1, 2017 OP68, 2019 UC, 2019 GT3, 2019 UB11, 2019 UR12, 2019 UD13.

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.

The Minor Planet Bulletin is a refereed publication and that it is available online at:

http://www.MinorPlanet.info/MPB/mpb.php

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 Bruce Cordell, acting section coordinator & scientific advisor,
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Richard Schmude, assistant coordinator,
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See also "Timing Jupiter's Satellite Eclipses: The 2015-16 Apparition" by John Westfall later in this Journal.

As already stated earlier in this Journal, Bruce Cordell has been appointed by the ALPO executive director as the new Jupiter Section Coordinator & Scientific Advisor, effective May 1, 2020. This allows Richard Schmude to return to his assistant coordinator position where he will continue to produce the Jupiter apparition reports for this Journal with assistance from Bruce Cordell.

Richard has already completed the 2017-2018 apparition report and passed it along to other Jupiter section members for their proofreading. He has now started on the 2019 Jupiter report and has also collected several brightness measurements of Jupiter taken before the COVID 19 crises started. He hopes to get more measurements later in the year when restrictions have hopefully been eased.

Assistant Coordinator Craig MacDougal reports that the ALPO Jupiter Yahoo e-mail list currently has 496 members as of

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April 15. A total of 55 images of Jupiter in 2020 have been shared by the group.

He adds that early impressions of this apparition being expressed on the ALPO Jupiter Yahoo e-mail list is that the Jovian South Equatorial Belt seems to be fading while in the North Equatorial Belt is very dark. The Great Red Spot has a strong color and its wake is very active. When imaging in the methane band, the Equatorial Zone is bright.

A request from new Acting Coordinator Bruce Cordell: 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
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The 2020-21 apparition of Saturn is well underway. The planet is now located in Sagittarius and will reach opposition on July 20, 2020, when it will be visible throughout the night. The following geocentric phenomena for the current 2020-21 apparition are presented for the convenience of readers for planning purposes:

The accompanying Table of Geocentric Phenomena for the 2020-21 Apparition in Universal Time (UT) is included here for the convenience of observers.

As of this writing (in late April), the ALPO Saturn Section has already received more than 50 digital images of the planet at visual and multiple other wavelengths, as well as disk drawings in integrated light (no filter) and using color filters. Observers have been regularly imaging discrete atmospheric phenomena in Saturn's northern hemisphere, including interesting small white spots in the EZn (northern half of the Equatorial Zone) interacting with the adjacent EB (equatorial band), plus possible small white spots in the EZs (southern half of the Equatorial Zone, as well as a diffuse white spot in the NTrZ (North Tropical Zone) at saturnigraphic latitude +43° Polar Region) as well as a curious white ripple or streak midway within the EB (Equatorial Belt).

Small white spots have been imaged within the NPR (North Polar Region) at saturnigraphic latitude +74.7°. The aforementioned white spot activity showed up well in most images captured using RGB, red, 685nmIR filters. It will be extremely important for observers during the current 2020-21 observing season to continue to monitor Saturn and attempt imaging with the same multi-wavelength filters to determine if the same or similar features persist and change morphology throughout the 2020-21 apparition.

Observers should be on alert for any new atmospheric phenomena that might suddenly appear. With the rings tilted by about +22° toward our line of sight from Earth in 2020-21, observers still have favorable opportunities to view, draw, or image the northern hemisphere of the globe and north face of the rings during this apparition despite Saturn's southerly declination of -21° for Northern Hemisphere observers.

Pro-Am cooperation with the Cassini mission has continued since the 2016-17 apparition, as NASA's remarkable close-range surveillance of the planet for nearly 13 years that started back on April 1, 2004, and concluded its amazing odyssey back on September 15, 2017 when it plunged into Saturn's atmosphere.

For quite a few years to come, planetary 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.

It should be emphasized, that ALPO Pro-Am efforts did not cease when the Cassini mission ended in September 2017. Indeed, as in the 2018-19 and 2019-20 apparitions, our team of observers are regularly monitoring Saturn for atmospheric phenomena and we are actively sharing our results and images with the professional community. Therefore, anyone worldwide 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.

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

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Saturn as well as the major ring components.

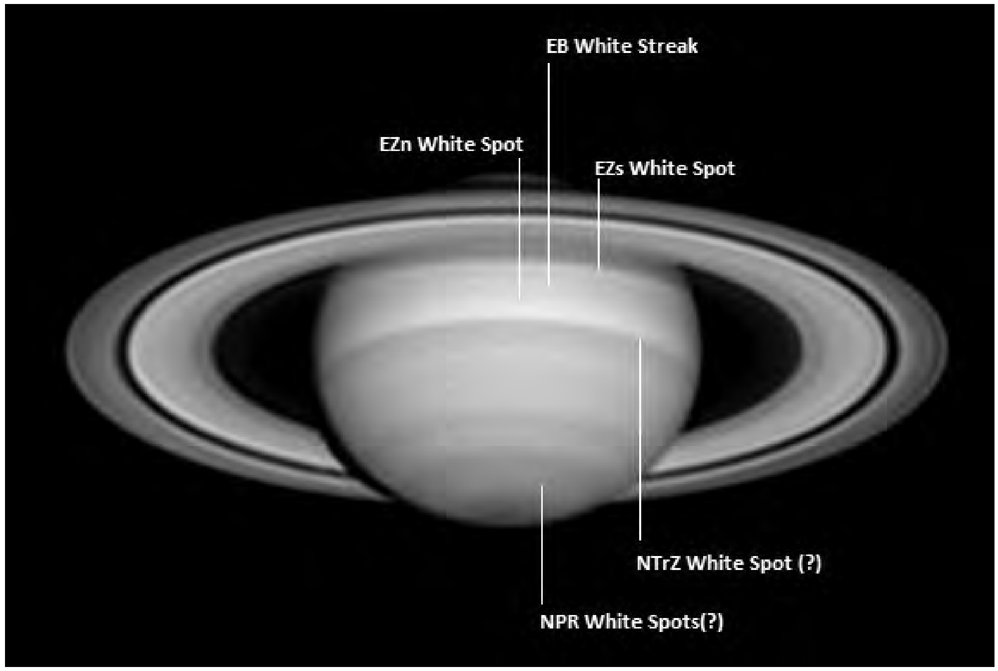
ALPO Saturn observing programs are listed on the Saturn page of the ALPO website at *http://www.alpo-astronomy.org/saturn* as well as in more detail in the author's book, *Saturn and How to Observe It*, available from Springer, Amazon.com, etc., or by writing to the ALPO Saturn Section for further information.

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. Cassini mission scientists, as well as other professional specialists, continue to request drawings, digital images, and supporting data from amateur observers around the globe in an active Pro-Am cooperative effort.

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

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



Detailed RGB image of Saturn taken by Clyde Foster of Centurion, South Africa, on March 29, 2020 at 03:08 UT. His image was captured in good seeing using a red filter with a 35.6cm (14.0 in.) SCT. His image reveals a curious elongated white streak within the EB (Equatorial Belt) as well as what appears to be small white spots in both the EZn (Equatorial Zone, Northern half) and EZs (Equatorial Zone, Southern half). A suspected fuzzy white spot appears in the NTrZ (North Tropical Zone) as well as suspected ill-defined fuzzy white spots in the NPR (North Polar Region). The apparent diameter of Saturn's globe was 16.2" with a ring tilt of +22.5º. CMI = 251.1º, CMII = 162.5º, CMIII = 172.0º. The apparent visual magnitude = +0.7. South is at the top of the image.

Table of Geocentric Phenomena for the 2020-21 Apparition of Saturn in Universal Time (UT)

Conjunction	2020 Jan 13^d 15^h UT
Opposition	2020 Jul 20^d 22^h UT
Conjunction	2021 Jan 24^d 00^h UT
Opposition Data for July 20, 2020	
Equatorial Diameter Globe	18.4″
Polar Diameter Globe	16.2″
Major Axis of Rings	41.7″
Minor Axis of Rings	15.4″
Visual Magnitude (m_v)	+0.1
B = Declination Constellation	+21.6° -20.6° Sagittarius

Remote Planets Section

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

See also "A Review of Ultraviolet Photometry of Uranus" later in this Journal.

The remote planets Uranus and Neptune will be well-placed in the early morning sky during July; Uranus will be in the constellation Aries and shining at magnitude 5.7 and will be around 70

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degrees from the Sun. The best time to observe it will be about one to two hours before sunrise.

Neptune will be in Aquarius and shining at magnitude 7.7 or 7.8 and will be around 120 degrees from the Sun.

Pluto remains very close to Jupiter and in front of Sagittarius, reaching opposition on July 15 and shining at about magnitude 14.5.

Jim Fox continues to produce excellent brightness measurements and submitted his latest package earlier this year. This writer also plans to carry out brightness measurements of Uranus and Neptune later in 2020.

This coordinator plans to write the 2019-2020 remote planets apparition report this summer and submit it for publication in the Autumn 2020 JALPO.

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 *skyandtelescope.com* is a great source to find specific locations of sky objects.]

Next, locate the target in the finder scope of your telescope. Finally, use a low-power eyepiece and center it in the field-of-view. Note that you may need a dark site to locate Neptune in binoculars and in the finder scope.

Both planets 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, a 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*

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Quarantined Observing

Early in May, we asked all ALPO members via e-mail for comments about how the “stay-at-home orders” related to Coronavirus-19 pandemic has affected your observing activities.

Have the stay-at-home orders kept you inside and away from your hobby? Or do you continue observing but now just do so alone? Or are you just doing armchair astronomy for the time being? Or have you given it up completely?

Below are replies presented in the order that they were received.

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Michael Amato, West Haven, CT USA — I still observe from my deck alone almost every clear day for solar astronomy & night. My brother, best friend & I do plan to observe comet swan later this month (May) together at his house through his 8 inch Dob. We will be wearing masks & we have hand sanitizer to use. We agreed if any of us doesn't feel 100%, then that person will remain home.

Tony Broxton, Cornwall, UK — I'm located deep in the south west of England, in a small village on the edge of Bodmin Moor amid a farming community. At night you can hear the grass growing. It is an isolated spot with little happening and one rarely sees another human from one day to the next even under normal conditions.

Taking solar observations is the highlight of the day. It is the one thing that helps to maintain our sanity, a reason to go out in the garden and enjoy the sunshine. The other diversions are crossword puzzles and jigsaws. God bless ALPO.

Darryl Davis, Albany, OR USA (ALPO member since 1971) — I have not been observing the last few years due to a health condition. The last time I looked through my telescope was for the last transit of Mercury. Meanwhile I continue reading the “Strolling Astronomer” and “The Lunar Observer”. So far as COVID-19 is concerned I have been staying at home in our house all of the time except occasionally to go out in the yard to perform some small task.

Andrew Salthouse, Millington, NJ, USA — I live in New Jersey and the stay-at-home orders have had no impact on my observing. I have my own observatory and telescope on my property, and I've always observed alone, so nothing has changed. Stay healthy.

These recent weeks I have been only observing from home. The Astronomical League asked all clubs to cancel or postpone all public activities at this time. But I'm still getting out at home and observing when the weather cooperates.

Don Knabb, West Chester, PA USA — Our club has switched to on-line meetings and “happy hour” informal chat sessions. We use Zoom and it is working well. We also moved our night school classes that we do for the local night school to on-line with the promise to all the students that we'll have an observing session when we are allowed to do so.

I have also been providing “Tour of the Universe” presentations using Mitaka software to several local groups, and they are well received. Take care and keep looking up.

Frank Melillo, Holtsville, NY USA — My family and I are all sitting tight. I am working from home and now I am starting to feel “cabin fever”. We only go out to the grocery stores and back home.

To stay home during the pandemic, most of the time, you can't do much. Sports are out. Theaters, museums and businesses are closed. Luckily, enjoying astronomy is no limit. It is one of the few hobbies around that you can really do it from home without going out. There are no restrictions. Just go out of your house into your backyard and enjoy the night sky.

Even though I work from home, I have more time for observing and imaging the Sun and Venus in daylight. Daytime astronomy is another role of enjoying the hobby.

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But there is one drawback. My local astronomy club, the Astronomical Society of Long Island (ASLI), which meets every single Wednesday night at the Vanderbilt Planetarium is cancelled until further notice. We can't interact with one another and we can't get together for a star party. Now we have virtual meetings with Webex every Wednesday night so we can get in touch and share our observing reports. But it is no comparison to when we meet in-person at the meetings.

Still, enjoying astronomy during the COVID-19 pandemic is a way to forget our daily problems and to stay away from the news and media. I don't think of what's going on in this world when it comes to something what we love - Astronomy. It never dies…

***Howard Eskildsen, Ocala, FL USA* —** The stay-at-home orders have eliminated any group observing with the Alachua Astronomy Club that I had hoped to attend, including at the Rosemary Hill Observatory west of Gainesville, FL. I expected it to cancel my April presentation to the club on solar imaging, but instead of cancelling the meeting, we did it on Zoom and it turned out very well.

Personal observing has definitely increased since I observe from my own home, and we have had to cancel planned trips that would have taken me away from my telescopes. I have gotten many more days of solar imaging than would have otherwise been possible. I also have gotten several lunar images which is good news and bad news. The "bad" side is that I have lots more images to process, and they do take considerable time, so I will have much to do. Actually even that's not so bad, not nearly as bad as having none to process.

***Jay Albert, Palm Beach, FL USA* —** In response to your request about any changes to how I observe, my answer is basically, not much. I do my lunar and planetary observing from my house, so no problem there. That's not too good for deep-sky observing so for that, I attend our local club's (semi) dark sky site here in Palm Beach County, FL. I was able to attend one of our club's observing sessions in March, just before the lockdown closing all the parks and natural areas. Of course, all three of our club's scheduled sessions in April were canceled. The natural area we go to is about to open up again this month with social distancing requirements, so our scheduled May sessions are back on. If anything, the social distancing and shut-down here has closed the theaters, our last opera of the season, the movies and limited social gatherings. This has eliminated conflicts with observing, so I'm actually able to get out more than usual, at least so far.

***Jay Miller, Bethesda, MD USA* —** All of my observing is normally from my house so the quarantine hasn't affected it. My problem has been weather and clouds!

***Jim Fox, Mayhill, NM, USA* —** The observatory is the perfect place to socially isolate! I just wish it kept the pollen out, too. I haven't done much planetary observing this spring, but I'm way ahead of schedule on my AAVSO measurements. All the surrounding states have had stay-at-home orders, too, so we have not been traveling at our usual pace and I have been home more in order to make those observations. Not only are other states closed down, but even here in New Mexico, all the highway rest areas are closed, and with the usual fast-food stores open only for drive-up service, there are few stops available for a traveler to "rest."

***John O'Neal, Statesville, NC, USA* —** The Covid-19 pandemic has truly changed the world. We hear new phrases like "the new normal, social distancing and self quarantining." As a matter of fact, these new phrases have become household terms, regardless of what corner of the globe we reside upon. And this has dramatically changed how we as amateur astronomers conduct our daily, or should I say, nightly business.

For most of us, our basic observing/imaging hasn't changed much. We still go out into our backyards and do our solitary observing/imaging just like we always did.

What has changed is the "social" dynamic of observing. In spite of what you see on the internet or hear on the TV, I honestly don't believe we are actually "socially distancing" ourselves at all. While we are all absolutely "PHYSICALLY" distancing ourselves, I don't see our self-quarantining practices as "SOCIAL" distancing at all, honestly. We, as human beings, as a society, and as amateur astronomers are as social as ever; we're just finding creative new ways to be social. Wearing masks and maintaining a physical minimum separation of 6 feet and limiting group sizes doesn't make us anti-social at all. It's simply a different way of socializing, but it is socializing, nonetheless.

Sure, in today's world we can't go to the local mall and set up our scopes in a parking lot and share the wonders of the heavens with passers-by. We can't go to our monthly public outreach events at our clubhouses. We can't invite our neighbors over to see Venus transiting the Pleiades. We can't go to those wonderful week-long star parties and walk the grounds looking into spectacularly different types and sizes of exotic telescopes and binoculars. We can't attend our monthly club meeting or attend the big ticket shows like NEAIC, NEAF and The Astronomy on the National Mall event.

But we amateur astronomers are a resourceful bunch. Our new normal means attending our monthly club meetings via Zoom or other electronic meeting apps. Now we get to see all our friends' & associates' living rooms and basements and check out their wall hangings and see them relaxing in tees and shorts, versus swaddled up in parkas to keep warm on those long chilly meeting nights.

We are utilizing SLOOH and the Night Sky Network and Facetime and Zoom

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and YouTube to share our outreach endeavors. We are making, posting and sharing videos and tutorials and how to guides at a pace never before seen in the amateur astronomy community. We are doing those things that social creatures do. We are fraternizing and socializing and sharing and communicating, albeit through a mainly electronic format, versus a face-to-face meeting, but we are socializing. Perhaps on a greater scale than before the pandemic...

So, in summary, you ask if the pandemic has changed what we do? I think not. We are still doing amateur astronomy. And we are still sharing our love of amateur astronomy with others.

Has the pandemic changed how we do what we do?

Absolutely. Necessity has precipitated change and we as a community have risen to the occasion. We have devised new methods of sharing and getting our message out to the world. We still attend our monthly club meetings, although the meetings are virtual. We attended the very first ever VIRTUAL NEAF this year. We host outreach events virtually now. And as the world continues to change, we will continue to change with it.

But, social distancing? I THINK NOT!

Julius Benton, Savannah, GA USA — The stay-at-home order did not really impact my personal observing habits, plus I have good observing opportunities from my residence which helps immensely. Since I'm retired, my observing schedule has remained essentially uninterrupted, although more frequent clear steady skies would have been nice during March, April and May. In addition to regular observing, I have been quite busy collecting and analyzing Saturn and Venus observations from observers worldwide who participate in our Saturn and Venus programs. Pro-Am collaboration has continued successfully as well. Working on apparition reports for future issues of the ALPO Journal has been a priority also. Overall, my astronomical activities have been a refreshing alternative to watching all the depressing COVID-19 TV news reports.

Larry Black, Cedar Rapids, IA USA — Regarding your question if this virus is affecting my observing, I say no, it has not in the least. The only things that affect me are the weather (Iowa is a cloudy place), and the fact that my telescope (a Celestron 11 Edge HD CGEM), is very heavy for me to lug up and down the basement stairs to set up and put away, so it doesn't get out as often as I would like. I live alone and am almost 70. I am looking into these JMI "Wheelie Bars" that may solve this by having the scope set up all the time and keep it in the garage and then just roll it out when I want to observe. I hope everyone else out there is doing fine. Best wishes.

Lawrence Garrett, Fairfax, VT USA — Given the heads-up on the excellent elongation of Venus by ALPO member Gark Nowak at our astronomy meetings last fall, I was able to put this information to work in this stay at home period.

I set about using my 6 inch, f/8 reflector to spot Venus each possible day, with my new orthoscopic eyepieces and filters. Being home all the time allowed me to check at any time it was clear for the best combination of seeing and lighting conditions. The short periods of excellent seeing were put to use with powers of over 200x here, for views of Venus I had not yet seen.

While my contribution to the ALPO Venus Section was a meager drawing of dark clouds seen, this was a learning experience in the fine art of observing a difficult planet.

Also, I took the time to learn the program "Pymovie" and produce my first light curve of a lunar occultation of a star, a project in still in progress.

Luigi Testa, Parma, Italy — Here in northern Italy, the crisis started before in USA and my firm is in lock-down until June. So ... obviously I'm continuing to observe alone, and now have time to spend in reading and studying ancient books (Flammarion or Schiapparelli), or ALPO report's '80th.. 2000 . It's always a good exercise for brain!!

Julian Parks, Queens, New York, NY USA — Since I live in the middle of virus central here in Queens, NYC, NY, I do not go out even for casual observing. There is always someone asking to take a look.

Jeff Beish, Lake Placid, FL, USA — Due to advancing age, I stopped observing on a regular bases and disassembled my two large telescopes for storage. Even if I were still observing this "stay-at-home" thing would not effect me; I live in the free state of Florida and I have very few neighbors. I am not an armchair astronomer. When something interesting pops up, I will haul out my 6 inch, f/4 to observe. I will be 80 years sometime soon.

Alberto Anunziato, Entre Rios, Argentina — I am an urban observer from the backyard of my house, so the COVID-19 lockdown essentially did not affect my observing habits. But I think the lack of personal contact with my friends in the Sociedad Lunar impoverishes our work. And it has also caused the cancellation of many public activities such as an international lunar symposium that we planned to carry out on March 14th and we had to suspend two days before. And also, the quarantine seems in the state in which I live, Entre Ríos in Argentina, a Kafkian dream, with 28 cases in 1.5 million inhabitants and 30 days without new cases, and still attempting to walk with your children in a park, for example, takes you to jail. It is a sadder life. But observation also influences life and it is a great comfort to observe landscapes from other worlds and share the observations with ALPO friends.

I am a 66 year-old retiree who has been an active astronomer since childhood. I am in relatively good health but I do have underlying conditions which, along with my age, make me more susceptible to the Covid-19 Virus. While these

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conditions are under control, I have to be aware of these conditions in this pandemic and take precautions.

Dr. W. Maynard Pittendreigh, Orlando, FL USA*; Astronomical League Executive Secretary, Astronomical League Observing Program Directors Team, Coordinator: Outreach Award, Beyond Polaris Program* — As the national coordinator of the Astronomical League's Outreach Program, I not only receive submissions for Outreach Awards, but I work closely with clubs and individuals on how to best conduct outreach events in their communities.

Before the pandemic, keeping up with this workload kept me active on a weekly and sometimes daily basis. It has now slowed to a minimal workload every month. The number of submissions for outreach awards has diminished sharply. The total number of submissions for the past two months are far less than a usual week's worth of submissions.

In my own outreach activity, I frequently worked with churches and schools in the community to conduct solar observing with students. I enjoyed a monthly opportunity with groups in the area, but that has completely disappeared.

I do, however, continue to enjoy time with the telescope for personal observing. The light pollution here in Orlando, Florida, has actually improved. It is, however, still worse than one would like. Unfortunately, I do not feel comfortable going to my dark sites. Because of the isolation of some of these areas and the presence of wildlife of snakes and alligators, I usually try to go with others. In this time of lockdown, this is not something I feel comfortable doing. So for the time being, I remain at home.

But there is a positive side. I am grateful that we live in an age of technology which allows me to do two things that improve my astronomical experiences. First, through social media, I keep in contact with astronomers all over the world, sharing photos and observing reports. Second, while the light pollution has been reduced with this time of lockdowns, I do much of my more serious observing through the use of remote controlled telescopes via the Internet.

Michel Legrand, Pays de la Loire, France — During these special moments, I continue to observe as usual from my garden (yard). Public lighting is off, which gives me a good and dark sky.

Nicholas Chudolij, USA — I observe more but still can't find Mercury!

Tom Mangelsdorf, Wasilla, Alaska USA — I am a NASA Solar System Ambassador. The SSA's go to museums, libraries, planetariums, schools and so on to give talks about all the cool NASA missions and what we are learning, That activity has been severely curtailed by the COVID-19 restrictions. This photo shows the solar scope set up outside the museum in Anchorage in April 2019.

I do my own solar observing from the south-facing deck off the back of my house, so no change for me. Being in Alaska, there wasn't much daylight in February and March. But the Sun started "hanging out" for longer and longer in April, and now even more so in May. We are coming up on the time of year when we will have daytime all night.

A bigger issue that impacted my own observing was my own health scare – and not COVID-19. I had a massive infection that hospitalized me for 3.5 weeks. I had seven surgeries on my head, two on my abdomen, and two on my back. Even after I got home, I couldn't muster the strength to carry the telescope out. I am on the mend now, and I took the scope out a couple days ago for a less-than-thrilling view of the blank Sun. Alas, during solar minimum the number of blank days is statistically important … but is less exciting.

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Paul Maxson, Surprise, AZ USA — My (observing habits) have not changed much, if at all. I always observe alone. If anything I have more time for the processing part of it.

Phil Plante, Youngstown, OH USA — I'm afraid I'm not able to do much observing, pandemic or not. All against my will. Physical constraints have kept me from dragging any scope out for a year or so. I did muster my 70mm binos for an ATLAS comet hunt and a few bright variable stars. New nearby "insecurity lights" have left no dark spots to hide a telescope and eyeball as I observe from my apartment. My weakness leaves our club observatory as a distant destination to get there and I'm not able to move the scopes around. Or climb ladders. In short: the stay-at-home restrictions have had no affect on my observing. My own body keeps me from a telescope. Stay at home policy seems normal to me now.

I hope to be able to get back to scope observing as soon as possible. I always keep the ALPO in my thoughts — some of my best friendships and memories the last 37 years.

Randy Shivak, Cape Coral, FL USA — Our weekly gig at the resort we do has of course been canceled. But Pam and I still set up the scope in the driveway to view the planets and Moon. I have taken this time to send my solar filter in for repairs, so no observing in H-alpha.

Rik Hill, Tuscon, AZ USA — My yard is walled in so I'm isolated. I'm also retired, age 71 and an overweight diabetic. So I'm a prime candidate to catch the Coronavirus, so I'm told. Six weeks ago, we decided I will stay put at the house and I'm ok with that. I have my telescopes out back, my fossils, my bonsai trees and eight rescue cats that need attention. Eight months ago (Sept. 2019), my right hip/leg quit working and that recuperation also occupies a lot of my time. I observe as much as I can and right now I am literally awash with lunar and Venus images (to process and post to the ALPO image gallery). Soon Jupiter, Saturn and Mars will be available to me when they rise over the tree to my east, before midnight. So the lockdown is almost a blessing to me. It helped with preparing the ALPOSS solar activity report and Section Report (for the ALPO Journal) and the only interruptions were visits to the doctors!

So I have no reason to go out. Dolores won't let me go out and the telescopes are out back waiting!

Robert Young, Harrisburg, PA USA — The club observatory is closed, my binocs are useful to observe the Moon and Venus. The rest is online or reading. For 40 years I've taught a public astronomy course. I'm getting rusty.

Roy Parish, Shreveport, LA USA — It really hasn't changed much for me. I haven't been active lately--bad weather for most of the last year plus just being lazy. I have just begun to get active again, though. One of our club members bought a Losmandy mount and I went out to help him with it. It felt good.

At home I have so many trees with just a small window to the sky that I can't do much from my back yard. The Moon is in that window for about two hours each night. Our club leases the old Worley Observatory, which we renamed "Shreveport Observatory" to honor the work of the members whose labor and money transformed the old, dilapidated buildings into a clean, safe, attractive place. We expanded our fenced area so we can feel safer at night, and it's big enough to let the usual crowd of 4 or 5 setups to be at least 10 feet apart. It's getting good again. Keep looking up!

John Sabia, South Abington, PA USA — I am stuck in a city, where observing comets thru light pollution is impossible with 10 x 50 binoculars. I've tried with a 70 mm, f/5.7, visually on a equatorial mount for the same comets without success.

There is too much local lighting around me to observe comets.

Weather has not been very accommodating here in any case. Two or three days out of the month, with Moonlight, if the temps are nice. Most of the time it's too cloudy and now snow in May again!

Waiting to use my own scope to observe, when weather and time allows. Planning some simple astrophotography with a new telephoto lens on an equatorial mount. North and East are viewable, South and West, not so much.

Also unable to use scopes in the college observatory building or the club's scope, but can visit for maintenance and building inspections during daylight hours.

Keeping up with astronomical events online, as usual.

During April I have only been able to observe from my yard.

Richard Schmude, Barnesville, GA USA — I have not been able to carry out as many brightness measurements of Mars, Jupiter and Saturn because of the pandemic. This is because my eastern horizon is blocked by trees. I have been able to continue to collect brightness measurements of Venus because it is in the western part of the sky and my western horizon is okay. I have also started doing some visual observations of Venus because I am able to see it from my yard.

Steve Tzekias, Reston, VA USA — Teleworking at home has converted my former commute time to an extra two hours per day of available time for other pursuits including astronomy. One of those astronomy pursuits has been investigating the science that can be done with the virtual telescope: h*ttps://www.virtualtelescope.eu/*

Tim Robertson, Simi Valley, CA USA — During this time, I have been able to do more observing than in the past; not having to get up for work allows me to stay up later and devote some time to astronomy.

I have been able to work from home during this time as well.

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One major advantage has been the ability to record more podcasts during this time too, because most people have extra time right now and are available for interviews on the "Observers Notebook" podcasts. So I have a decent backlog of episodes in the queue.

Dr Anthony Cook, Dept. of Physics, Aberystwyth University, Penglais, Aberystwyth, Ceredigion, United Kingdom — Stay at home rules here in the UK let us go for exercise once per day, and allows us to do essential visits only, for example, one supermarket run each week. So long as we stick to social distancing.

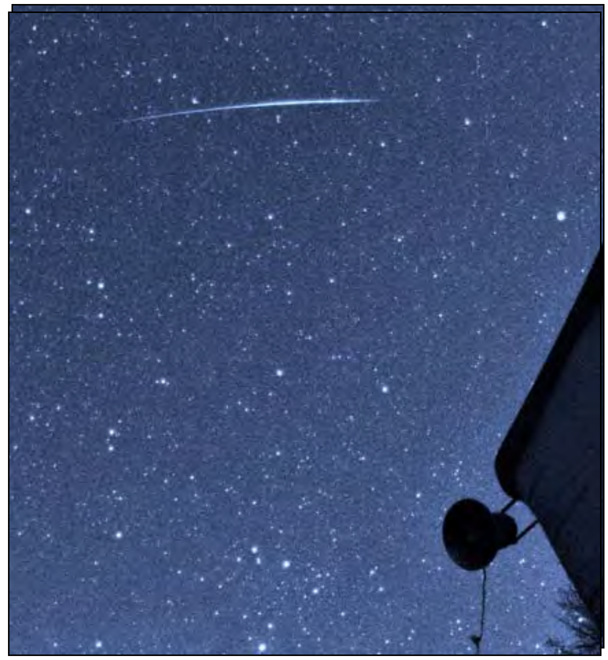
I work from home marking student coursework from Aberystwyth University, supervising my PhD student, and taking part in staff meetings via TEAMS.

The great thing I like is that I don't have to get up early to go to work - I rise at about 9 a.m. each morning. So as and when the British weather permits, I get to observe the Moon a little more often in the evening-late night and don't get tired out the next day as I would normally getting up to catch an early train into work.

University (teaching) work normally prevents me from doing a lot more things I would like to do at home, so the lack of three hours on a train each day gives me a bit more time to catch up with astro-related projects I planned to do at home; for example, I built a 3D printer from kit about 3-4 years ago but never quite finished it and it this has been sitting in the lounge gathering dust! I have now had time to very nearly get it working. I just got to fix a fault on the Y axis. I've had plans to use this for some mini projects such as building a lunar spectrograph to take spectral data cubes of the lunar surface and also to generate some 3D models of lunar craters that I can take along to public astronomy events over here.

Our LTP observers overseas have done a really good job in continuing to send in their observations. In fact, you almost could say that the quantity and quality of the observations received have been unaffected.

David Levy, Vail, AZ USA — Actually, observing here at the Jarnac Observatory hasn't changed much over the last three months. Even though Wendee and I are taking this very seriously (we wear masks during our rare visits to the grocery or to doctors appointments), observing is an entirely different story. When I go outside at night, I do not need a mask. I even doubt that anybody outside is within a square kilometer of me. I have done some enjoyable meteor observations (enclosed is an image I caught a couple weeks ago of a Lyrid meteor) and I still enjoy my visual comet hunting.



Vince Giovannone, Latham, NY USA — I've still been doing observing when I can, so for me it's been status quo.

Clif Ashcraft, Perrineville, NJ, USA — It has had little effect on my observing habits. I belong to an active club (Amateur Astronomers, Inc.) with an observatory in Cranford, NJ, however, the observatory is about an hour's drive away from home, so I don't go there for my own nightly observing program. Apart from occasionally looking through our telescopes (a 10 inch reflector we built and a 24 inch reflector that we rebuilt) after club meetings, I do all my observing from home where I have a backyard observatory consisting of three shacks with roll-off or fold-off roofs with a 7 inch Schupmann catadioptric telescope, as well as a C11 and a C14. My only associate in my observatory is my dog and the occasional wild critter walking by. The pandemic has affected my club meetings, though. All are happening by Zoom, however, I am now also going to meetings of the BAA (England) and the VAA (Victoria, Australia). I probably would have never thought to do that before.

Maurice Collins, Palmerston North, New Zealand. — Under our Level-4 total lock-down (which ended 28 April), I personally found there was no difference whatsoever because I do astronomy alone and don't attend any clubs or other social activities that would have been banned. So just the normal clouds and other issues to contend with, so no difference to my observing due to the virus. One big positive aspect of the lock-down, though, was it was much quieter out there! No cars on the roads and people were very quiet, especially near the beginning, and even in the daytime it was so still and quiet. Now the road noise is back as things are getting going again here under Level-2 restrictions.

Book Review
Luna Cognita

Review by Robert Reeves,
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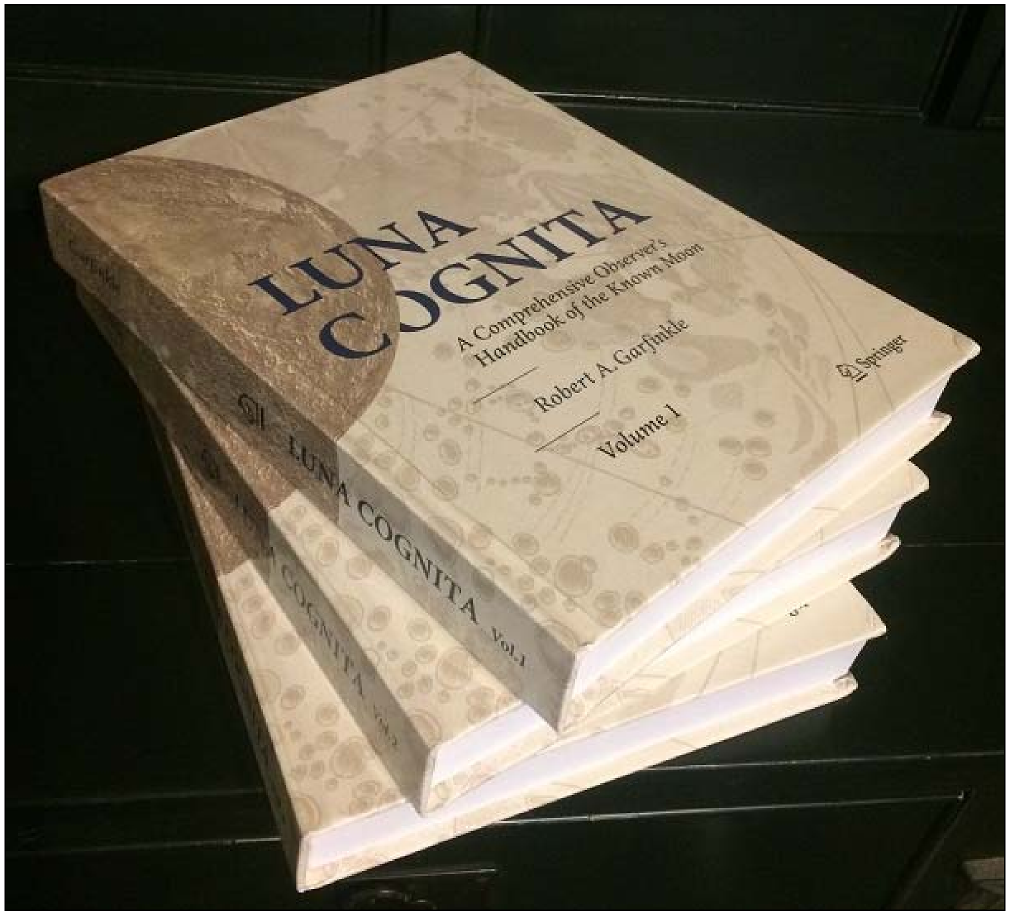
'Luna Cognita" by Robert Garfinkle superbly reveals the Moon. Copyright 2020 by Springer (print ISBN 978-1-4939-1663-4, online ISBN 978-1-4939-1664-1); 1,680 pages, hardcover; list price $89.99, soft cover list price $69.99.



For the past 60 years, I have pursued the Moon as both a historical object and observational target. Over that time, I have accumulated a large library of Moon-related books, some adequate for their purpose, others classics in their realm. Recently I was happy to receive a new three-volume set about the Moon that I rate as extraordinary: *Luna Cognita* by Robert Garfinkle.

Luna Cognita is a triumph of both Garfinkle's desire to spread his love of the Moon and Springer's ability to publish such a huge high-quality volume. *Luna Cognita* effectively folds lunar mystery and lore, science and statistics, facts and figures and observational data into one massive collection that more than fulfills a true selenophile's yearning to have everything Moon at their fingertips. Well laid out, excellently printed and bound with glossy paper with many illustrations in color and presented in 8.5 x 11-inch hardback format, *Luna Cognita* is available from Springer for the surprisingly modest price of only $89.99 in print and only $69.99 in e-book format.

Those of us who are true selenophiles, that is, people who love the Moon, have long awaited Garfinkle's lunar masterpiece. It has been no secret within the astronomical community that this book has been in the pipeline for some time. Now published by Springer in a three-volume set spanning a total of 1,680 pages and weighing an astonishing 14 pounds, it is easy to see why *Luna Cognita* has taken a while to reach maturity. A work of this scope is not something thrown together to meet anticipated commercial demand driven by a historical anniversary or upcoming holiday. Instead, *Luna Cognita* took decades to reach its current form because of the sheer volume of information contained within it, and Garfinkle's passion to present our neighboring world in a logical, readable form.

Now the wait is over and readers of *Luna Cognita* are in for a treat! This lunar volume should not be approached like a novel. *Luna Cognita* can be equated to the "War and Peace" of lunar literature because of its sheer size, and as a result, *Luna* Cognita is one of the best, most comprehensive, and well-researched references for lunar observers. Garfinkle has raised the bar enormously! The book's massive index makes it easy for astronomical history buffs and for both novice and seasoned observers to find information relevant to their lunar interest.

Garfinkle is more than just an author who researched and reported on his topic. He has lived with lunar research most of his adult life. Indeed, when the revered International Astronomical Union's *Gazetteer of Planetary Nomenclature* was prepared, Garfinkle supplied over 900 corrections. Robert is so attuned to modern lunar research that he was able to correlate the cyclic sticking of his Bay Area (San Francisco, CA) home's bedroom double doors to the periodic tidal heaving of the west coast landmass caused by lunar gravity. That deduction is something even the most experienced handyman would have missed!

Self-billed as a comprehensive observer's guide to the known Moon, *Luna Cognita* is far from being just an observer's guide to help you telescopically hop-scotch across the lunar face. While the actual observing guide is massive and almost overwhelming, it is only a portion of *Luna Cognita's* three volumes. The book is also crammed with history, maps, photos, charts, and data that make it a comprehensive encyclopedia about the Moon.

Luna Cognita is best absorbed in bits and pieces. Any lengthy attempt to plunge into this deep blue pool of lunar knowledge leaves my head spinning from overload. Though excellently written, *Luna Cognita's* sheer length makes it impossible to review cover to cover within a reasonable time. A person cannot possibly absorb all the data, anecdotes, history and observational wisdom in this book without devoting uninterrupted weeks to the effort. But word of how good this lunar masterpiece is needs to get to the astronomical community now. Thus, instead of a detailed reading of the over one million words across the three volumes, I can only render the opinion of someone who also passionately loves the Moon and has spent several weeks diving into selected portions of this masterwork.

- The history buff will be delighted to sink into sections on each period of lunar exploration being discussed. I was fascinated by the inclusion of detailed copies of dozens lunar maps created by master selenographers over the centuries of telescopic observation. Comparing the maps drawn by different famous observers, it is hard to believe they were observing the same world!

- The theorist will relish the pages of diagrams and explanations of phenomena and orbital motions. The thorough discussion of the Moon's inconstant orbit, tides, eclipses, transient lunar phenomena, and more goes on until the reader can achieve an expert status on these topics.

- The observer can spend hours picking and choosing telescopic targets while pursuing all the copious information about specific lunar features. There is no feature on the Moon that is not dissected and discussed in exquisite detail.

It was a pleasure to see the three volumes illustrated with many photos taken by skilled lunar photographers that may be familiar to *JALPO* readers, including Richard "Rik" Hill, Howard Eskildsen and Damian Peach. Having taken thousands of lunar photos myself, I know the hard work and skill sets needed to produce the massive collection of lunar surface photographs that illustrate this work.

But since photography is my realm, it is with the photos spread throughout all three volumes that I make my only criticism about *Luna Cognita*. The illustrations should dare to show a little more of the Moon that we normally see in an eyepiece view. After all, they are present to educate us about the reality of the Moon's surface. For the most part, the images gathered from the contributors perform that task well. However, *Luna Cognita* presents a spectrum of image quality where low-resolution film camera images compete for attention with ultra-high-resolution photos taken by satellites in low lunar orbit. But this observation is only a personal quibble about the aesthetics of presentation and acknowledges that it does nothing to detract from the extraordinary value of *Luna Cognita*.

I gladly defer to Garfinkle about the accuracy of the technical writing in *Luna Cognita*, but it did not take long to find one of the little editorial slips that creep into such a massive volume. Illustration 7.74, a photo of Nunn crater, repeats as illustration 7.75 instead of a photo of Tacchini crater. As the author of many

Figure 11.70. *The cluster of small generic-named features located on the southeastern side of Mare Serenitatis, to the northeast of Dawes, and southwest of Mons Argaeus. Image cropped from the electronic WAC version of LAC-42.* (North up.)

books myself, I can sympathize with such an editorial slip and say that overall, Garfinkle has done an astonishing job of "herding so many cats" while assembling an otherwise relatively error-free book.

I did find the inclusion of Figure 11.70 to be a personal delight. There is a region on Mare Serenitatis near Dawes crater containing small craters named with generic "first names". In this case, the sub-kilometer craters Robert and Mary lie within walking distance of each other. Though named after no one in particular, I unofficially claim these two craters to honor my four-decade union with my dear wife, Mary. Robert and Mary craters are shown in Figure 11.70 and both are described on page 11-54. It is the first published mention I have seen for "my" craters.

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About the Reviewer

Robert Reeves of San Antonio, Texas, USA, has written many dozens of astronomy articles for Astronomy magazine, the Astrograph, The Reflector, Amateur Astronomy magazine and the now-defunct Deep Sky and Deep Sky Journal magazines. In May 2000, his book "Wide-Field Astrophotography" was published by Willmann-Bell and was followed in 2005 by "Introduction to Digital Astrophotography", also from Willmann-Bell. His latest book, "Introduction to Webcam Astrophotography", was released in May 2006, also from Willmann-Bell...

Papers & Presentations:

A Report on Carrington Rotations 2221 through 2225 (2019-08-22-2136 UT - 2020-01-06-0911 UT)

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

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

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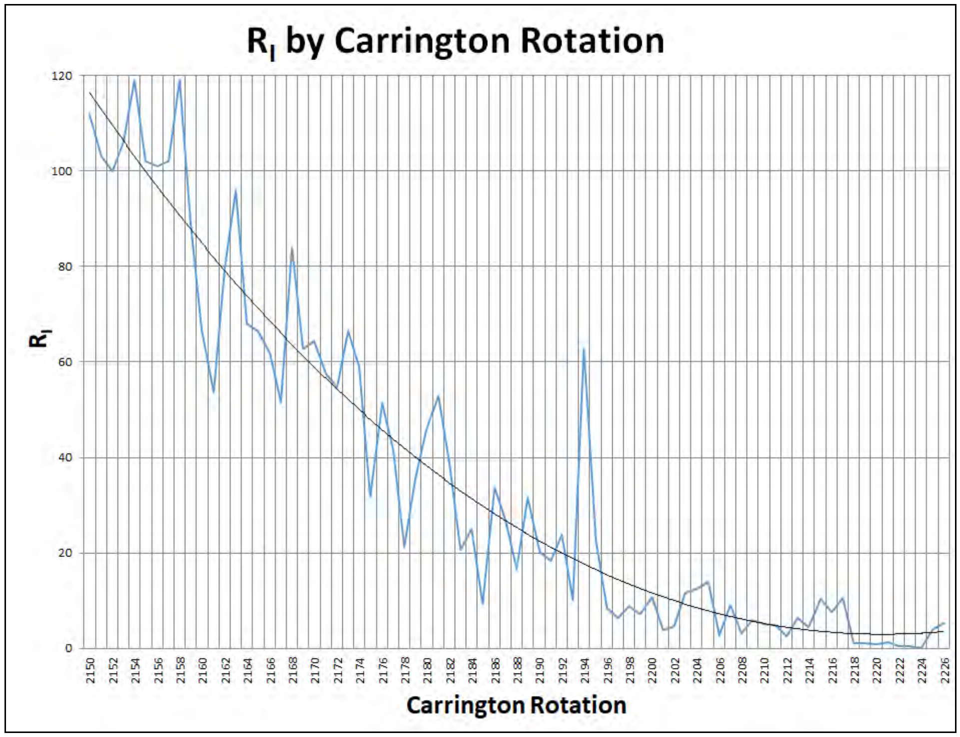
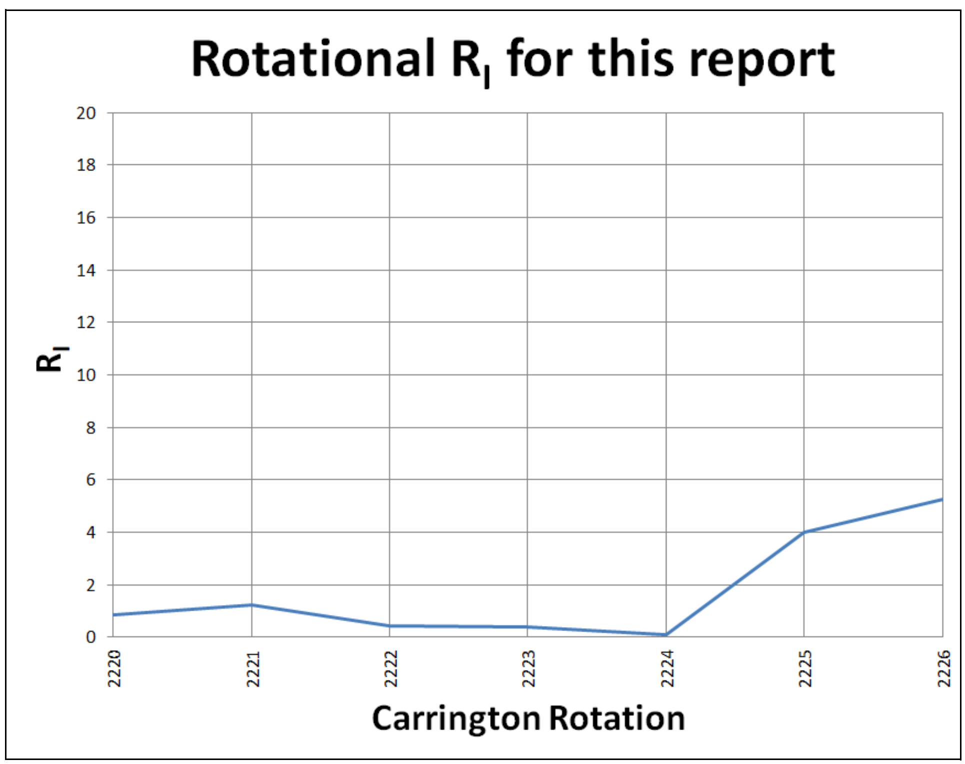
Overview

Activity was extremely low with an average R_I for the period of 1.17, well below the 3.75 of the previous reporting period (CR 2216-2220). As we dive further into the solar minimum, the often asked question, “Are we there yet?” is one that can only be answered with hindsight, and after we have passed through it, though, it is worthwhile to point out that we have not had any rotations with no spots. Of the 135 days covered in this report, 120 days (about 89%) were spotless. So we are getting close.

From the ending low of the last report, CR 2220 with an R_I average of 0.85, activity fell further to the extreme low of 0.11 in CR 2224, rising a little afterwards. Peak daily activity occurred on 12/25 with an R_I of 23 from two ARs, 2753 & 2754, each measuring only 10-20 millionths in area.

Much of the professional data usually used in these reports was not available to the author due to faulty software and failure of the websites to update their data. It is not known if this had any connection to the Coronavirus pandemic, but with so many departments and businesses on skeleton crews, this is likely.





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.

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 = 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 Gal-

Table 1. Table of Contributors to the Solar Section

Observer	Location	Telescope (aperture, type)	Camera	Mode	Format
Michael Borman	Evansville IN	102mm, RFR	Point Grey GS3	w-l	digital images
		90mm RFR		H-a	
		102mm, RFR		CaK	
Richard Bosman	Enschede, Netherlands	110mm, RFR	Basler Ace 1280	H-a	digital images
		355mm, SCT		w-l	
Raffaello Braga	Milano, Italy	112mm,RFR	PGR Chameleon mono 2.0	H-a	digital images
Tony Broxton	Launceston, Cornwall, UK	127mm, SCT	N/A	w-l	drawings
Jeffery Carels	Bruges, Belgium	100mm, RFR	ZWO-ASI 120MM	w-l	digital images
Gabriel Corban	Bucharest, Romania	120mm, RFL-N	Point Grey GS3-U3	H-a	digital images
				w-l	
Brennerad Damacenco	Sao Palo, Brazil	90mm, MCT	ASI224MC	w-l	digital images
Michel Deconinck	Artignosc-sur-Verdon, Var, France	152mm, RFR	—	w-l	drawings
Franky Dubois	West-Vlaanderen, Belgium	125mm, RFR	N/A	Visual Sunspot Reports	
Howard Eskildsen	Ocala, FL	80mm, RFR	DMK41AF02	w-l wedge	digital images
				CaK	
Joe Gianninoto	Tucson, AZ	85mm, RFR	N/A	w-l	drawings
		60mm, RFR		H-a	
Guilherme Grassmann	Curitiba, Brazil	60mm, RFR	Lumenera Skynyx 2.0	H-a	digital images
Richard Hill	Tucson, AZ	90mm, MCT	Skyris 445m	w-l	digital images
		120mm, SCT			
David Jackson	Reynoldsburg, OH	124mm, SCT	N/A	w-l	drawings
Jamey Jenkins	Homer, IL	102mm, RFR	DMK41AF02	w-l	digital images
		125mm, RFR		CaK	
Pete Lawrence	Selsey, West Sussex, UK	102.5mm, RFR	ZWO ASI174MM	H-a	digital images
Monty Leventhal	Sydney, New South Wales, Australia	250mm, SCT	Canon Rebel T3i EOS 600D	w-l/H-a	drawings
				H-a	digital images
Tom Mangelsdorf	Wasilla, AK	120mm, RFR	N/A	w-l	drawings
Frank Mellilo	Holtsville, NY	200mm, SCT	DMK21AU03AS	H-a	digital images
Efrain Morales	Aguadilla, Puerto Rico	50mm, RFR	Point Grey Flea 3	H-a	digital images
German Morales C.	Bolivia	200mm, SCT	N/A	Visual Sunspot Reports	
John O'Neal	Statesville, NC	152mm, RFR	ZWO AS174MM	Na-D Quark	digital images
		60mm, RFR		H-a	
		100mm, RFR		CaK	

Table 1. Table of Contributors to the Solar Section (Continued)

Observer	Location	Telescope (aperture, type)	Camera	Mode	Format
Theo Ramakers	Oxford GA	80mm, RFR	ZWO ASI174MM	H-a	digital images
		280mm SCT	DMK41AU02AS	w-l	digital images
		40mm, H-a PST	DMK21AU03AS	H-a	digital images
		40mm, CaK PST	DMK21AU03AS	CaK	digital images
Ryc Rienks	Baker City OR	203mm, SCT	N/A	w-l	drawings
		40mm, H-a PST		H-a	
Laura Schreiber	Wuertzburg, Germany	280mm, SCT	Basler IMX174	w-l	
Chris Schur	Payson, AZ	152mm, RFR	DMK51	CaK	digital images
				w-l (CaK-offband continuum)	
		100mm, RFR		H-a	
Randy Shivak	Prescott, AZ	152mm, RFR	ZWO-ASI174	H-a	digital images
Avani Soares	Canoas, Brazil	120mm, RFR	ZWO-ASI 224	w-l	digital images
Randy Tatum	Bon Air, VA	180mm, RFR	DFK31AU	w-l-pentaprism	digital images
David Teske	Louisville, MS	60mm, RFR	N/A	w-l/H-a	drawings
		100mm RFR	ZWO-ASI120mm	H-a	digital images
Vince Tramazzo	Tucson, AZ	94mm, RFR	N/A	w-l	drawings
		50mm, RFR		H-a	
James Kevin Ty	Manila, Philippines	TV101-RFR	ZWO-ASI 120MM	H-a	digital images
David Tyler	Buckinghamshire, UK	178mm, RFR	ZWO ASI 120	w-l	digital images
		90mm, RFR		H-a	
Christian Viladrich	Nattages, France	300mm, RFN	Basler 1920-155	w-l	digital images
Telescope Types: Refractor (RFR), Newtonian Reflector (RFN), Schmidt Cassegrain (SCT), Maksutov-Cassegrain (MCT), Cassegrain (Cass)					

Carrington Rotation 2221

Dates: 2019-08-22.2136 to 2019-09-19.0347 UT

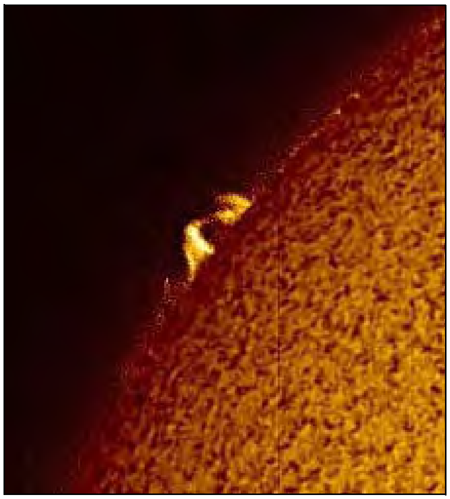
Avg. R_I = 1.22
High R_I = 14 (9/1 & 9/2)
Low R_I = 0 (24 days)

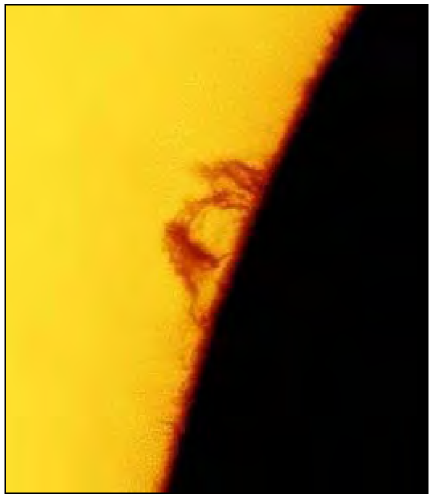
This rotation was characterized by very low activity confined to one AR that never got beyond 20 millionths of the disk. There were 24 days of zero spots and three days all below an R_I of 15.

Using orientation from Broxton, Leventhal and Teske observations (drawings), we see a nice persistent loop prominence on the NE limb on 8/31. This was imaged in H-a by Grassmann at 12:49 UT (Figure 1) and Corban a little later at 13:03 UT (Figure 2).

There was only one feeble sunspot group, AR 2748, that provided some enjoyable imaging opportunities for our sunspot-starved observers as evidenced in Ramakers H-a and CaK at 12:52 UT and 12:58 UT respectively. This little region was reported as a Bxo group by Broxton at 08:35 UT on 9/1, as a “B” group of 4 umbral spots at 15:51 UT by Teske in one of his composite w-l/H-a whole-disk drawings and then by Leventhal as a Bxi group at 22:15 UT. Then on 9/1, Teske listed AR 2748 as still a “B” group now of 3 umbral spots at 15:04 UT, and Leventhal classed it as Axx a little later at 22:40 UT. On this day, both Grassmann (Cak at 13:03 UT) and Ramakers (H-a at 13:10 UT) captured the best images of this small region (Figure 3).

All that was left by 9/3 was a little plage as shown in another composite view by Ramakers (H-a at 12:48 UT) and Grassmann (CaK at 13:03 UT) (Figure 4).





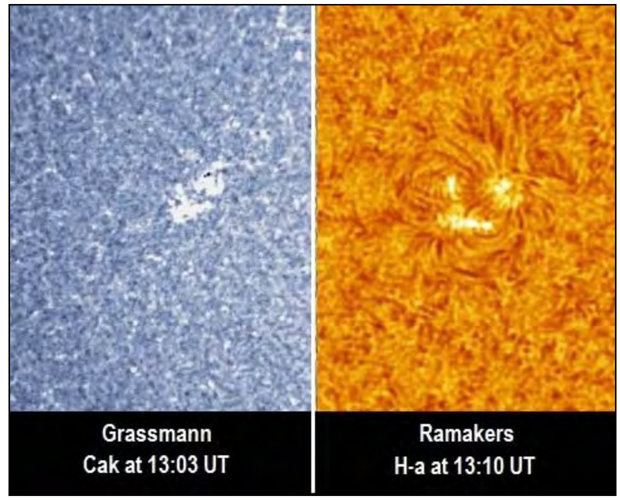
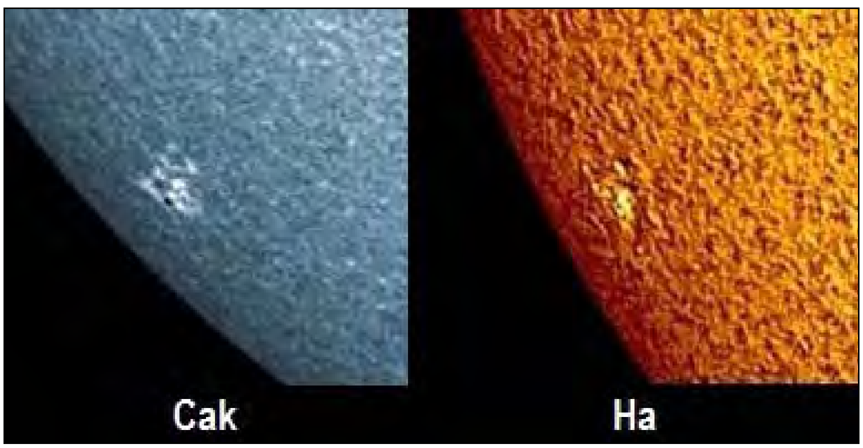


Figure 1. A small limb prominence observed by Grassmann in H-a at 12:49 UT on 8/31.

Figure 2. The same prominence seen in Figure 1 observed by Corban on 8/31 at 13:03 UT.



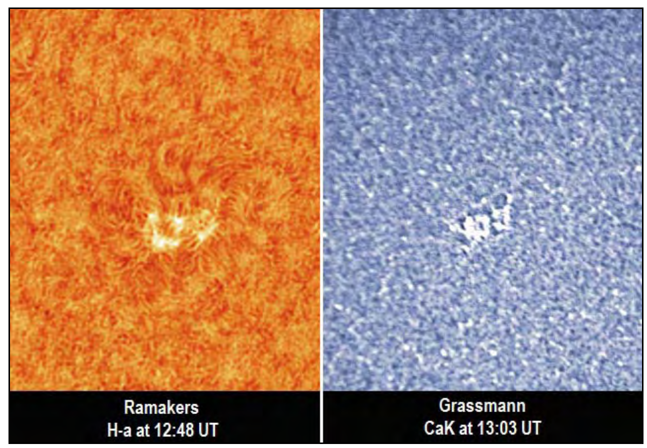


Figure 3. A two-pane look on 9/2 of AR 2748 by Grassmann (CaK at 13:03 UT) and Ramakers (H-a at 13:10 UT).

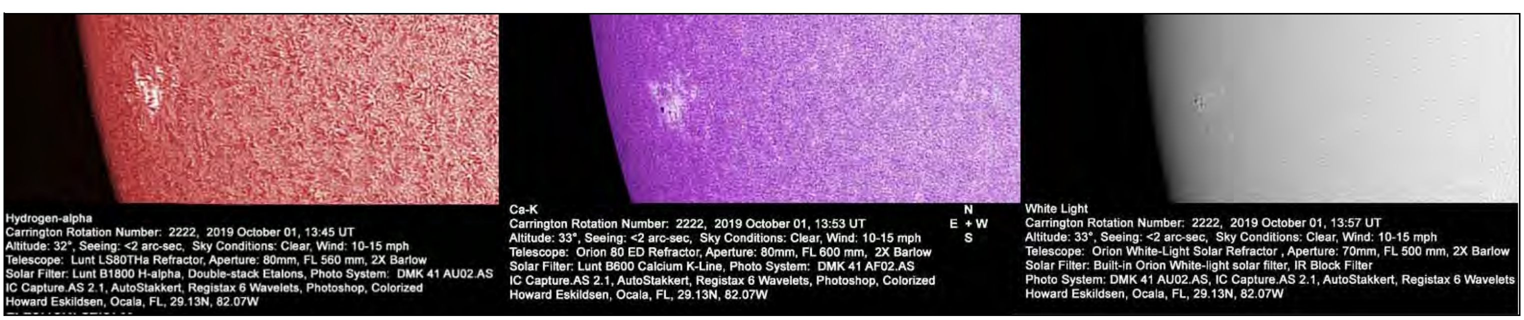


Figure 4. A look at AR 2748 on 9/3 by Ramakers (H-a at 12:48 UT) and Grassmann (Cak at 13:03 UT).

Figure 5. Two views of AR 2749 by Grassmann on 10/1CaK right and H-a left at 11:30 UT.

Figure 6. A three-pane montage of AR 2749 by Eskildsen in a H-a at 13:45 UT, CaK at 13:53 UT and w-l at 13:57 UT on 10/1.

Carrington Rotation 2222

Dates: 2019-09-19.0347 to 2019-10-16.1033 UT

Avg. R_I = 0.44
High R_I = 6 (10/2 & 10/3)
Low R_I = 0 (25 days)

During this rotation, the average R_I dropped to a third of the previous rotation. A total of 25 days had no spots at all with the high count of 6 occurring on 10/2 and 10/3.

The only active region for this rotation was AR 2749. Professionally it was seen to have only been a plage, but often such regions can form sunspots that last for a very short while. Such must have been the case with this region as a number of ALPO Solar Section observers recorded spots: Grassmann in Cak and H-a at 11:30 UT (Figure 5); Eskildsen in a H-a at 13:45 UT, Cak at 13:53 UT and w-l at 13:57 UT (Figure 6); Deconinck w-l drawing at 15:42 UT (Figure 7); and Teske in an H-a drawing at 16:32 UT (Figure 8).

This spans an interval of 5 hours, during which several spots were clearly recorded and a class of "B" was assigned by Teske and a count of 13 by Deconinck.

All other activity of note for this rotation consisted of some prominences captured in wonderful images by Ramakers on 9/20 at 12:52 UT (Figure 9), Melillo on 9/21 at 20:30 UT (Figure 10) and 9/28 at 15:18 UT (Figure 11), and Shivak on 10/11 at 10:26 UT (Figure 12). This latter image is very reminiscent of the images that came out of the McMath Hulbert Observatory in the 1960s that inspired this author (who lived very nearby at that time) to go into solar observing!

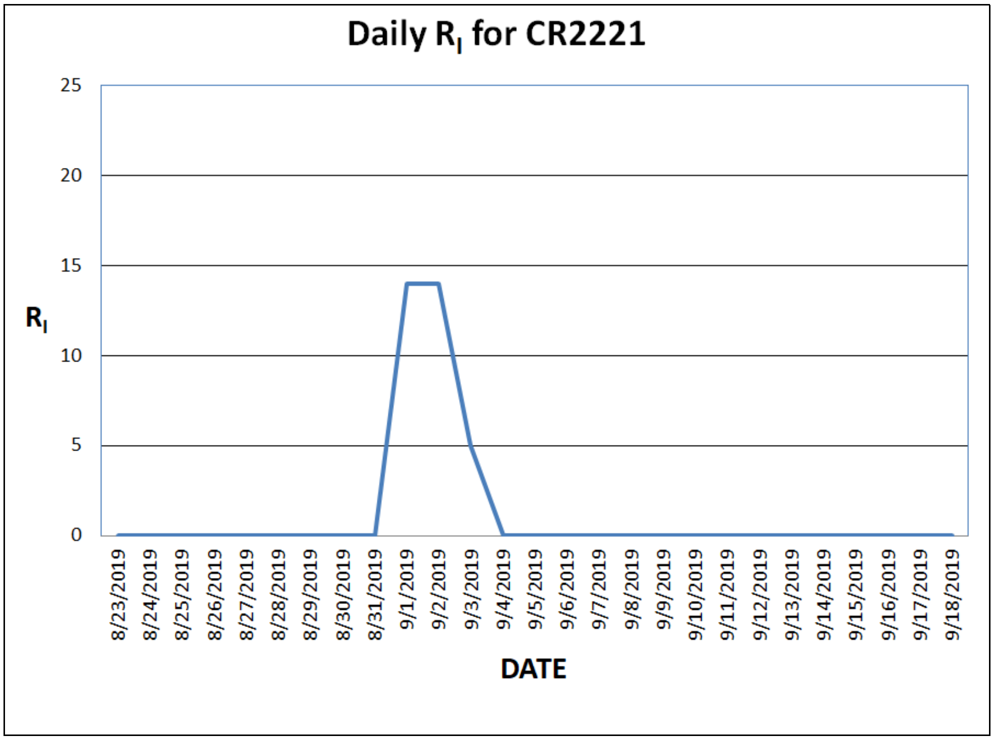
Carrington Rotation 2223

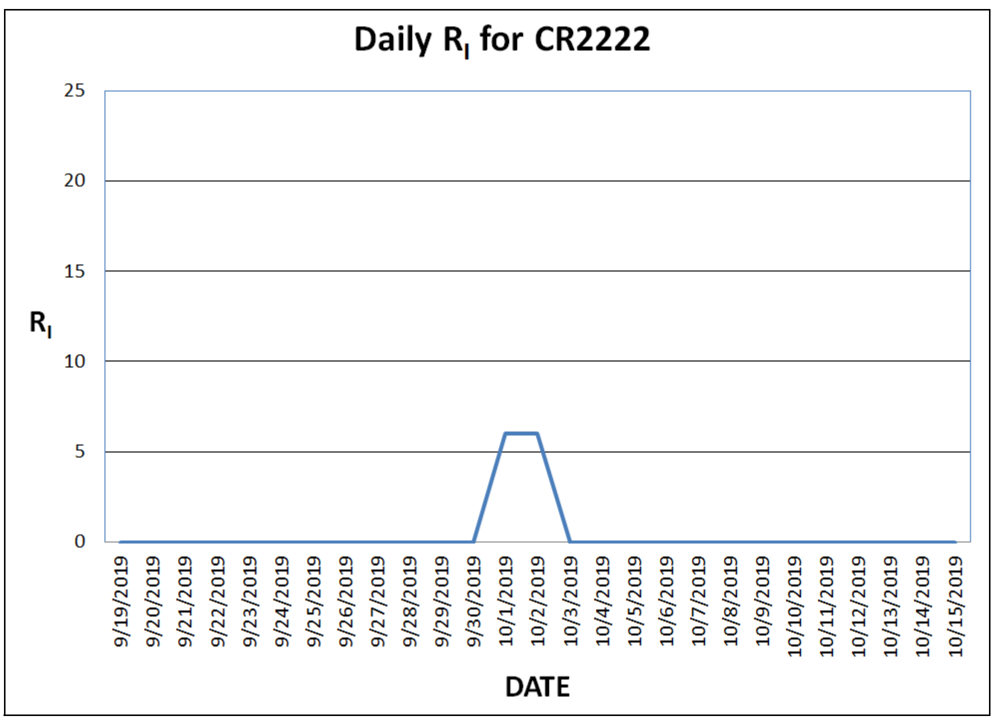
Dates: 2019-10-16.1033 to 2019-11-12.1744 UT

Avg. R_I = 0.39
High R_I = 7 (11/1)
Low R_I = 0 (26 days)

Activity was extremely low during this rotation: zero sunspots were seen on 26 days with the high R_I being 7 on 11/1. Only two active regions were designated during this rotation: AR 2750 and AR 2751, neither of which attained an area greater than 10 millionths of the disk or an official lifetime of more than one day.

AR 2750 was seen by our observers on several days, but professionally seen in the southeastern quadrant only on 11/2 and then AR 2751 was designated in the northwestern quadrant the next day. Ramakers may have gotten an early view of this region on 10/28 as an area of faculae near the limb at 15:05 (Figure 13).





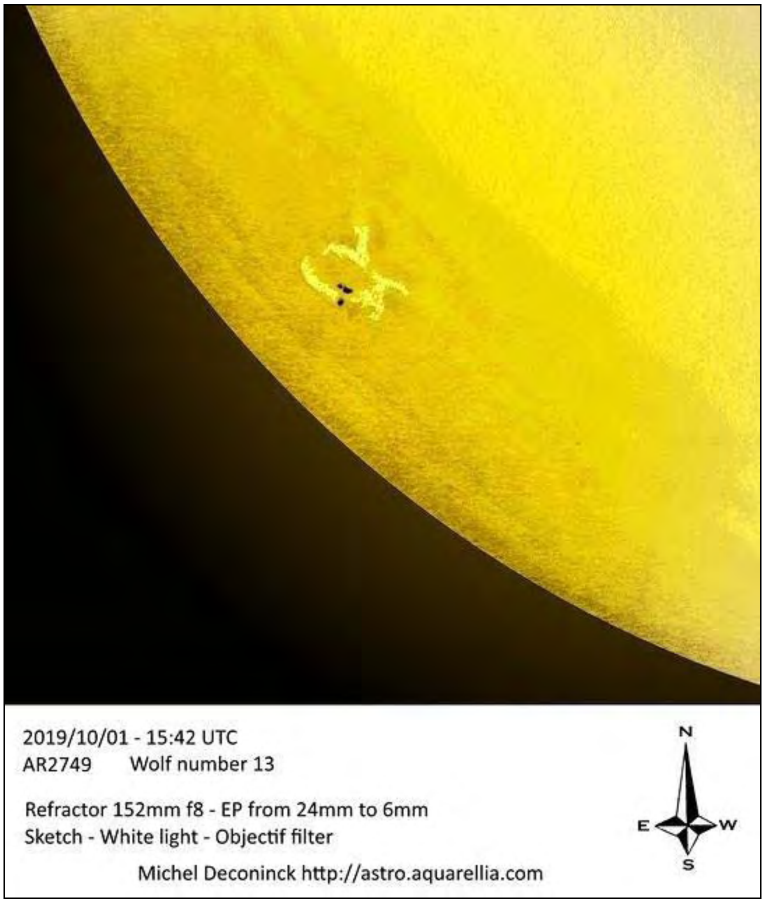


Figure 7. A w-l painting of AR 2749 by Deconinck at 15:42 UT.

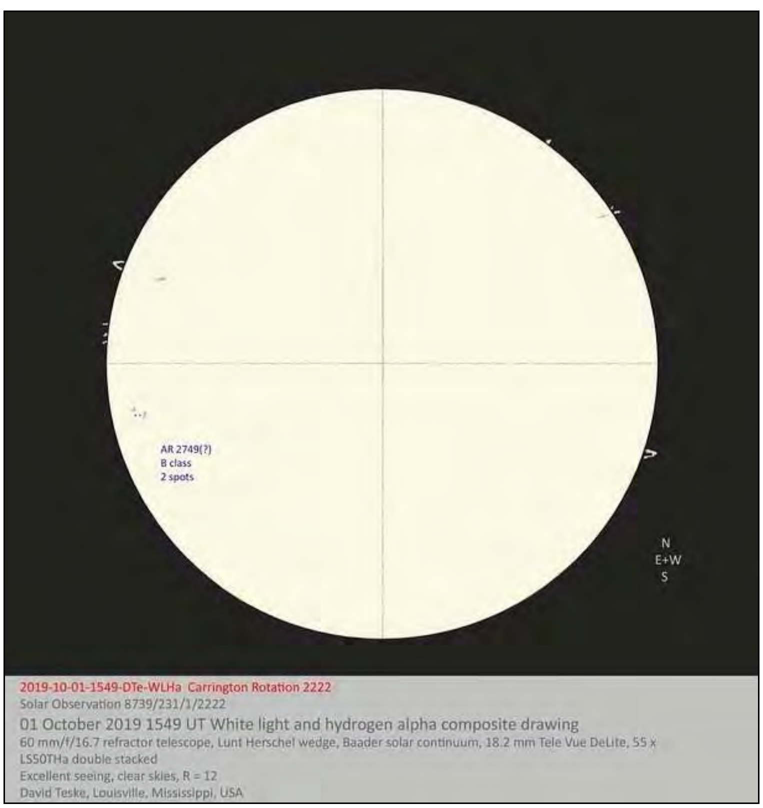


Figure 8. Whole-disk w-l/H-a composite image of the Sun on 10/1 by Teske at 16:32 UT.

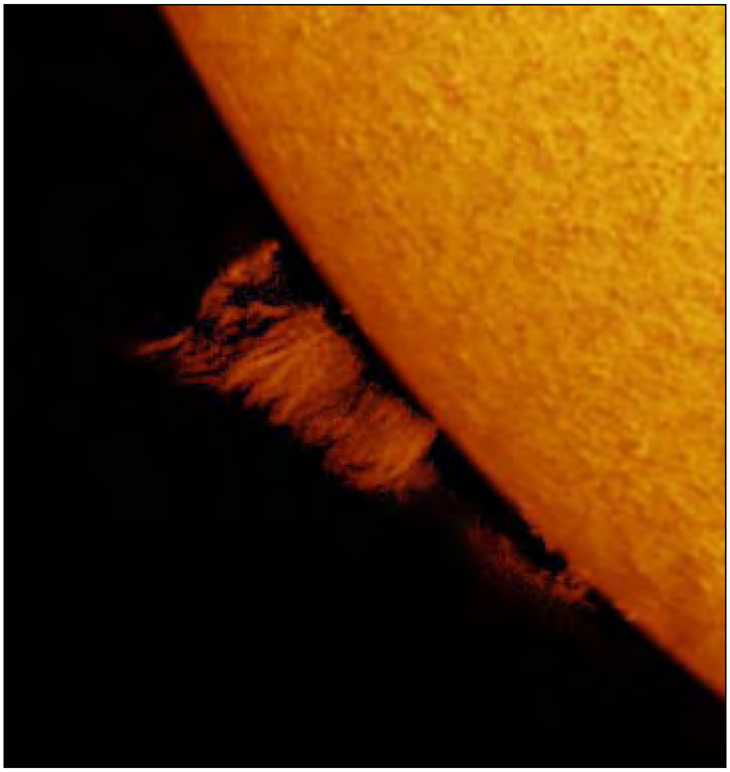


Figure 9. Solar prominences on the southeast limb by Ramakers on 9/20 at 12:52 UT in H-a.

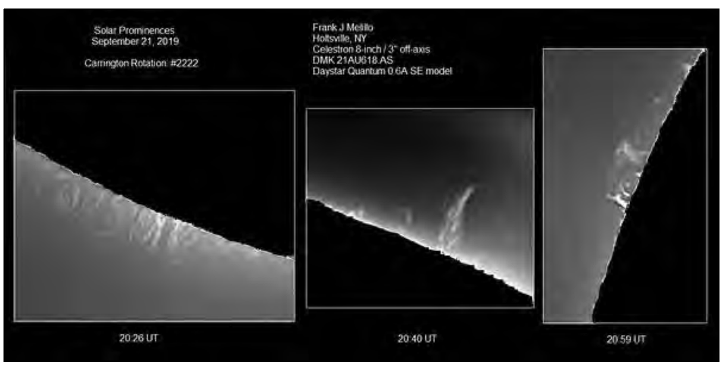


Figure 10. Three prominences capture by Melillo in H-a on 9/21 at 20:26, at 20:40 and at 20:59 UT.

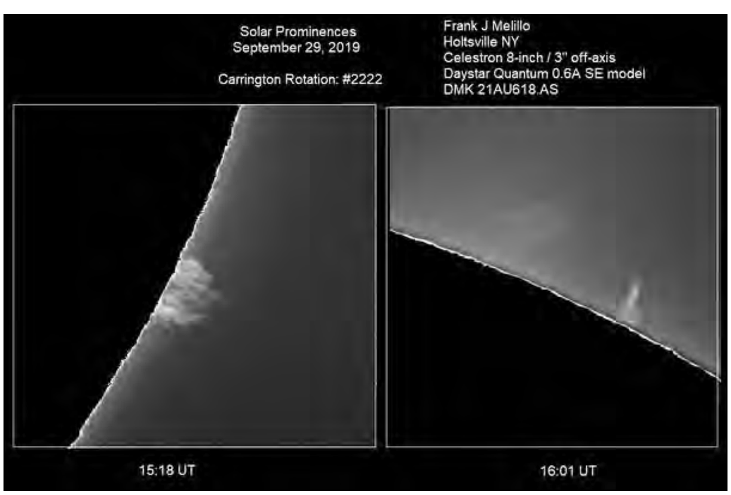
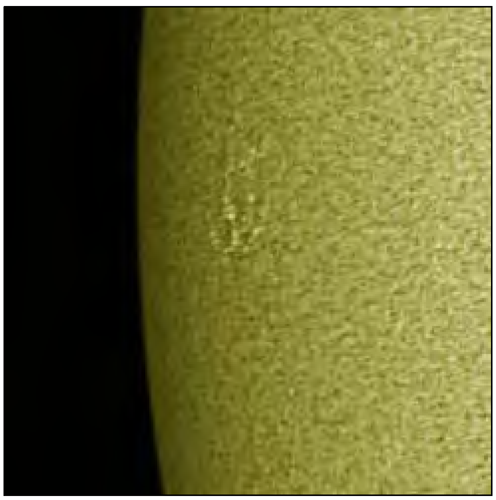


Figure 11. Two prominences in H-a by Melillo on 9/29 at 15:18 UT and 16: 01 UT.

Figure 12. A remarkable H-a limb prominence image by Shivak on 10/11 at 10:26 UT.



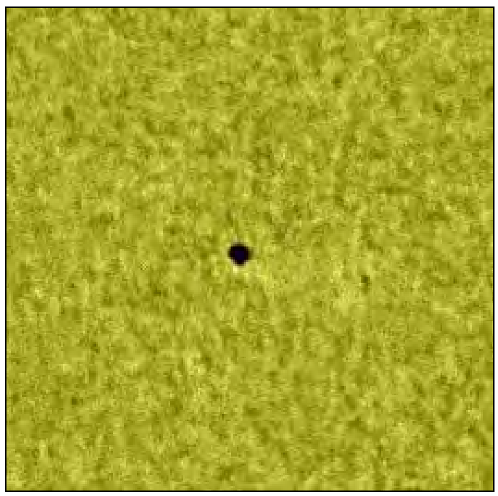
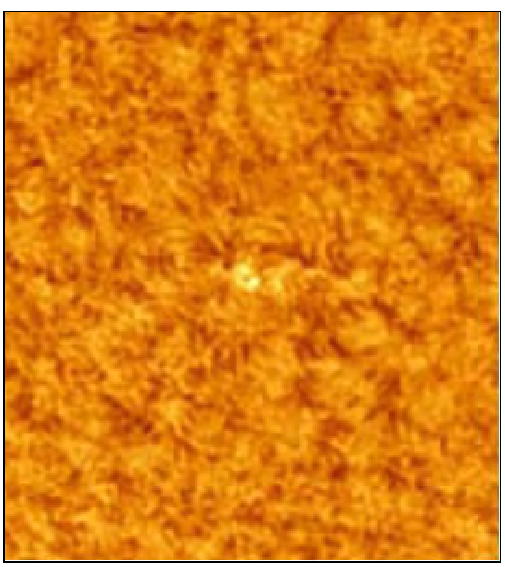


Figure 13 (left). Faculae near the limb in an image by Ramakers on 10/38 at 15:04 UT.

Figure 14 (right). A Ramakers image of AR 2750 in w-l on 11/1 at 14:00 UT.



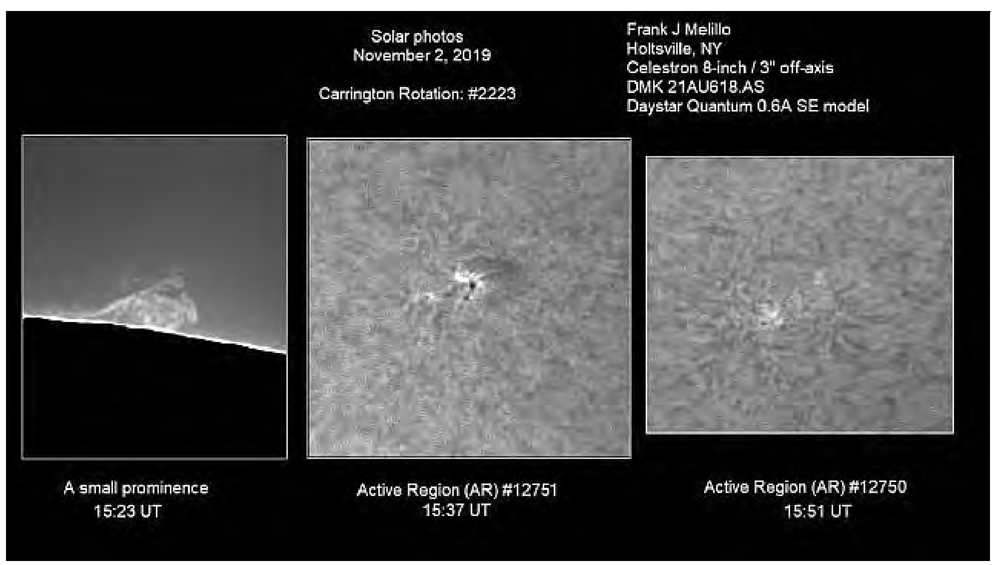


Figure 15 (left). AR 2750 in H-a on 11/1 at 14:12 UT by Ramakers.

Figure 16 (right). A Melillo 3-pane montage on 11/2 showing a prominence at 15:23 UT, AR 2751 in w-l at 15:37 UT, then AR 2750 in w-l at 15:51 UT.

AR 2750 was classed by Teske as "A" class and Ramakers got a good w-l image of the single umbral spot on 11/1 at 14:00 UT (Figure 14). In his H-a image taken just 12 minutes later (Figure 15), there is nothing remarkable at that spot!

The next day, we have a nice montage from Melillo showing all the action on the Sun for that day (Figure 16). First is a "small prominence" at 15:23 UT with interesting detail. He also shows AR 2751 in the middle at 15:37 UT, possibly showing a sub-flare. Finally, on the right, he shows AR 2750 at 15:51 UT now breaking down.

Carrington Rotation 2224

Dates: 2019-11-12.1744 to 2019-12-10.0166 UT

Avg. R_I = 0.11
High R_I = 3 (11/13)
Low R_I = 0 (26 days)

Activity for this rotation was again extremely low: the lowest seen since 2009 and the nadir of this reporting period. Except for the only active region, AR 2752, there was no significant activity. However, the reader is cautioned to not think this is the instant of solar minimum. Solar cycle prediction models do not agree with one model showing a dramatic increase from the minimum and another showing a much more gradual rise (Figure 17). Neither model seems to consider a flat-bottomed minimum where average R_I may equal zero for a few rotations. This has happened before and should not be surprising now.

AR 2752 was a plage noted by a few observers in monochromatic observations, but it never produced w-l spots. It was a Cycle 25 region in terms of polarity showing that the next cycle is on its way! O'Neal was first to observe this region in a two-disk montage (H-a and CaK) at 11:37 UT on 11/13 (Figure 18). It was shown in some detail in CaK by Ramakers three hours later at 14:46 UT with a possible sub-flare (Figure 19). Melillo showed it breaking down in H-a on 11/16 at 16:03 UT (Figure 20).

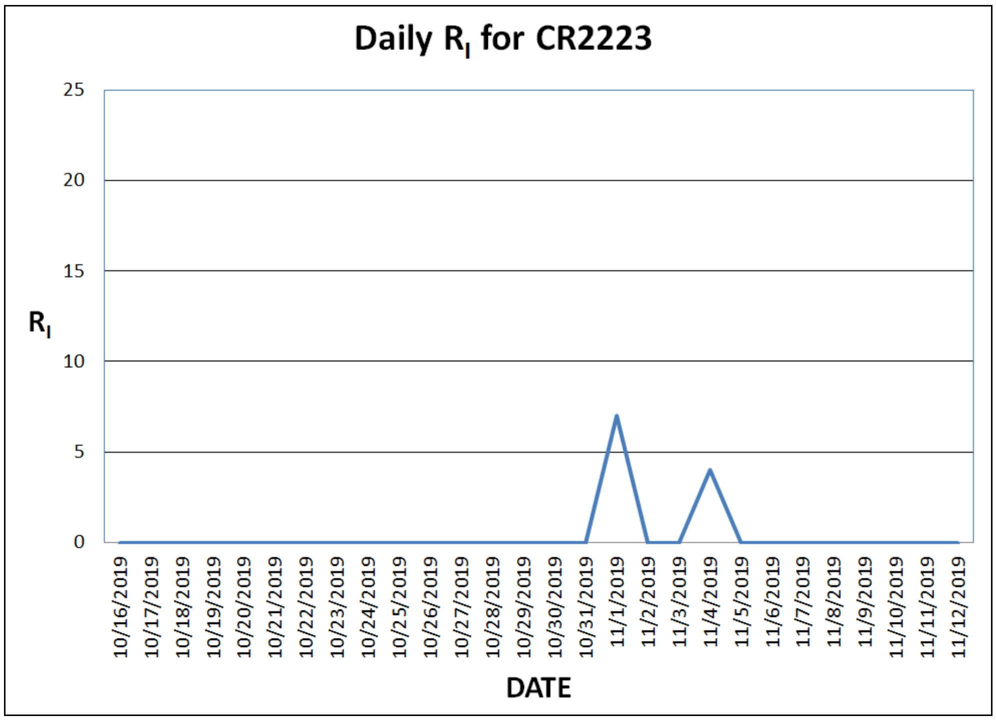
Carrington Rotation 2225

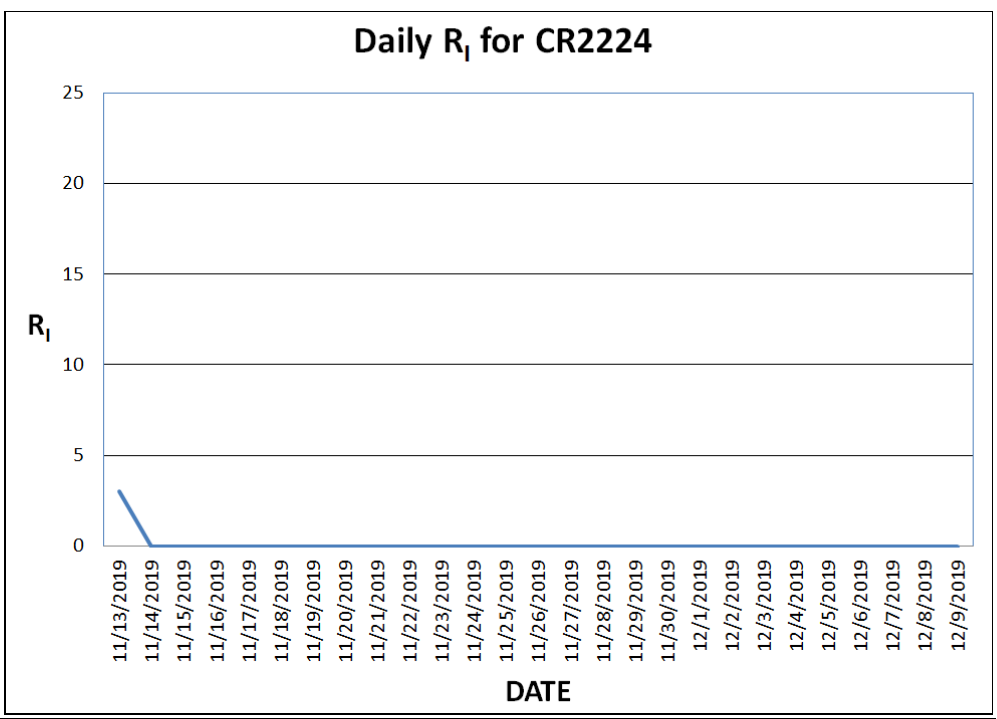
Dates: 2019-12-10.0116 to 2020-01-06.0911 UT

Avg. R_I = 4.0
High R_I = 23 (12/25)
Low R_I = 0 (19 days!)

With only 19 days of zero spots, activity increased slightly to "very low" in this rotation. There were three active regions (AR's 2753 to 2755) with the last, AR 2755, being the largest and measuring only 20 millionths of the disk! All three of the active regions were new (Cycle 25) and may be signaling a short minimum - but there are no guarantees.

We get a good look at both AR 2753 and 2754 in CaK images by Grassman,





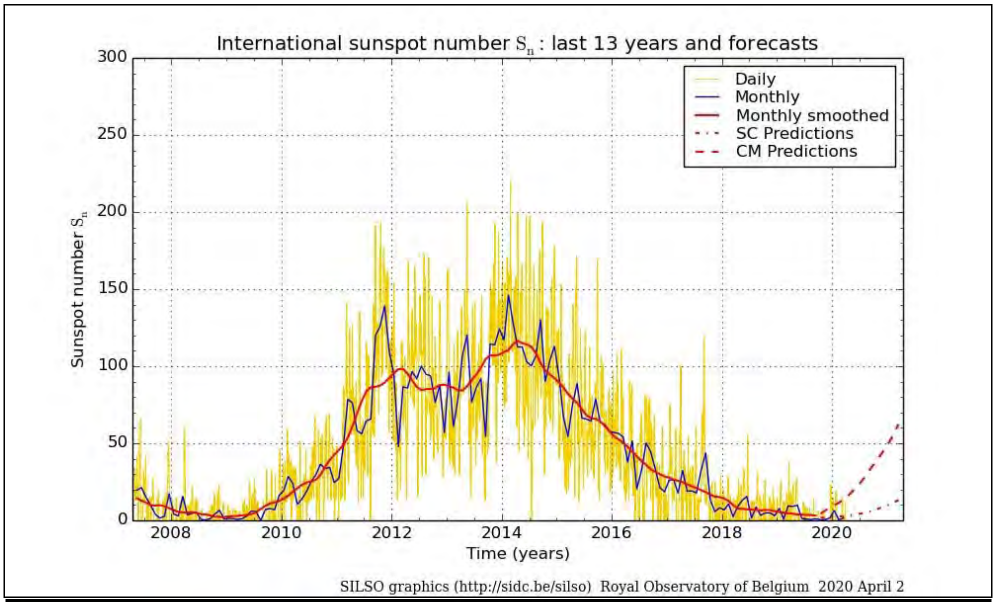


Figure 17. A graph of solar activity for Cycle 24 with predictions after 2020.

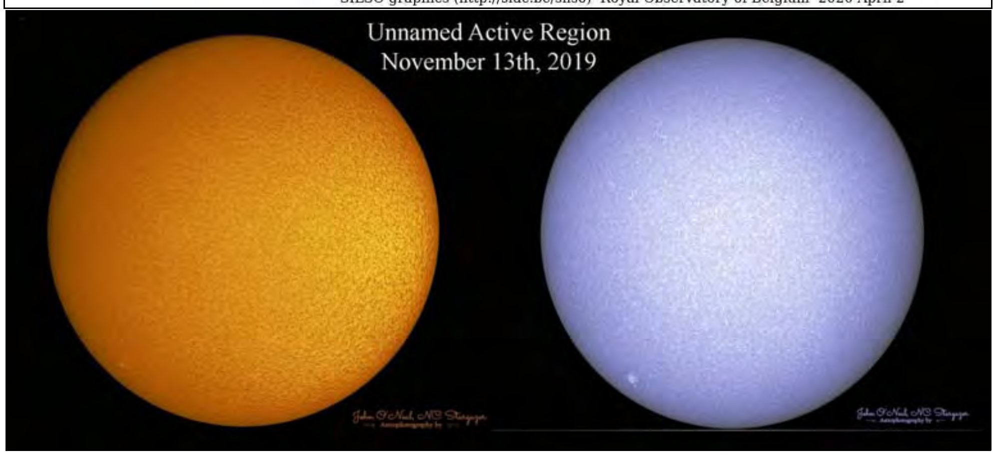


Figure 18. A two-disk view of the Sun in H-a and CaK on 11/13 at 11:37 UT by John O'Neal.

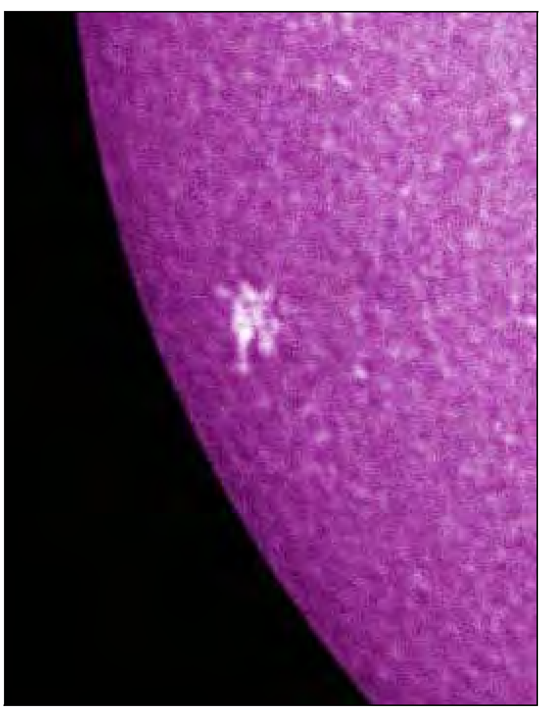


Figure 19. A CaK view of AR 2752 by Ramakers on 11/13 at 14:46 UT.

Figure 20. Two views of the Sun in H-a by Melillo on 11/16, a prominence at 16:09 UT to the left and AR 2762 at 16:03 UT on the right.

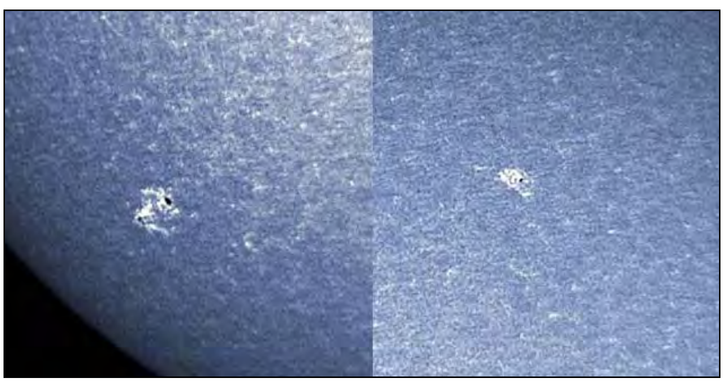


Figure 21. AR 2754 in CaK on 12/24 at 11:38 UT by Grassmann.

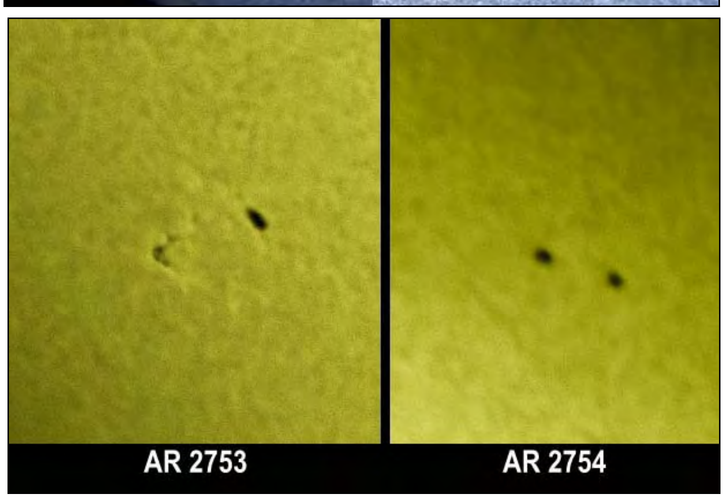


Figure 22. Two w-l view of activity on the Sun on 12/24 by Ramakers: AR 2753 on the left and AR 2754 on the right.

first on 12/24 at 11:38 UT (Figure 21). Then a w-l set on both by Ramakers on the same date at 14:26 UT (AR 2753) and 14:27 UT (AR 2754) showing just small umbral spots in each with both being Bxo class (Figure 22). On 12/25, Grassmann again caught both regions in CaK at 12:55 UT (AR 2754) and 12:56 (AR 2753) (Figure 23). Both regions were reduced to plages the next day and remained that way until they left the disk on 12/27 for AR 2753 and 12/31 for AR 2754.

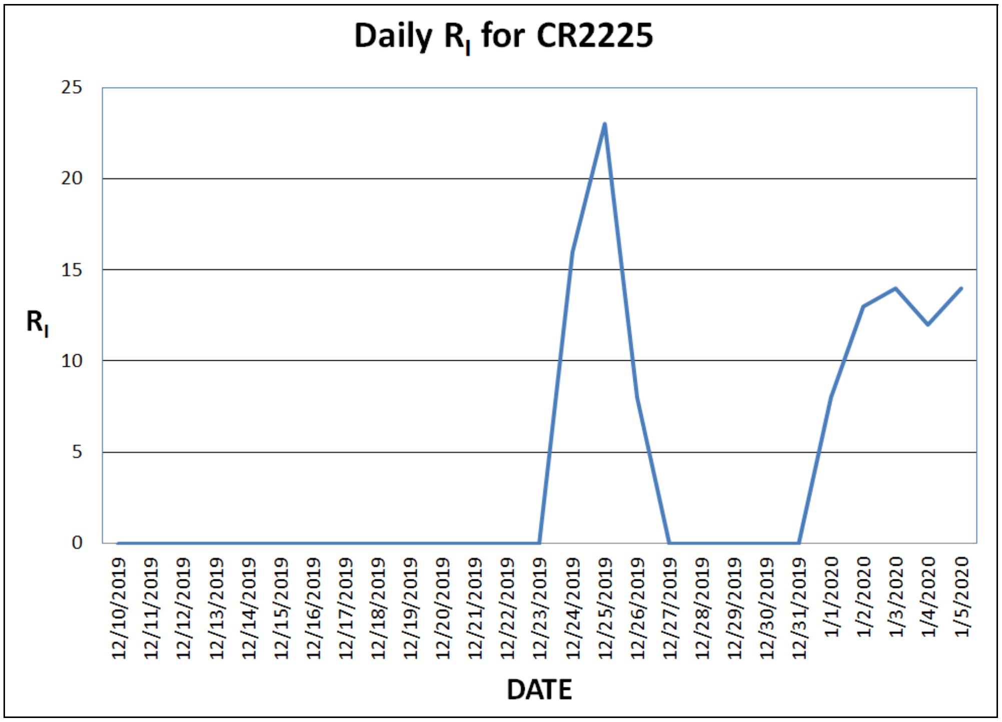
AR 2755 was first noted on 12/31 by Teske as a small spike prominence on the limb in one of his composite w-l/H-a whole-disk drawings. On 1/1, Ramakers made a nice composite of the region in w-l, H-a and CaK with a magnetogram showing the polarity of a Cycle 25 region (Figure 24). This region achieved a whopping 20 millionths of the disk a day later when we have a three-pane view from Eskildsen in w-l (16:48 UT), H-a (16:40 UT) and CaK (16:44 UT) (Figure 25). It held this level of development as a Bxo region of 20 millionths for one more day and by meridian passage on 1/6, it was Axx of only 10 millionths. From here it slowly disappeared becoming just a plage as it crossed over into the next rotation.

Conclusion

We are not yet at minimum and will not know when we have been at minimum until we've passed through it. From Jan 1 to May 1 2020, we have had 90 spotless days (75%) compared to 281 spotless days (77%) for all of 2019. This already makes this a deeper minimum than 2008/2009. Predictions range from the sudden rise seen in Figure 17 to another Maunder-type minimum of an extended period. Your observations will validate one of these predictions!

Wishing you all Sunny Skies!

For more information go to:



http://www.alpo-astronomy.org/member/ALPO_Standard_Memberships.html

Sunny skies to you all!

References

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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/*

Figure 23. (left) CaK views of AR 2753 at 12:55 UT and AR 2754 at 12:56 UT by Grassmann on 12/25.

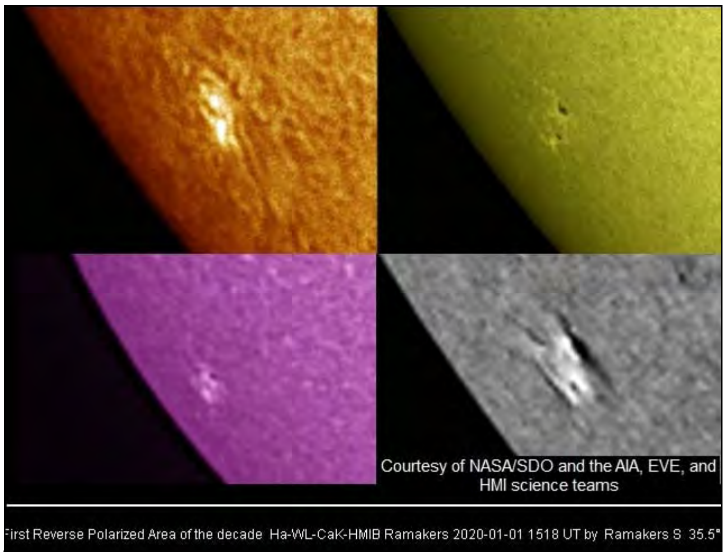
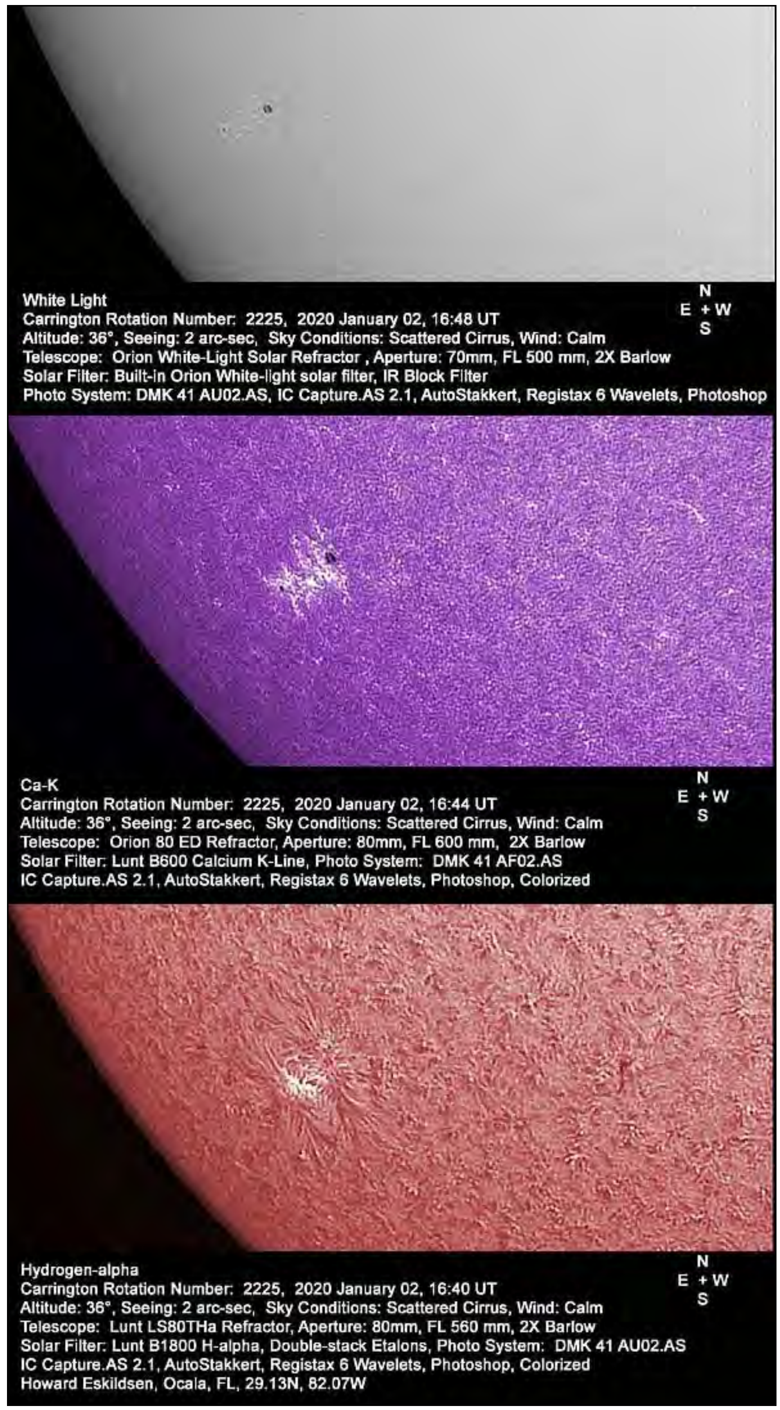


Figure 24. (above) Four views of AR 2755 on 01/01 in CaK, H-a and w-l by Ramakers and a magnetogram by NASA/SDO, showing the reversed polarity of coming Cycle 25.

Figure 25. (right) A three-pane view of AR 2755 on 01/02 by Eskildsen in w-l at (16:48 UT), in CaK at 16:44 UT, and in H-a at 16:40 UT.



ALPO Solar Section

OBSERVER____

ADDRESS____

DATE/TIME____UT

SEEING____________ CLOUDS____________ WIND____________

APERTURE__________mm FOCAL LENGTH__________mm TYPE______

EYEPIECE_______mm FILTRATION__________________________

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

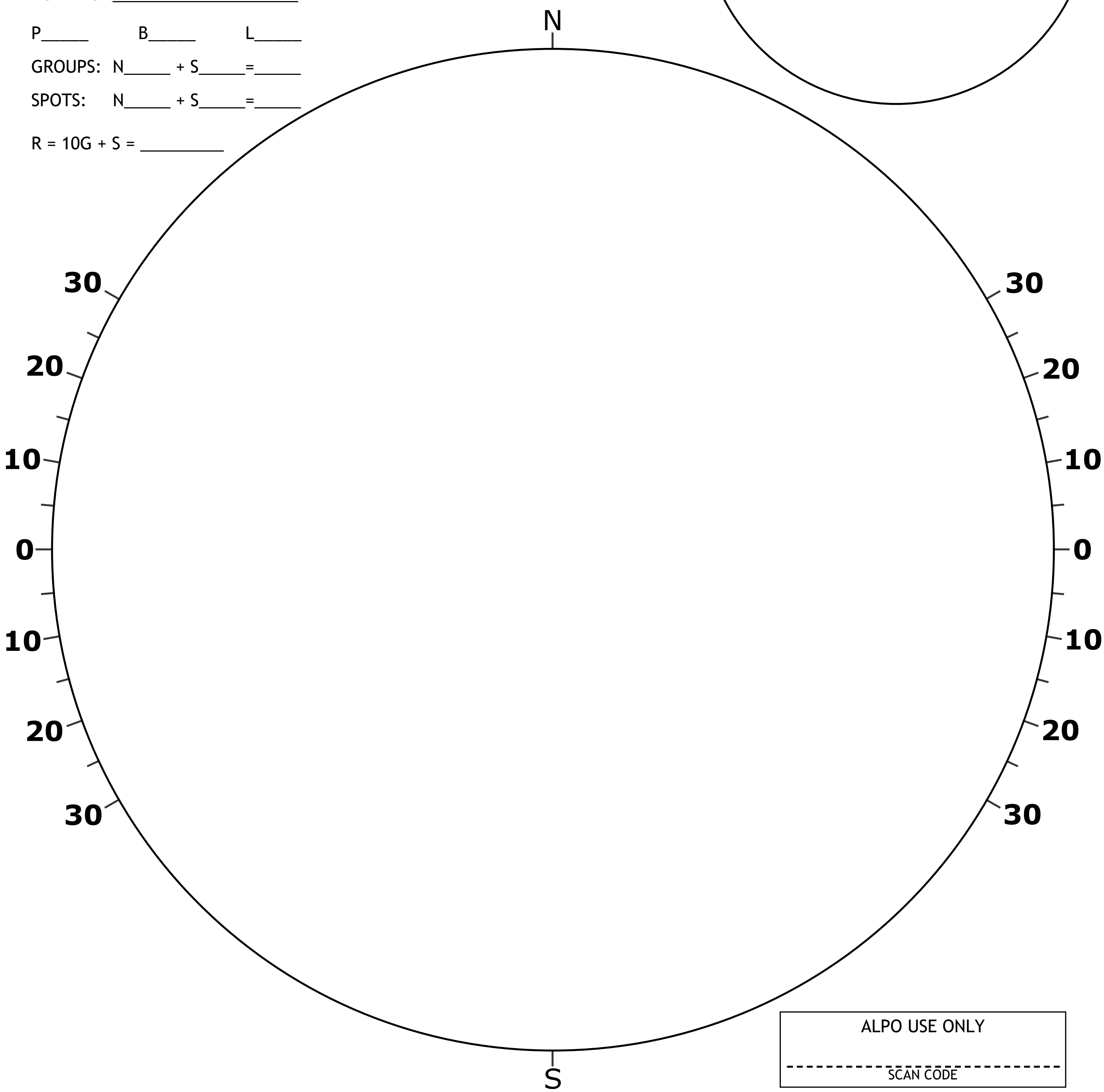
ROTATION______________

P_____ B_____ L_____

GROUPS: N_____ + S_____=_____

SPOTS: N_____ + S_____=_____

R = 10G + S = _________



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Papers & Presentations

Lunar Nighttime Thermal Analysis

Darryl Wilson
stargazer_guy@juno.com
(See "About the Author" at the end of this paper)

This paper is the first of several by Mr. Wilson on this topic. Look for follow-up papers on Lunar Thermal Imaging in coming issues of this Journal.

Introduction

Thermal infrared (TIR) imaging is a technique that generates pictures of a scene based on the heat radiated from the scene contents. Normal photography uses reflected visible light to generate an image. TIR imaging uses no visible light at all. Since the resulting image contains information that we can never see, it provides an opportunity to gain new insight into the objects being viewed. The heat radiation provides information related to surface temperature, emissivity, material composition, texture and geometry.

This article describes thermal imaging of the surface of the Moon using a Visimid Handheld Thermal Imager (TIR) and an 18-inch Obsession Newtonian reflector. The camera senses radiation at wavelengths from 7 microns to 14 microns. Lunar features that are prominent in this wavelength range are described, and a discussion of limitations on thermal detection of features is included. Finally, contact information for the suppliers of two thermal sensor systems that the author has used is provided.

Initial Observations

Four pairs of images are included in this article. Each is composed of a thermal image of the Moon and a visible light image of the same region of the lunar surface taken at about the same spatial resolution. The thermal images were taken on two dates, September 20 and October 19, 2019. The significant time difference between images in each pair is intentional so that the visible light reference image can show the area on the Moon that corresponds to the glowing areas in the thermal images. Some of the thermal features are visible more than two days after lunar sunset, so the lunar phase corresponding to the visible light images had to be two to three days earlier than that of the thermal ones.

Numerous bright spots can be seen in the thermal images. Almost all correspond to the locations of small craters. The following 10 locations are circled and labeled in the images:

A - Bessel

B - Dawes

C - Ross

D - Area immediately SW of Julius Caesar

E - Broken crater wall

F - Burg

G - Grove

H - Hercules

I - Proclus

J - Messier/Pickering

For selenographic reference, a white "X" marks the location of the Apollo 11 landing site in the Sea of Tranquility. About 250 miles to the southwest, another "X" marks the Apollo 16 landing site. All of the labeled craters are responsible for hotspots in the thermal images. There are many other hotspots for which the author does not have crater names or designations, so they remain unlabeled here. Most of the spots are associated with craters from about 5 to 10 miles in diameter. Craters larger than about 10 miles in diameter do not seem to produce glowing bright areas in the lunar night. Craters smaller than about 5 miles in diameter are not visible in these thermal images.

The thermal image in ***Figure 1*** was taken on September 20, 2019. Sunset on the Sea of Tranquility occurred September 19, one Earth-day earlier. The visible light image in ***Figure 2*** was taken on September 18, 2019, two days prior to the thermal image. The Apollo 11 landing site had been in darkness almost 24 hours at the time the thermal image was taken, and the Apollo 16 landing site had experienced sunset just an hour or so earlier. Bessel (A), Dawes (B), and Ross (C), are clearly visible as warm spots, as are numerous other small craters.

Within a few hours of sunset, immediately adjacent to the terminator, features other than small craters are still sometimes visible. Immediately south-southeast of the crater Julius Caesar, a somewhat amorphous warmer area (D) does not correspond to any apparent crater at this resolution. Also, about 15 miles east of the Apollo 16 landing site, two closely spaced bright spots (E) seem to correspond to parts of a crater wall.

Figure 3 shows the same region of the Moon, imaged about 16 minutes before ***Figure 1***. It apparently has lower signal-to-noise ratio (SNR) than ***Figure 1***, since only the brightest spots are visible. Bessel (A) and Dawes (B) are labeled. ***Figure 4*** is a visible light reference image taken on September 18, 2019, two days prior to the thermal image in ***Figure 3***.

The high SNR thermal image in ***Figure 5***, taken on October 19, 2019, shows bright spots corresponding to Burg (F), Grove (G), and a location inside Hercules (H), as well as a number of other small craters. Immediately to the right of Hercules is a diffuse bright area that seems to correspond to the interior of Atlas. This area was not circled and labeled in order to limit clutter in the annotated image. ***Figure 6*** is a visible light image taken for comparison on October 16, 2019, three days prior to the thermal image in ***Figure 5***.

Figure 7 is a high SNR thermal image taken on October 19, 2019 that shows bright spots caused by Dawes (B), Proclus (I), the Messier/Pickering pair (J), as well as many others. For reference, the broken crater wall next to the Apollo 16 site (E) is also noted. ***Figure 8*** is a visible light image taken for reference on October 16, 2019, three days prior to the thermal image.

Although craters in the 5-to-10 mile size range tend to remain visible for many hours — even days — after sunset, other types of surface features, including the Sun-facing side of crater walls, mountain peaks, and basalt lava plains apparently cool rapidly and are not visible in the images more than a few hours after lunar sunset. Additionally, the lunar limb was not apparent in any of the images processed so far.

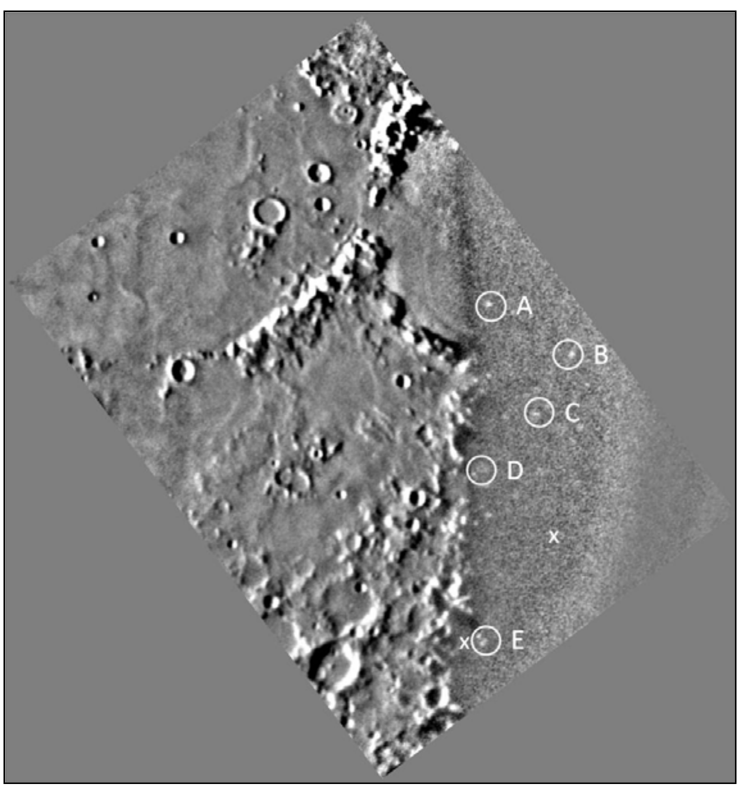
Discussion

The appearance of small craters glowing in the lunar night may be due in part to something known as the "cavity effect." Concave areas in thermal images appear to have higher emissivity than flat areas of the same material at the same temperature, and the deeper the concavity, the greater the effect. Most of the craters listed above are relatively smooth, deep concavities.

The cavity effect is not the entire story, though. Geometric calculations show that the center point in a crater that is six miles in diameter and one mile deep is only exposed to about 2/3 (68.4%) the area of the sky that a point on a flat surface (for example, mare) would be. Radiative cooling is the only mechanism available to the surface after sunset. Therefore, a point on the mare surface will experience cooling at a 50% greater rate than a point near the center of the crater.

These geometric effects at least partly explain why mountain peaks, flat plains, and isolated walls apparently cool more rapidly to a point below the limit of detection and do not continue to visibly glow after sunset.

What about the narrow size range of visibly glowing craters? Can we explain



(Left to right) Figure 1. Thermal image of the Sea of Tranquility taken on September 20, 2019, 06:02 UT. Equipment: Obsession 18 in. Newtonian, Visimid Phoenix X640 Thermal Imager. Sunset had already occurred on September 19. See text for items A thru E.

Figure 2. Visible light image taken on September 18, 2019, 04:17 UT. Equipment: 80 mm APO refractor, Celestron Skyris 274C planetary

that? Well, the lower size limit can be explained by the telescope's resolution limit in the TIR range of the spectrum. The resolving power of a telescope is calculated as R = 1.22 λ / D, where λ is the wavelength of light, D is the telescope aperture, and R is the resolution. The units for λ and D must be the same, and R will be in units of radians. Multiply R by 206,265 to get the answer in arc seconds. If 460 nm (blue light) is used for the wavelength (λ = 1.811 x 10^{-5} inches), after multiplication by 206,265 the equation reduces to the well-known Dawes formula R = 4.56 / D.

But we are imaging at much longer wavelengths, so we need to plug in a different value for λ. The Visimid camera is sensitive to radiation in a range from 7 to 14 microns. Using the midpoint of 10.5 microns (1.05 x 10^{-5} meters) for λ, and 0.457 meters (18 inches) for D, we get R=2.80 x 10-5 radians. Multiply that by 206,265 arcseconds per radian and we get R=5.8 arcseconds. That's equal to 6.7 miles on the lunar surface at its mean distance from Earth.

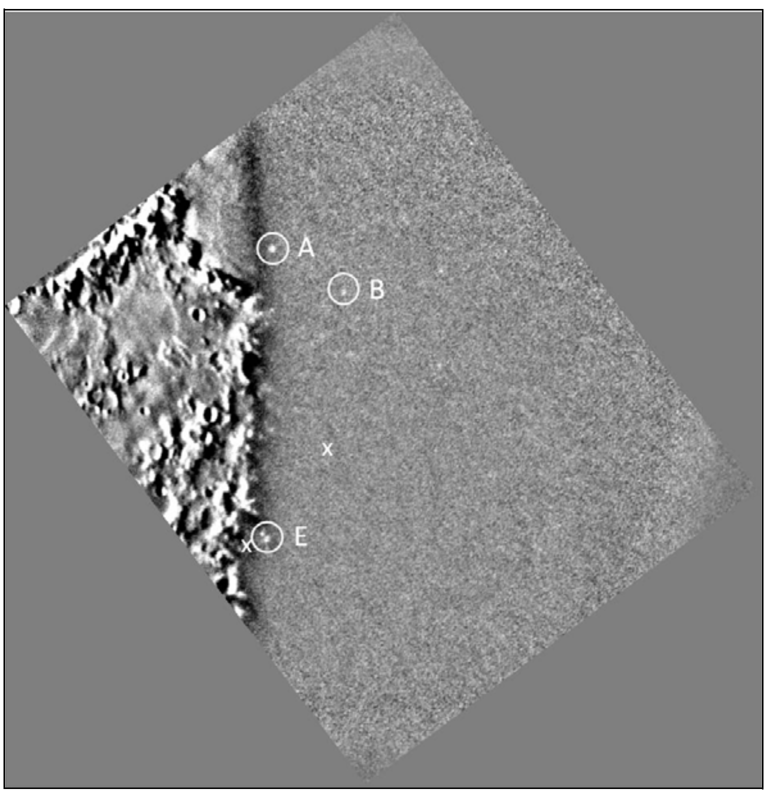
Is this really true? Does an 18 inch telescope imaging in the TIR really have poorer resolution than a one-inch spotting scope used with the human eye, or have we overlooked something? Alas, our calculations are correct. This is indeed the way electromagnetic radiation and optics interact.

Since TIR wavelengths are about 20 times longer than those of visible light, the resolving power of your telescope will be 20 times worse. The calculated spatial resolution of 6.7 miles explains why craters smaller than about 5 miles in diameter are not seen to glow in the night.

The sudden cutoff in visibility for craters larger than about 10 miles in diameter is a little puzzling, though. However, in general, the larger the crater, the less deep the concavity. This partly explains the observation, but other factors may also be involved, including variations in surface material composition, and further analysis is needed.

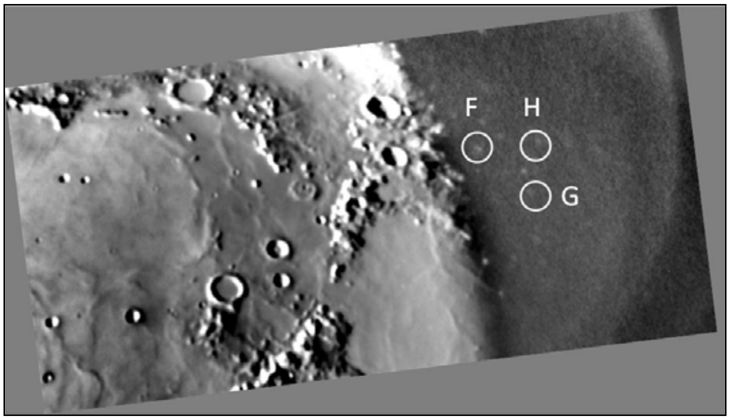
The somewhat amorphous warmer area immediately south-southeast of crater Julius Caesar is currently unexplained. At this resolution, the visible image does not show any obvious cause. Likewise, the comparatively warm area in the vicinity of crater Atlas does not follow the pattern of almost all of the other nighttime thermal features. Perhaps examination of higher resolution imagery will prove enlightening.

The two bright spots just east of the Apollo 16 landing site are easy to explain. There is a somewhat broken crater wall in that vicinity. It would have received solar illumination at a steeper angle than the adjacent surface until the time of sunset, and it would have continued to be illuminated for an hour



(Left to right) Figure 3. Thermal image of the same area as Figure 1; taken on September 20, 2019, 05:46 UT. Equipment: Obsession 18 in. Newtonian, Visimid Phoenix X640 Thermal Imager. Sunset had already occurred on September 19. Note items A, B and E.

Figure 4. Visible light reference image taken on September 18, 2019, 04:17 UT. Equipment: 80 mm APO refractor, Celestron Skyris 274C



(Left to right) Figure 5. High SNR thermal image taken October 19, 2019, 04:57 UT. Equipment: Obsession 18 in. Newtonian, Visimid Phoenix X640 Thermal Imager. See text for info on craters Burg (F), Grove (G) and a location inside Hercules (H), as well as a number of other small craters.

Figure 6. Visible light image taken October 16, 2019, 05:21 UT. Equipment: 80 mm APO refractor, Celestron Skyris 274C planetary imaging camera. This image taken three days prior to the thermal image in Figure 5.

or so after sunset on the adjacent area. Since sunset just occurred, it had not had time to cool.

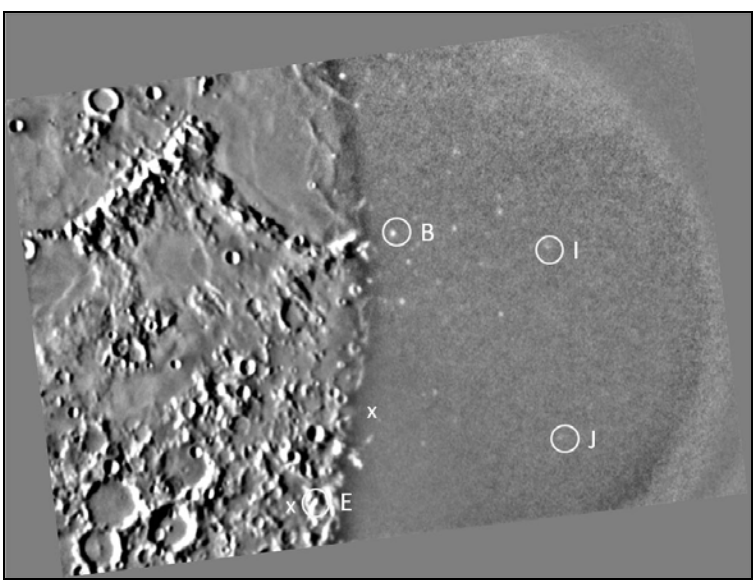
Individual frames from the thermal imager are visibly noisy, and stacking multiple images results in a final image with a higher SNR.

The September 20 images are the result of stacking about 41 individual frames. ***Figure 5*** is the result of a 360-frame stack, while ***Figure 7*** is a 160-image stack. It is not surprising that improving the SNR increases the number of features that can be detected after lunar sunset. Future processing with larger image stacks will further increase radiometric sensitivity and reveal more details of the surface after sunset.

The current version of software available with the Visimid X640 has limited functionality. It does not provide for exposure, gain or gamma control. The camera's electronic auto-gain feature results in a constantly changing sensitivity that affects image brightness, contrast, SNR and vignetting. It is hoped that the next version of control software from Visimid will greatly improve the situation. (See *The Lunar Observer,* September 2019 pages 36-38 at *http://Moon.scopesandscapes.com/tlo_back/tlo201909.pdf* for more details).

Some Areas for Amateur Observers to Contribute

Thermal imaging in the 7-to-14-micron region of the spectrum can be used to capture at least some features on the



(Left to right) Figure 7. High SNR thermal image taken October 19, 2019, 04:57 UT. Equipment: Obsession 18 in. Newtonian, Visimid Phoenix X640 Thermal Imager. Note bright spots caused by Dawes (B), Proclus (I), the Messier/Pickering pair (J), as well as many others.

Figure 8. Visible light image taken October 16, 2019, 05:21 UT. Equipment: 80 mm APO refractor, Celestron Skyris 274C planetary imaging camera. This image taken three days prior to the thermal image in Figure 7.

lunar surface more than 48 hours after sunset. With improved software control, the capability can be extended. It is hoped that the nighttime side of the terminator will reveal surface details several hours into the lunar night so that the surface thermal properties may be observed and studied. The radiative behavior during and after a lunar eclipse should also prove interesting, and thermal video would be an ideal observation method for such an event. If the next version of software provides enough capability, it may even be feasible to collect thermal video and post-process it to detect transient events such as meteoroid strikes.

Thermal Imaging Hardware Availability

The imager used to collect all of the images in this article is a Visimid X640 Handheld Thermal Camera. It can be purchased through the company's website and is available in the U.S. and can be exported to numerous other countries.

I recommend that anyone who is interested contact the company directly and explain the intended use of the camera, since astronomy is not their primary focus. They should be able to ensure that you get the best version of the software, and they can eliminate the lens thread grease that provides protection against accidental submersion in water. This will make it easier for you to remove the camera lens, which is necessary to use your telescope as the primary optic. They are currently in the process of developing a new version of their application software, and the author has provided several user-interface suggestions that would be useful to amateur astronomers. They can be contacted at https://visimid.com/ or phone (469) 906-2660.

The author's experience with thermal imaging of the Moon and planets began several years ago with another brand of imager. The South Korean company, i3System, sells thermal imagers comparable in performance to the Visimid X640. Although no rigorous testing has been performed, the author's qualitative assessment is that the i3System imaging hardware may be slightly better than the Visimid camera. Unfortunately, the author was unable to successfully install and run the full-featured software that accompanied the i3System imager on a Windows 7 computer system. Apparently, i3System has focused their development efforts on Windows 10 and later. Their control software was much more advanced than Visimid's. If you have a Windows 10 system, you might want to consider this option for a full-featured thermal imaging system and an excellent camera. The author's contact is Terry Clausing of Drysdale & Associates; phone (513) 831-9625 or e-mail him at terry@drysdaleenergy.com.

The company's website is https://www.drysdaleassoc.com/. They can also supply anywhere in the U.S. and export to several other countries.

Although purchasing a thermal imaging camera is one of the necessary first steps toward producing thermal images of the Moon and planets, there are a number of potential pitfalls that must be successfully navigated in order to produce good quality thermal images of the Moon. The author hopes to provide helpful guidelines, dos and don'ts, and must-haves in a future article.

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About the Author

Darryl Wilson, a retired scientist, became interested in astronomy at the age of 12. He still has his observing log from that time when his equipment consisted of a Jason-Empire 60 mm refractor on an alt-azimuth mount. With 60 mm of aperture, the Moon and bright planets were his regular targets. When he first applied to ALPO, Walter Haas wrote back explaining that a 12-year-old with a small refractor was too young and inexperienced to make contributions. Walter may have been right, but no loss of enthusiasm resulted. Two years later, high school athletics, then college, reduced observing time to zero for many years, but did not dim the memories of seeing Saturn for the first time at 47x - amazing rings and all. In 1994, he bought an 18 in. reflector from Obsession telescopes, which is the same scope he used to take all of the thermal images presented in this paper. Primarily a planetary and DSO (deep sky object) observer, he was recently drawn back to the Moon (and Venus and Mars) because he wanted to explore the possibility of imaging in the thermal infrared region of the spectrum. The Moon promised to be the easiest place to start. In the summer of 2019, he began to achieve good results with his newest thermal imager and he decided it was time to contact ALPO once again to see if there was any interest in sharing the capabilities of this new technology. In the future, he hopes to apply other high technology imaging techniques (for instance, hyperspectral) to lunar and planetary observing and to share the results with other amateurs who want a new way to see the universe.

Darryl has been an affiliate faculty member with the Physics and Astronomy Department at George Mason University since 2011. You can find other articles on thermal imaging he has published beginning with the September 2019 issue of “The Lunar Observer” (http://moon.scopesandscapes.com/tlo_back.html).

Papers & Presentations

Lunar Domes in the Milichius - Tobias Mayer Region: Dome M24

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Abstract

In this study, we examine a lunar dome designated M24 using CCD terrestrial images, Lunar Reconnaissance Orbiter (LRO) Wide Area Camera (WAC) images, the Laser Altimeter Digital Elevation Model (LOLA DEM), and the LRO WAC-based GLD100 Digital Terrain Model (DTM) along with data from the Chandrayaan-1 Moon Mineralogy Mapper (M^3) and Kaguya Multiband Imager.

The dome lies to the south of the crater Brayley D, at 19.17° N and 32.55° W, and has a base diameter of 18±0.2 km, height of 95±10 m and average slope angle of 0.60°±0.06. Spectral data are consistent with olivine-rich basaltic composition.

Based on the morphometric properties, we infer the physical conditions under which the dome was formed (lava viscosity, effusion rate, magma rise speed) as well as the geometries of the feeder dikes.

Introduction

Lunar domes formed during the terminal phases of lunar eruptions and mostly occur in the maria. These volcanic constructs, formed during the later stages of volcanism on the Moon, are characterized by a decreasing rate of lava extrusion and comparably low eruption temperatures, resulted in the formation of effusive domes [references 1 thru 3].

Guy Heinen from Linger, Luxembourg, reported a possible dome, with an elongated vent on the summit, located to the south of the crater Brayley D (Figure 1). This feature is named M24 to be consistent with previous classification of domes in the Milichius -T.Mayer area. A map of this region is shown in Figure 2. M24 is located at coordinates of 19.17° N and 32.55° W. The geologic map USGS I-465 displays the examined feature as a dome (*https://www.lpi.usra.edu/resources/mapcatalog/usgs/I465/150dpi.jpg*). Apollo 17 imagery shows the examined dome and the elongated vent on the summit (figures 3 and 4).

In the revised catalog of lunar domes by Kapral and Garfinkle [Reference 5], a dome — described as "unverified" — is reported at same coordinates but without any data on height, slope and volume.

In this paper we examine the morphometric and spectral characteristics of M24 — derive information about the physical parameters of dome formation, and provide a geological interpretation of our morphometric, morphological, and spectral data.

Data Sources & Methods

The new global topographic map of the Moon obtained by the Lunar Reconnaissance Orbiter (LRO) is the principal source of topographic information used in this study.

Associated topographic profiles were extracted from the LOLA DEM and the GLD100 data set using the Quickmap LRO global basemap (*http://target.lroc.asu.edu/da/qmap.html*).

Data from the Chandrayaan-1 M^3 instrument were used to derive spectra that highlight mineralogical characteristics of lunar volcanic materials. M^3 is an imaging spectrometer that detects 85 channels between 460 to 3,000 nm, and has a spatial resolution of 140 or 280 meters per pixel [Reference 4].

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 and OP2A.

A continuum removal method that enhances the features in the 1,000 nm absorption band and more accurately shows the position of the band center has been used. We fit a straight line between 750 and 1,500 nm to remove the continuum.

Online Readers

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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.

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°.

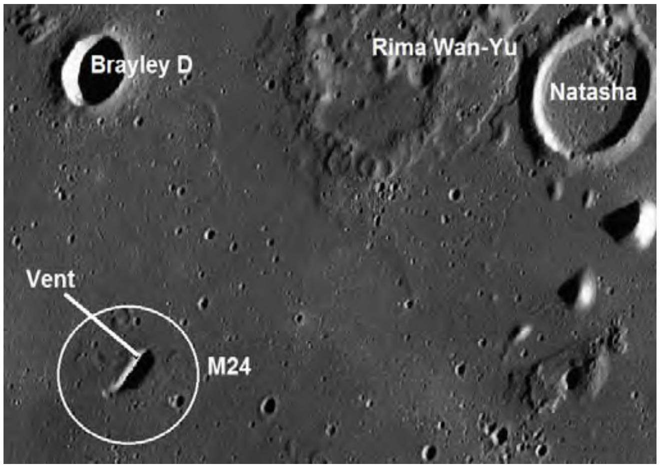
Putative Intrusive Domes

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°.



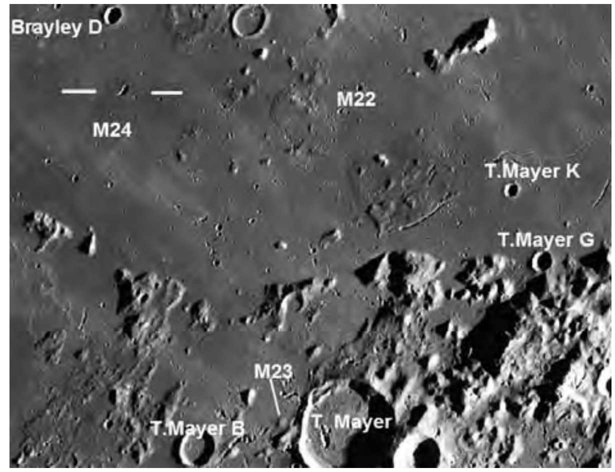
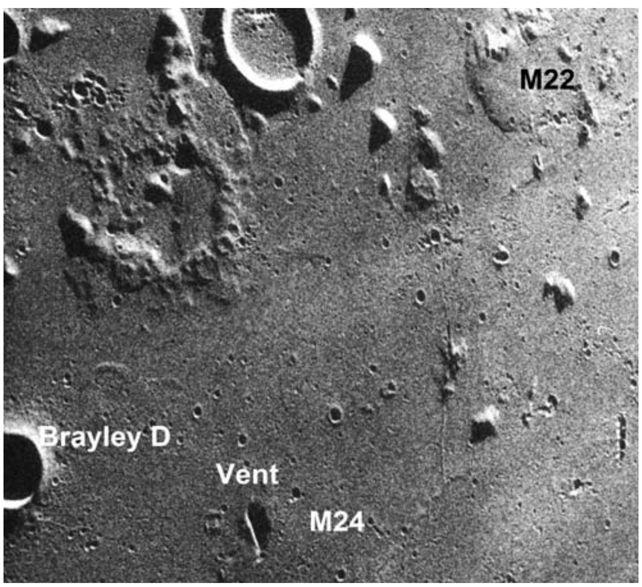


Figure 1 (Left): WAC imagery showing the location and appearance of M24 and its vent.

Figure 2 (Right): WAC imagery including T. Mayer crater, Brayley D and the domes named M22-23, previously examined by the authors [9].



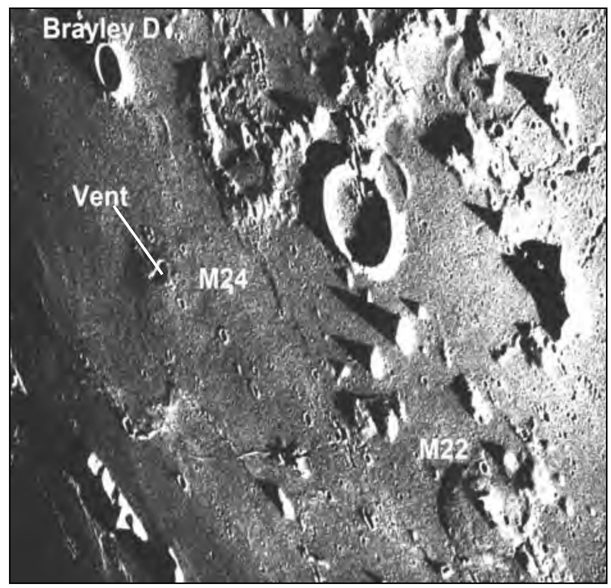


Figure 3 (Left): Apollo 17 image (AS17-160-23992); north is on the left and west on the bottom. The image displays M24, the vent and the dome M22 previously described [9].

Figure 4 (Right): Apollo 17 image (AS17-160-23983). The image displays the domes M24 and M22.

We have also used the Kaguya Multiband Imager for the study of the dome composition — it provides a spatial resolution of ~20m/pixel in the UVVIS, and ~60m/pixel in the NIR and its reflectance data have been corrected for the shading effects of topography, which drastically reduces the error in mineral abundance estimations [Reference 6].

Finally, using physical models, we have estimated the rheologic properties and dike geometries according to our methods used in previous studies [references 3, 7 through 8] for a large number of monogenetic lunar mare domes. These parameters are closely related to the physical and compositional properties of the erupted magma.

Results and Discussion

Volcanic Vent

Many lunar domes have a summit crater pit likely representing the vent of the volcano which was enlarged by magma withdrawal and/or later erosion [references 1 through 3].

Dome M24 does not display a circular summit pit, but instead an elongated

Figure 5 (Left). WAC image of the elongated vent of M24. It is breached in southwest direction.

Figure 6 (Right). Elongated vent of M24 under high solar illumination angle with dark material.

fissure 4.5 km in length crosses the summit, as shown in Figure 1. Volcanoes can have such elongated vents especially when they were formed along a fissure or by a dike intrusion.

Hence, this depression represents the original vent, the place at which lava poured out over the lunar surface, successively building up a shield-like volcano around it [references 1 through 3].

Central vents — the most common types of volcanic vents — are the conduit pipes through which magma is forced upward to the surface and then ejected as lava or pyroclastic fragments.

A central vent connects the magma chamber to the open vent on top of a volcano, and is maintained open by the continuous release of volcanic material.

Note that the vent of M24 is breached in the SW direction and material of lower albedo is present near the rim and nearby soil, which could be pyroclastic material. A WAC image of the vent under examination is shown in Figure 5. The dark material and the breached vent are easily discernible in Figure 6.

Morphometric Properties

Morphometric data was obtained from the LRO LOLA instrument with a grid size of 1/1,024 degrees [Reference 11] and from the GLD100 data set [Reference 12].

The 3D reconstruction using WAC mosaic draped on top of the GLD100 elevation model is shown in Figure 7. The cross sectional profile of M24 is shown in Figure 8. Dome M24 has a base diameter of 18±0.2 km, a height of 95±10 m and average slope angle of 0.60°±0.06. Assuming a parabolic shape, the feature's edifice volume is 11.45 km^3.

Rendered Images of M24

A synthetic image of a dome can be generated based on an available DEM as seen from a given direction for lighting from some other specified direction. The LTVT software [Reference 10] was used to generate synthetic view of selected parts of the LOLA DEM (Figure 9). The LOLA DEM data and the rendered image display the domical shape of M24, and its elevation, but only under a strongly oblique solar illumination angle (of about 1°). This illustrates the low profile of M24 due to the dome's shallow slope angle.

Ground-based Observations

The ALPO Lunar Domes Studies Program encouraged observers to obtain more high-resolution imagery under strongly oblique solar illumination angles of this area [Reference 13]. We have analyzed 11 CCD images, as reported in Table 1.

We have also received a report and an image of the Copernicus region near the sunrise terminator, made by Glenn on April 15, 2019 at 05:53UT, from San Diego, CA, using a Celestron C9.25 Edge HD telescope and a ZWO ASI183MM (mono) camera with a 500 nm - 575 nm bandpass filter.

In accord with our results, Glenn describes an estimated diameter of 18 km and an elevation of M24 slightly over 100 m above the surrounding terrain.

Table 1. Observers and number of the analyzed CCD images

Observers	Images	Telescope
H. Eskildsen (USA)	2	Refractor 6 in. (150 mm) and Schmidt Cassegrain 9.25 in. (235 mm)
G. Heinen (Luxembourg)	3	Schmidt Cassegrain 9.25 in. (235 mm)
R. Hill (USA)	2	Mak Cassegrain 7 in. (180 mm)
K.C. Pau (Hong Kong)	2	Newton 10 in. (254 mm)
M. Teodorescu (Romania)	1	Schmidt Cassegrain 14 in. (355 mm)
M. Watanabe (Japan)	1	Schmidt Cassegrain 14 in. (355 mm)

As shown in Figure 10, the dome, with its low flank slope, displays significant contrast and the domical shape only when the solar elevation angle is 1°. In fact, M24 is clearly detectable only at low solar elevation angles demonstrating that it must be imaged close to the terminator.

Another image of M24 is reported in Figure 11. Observations at higher solar elevation angles may result in strong differences to the appearance of M24 (cf. images reported in Table 1) so that its domical shape is not very obvious.

3D Reconstruction Based on CCD Telescopic Images

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 method makes use of the fact that surface parts inclined towards the light source appear brighter than surface parts inclined away from it [Reference 3].

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 along with knowledge of the illumination conditions, to derive an elevation value for each image pixel [Reference 14].

The SfS method requires accurate knowledge of the light-scattering properties of the surface in terms of the bidirectional reflectance distribution function (BRDF).

The iterative methods used for photoclinometry and the SfS approach are described in some of our previous articles [references 15 and16].

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 is determined according to:

slope = arctan 2h/D

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 M24 is shown in Figure 12.

The height of the M24 dome was also computed from Figure 10 using the shadow length method according to the relation:

h = l tan α

where l is the shadow length, corrected for foreshortening and measured in kilometers and tan α is the tangent of the solar altitude.

This measurement was performed using the LTVT software package created by Mosher and Bondo [Reference 10]. Accordingly, a height of 85±10 m is obtained, in agreement with the 95 m result shown in Figure 12.

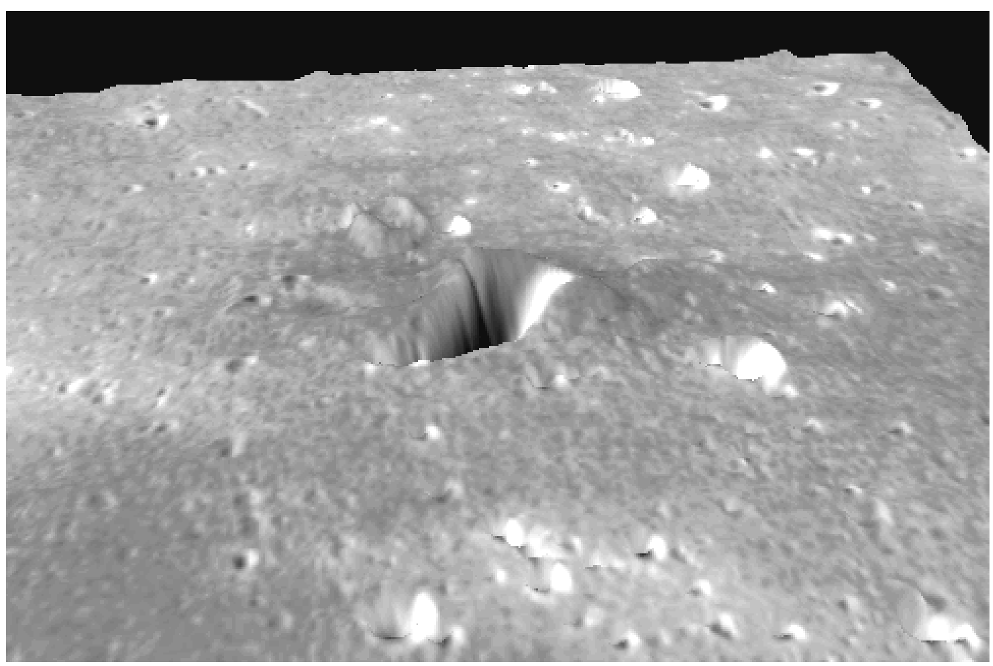


Figure 7. WAC draped on top of the global LRO WAC-derived elevation model (GLD100). The elevation of the dome measures 95±10 m. The vertical axis is 7 times exaggerated.

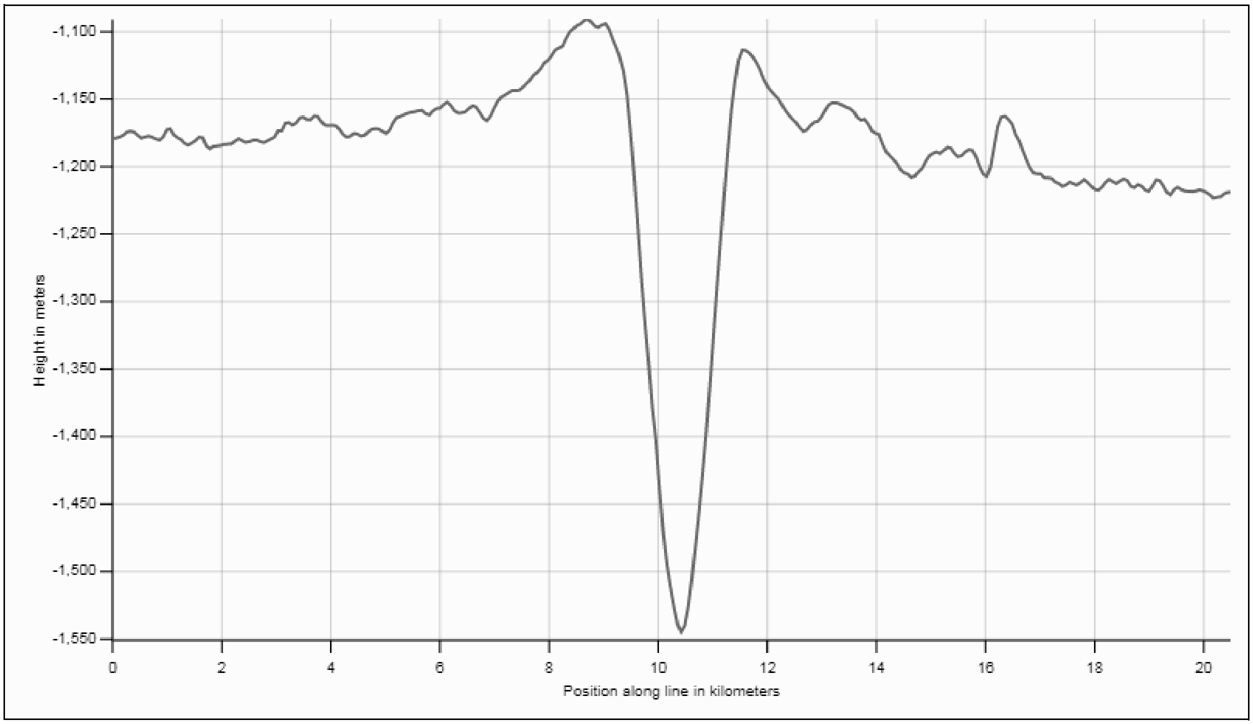


Figure 8. LOLA DEM. Cross-sectional profile in E-W direction of dome M24.

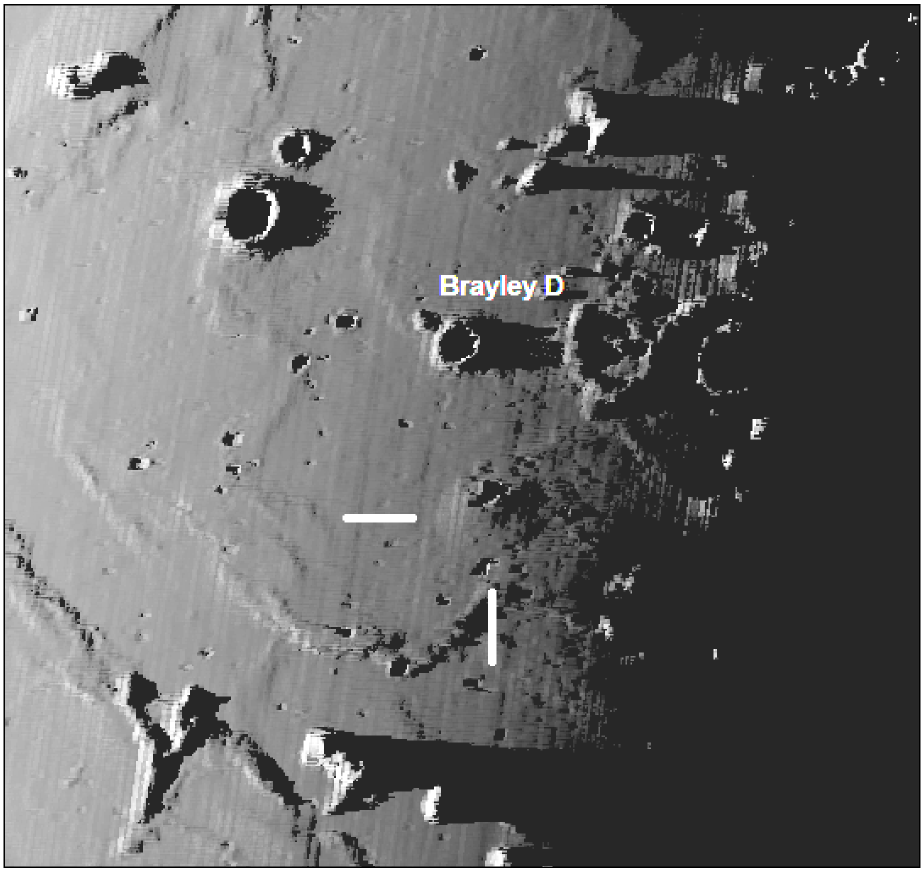


Figure 9. Rendered image based on the LOLA DEM using LTVT under strongly oblique solar illumination angle (of about 1°). M24 is marked with white lines.

Spectral Analysis

Pyroxenes are characterized spectrally by distinct absorption bands around 1,000 and 2,000 nm, with low-calcium pyroxenes displaying bands shifted to slightly shorter wavelengths, and high-calcium pyroxenes exhibiting bands at slightly longer wavelengths with increasing Ca and Fe [Reference 17].

Olivine has a complex absorption profile centered beyond 1,000 nm, with weak or no absorption at 2,000 nm. Therefore, olivine-rich lunar deposits are characterized by a broad 1,000 nm absorption band which is enhanced relative to the 2,000 nm band [Reference 3].

For lunar glass the 1,000 nm band center is generally shifted to longer wavelengths when compared to pyroxene, and the 2,000 nm band center to shorter wavelengths. Thus, two 1,000 and 2,000 nm band center positions of lunar glasses will typically appear close together than those of pyroxenes [Reference 17].

The spectra obtained using the M^3 data set are separated into two specific groups. The first group displays units located to the east of the vent (Figure 13). The spectra for this group are characterized by a broad 1,000 nm absorption band, while the 2,000 nm absorption band is weak or absent and characteristic of an olivine-rich composition.

The strong 1,000 nm absorption is centered at 1,049-1,060 nm and shows a secondary feature at around 1,100-1,200 nm, while the 2,000 nm absorption within these basalts is also relatively weak and consistent with the presence of olivine.

The second group displays units located to the west and northwest of the vent (Figure 14). The spectra for this group is characterized by strong and broad 1,000 nm absorption features indicative of a pyroxene and olivine mixture, supporting a mare volcanic origin for many of these deposits.

The strong 1,000 nm absorption shows a secondary feature at 1,100-1,200 nm, while the 2,000 nm absorption within these basalts is relatively weak or displays an absorption which may, in part, be attributable to a mixture with high Ca pyroxene or to chromites inclusions associated with the olivine [references 18 and 19].

Alternately, it could be the result of the difficulty of thermally correcting data. Fe-rich lunar glasses also contain broad absorption features extending beyond 1,000 nm but, according to Besse et al. [17], these are more symmetrical than the composite absorption pattern observed within olivine.

Olivine content is thus the likely main difference between the two defined units of the region under study. The darker volcanic deposits detectable along the western and eastern rim of the vent (Figure 6) may represent a final effusive product slightly differing in olivine rich basaltic composition or may also be constituted by small amounts of Fe-rich glasses material intermixed with basalts suggesting a pyroclastic origin.

However, the presence of mare basalts that are already very dark may make the identification of glasses more difficult in spectral analysis at this location. The high-Ti flows within Imbrium and Procellarum also appear to contain olivine but at lower or more variable concentrations relative to their pyroxene abundances as observed in a number of different regions with a wide range of estimated ages described by Hiesinger et al. [Reference 20].

The Kaguya Multiband Imager acquired data in nine visible (415, 750, 900, 950, 1,001 nm) and near-infrared (1,000, 1,050, 1,250, and 1,550 nm) spectral bands. The Kaguya Multiband Imager provides a spatial resolution of ~20 m/pixel in the ultraviolet-visible range, and ~60m/pixel in the near-infrared range.

Maps in wt% of the minerals plagioclase, olivine, clinopyroxene (high-calcium pyroxenes) and orthopyroxene (low-calcium pyroxene) created from topographically corrected Mineral Mapper reflectance data acquired by the Kaguya mission have been recently released for the area ranging from -50° to 50° latitude [Reference 6].

Based on M^3 spectral analysis, M24 displays a high abundance of the mineral olivine in the examined region and nearby mare soils (Figure 15), which is also characterized by high FeO content estimated >20 wt%.

Finally, TiO_2 abundance in wt% has been derived from the LROC WAC 321/415 nm band ratio. The 321/415 nm ratio map was converted to the TiO_2 abundance estimate map according to the work by Sato et al. [Reference 21], with

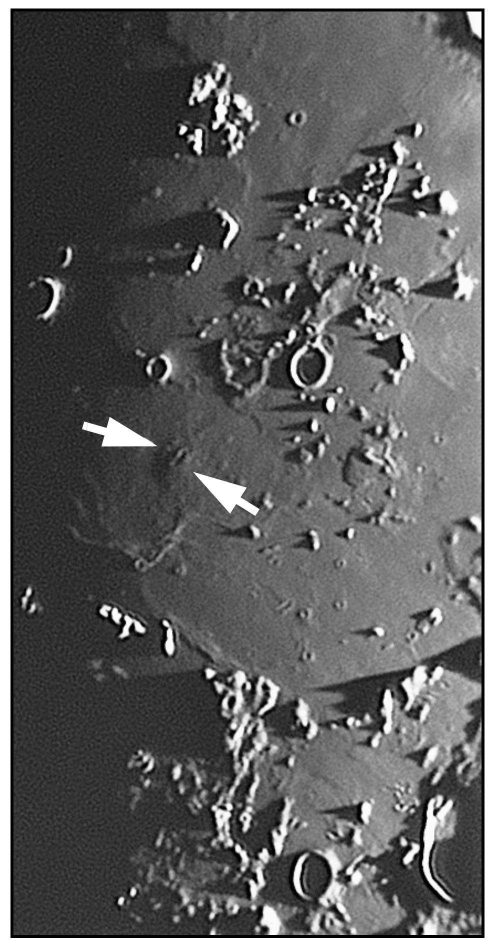


Figure 10. Dome M24 imaged by Pau on November 7, 2019 at 13:03 UT with a 250 mm f/6 Newtonian reflector, 2.5x barlow and a QHYCCD290M camera. The solar illumination angle corresponds to 0.9°.

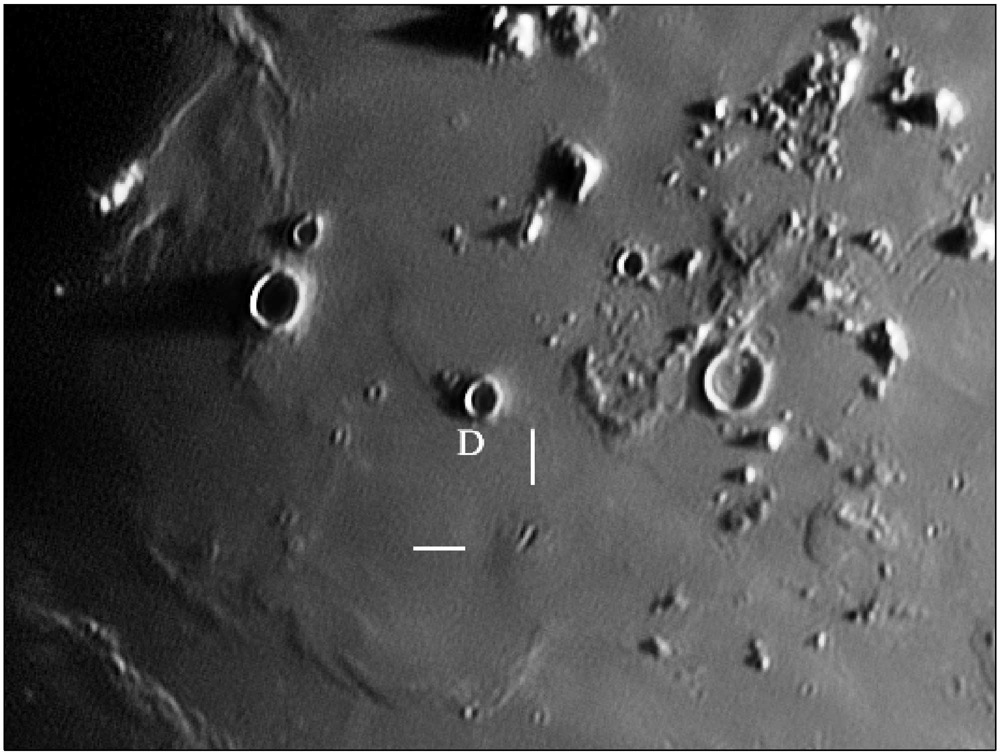


Figure 11. Dome M24 imaged by Eskildsen on January 5, 2020 at 23:16 UT with a 235 mm Schmidt Cassegrain with a DMK 41AU02 camera.

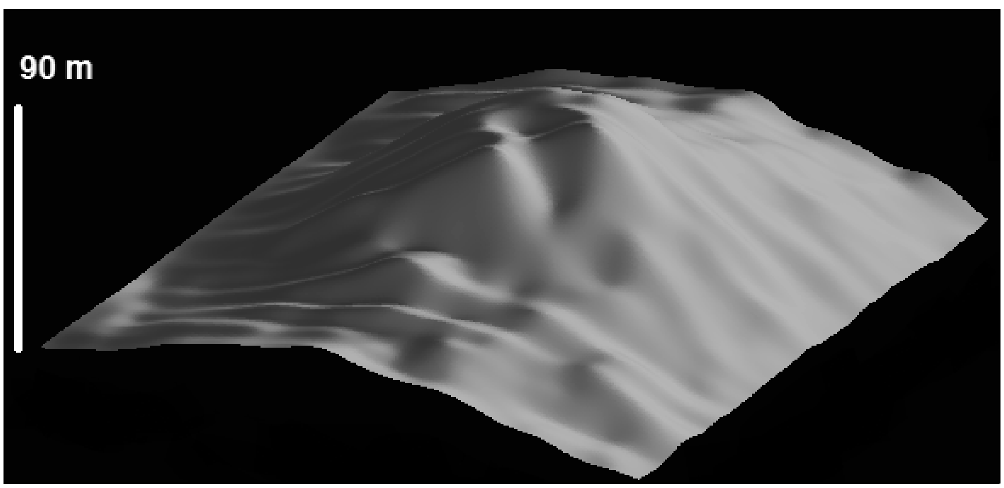


Figure 12. A 3D reconstruction of M24 based on terrestrial CCD image taken by Pau shown in Figure 10. The vertical axis is 20 times exaggerated.

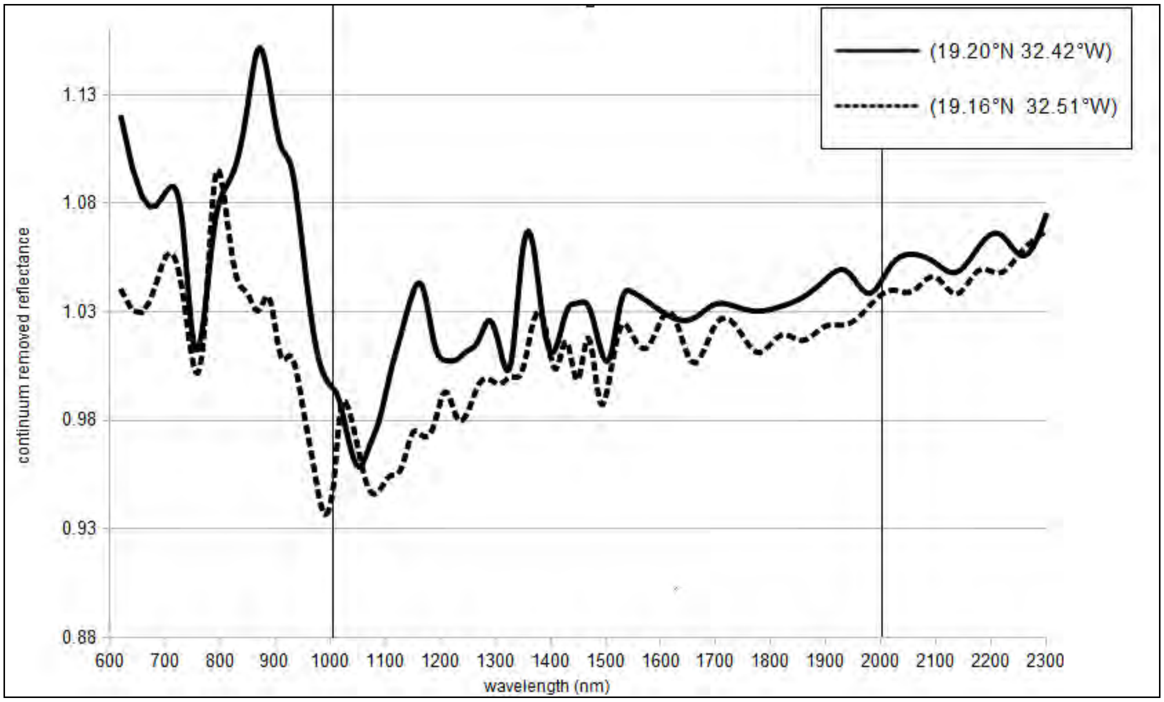


Figure 13. M^3 spectra of the examined regions to the east of the vent. The green spectrum is a mixture of high calcium pyroxene and olivine. (See text for detail.)

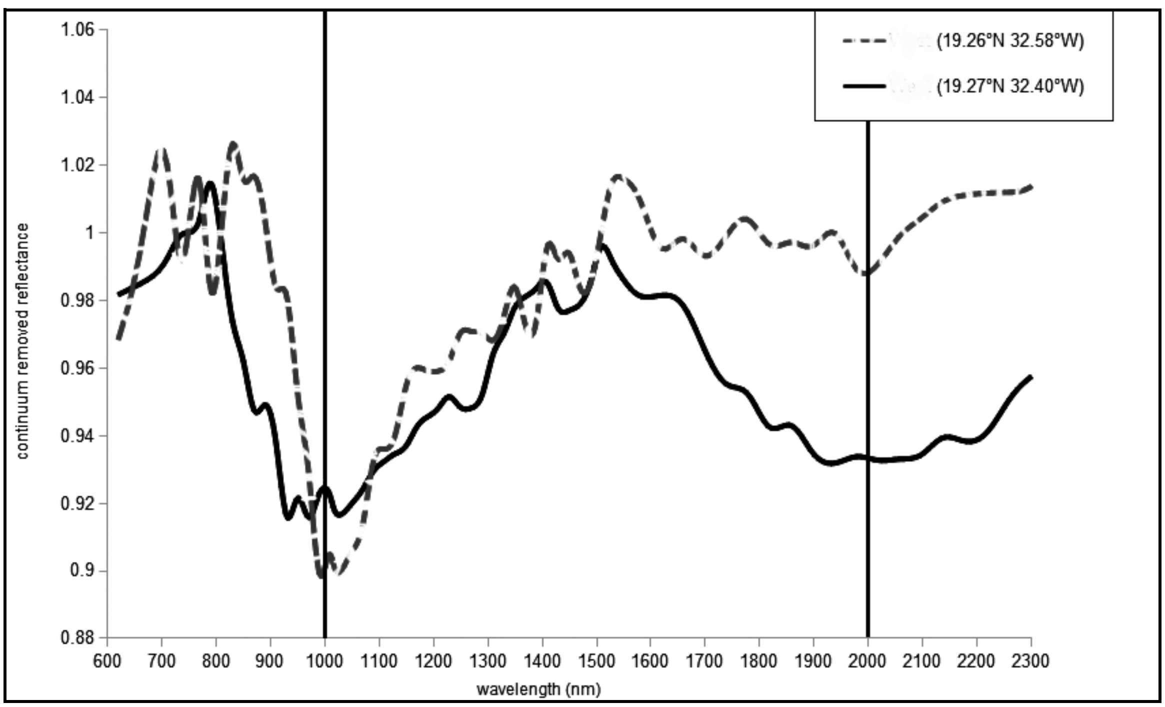


Figure 14. M^3 spectra of the examined regions to the west and northwest of the vent.

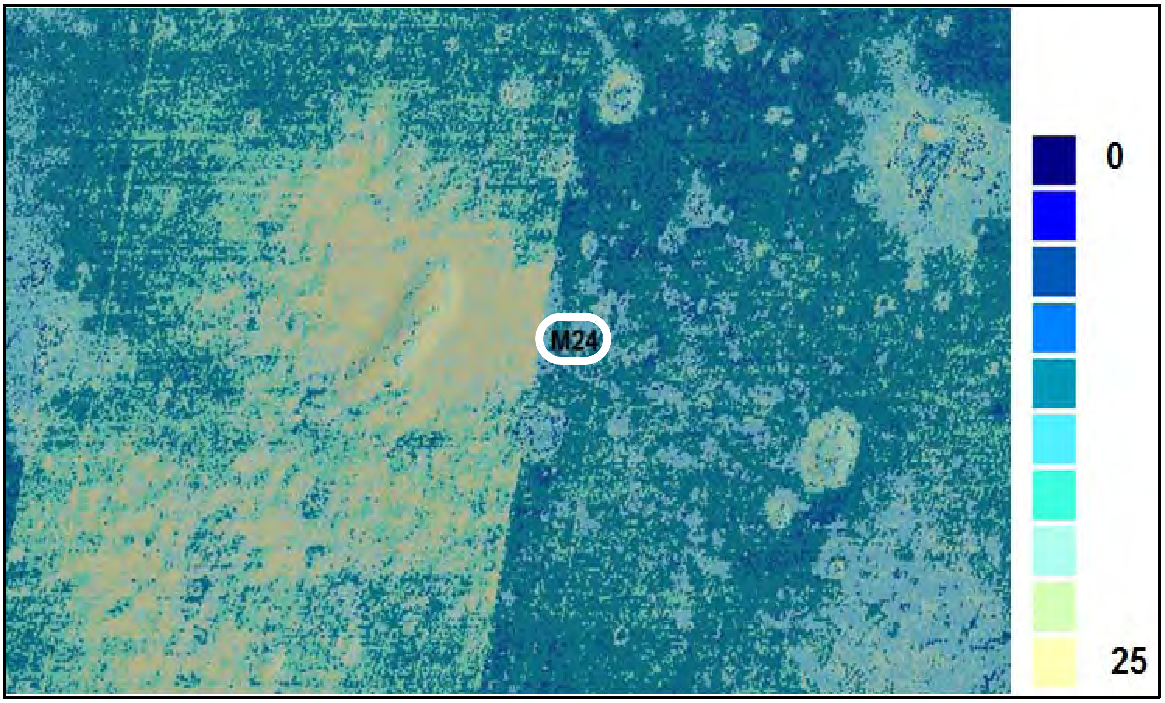


Figure 15. Abundance map in wt% of olivine content for the examined dome using Mineral Mapper reflectance data acquired by the JAXA SELENE/Kaguya mission. The map is extracted using the Quickmap LRO global basemap (http://target.lroc.asu.edu/da/qmap.html).The map also confirms that the nearby mare soils display spectral signatures consistent with olivine-rich basaltic composition.

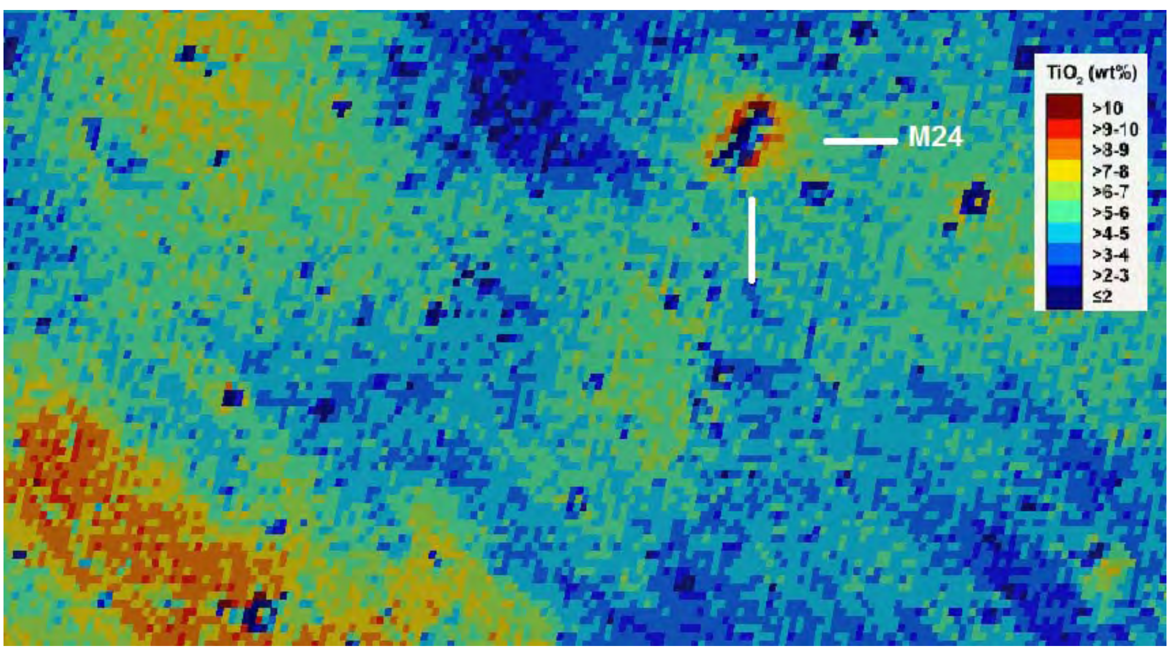


Figure 16. Abundance map of TiO_2 in wt%.

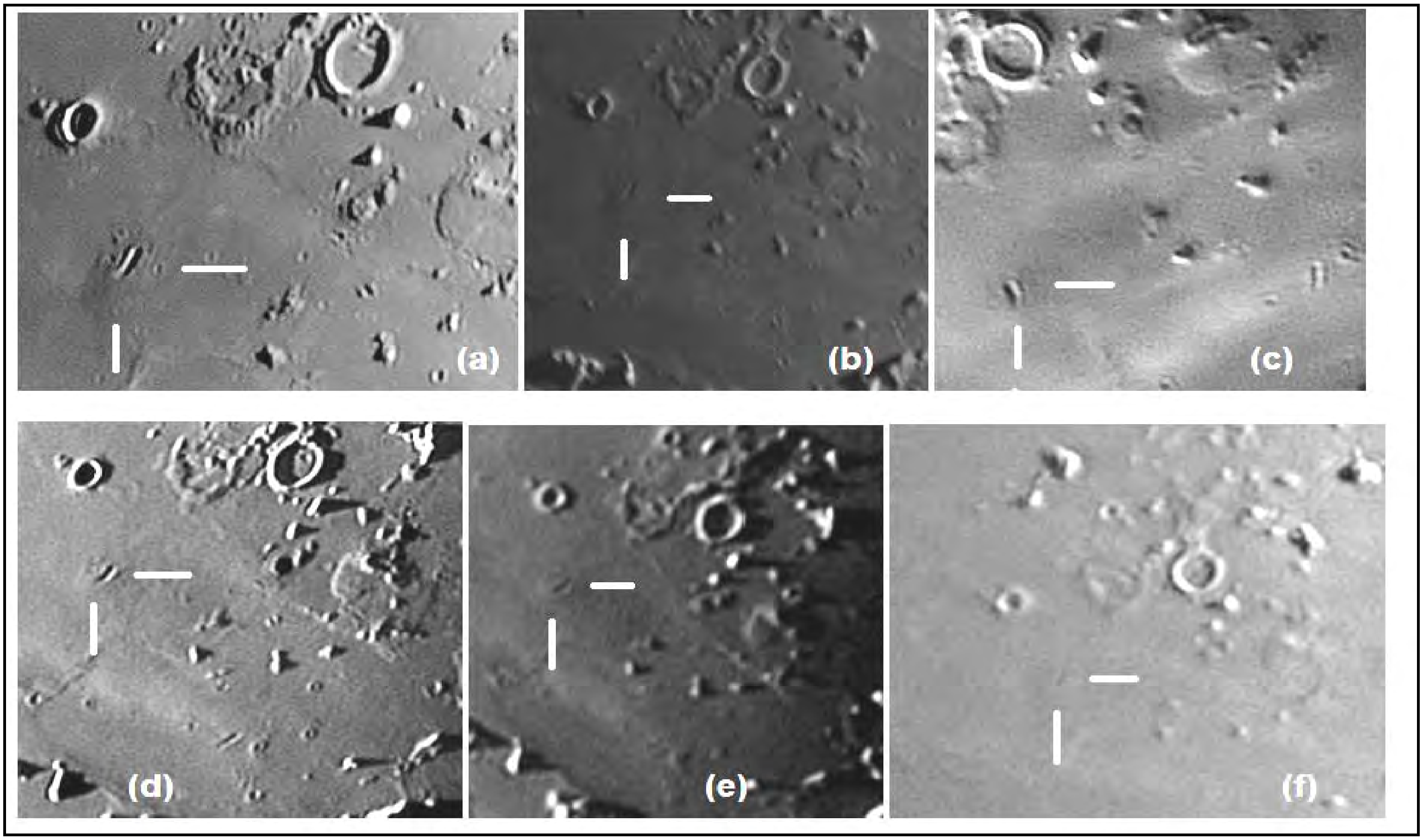


Figure 17. Ground-based observations of dome M24. This selection of CCD images taken by (a) Watanabe, (b) Teodorescu, (c) Heinen, (d) Pau, (e) Eskildsen and (f) Hill.

dark blue color indicating TiO_2 <2 wt% and dark red color indicating a TiO_2 >10 wt% (Figure 16). M24 displays a TiO_2 content >7-8 wt%.

Rheologic Model and Classification of M24

Wilson and Head provide a quantitative treatment of dome-forming eruptions [Reference 22]. This model estimates the yield strength, that is, the pressure or stress that must be exceeded for the lava to flow, the plastic viscosity yielding a measure for the fluidity of the erupted lava, the effusion rate E, that is, the lava volume erupted per second, and the duration T = V/E of the effusion process.

This model relies on the morphometric dome properties and several physical constants such as the lava density, the acceleration due to gravity, and the thermal diffusivity of the lava. In the computation, we assume a magma density of 2,800 kg m^{-3}.

Based on the morphometric properties of M24, we obtain a moderate lava viscosity of 1.8 x 10^4 Pa s, a high effusion rate of E = 915 m^3 s^{-1}, and a duration of the effusion process of T = 0.4 years. The magma rise speed amounts to U = 3.5 x 10^{-4} m s^{-1} and the dike width and length to 10 m and 36 km, respectively.

Three rheologic groups of effusive lunar mare domes [references 3 and 7] differ from each other by their rheologic properties and associated dike dimensions, where the basic discriminative parameter is the lava viscosity.

- 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.

- 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. The dome M24 clearly belongs to rheologic group R_1 and to class C_1 in the classification scheme of lunar mare domes being characterized by high effusion rate of 915 m^3 s^{-1} [Reference 3].

For M24 and other domes in Milichius region of rheologic group R_1 with lower lava viscosities of 10^4 Pa s (M1, M5, M7, M15), the situation is quite similar since their associated dike lengths imply magma reservoirs at depths of 30 km.

For domes which were formed from lavas of somewhat higher viscosities of several 10^5 Pa s (H7, M3, M4, M6, M10), the magma reservoirs are situated at depths between about 60 - 160 km.

According to Wieczorek et al. [Reference 23], the total crustal thickness in the Hortensius/Milichius/T. Mayer region amounts to 50 km while the thickness of the upper crust is 22 km.

The magma reservoirs of the domes in this region that formed from lower-viscosity magmas — including the M24 dome — were located in the lower crust, while the reservoirs of the domes associated with higher viscosity magmas were situated at or well below the border between lunar mantle and crust.

Summary and Conclusion

The LOLA DEM indicates the low profile of M24, with a slope angle of only 0.6°. In fact the domical shape of M24, and its elevation, is clearly detectable only under a strongly oblique solar illumination angle (about 1°).

Spectral analysis indicates a high abundance of the mineral olivine in the M24 region and nearby mare soils: thus the dome is characterized by an olivine-rich basaltic composition. It belongs to class C_1 [Reference 3].

The conditions under which domes of classes B_2 and C_1 formed were similar, except that in the case of the C_1 domes, the effusion rates were much higher. In this scenario, the influence of the impact-induced stress fields was that magma flow through the crust was easier for the class C_1 domes, with high effusion rate and short effusion time, as is the case for M24.

As reported in previous studies [Reference 7], the domes in the Milichius - T.Mayer region display elongated summit vents or fissures oriented in parallel, radially with respect to both the Insularum basin and that of the Eastern Procellarum basin.

Similarly, M24 is oriented radially with respect to the Imbrium basin. The explanation for these observations is that the domes were formed along crustal fractures generated by major impact events, hence running radially with respect to the basin locations.

In this context, the elongated summit vent of M24 is interpreted to indicate the direction of the dike through which the magma ascended to the lunar surface.

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Papers & Presentations

Report of a Probable Comet Impact on Mars in 1973

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Abstract

Evidence is presented that a comet consisting of large amounts of ice probably impacted Mars on September 2, 1973. Four members of the McDonnell Douglas Amateur Astronomers Club observed the aftermath of the proposed comet impact. Descriptions of visual telescopic observations are given beginning with two very large side-by-side circular white clouds. Black-and-white images of the clouds are shown that were recorded over a period of 2 hours and 52 minutes, including one beginning at 07:50 UT, then one at 08:21 UT and the last at 10:42 UT. During this period, the clouds began to merge and finally did merge into one large cloud. Mariner 9 maps of the Corprates quadrangle were compared with the Viking map, providing before-and-after impact evidence. Six new craters were found in a cluster with diameters ranging in size from 4.2 km to 10.0 km. The September 2 clouds are compared against seven categories of Martian clouds - limb/terminator hazes, equatorial cloud bands, discrete clouds, orographic clouds, polar clouds and hazes, frosts and fogs, and dust clouds - and are explained as being inconsistent with any of these cloud types.

Instruments and Methods

The McDonnell Douglas Amateur Astronomers Club sponsored a Mars photo patrol in 1973 with five of the 15 members participating. The club bought a 100-foot roll of Kodak 35mm SO-410 black-and-white negative film. It was described in Kodak's literature as a panchromatic film having a very fine grain with an extended red sensitivity (Eastman Kodak Company, 1972). The red sensitivity allowed the recording of surface details on Mars much as a red filter would. The film was loaded into 36-exposure, 35mm film canisters and distributed to members who wanted to image Mars.

As part of this "Mars Patrol," four members observed and imaged Mars during the wee hours of the morning on September 2, 1973. In St. Louis, Missouri, the author and Rick Melvin used an 8 inch Newtonian telescope and George Fiedler used a 6 inch Newtonian telescope, while in Las Cruces, New Mexico, Lionel Brown used a 12.5 inch Cassegrain telescope. Each imager used eyepiece projection with 35mm single lens reflex camera bodies to record the images.

In his well-equipped dark room, Rick Melvin printed about 25 of the images that were obtained by members during this photographic patrol. The author digitized the September 2 and the October 2 photograph prints, making it easy to stretch contrast and to create negative images. The contrast of all of the images was stretched to better show the clouds and surface markings. The software application *WinJUPOS* (Hahn, 2019) was used to measure the latitudes, longitudes and sizes of the clouds.

The author recently found a set of global USGS photomosaic maps based on images recorded by Mariner 9 while it orbited Mars in 1971 and 1972, more than a full year before our photographic patrol. *Figure 1* shows the front cover of this set of maps. The United States Geological Survey (USGS) group divided the surface of Mars into 30 cartographic quadrangles. Each quadrangle is a region covering a specified range of latitudes and longitudes on the Martian surface.

Online Features

Left-click your mouse on:

- The author's e-mail address in blue text to contact him directly.
- The hyperlinks and source material references in blue text to jump to source material or information about that source material (Internet connection must be ON).

The names of large classical albedo features were given to the quadrangles. A list of the quadrangles, together with up-to-date geologic images of them, is available online (Wikipedia, 2019). The Viking Orbiter map, compiled from images made in 1975 and 1976, is available in resolution of 2.5 km per pixel (Planetary Society, 2014) and in 232 m per pixel (US Geological Survey).

The author's finding of the Mariner 9 maps sparked him to publish a report

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DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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INTERAGENCY REPORT: ASTROGEOLOGY 56

MARS CARTOGRAPHY:
The 1:5,000,000 Map Series

by

R.M. Batson

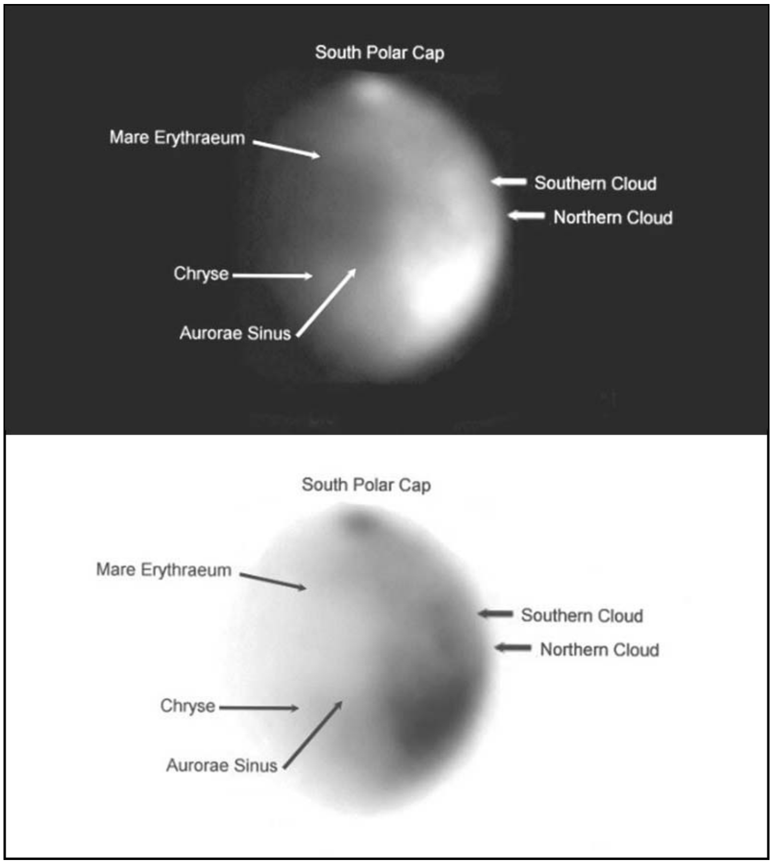
October, 1973

Prepared under JPL Contract WO-8122

This report is preliminary and has not been edited or reviewed for conformity with U.S. Geological Survey standards and nomenclature.

Prepared by the Geological Survey for the National Aeronautics and Space Administration

Figure 1. Cover of the Mars Cartography document that contains the 1971 and 1972 Mariner 9 images (Batson, 1973).



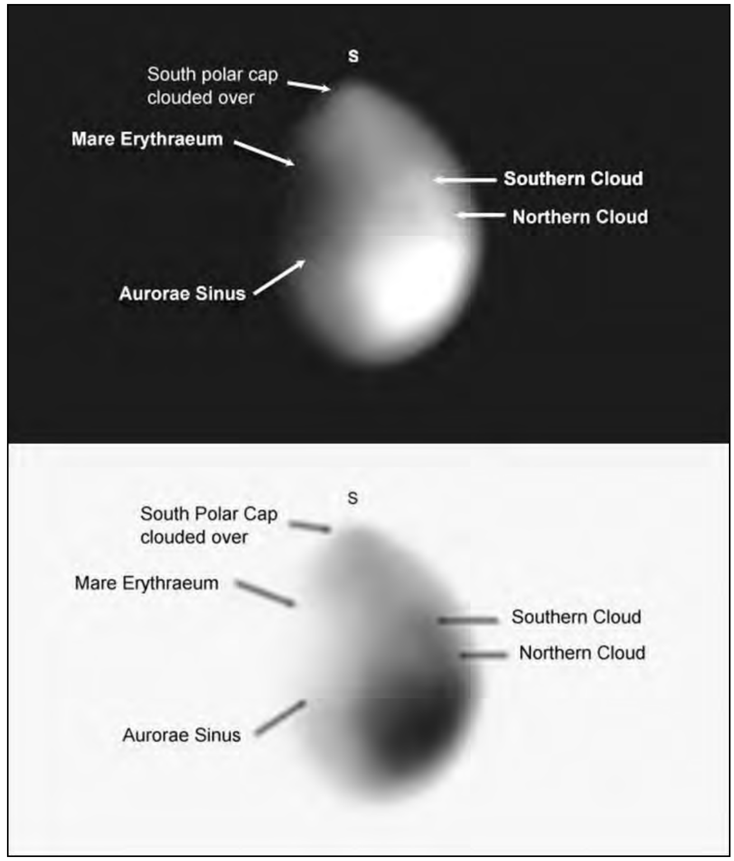


Figure 2 (above left). The first image of the peculiar clouds. Digitally scanned positive and negative reproductions of a grayscale photograph of Mars made by Jim Melka and Rick Melvin, observing from St. Louis, MO, USA, on September 2, 1973, at 07:50 UT. Newtonian telescope of 8-inch aperture, 35 mm single lens reflex camera, using Kodak SO-410 film. Mars was at Ls 274°. The apparent angular diameter was 16.8 seconds of arc, the phase 0.90, and the central meridian 49.2° west longitude. South is up.

Figure 3 (above right). Digitally scanned positive and negative reproductions of a grayscale photograph of Mars made by George Fiedler, observing from St. Louis, MO, USA, on September 2, 1973, at 08:21 UT. Newtonian telescope of 6-inch aperture, 35 mm single lens reflex camera, using Kodak SO-410 film. Mars was at Ls 274°. The apparent diameter was 16.8 seconds of arc, the phase 0.90, and the central meridian 56.7° west longitude. South is up.

because “before and after” maps are now available. He compared the Mariner 9 maps with the same quadrangles produced from images recorded by the Viking orbiter in 1976, searching for craters that are present in the 1976 images but absent in the 1971-1972 images. The relevant quadrangles in each map set are Mars Chart (MC) 17 Phoenicis Lacus, MC 18 Corprates and MC 25 Thaumasia.

Table 1. Table 1. Cloud Locations and Sizes

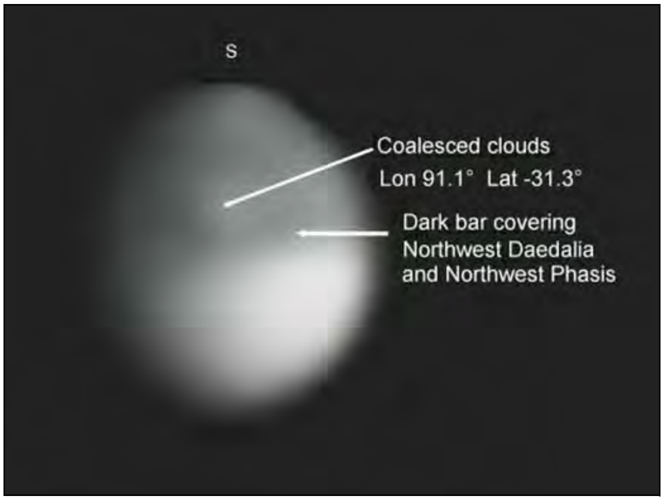
	Northern Cloud	Southern Cloud
Latitude	- 21.6°	- 31.9°
Longitude W	95.0°	90.9°

The sizes of new craters were measured using the software tool *JMARS* (Christensen, et al, 2009). *JMARS* stands for “Java Mission-planning and Analysis for Remote Sensing”. It is a geospatial information system (GIS) developed by Arizona State University's Mars Space Flight Facility to provide mission planning and data-analysis tools for NASA's orbiters.

Results, Part 1: The Images

The Martian longitude of the Sun (Ls) at the time of these observations was 274°. The author and Rick Melvin imaged Mars on Sept. 2, 1973, at 7:50 UT. The image is shown in the top panel of *Figure 2*. The bottom panel of *Figure 2* is a negative of the top panel, and both show clearly the two clouds. These images show only the cores of the clouds because of the extended red sensitivity of SO-410. However, the location of the center of each core could be measured. These measurements are presented in *Table 1*. Melka and Melvin also observed the clouds visually and noted that they appeared as bright as the South Polar Cap (SPC), with their perimeters just touching.

George Fiedler imaged Mars on September 2, 1973, at 08:21 UT, which was 31 minutes after the image in *Figure 2*. The two clouds are shown as a positive image in the top panel of *Figure 3*, but perhaps are seen better in the negative of his image, in the bottom



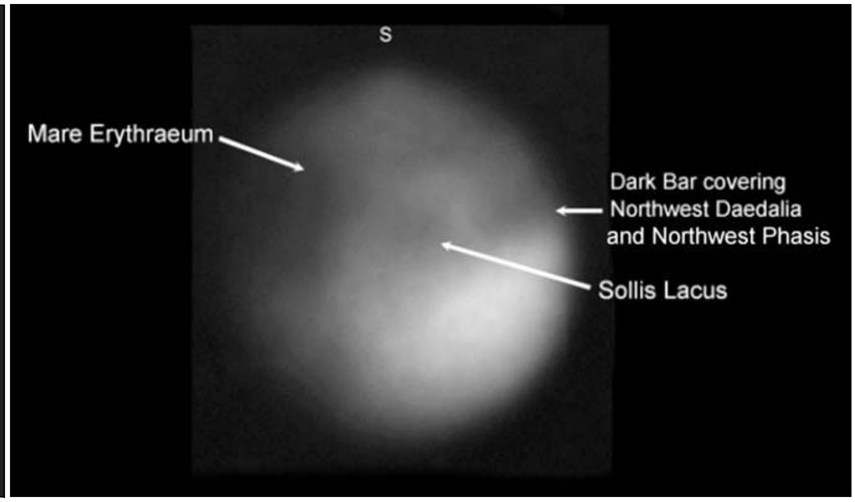


Figure 4 (above left). Digitally scanned positive reproduction of a grayscale photograph of Mars made by Lionell Brown, observing from Las Cruces, NM, USA, on Sept. 2, 1973, at 10:42 UT. Cassegrain telescope of 12.5-inch aperture, 35 mm single lens reflex camera, using Kodak SO-410 film. Mars was at Ls 274°. The apparent angular diameter was 16.8 seconds of arc, the phase 0.90, and the central meridian 91.1° west longitude. South is up.

Figure 5 (above right). The usual appearance of this area of Mars using the same equipment as for Figure 2. Digitally scanned positive reproduction of a grayscale photograph of Mars made by Jim Melka and Rick Melvin, observing from St. Louis, MO, USA, on October 2, 1973, at 03:30 UT. Newtonian telescope of 8-inch aperture, 35 mm single lens reflex camera, using Kodak SO-410 film. Mars was at Ls 293°. The apparent angular diameter was 20.7 seconds of arc, the phase 0.97, and the central meridian 71.6° west longitude. South is up.

panel of that figure. In comparison with *Figure 2*, the two clouds look to be merging in *Figure 3*.

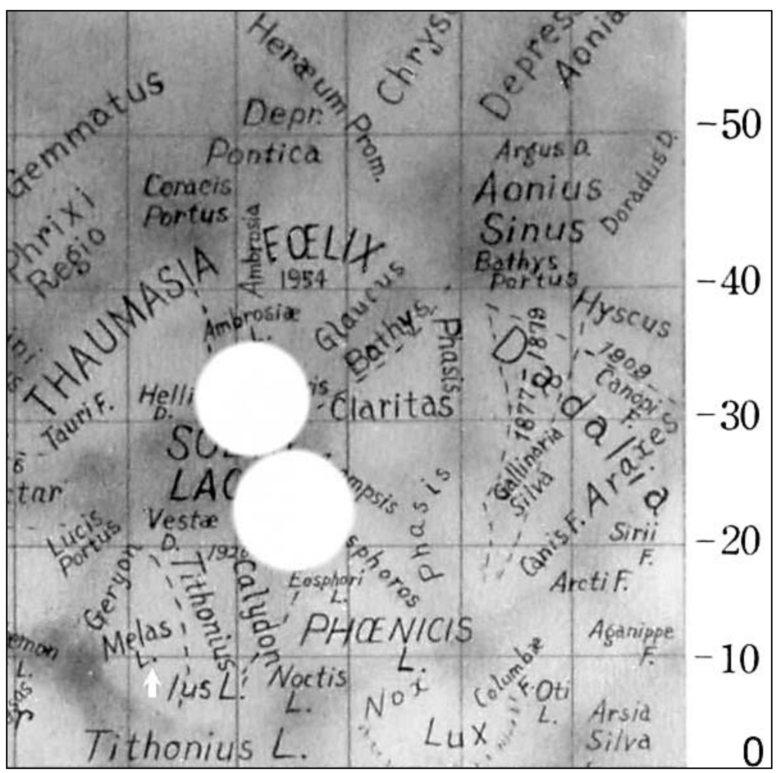
Fiedler's image does not show the SPC. Therefore, the author proposes that airborne dust was by this time propelled all the way to the SPC. Since there is no evidence of dust to the north of the clouds, it is thought that the comet was moving in a southerly direction through the atmosphere. The dark markings west of Mare Erythraeum including Solis Lacus are not visible. It is suspected that a shock wave from the impact produced dust clouds covering the entire impact region.

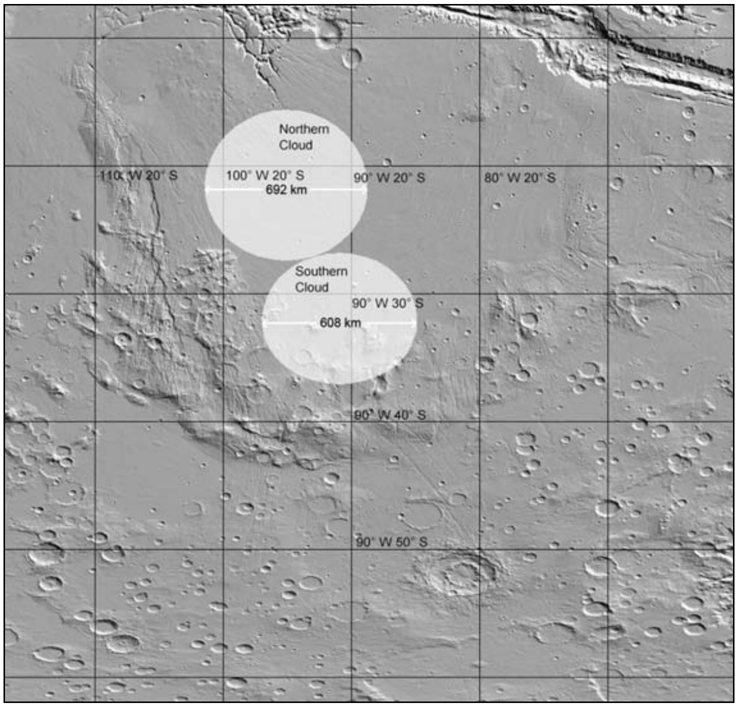
On the same date, Lionel Brown imaged Mars at 10:42 UT, two hours and 52 minutes after the photo in *Figure 2*. His image is presented in *Figure 4*. The two clouds appear to have merged into one cloud covering most of Solis Lacus. The dark bar in northwestern Daedalia and northwestern Phasis is now visible.

For the purpose of this article, it is useful to be familiar with the usual appearance of Mars in images made by amateur photographic equipment of that day. Therefore, the author has included as *Figure 5* an image taken a month later, on October 3, 1973, which illustrates the usual appearance of the Solis Lacus vicinity as imaged by the same imagers and using the same equipment as in *Figure 2*. The dark feature called Solis Lacus is prominent, though it was hidden by the clouds on September 2.

The ratio of the diameter of the northern cloud to that of the southern cloud was estimated to be 1.2:1 from the images of the clouds. To map the clouds, they were

Figure 6. Shiro Ebisawa's 1957 albedo map with the clouds of September 3, 1973, superimposed. South is up and the latitude scale on the right is in degrees.





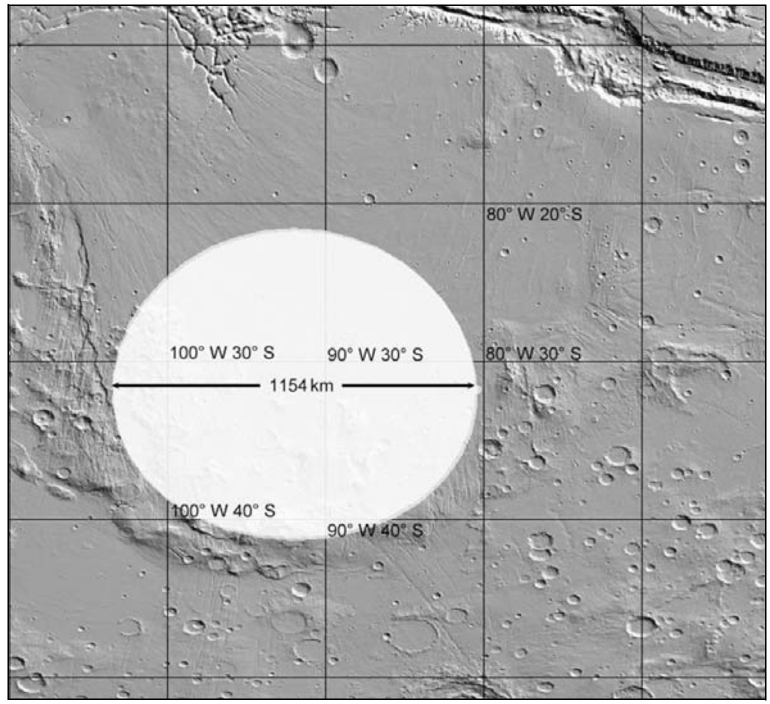


Figure 7 (above left). The positions and extents of the clouds superimposed on the MGS elevation map made from MOLA data. North is up, unlike the preceding images and diagrams of this article. This view includes parts of Mars quadrangles Coprates, Phoenicis Lacus, and Thaumasia.

Figure 8 (above right). The position and extent of the cloud at 10:52 UT, 1973, superimposed on the MGS elevation map made from MOLA data. North is up. This view includes parts of Mars quadrangles Coprates, Phoenicis Lacus, and Thaumasia.

positioned at a point where their perimeters were tangent to each other, because the observers described this tangential formation. In *Figure 6*, the latitude and longitude of each cloud's core (see *Table 1*) was used to position it on Shiro Ebasawa's well-known map of the named albedo features of Mars (Ebisawa, 1957). Note the adjacent positions of the clouds.

Figure 7 shows the locations of the clouds against a background of a gray version of the Mars Global Surveyor's (MGS) Mars Orbiter Laser Altimeter (MOLA) map of the region (NASA, 2007). In this figure, north is up, in contrast to the previous figures in this article. After plotting the clouds, the author measured their diameters with the *JMARS* tool and found a diameter of the northern cloud of 692 km and a diameter of the southern cloud of 608 km, as shown in *Figure 7*. Thus, the two clouds covered a distance of 1,300 km along their mutual axis!

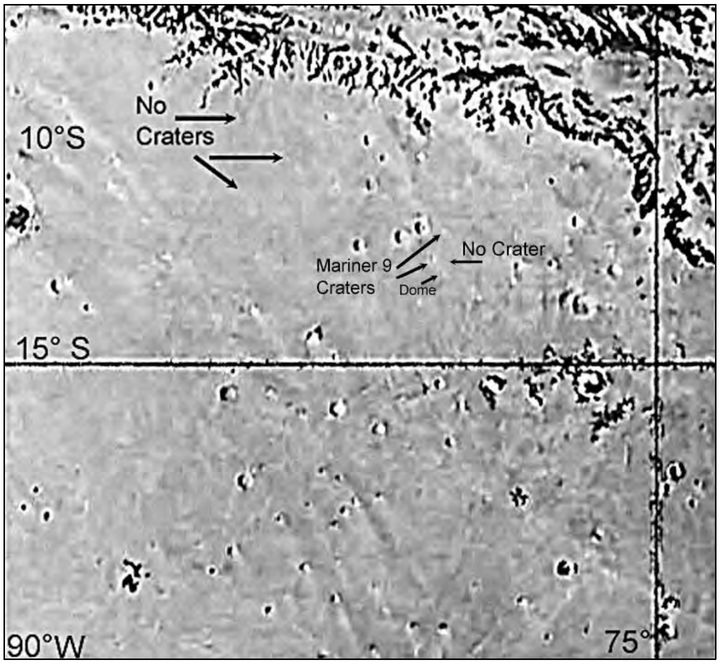
Lionel Brown's image of the merged cloud at 10:42 UT shows it to be roughly circular. Using the *WinJUPOS* measurement engine, its diameter was found to span 23.6° in longitude, and the location of its center was at longitude 91.1° W and latitude of 31.3° S. These coordinates are near the center of the original southern cloud (see *Table 1*). Upon plotting this cloud on the MOLA map, its diameter was found to be 1,154 km, as measured with the *JMARS* tool (see *Figure 8*).

These images show that the form of the clouds changed during the period of time from 07:50 UT to 10:42 UT. Their visual appearance resembled a figure "8" at 07:50 UT and changed to a single large cloud by 10:42 UT. It is suspected that the comet had two nuclei based on the fact that the initial appearance of the cloud was of two circular bright white clouds. The time of impact is unknown. The dark markings of Daedalia to the west were obscured at first, presumably by dust raised by the impact, but over the several hours of observation, the SPC became obscured while the dark markings of Daedalia became visible. As far as this author knows, such rapid changes in clouds and obscurations on Mars are unique to these observations.

Results, Part 2: The Craters

More evidence indicating an external source for the clouds is the recent finding by the author of a cluster of new craters. The new craters were found in MC 18 Corprates. None were found in MC 17 Phoenicis Lacus or MC 25 Thaumasia. The pair of clouds occupied parts of MC 17, MC 18, and MC 19.

The relevant part of the Corprates quadrangle is shown as it appears on the Mariner 9 map in *Figure 9* and as it appears on the Viking Orbiter map in *Figure 10*. Arrows in *Figure 9* point to regions where there were no craters on the 1972 Mariner 9 map, but there are craters on the 1976 Viking map of *Figure 10*. The Mariner 9 map also points to two craters existing in 1972, so they will not be confused with a nearby new crater marked on the Viking map.



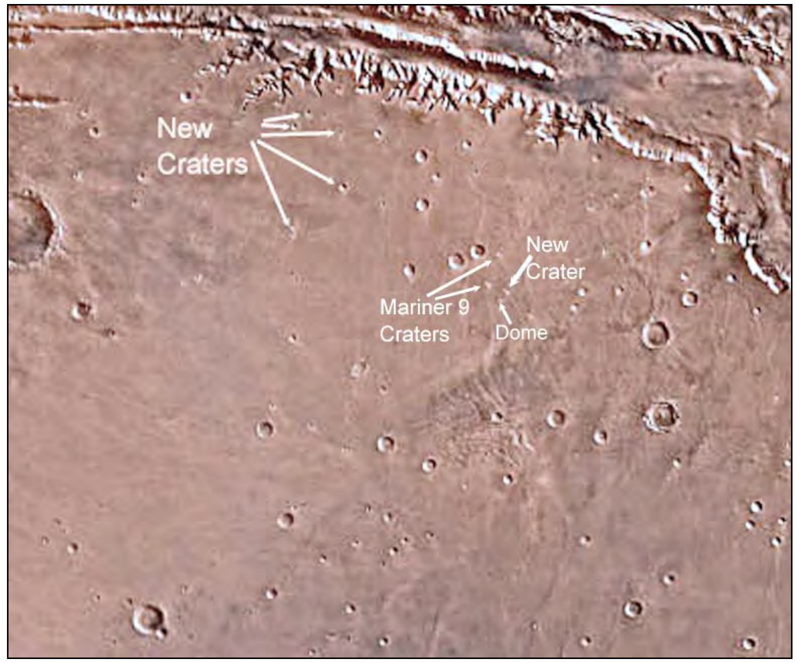


Figure 9 (above left). New crater region on the Corprates quadrangle as it appears on the pre-impact 1972 Mariner 9 map. Mercator projection and North is up.

Figure 10 (above right). New crater region on the Corprates quadrangle as it appears on the post-impact 1976 Viking map. North is up.

There are six new craters marked on the Viking map of *Figure 10*. These are in a group of five new craters northeast of the northern cloud and one new crater just east of those (see *Figure 11*).

The Mariner 9 maps are believed to show identifiable features as small as 1 to 2 km in size for 70% of the Martian surface, and as small as 3 km in size for the remaining 30% of the surface (Batson, 1973). If the new craters were smaller than 3 km size, their absence from the Mariner 9 maps might be considered to be inconsequential. However, the diameters of the six new craters were measured with *JMARS* using the MOLA images of the Corprates quadrangle, and were found to have diameters ranging from 4.2 km up to 10.0 km. These diameters are marked on the MOLA image in *Figure 11*, which also shows the craters' positions with respect to the northern cloud. The author believes that this cluster of six craters supports the assertion that its origin was from the proposed comet and are not random impacts.

Discussion and Conclusions

The pair of white clouds observed on September 2, 1973, at Ls 274° can be compared against the seven categories of Martian clouds listed by Beish and Parker: limb/terminator hazes, equatorial cloud bands, discrete clouds, orographic clouds, polar clouds and hazes, frosts and fogs, and dust clouds (Beish and Parker, 1990). The following discussion follows their descriptions and Ls of the cloud types:

1. Limb hazes are narrow cloud bands that hug the limbs. They have been observed starting at Ls 330° and peak between Ls 80° and 130° and then show a dramatic reduction before Ls 180°. The circular clouds presented in the present paper occurred at Ls 274°. They were very far from the limbs and did not appear as hazes. For these reasons they do not belong to the limb hazes category.

2. The equatorial cloud bands are faint horizontal streaks. Since the two circular clouds described here were as bright as the SPC and were not shaped as streaks, they do not fit the cloud bands category.

3. Most discrete clouds have randomly shaped outlines and are nebulous in appearance. From about Ls 330° up to Ls 170°, there is an excess of water vapor in the atmosphere that supports cloudiness over the entire globe. Starting in fall in the Northern Hemisphere at Ls 180°, the excess H_2O begins to be deposited as ice onto the North Polar Cap. The Ls of 274° at the time of our observations was the beginning of winter in the Northern Hemisphere, so there was little water vapor available for cloud formation. Thus, these clouds do not fit the discrete cloud category.

4. The clouds cannot have been orographic clouds like those that form over the Tharsis volcanoes, as they were too far away from these volcanoes to be considered orographic. Orographic clouds form on Mars when moisture-laden air freezes out while rising along the slopes and over the peaks of these great mountains. They only exist over and in the close vicinity of mountains. The center of the northern cloud was more than 1,500

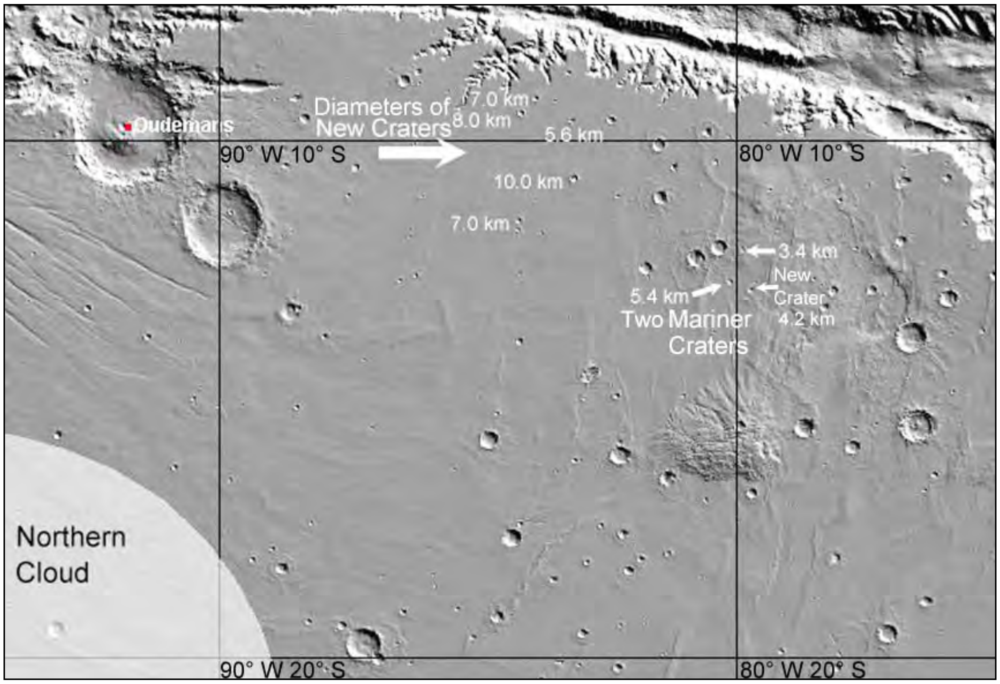


Figure 11. Shown are a group of five new craters northeast of the northern cloud and one new crater just east of those.

km from Arsia Mons and Pavonis Mons, the closest mountains, while the southern cloud was even farther away. Furthermore, at Ls 274°, it is the wrong season for orographic clouds. ALPO image data shows that orographic clouds begin about Ls 60° and end about Ls 140°.

5. Polar clouds and hazes are either discrete clouds or the polar hoods. Polar hoods only form over the poles. Discrete clouds have already been discussed but another type of cloud in this category is spiral clouds. Some clouds with a spiral shape have been observed only in the North Polar Region (Wang and Ingersol, 2002). One was of hurricane-size with a dark “eye” visible. The two Ls 274° clouds showed neither a spiral shape nor a dark center. The two clouds are in the tropics where spiral clouds have not been observed.

6. Frosts and fogs are on the ground or very close to the ground. Because all of the dark albedo features west of Mare Erythraeum were missing on September 2, the author believes that a blanket of airborne dust covered the region under the bright clouds. Frosts and low altitude fogs, if they were present, would have been hidden under the dust. The two Ls 274° clouds do not fit the frosts and fogs category.

7. Dust clouds have a distinctly brown color, as shown by color-balanced streaming video images of Mars. The two Ls 274° clouds were visually observed to be very white in color, which rules out a dust source.

The two clouds on September 2, 1973 are not in any of the above seven cloud categories. This means they are rare and atypical. They should reasonably be considered to have been a manifestation of a comet impact.

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Papers & Presentations

Timing Jupiter's Satellite Eclipses: The 2015-16 Apparition

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Galilean Satellite Eclipses

EDITOR'S NOTE: John submitted this report before he passed away in July 2018. Questions or comments on this report should be directed to the ALPO Jupiter Section Coordinator Richard Schmude at: *schmude@gordon-state.edu*

Abstract

During the 2015/16 Jupiter apparition, two observers made 33 visual timings of the eclipses of Jupiter's four Galilean satellites - Io, Europa, Ganymede and Callisto. We compare the means of their observed eclipse disappearance and reappearance times with the predictions of the IMCCE (Institut de Méchanique Céleste et de Calcul des Éphémérides) E-5 ephemeris.

Introduction

The apparition covered here is the 38th observed by the ALPO Jupiter Section's Galilean Satellite Eclipse Timing Program, which conducts visual timings of the eclipses by Jupiter of the four Galilean satellites Io, Europa, Ganymede and Callisto.

Our observers timed the "last speck" visible when a satellite entered Jupiter's shadow (disappearance) and the "first speck" visible when it emerged from eclipse (reappearance). Each satellite's mean disappearance and reappearance timings were then averaged to determine if its position corresponded to its ephemeris. (Our 1998/99 Apparition report described in detail our method of reduction; see also our 2012-13 report [Westfall 2009, 201*.]) We have compared our reduced timings with the IMCCE predictions, using the INPOP13C planetary theory and Lieske E-5 satellite theory.

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The references in blue text to jump to source material or information

Table 1 lists the pertinent dates and other circumstances of the 2015/16 Apparition.

Table 1. 1. Circumstances of the 2015/16 Jupiter Apparition

Apparition		Observing Season	
Initial solar conjunction	2015 AUG 26, 22h	First eclipse timing§	2015 OCT 26 (+61d)
First maximum phase angle	2015 DEC 14, 02h (10.48°)	Last eclipse timing§	2016 JUL 13 (-75d)
Opposition to the Sun*	2016 MAR 08, 11h (δ = +6.0°)	Duration	261d
Closest approach to Earth†	2016 MAR 08, 18h (D = 44.4")	Solar Elongation Range	047°W – 057°E
Second maximum phase angle	2016 JUN 04, 23h (10.75°)	Sources: Meeus 2015; *Astronomical Almanac*, 2015 and 2016 editions; JPL *HORIZONS* website. Dates and times throughout this report are in Universal Time (UT).	
Final solar conjunction	2016 SEP 26, 06h		
Zenocentric latitude of Sun	-0.97° to -2.57°	* δ = Jupiter's declination at opposition. † D = Jupiter's equatorial diameter in arc-seconds. § In parentheses are the number of days after initial solar conjunction (+) or before final solar conjunction (-).	
Zenocentric latitude of Earth	-0.78° to -2.34°		

This apparition saw the Sun and Earth move further south of Jupiter's equator. Callisto's most recent eclipse series ended during the apparition, while Io, Europa and Ganymede entered and exited Jupiter's shadow at increasingly oblique angles relative to the shadow edge.

Jupiter's northerly declination at opposition favored our observers, all of whom were located in the Earth's northern hemisphere.

Observations and Observers

The 33 timings received for 2015/16 brought our 38-apparition total to 11,233 observations, but showed a marked decrease from the 56 received for the 2014/15 Apparition. Table 2 gives descriptive statistics for the 2015/16 observations.

There was an almost two-to-one imbalance between the number of observations made following opposition and of those made before. This inequality is understandable, given the inconvenience of observing after midnight, but the statistical significance of our results would be improved were the observations more evenly distributed.

Table 3 lists the participants in our program during 2015/16, with their nationalities, instrument apertures and number of timings, both short-term and long-term.

The contributors used moderate-size telescopes in the aperture range 15 to 23.5 cm. The mean aperture, weighted by number of observations, was 17.3 cm.

Timings Analysis: Satellite Positions

The individual eclipse timings made by our participants in 2015/16 are listed in Table 5 at the end of this report. Table 4, below, summarizes the eclipse timings made in this period, with the means, standard errors of the means, and medians of the differences ("residuals") between our timings and the IMCCE E-5 ephemeris. All the residuals were corrected for oblique contact with Jupiter's shadow at disappearance and reappearance, using the formula R' = R cos β', where R' is the corrected residual, R the original residual, and β' the zenographic latitude of the satellite relative to Jupiter's shadow. This correction made a difference of 1-2 seconds for Io, 1-8 seconds for Europa, 19-46 seconds for Ganymede, and 81-413 seconds for Callisto, which contacted the umbra at angles ranging from 37° to 70° from perpendicular.

In 2015/16, neither Io, Ganymede nor Callisto differed significantly from the IMCCE E-5 ephemeris. At the 5-percent level of significance, Europa's eclipses occurred an average of 9.5 seconds early compared to the ephemeris.

Table 1. 2. Number of Eclipse Timings, 2015/16 Apparition

Number of Timings	33
Timings before Opposition	12 (36%)
Timings after Opposition	21 (64%)
Disappearance Timings	14 (42%)
Reappearance Timings	19 (58%)

Table 2. 3. Participating Observers, 2015/16 Apparition

Observer and Telescope					ALPO Timing Program Total	
I.D. No.	Name	Nationality	Telescope Aper. (cm)	Number of Timings (total)	Number of Apparitions	Number of Timings
2	Hays, R.H., Jr.	USA (IL)	15	26	25	448
3	Westfall, J.	USA (CA)	23.5	7	35	624
Mean Number of Timings per Observer				16.5		

Table 3. 4. Timing Residual Statistics, 2015/16 Apparition

Quantity	Satellite			
	Io	Europa	Ganymede	Callisto
Disappearances: Number of Timings	6 (6)	2 (2)	4 (4)	2 (2)
Disappearances: Mean	+75.0±3.4s	+80.0±1.0s	+246.2±12.6s	+290.0±19.8s
Disappearances: Median	+75.0s	+80.0s	+243.0s	+290.0s
Reappearances: No. of Timings	9 (9)	2 (2)	4 (4)	4 (3)
Reappearances: Mean	-90.1±2.5s	-99.0±4.0s	-260.8±14.9s	-345.7±15.7s
Reappearances: Median	-90.5s	-99.0s	-259.0s	-332.0s
(Disap.+Reap.)/2: Means	-7.6±2.1s	-9.5±2.1s *	-7.2±9.8s	-27.8±12.6s

Conclusion

The analysis of our program's timings made during the 2015/16 Jupiter apparition showed that the times of eclipses by Jupiter of Io, Ganymede and Callisto did not differ significantly from the IMCCE E-5 ephemeris, although Europa events averaged 9.5 seconds early at a 5-percent level of significance.

We thank the observers who contributed timings during 2015/16.

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Table 1. 5. Galilean Satellite Eclipse Timings, 2015/16 Apparition

UT	LD	Lat	ObN	STB	Dif
Io Disappearances					
51026	13	-8	1	100	+75
51102	14	-8	1	000	+77
51125	18	-8	1	100	+74
51211	20	-9	1	100	+78
60211	12	-10	1	000	+89
60220	8	-10	1	102	+63
Io Reappearances					
60321	7	-11	1	002	-94
60330	10	-11	2	100	-85
60406	13	-11	1	100	-101
60415	15	-12	1	000	-104
60429	18	-12	2	100	-79
60508	20	-12	1	010	-93
60524	20	-12	1	000	-88

UT	LD	Lat	ObN	STB	Dif
Io reappearances – Cont.					
60531	20	-12	1	000	-92
60616	19	-13	1	000	-93
Europa Disappearances					
51113	26	-10	1	000	+82
60102	32	-13	1	100	+81
Europa Reappearances					
60331	16	-18	2	000	-100
60603	31	-21	1	000	-111
Ganymede Disappearances					
51225	51	-21	1	000	+299
60130	39	-23	1	100	+264
60425	6	-29	2	100	+280
60713	9	-34	1	002	+265

UT	LD	Lat	ObN	STB	Dif
Ganymede Reappearances					
60418	40	-29	1	001	-339
			2	011	-286
60425	44	-29	2	100	-305
60531	51	-31	1	110	-266
Callisto Disappearances					
60119	78	-48	1	000	+472
60326	6	-56	1	102	+472
Callisto Reappearances					
51113	42	-37	1	100	-409
60326	33	-55	1	000	-572
60412	59	-57	1	000	-693
60618	77	-70	1	002	-626

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

Papers & Presentations

A Review of Ultraviolet Photometry of Uranus

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Abstract

This paper reviews ultraviolet brightness measurements made of Uranus since the 1949-50 apparition. In all cases, brightness measurements were transformed to the Johnson U photometric system. Four conclusions are: 1) There is not a statistically significant relationship between the reduced U-filter brightness and either the phase angle or sub-Earth latitude over limited ranges; 2) there is a statistically significant relationship between the reduced U-filter brightness and the sunspot number for 2014-18; 3) there was no large (>0.1 magnitude) brightness increase in a brightness versus longitude of the central meridian graph, which is consistent with the magnetic pole near 44° N not affecting brightness and 4) the absorption minima of a spectrum recorded in 2018 closely match those in a spectrum recorded in 1981.

Introduction

Giclas (1954) reports early ultraviolet brightness measurements of Uranus starting with the 1949-50 apparition. Hardie and Giclas (1955) re-evaluated these measurements to allow for the color distribution with Giclas' yellow filter. Hardie and Giclas also report additional U-filter measurements for Uranus.

Their results show small brightness changes for that planet. Harris (1961) reports U–B and B–V values of 0.28 and 0.56 for Uranus, respectively. He cites two unpublished sources obtained by Hardie at the McDonald and Lowell Observatories. No dates are reported for these measurements.

Appleby and Irvine (1971) report ultraviolet, and visible light brightness measurements made in 1964. The narrow-band results of Appleby and Irvine were used in computing a reduced magnitude for Uranus by Wamsteker (1973). He also reported a reduced magnitude based on measurements made in 1971-72. Savage et al. (1980) report geometric albedos of Uranus in the 180-330 nm range based on data collected by the Astronomical Netherlands satellite. Caldwell et al. (1981) report ultraviolet spectra of Uranus over the 210-320 nm range from the International Ultraviolet Explorer. Lockwood et al. (1983) report geometric albedo spectra covering wavelengths between 329.5 to 767.6 nm. Their graph is consistent with a U-filter albedo of 0.51 for a wavelength of 360 nm. The blue portion of this spectrum is based on measurements made on June 17-18, 1981. Lockwood et al. also re-evaluated albedo data recorded by Younkin (1970). The geometric albedo of Uranus, based on the re-evaluated data of Younkin, is 0.46.

The Voyager 2 spacecraft flew past Uranus in January 1986, enabling astronomers to gain new information. For example, Lane et al. (1986) report there is no enhanced absorption of ultraviolet light towards the pole at a wavelength of 270 nm. They point out this is different from Jupiter and Saturn. Broadfoot et al. (1986) used the Voyager 2 ultraviolet spectrometer to collect a spectrum from the sunlit side of Uranus at wavelengths of 50 - 170 nm. They report it is dominated by emissions from atomic and molecular hydrogen. They also report an aurora on Uranus' dark hemisphere. Ness et al. (1986) report the magnetic field of Uranus may be represented by a dipole that is not centered at the planet center. Based on their Figure 4, the magnetic poles intersect the surface at 15° S and at 44° N; the latitude convention in the JPL Horizons website (*https://ssd.jpl.nasa.gov/?horizons*) is used here. Furthermore, the strongest surface magnetic field, 1.1 Gauss, was on the northern (dark) hemisphere in 1986. This is also consistent with Voyager 2 radio observations (Warwick et al. 1986).

By the 1990s, astronomers were taking advantage of digital cameras and the Hubble Space Telescope to learn more about Uranus. The whole-disk spectrum of Uranus reported by Karkoschka (1994) is consistent with an albedo of 0.52 at 360 nm. He also reports synthetic U–B and B–V values of 0.27 and 0.55 for Uranus from his spectrum. His values are for July 24, 1993. In a second, similar study, Karkoschka (1998) reports additional spectra collected at the European Southern Observatory. He reports synthetic, reduced magnitudes of -6.36, -6.64 and -7.17 for the U, B and V filters, respectively. Karkoschka (2001) used Hubble Space Telescope images taken in 1997 to construct brightness models of Uranus as a function of the Sub-Earth latitude (see Figure 1 and

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The references in blue text to jump to source material or information accompanying footnote). At this time, the sub-Earth latitude was 40° S and, hence, latitudes northward of 50° N were not sampled.

In the models, it was assumed no physical atmospheric parameter was changing. That is, there were no changes like the sudden appearance of a large bright cloud. Interestingly, he predicts Uranus will darken slightly as the sub-Earth latitude increases towards 82° S, which is the opposite of what happens in blue and green light.

In their review, Bhardwaj and Gladstone (2000) report that early 1980s data from the International Ultraviolet Explorer satellite are consistent with aurorae on Uranus. For example, see Clark (1982). More recently, Hubble Space Telescope images in 1998, 2011, 2012 and 2014 have shown the presence of aurorae (Lamy et al. 2012), (Barthélemy et al. 2014), (Lamy et al. 2017). Aurorae on Jupiter, near the magnetic poles, are bright in ultraviolet wavelengths (Rogers, 1995). Similar aurorae on Uranus may affect its brightness. Lamy et al (2012) report evidence for aurorae in 1998 and 2011 in the 115 - 175 nm wavelength range. They report emissions on November 16 and 29, 2011. These dates correspond to the predicted arrival of pressure fronts from solar wind events. The results are consistent with the magnetic pole latitudes remaining nearly fixed between 1986 and 2011.

Mallama et al. (2017) review previous U-filter work along with u' magnitudes made from the Sloan Digital Survey. They report a reduced magnitude of -6.28 and a geometric albedo of 0.502 for the U-filter. They select a reduced Sloan u' magnitude of 5.49 and a corresponding geometric albedo of 0.541. Bear in mind the u' filter transformed to the Sloan system has different characteristics than one transformed to the Johnson U system. They point out the general agreement for the geometric albedos between the two systems. Lockwood (2019) has published a summary of his b and y filter measurements covering years through 2016.

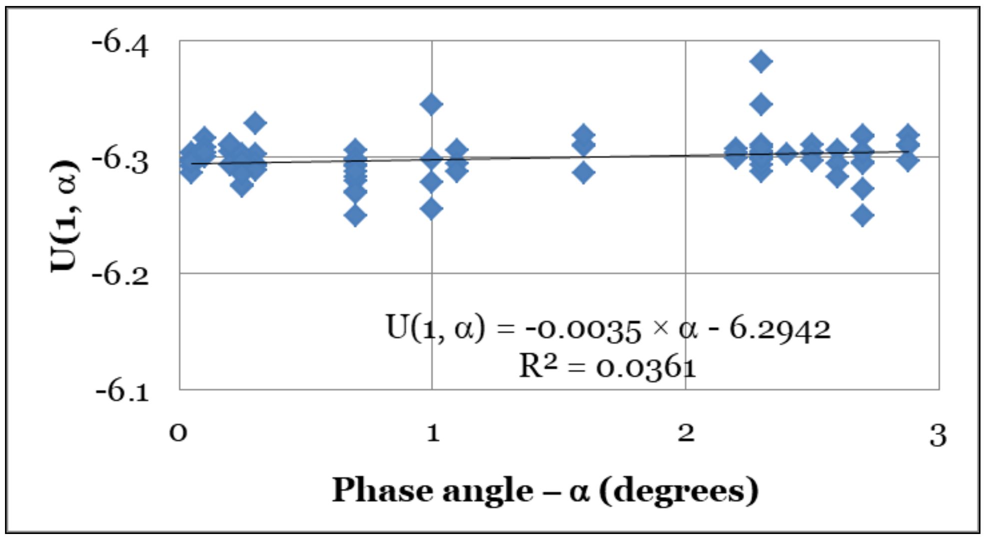
Schmude (2017, 2018, 2019a, b) report U-filter brightness measurements covering 2014-2018. These were made when the sub-Earth latitude was near the latitude of a magnetic pole.

Scope and Objectives

This paper describes trends in U-filter measurements made since the mid-Twentieth century. The following questions are addressed: Does the U-filter brightness change with the phase angle or the Sub-Earth latitude over limited ranges? Does this brightness change with the sunspot number? Have the wavelengths of intensity minima in the spectrum of Uranus changed since 1981? Does Uranus brighten when a magnetic pole points to Earth?

Method and Materials

An Optec SSP-5 photoelectric photometer with a 9-stage side-mount photomultiplier tube was used in making all U-filter brightness measurements during 2014-2018 (Optec, Inc. 1990). A filter, transformed to the Johnson U-system, along with a 0.20 m Maksutov-Cassegrain telescope were also used. This filter has an effective wavelength of 360 nm with a full-width-at-half-maximum near 70 nm (Optec Inc.,



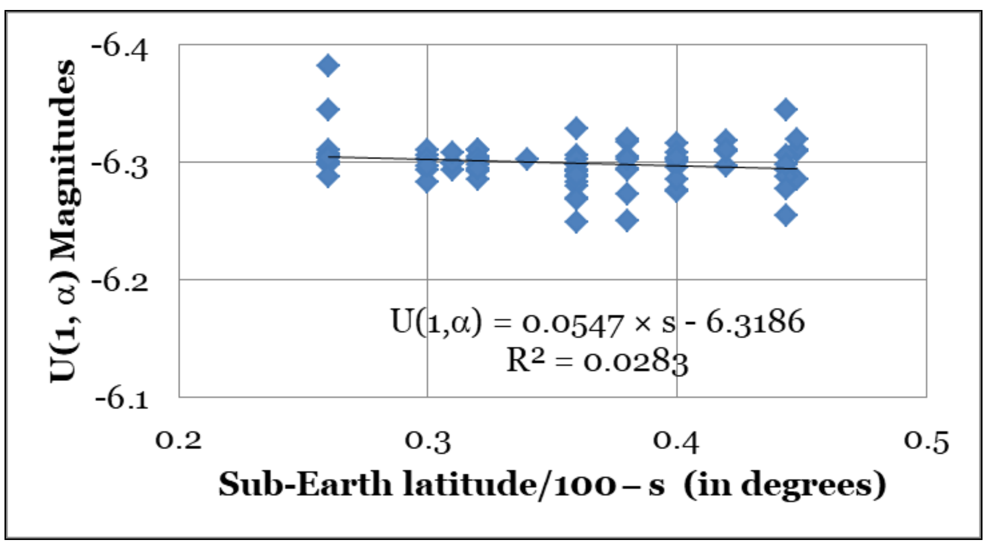


Figure 1. Plots of the Reduced Magnitude – U(1, α) versus the Phase Angle (top figure) and the sub-Earth Latitude (bottom figure). The phase angle is measured between the Earth and the Sun from Uranus. The sub-Earth latitude is the one where Earth is at the Zenith. The sub-Earth latitude in the bottom figure was divided by 100 to insure the computation of more precise values of Uo and the slope.

1990). All 2014-2018 measurements were made near Barnesville, GA (33.05° N, 84.15° W) at an elevation of ~250 m. The measurements were corrected for both atmospheric extinction and color transformation using the procedure described in Hall and Genet (1988). A secondary extinction coefficient of k" = -0.03 was used in correcting all U-filter measurements.

The magnitude scale is based on measurements made of a group of stars (Johnson and Morgan, 1953). The zero point has traditionally been the A2 star Vega. There are no units for the magnitude scale but the brightness, based on a magnitude value for a given filter can be converted into appropriate units as described in Chapter 2 of Shepard (2017). The term reduced magnitude is also be used which is the magnitude the target has when it is 1.0 au from the Earth and Sun and is at a phase angle, α. The phase angle of Uranus is defined in the Figure 1 caption. It may range from 0° to 3° from Earth (Shepard, 2017). The absolute magnitude for solar system objects is the reduced magnitude for a phase angle of 0° (full illumination).

A t-test at the 95% confidence level was carried out on linear fits of U(1, α) values versus the solar phase angle and the U(1, α) versus sub Earth latitude. (Larson and Farber, 2006). In both cases, the t-test was used to determine if the correlation coefficients were statistically significant.

Christophe Pellier collected a spectrum of Uranus on November 18, 2018. He calibrated and corrected it using the solar-like G2V star HD 9986. Its apparent magnitude values are B = 7.43, V = 6.76 (SIMBAD star database, http://simbad.u-strasbg.fr/simbad/). The spectrum covers the wavelength range 380 - 750 nm. Therefore, some of the ultraviolet portion is included. He also used a 0.305 m Newtonian f/5 telescope along with an SA 100 grating at 6.52 Ang/pixel + ZWO AS1290 MM monochrome webcam.

Results

The reduced magnitude, U(1, α), accounts for changing distances and is computed as

$$U(1, \alpha) = U_m - 5 \times \text{Log}[r \times \Delta] \qquad (1)$$

In this equation, U_m is the measured U filter magnitude, r is the Uranus-Sun distance and Δ is the Uranus-Earth distance at the time U_m was measured. Both r and Δ are in units of astronomical units.

Does the U(1, α) value change with the phase angle and/or the sub-Earth latitude over limited ranges? Figure 1A illustrates a graph of U(1, α) versus α based on 81 different measurements made between 2014 and 2018. The correlation coefficient equals 0.19. Based on a t-test (Larson and Farber, 2006), there is no correlation between U(1, α) and α. Lockwood and Thompson (1999) report the reduced blue magnitude of Uranus changes by 0.003 magnitudes per 1.0° change in phase angle. Therefore, any change in U(1, α) as α drops from 3° to 0° is probably also small. Figure 1B shows how the U(1, α) value changed with the sub-Earth latitude of Uranus. The data were fit to the linear equation:

$$U(1, \alpha) = U_s + b \times s \qquad (2)$$

where U_s is the U(1, α) value when s = 0°, s is the sub-Earth latitude in degrees and b is an adjustable parameter. The correlation coefficient for this graph is 0.168. Once again, a t-test was carried out and the result is consistent with the trends not being statistically significant. Therefore, we conclude there is little change in U(1, α) as the sub-Earth latitude increased from 26° N to 45° N.

Table I. Summary of Equations Relating the Value of Reduced Magnitudes*

Equation	Standard Error of Estimate (Magnitudes)	Statistically Significant[a]
U(1, α) = -6.2991	0.0191	–
U(1, α) = –6.2942 – 0.0035α	0.0187	No
U(1, α) = –6.3186 – 0.000547s	0.0188	No
U(1, α) = –0.0093SN – 6.2952	0.0185	Yes
U(1, α) = –6.3106 – 0.00044s – 0.00295α	0.0186	–

* U(1, α) to the phase angle – α, the sub-Earth latitude – s, the sunspot number – SN and both α and s. Both α and s are defined in the Figure I footnotes.

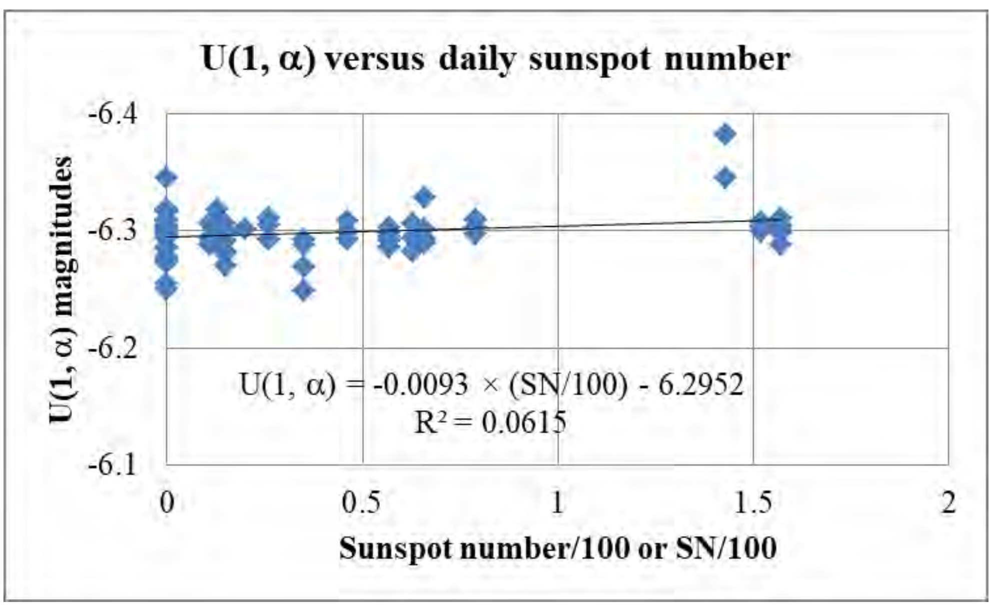


Figure 2. The Reduced Magnitude – U(1, α) values plotted against the Daily Sunspot Number for 2014-18. The daily sunspot number is from the Quandl website and is divided by 100 in the graph.

Finally the U(1, α) values were fit to a two-parameter equation of the form:

$$U(1, \alpha) = U_{\alpha,s} + b \times s + c \times \alpha \qquad (3)$$

where $U_{\alpha,s}$ is the value of U(1, α) when α = s = 0°, α and s are defined earlier. Both b and c are adjustable parameters. Values of the adjustable parameters are summarized in column 1 of Table 1. If there are no adjustable parameters, the standard error of estimate is 0.0191 magnitudes, which is only slightly higher than the corresponding value for the two-parameter equation. This shows there is almost no dependence between U(1, α) and both α and s for 2014-2018.

Does the reduced normalize magnitude value change with the sunspot number? To answer this question we obtained the sunspot number from Quandl: *https://www.quandl.com/data/SIDC/SUNSPOTS_D-Total-Sunspot-Numbers-Daily*. A graph of U(1, α) versus the sunspot number was constructed and the result is shown in Figure 2. The graph shows

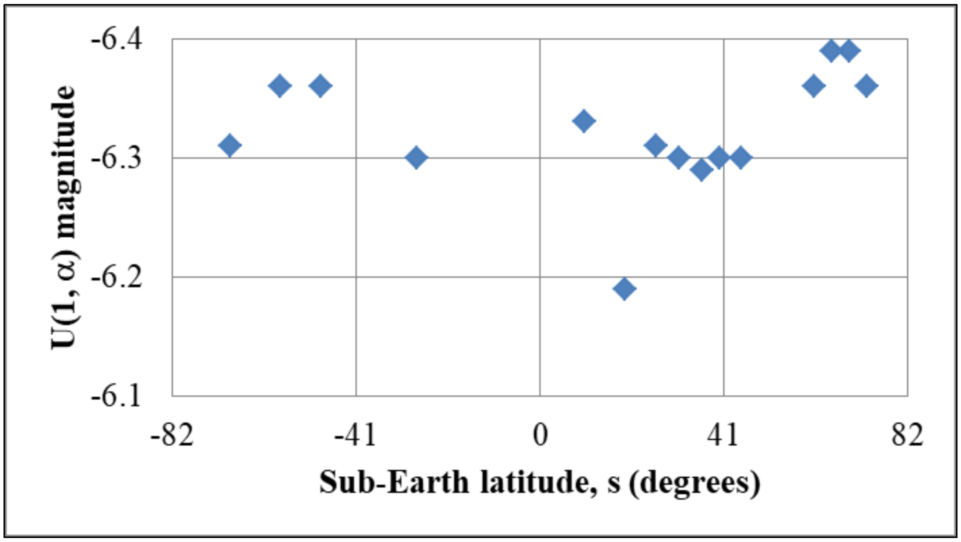


Figure 3. The reduced magnitude – U(1, α) values plotted versus the sub-Earth latitude based on measurements made since 1949-50. The sub-Earth latitude is defined in the Figure 1 caption.

Table II. Reported U-Filter Magnitudes of Uranus

Year	U(1, α)	U – B	U – V	Sub-Earth latitude[a]	Geometric Albedo[b]
1949-50	–6.36	0.28	0.83	73° N	0.536
1950-51	–6.39	0.26	0.81	69° N	0.551
1951-52	–6.39	0.25	0.80	65° N	0.551
1953-54	–6.36	0.26	0.81	61° N	0.536
1961-63	–6.19[c]	–	–	~19° N	0.460
1964	–6.33[d]	–	–	~10° N	0.521
1971-72	–6.30[e]	–	–	~27.5° N	0.507
June 17-18 1981	–6.31[f]	–	–	69° S	0.510
July 24, 1993	–6.36[g]	0.27[g]	0.82[g]	58° S	0.536
July 7, 1995	–6.36[h]	0.28[h]	0.81[h]	49° S	0.536
Late 2014	–6.31	0.32	0.82	26° N	0.512
2015-16	–6.30	0.30	0.83	31° N	0.507
2016-17	–6.29	0.29	0.85	36° N	0.503
2017-18	–6.30	0.32	0.86	40° N	0.507
Late 2018	–6.30	–	–	44° N	0.507
Harris (1961)	-6.35[i]	0.28[i]	0.84[i]	–	0.531

[a] The sub-Earth latitude is defined in the Figure 1 caption.

[b] The geometric albedo was computed using the technique described in Schmude et al. (2015) and Mallama et al. (2017) using a value of U(1, 0) = -25.90 for the Sun.

[c] Recomputed by Lockwood et al. (1983) from data in Younkin (1970).

[d] Value is from Wamsteker (1973) who recomputes the narrow-band data of Appleby and Irvine (1971) and transforms it to the Johnson U system.

[e] Wamsteker (1973) [f] Lockwood et al. (1983) [g] Karkoschka (1994)

[h] Karkoschka (1998) [i] Computed using Table 9 values as selected by Harris (1961)

a slight trend of more negative U(1, α) value as the sunspot number rises. The data were fit to a linear equation and the correlation coefficient is r = 0.2480. A t-test shows the correlation between these two quantities is statistically significant. This is also consistent with the findings of Aplin and Harrison (2017) who report solar activity also affects the brightness of Uranus in visible wavelengths.

The result in Figure 1B is consistent with Uranus showing almost no U-filter brightness change as its sub-Earth latitude increased from 26° N to 45° N. This is consistent with the results in Karkoschka (2001) for the southern hemisphere. For longer wavelengths (blue and green light), that planet grew brighter as its south pole faced Earth. For example, Lockwood and Jerzykiewicz (2006) report Uranus brightened by 0.07 and 0.12 magnitudes in the intermediate-band b and y filters between 1972 and 1988 and it dimmed by a similar amount between 1988 and 2004. Their measurements are for the southern hemisphere. Hammel and Lockwood (2007) suggest much of this brightness change can be interpreted as seasonal, caused by viewing angle changes.

Table II summarizes ultraviolet brightness values measured since the 1949-50 apparition. Most of these were recorded when Uranus' northern hemisphere faced us. The reduced magnitudes were plotted against the sub-Earth latitude and the results are shown in Figure 3. The data suggest Uranus may brighten as the sub-Earth latitude approaches the North Pole. It will be interesting to see if this happens in the 2020s.

Does Uranus brighten as the magnetic pole directly faces Earth? Studies carried out since 1986 (Ness et al. 1986), (Lamy et al. 2012) are consistent: Uranus' magnetic poles remained nearly fixed in latitude between 1986 and 2011. No comments can be made about longitude since the rotation rate of Uranus is only known to an accuracy of 0.01 hours and over thirty-plus years, this could lead to several rotations. If the latitude of the magnetic pole has continued through 2018, one of the poles pointed towards the Earth during 2017 and 2018. The longitudes for each U(1, α) measurement in 2017 and 2018 were determined from the JPL Horizons website. The results are plotted in Figures 4A and 4B. There does not appear to be a spike at any one longitude; however not all longitudes were sampled. Furthermore, the Sun was approaching sunspot minima during that time.

The geometric albedo of Uranus was computed using the same procedure in Schmude et al. (2015) and Mallama et al. (2017). Geometric albedos are also listed in Table II. Those between 2014 and 2018 are near 0.51. This is similar to the value reported by Lockwood et al. (1983) for the southern hemisphere. The mean value of the geometric albedo for all 16 values in Table II (equally weighted) is 0.519 with a standard deviation of 0.023. The mean geometric albedos for the southern and northern hemispheres are 0.528 and 0.517, respectively based on the equally weighted results in Table II.

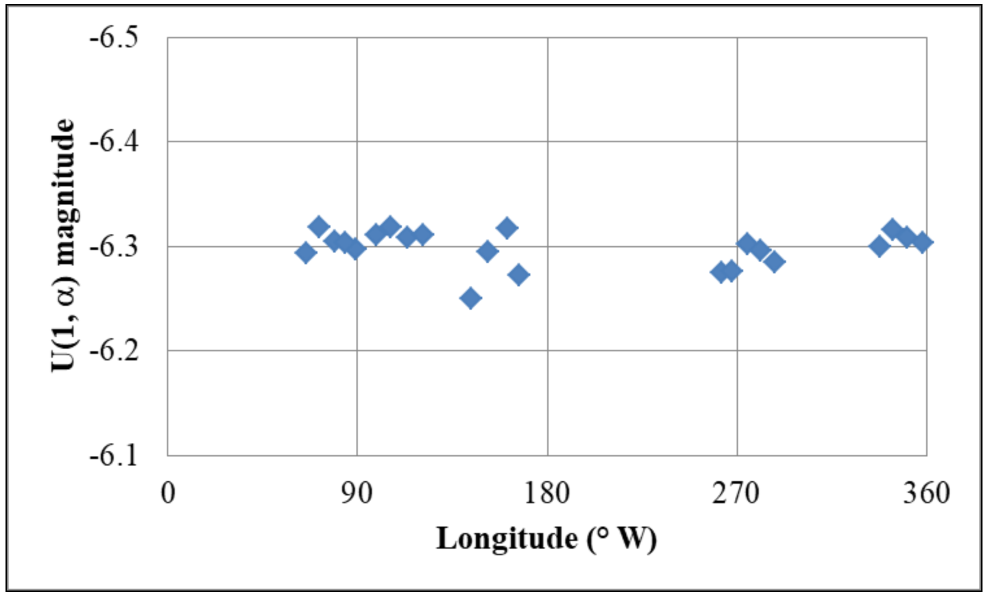


Figure 4A. A graph of U(1, α) versus the longitude of the central meridian based on the JPL Horizons website for measurements made between July 31, 2017 and February 3, 2018. The uncertainty in the rotation period is 0.01 hours which over the time increment in this graph-

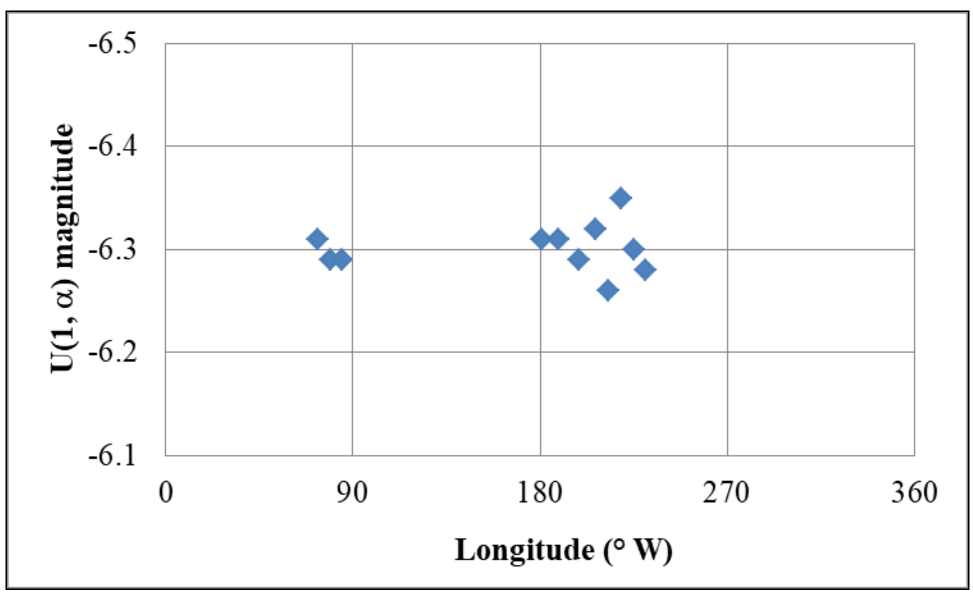


Figure 4B. A graph of U(1, α) versus the longitude of the central meridian based on the JPL Horizons website for measurements made between September 21, 2018 and October 4, 2018. The uncertainty in the rotation period is 0.01 hours which over the time increment in this graph-14.03 days results in a longitude uncertainty of 4°.

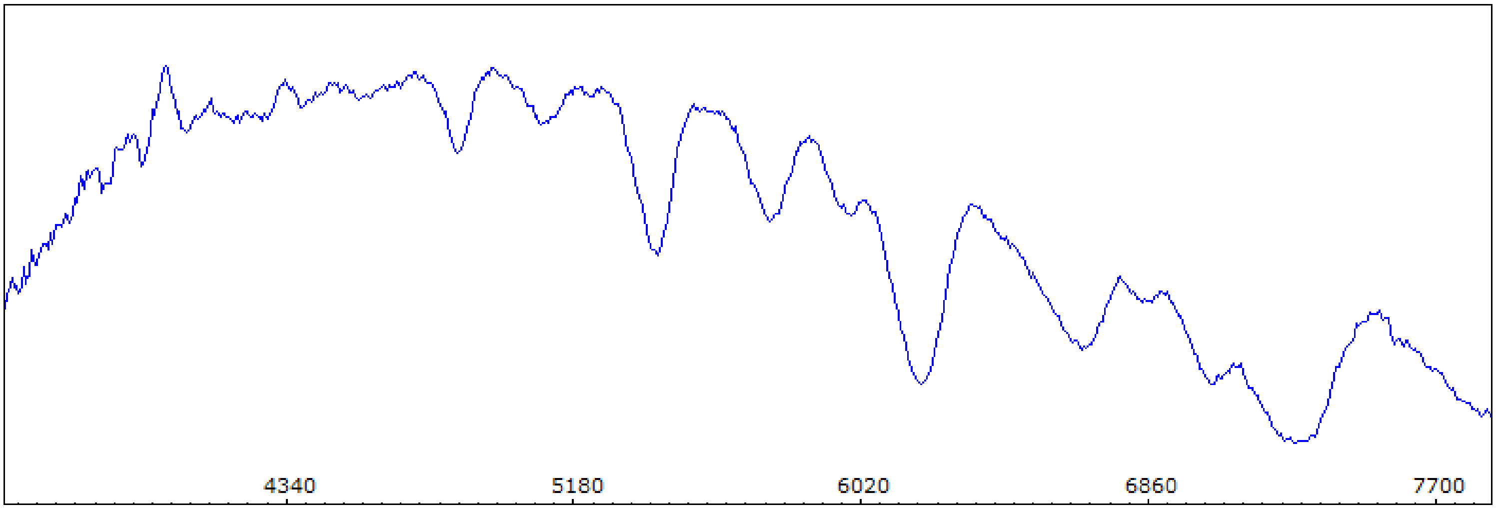


Figure 5. Spectrum of Uranus collected by Christophe Pellier on November 18, 2018. He calibrated and corrected it using the solar-like star HD 9986. Details of his equipment are in the method and materials section. The horizontal axis lists the wavelength in Angstroms and the vertical axis shows intensity.

Figure 5 illustrates the spectrum of Uranus measured by Pellier. It was obtained by dividing the raw planet spectrum by that of a nearby solar-like star. It shows absorption features (intensity minima) at 390 nm, 482 nm, 542 nm, 577 nm and 619 nm. The corresponding minima in the spectrum recorded by Lockwood et al. (1983) are 392 nm, 484 nm, 540 nm, 574 nm and 616 nm. Therefore, there is good agreement between the two spectra. This is additional evidence the photometric and spectral characteristics of the southern and northern hemispheres are similar.

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Lunar Banded Craters Program

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Lunar Meteoritic Impacts Search Program

http://www.alpo-astronomy.org/lunar/lunimpacts.htm

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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)
- **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*

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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:
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- **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 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

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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.

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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.

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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.

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