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# Journal of the Association of Lunar & Planetary Observers

## *The Strolling Astronomer*

Volume 59, Number 4, Autumn 2017

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See page 3 for details.

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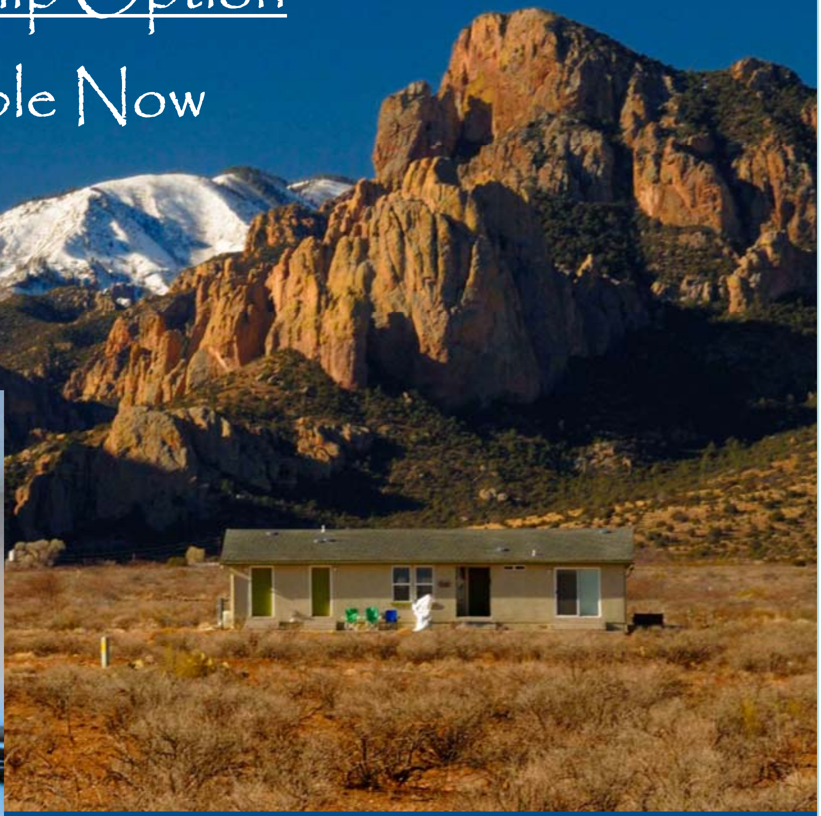

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# Journal of the Association of Lunar & Planetary Observers

## The Strolling Astronomer

Volume 59, No.4, Autumn 2017
This issue published in September 2017 for distribution in both portable document format (pdf) and hardcopy format.

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

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



For membership or general information about the ALPO, contact:

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

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

Founded in 1947

## Inside the ALPO



## Papers & Presentations



## ALPO Resources

# Inside the ALPO
# Member, section and activity news

## Association of Lunar & Planetary Observers (ALPO)

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*Publications*

**Editor & Publisher:** Ken Poshedly

*Primary Observing Section & Interest Section Staff*

(See full listing in *ALPO Resources*)
**Lunar& Planetary Training Section:** Timothy J. Robertson
**Solar Section:** Rik Hill
**Mercury Section:** Frank Melillo
**Venus Section**: Julius L. Benton, Jr.
**Mercury/Venus Transit Section**: John E. Westfall
**Lunar Section**:
*Lunar Topographical Studies & Selected Areas Program*; Wayne Bailey
*Lunar Meteoritic Impact Search;* Brian Cudnik
*Lunar Transient Phenomena;* Anthony Cook
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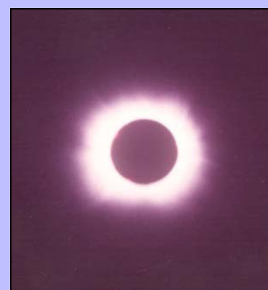
**Eclipse Section**: Michael D. Reynolds
**Comets Section:** Carl Hergenrother
**Meteors Section:** Robert D. Lunsford
**Meteorites Section:** Dolores Hill
**ALPO Online Section:** Larry Owens
**Computing Section:** Larry Owens
**Youth Section:** Timothy J. Robertson

*Point of View*

## After the Eclipse

**By Matt Will, ALPO Membership Secretary/Treasurer**



Memories… Totality, February 26, 1979, photo by Chris Will, taken with Ektachrome 200 film, using a 230mm lens, exposure 1/15 of a second, camera hand held. North at top.

By the time you read this, The Great American Total Solar Eclipse of 2017 will have been done and over with. For those of us that had the good fortune of clear weather, some will have made some valuable scientific observations that can be submitted to the ALPO's Eclipse Section or other scientific venues.

For many of us that have viewed totality from past eclipses, the visual observing of that event was both beautiful and quite awe inspiring. Some have even said that it was a spiritual happening for them. As I am sure many of you will agree, a total solar eclipse is very dynamic, from its grounding in scientific concepts, to the rich splendor of features that only nature, through totality, can provide.

The build-up to this event, and the human interaction before, during, and after the eclipse can be special and unique. Whereas our scientific observations give the lowdown on exactly what was seen, the social aspects of how the eclipse impacted you and the people around you can be culturally insightful as well.

I would greatly encourage you to preserve not only your scientific observations, but to compose an essay or memoir of the interesting things you encountered with others, problems you had along the way and how you overcame them. Record your personal impressions of the whole event, preparing for the eclipse, the eclipse itself, and the personal impressions you and others had, after the eclipse.

My first total solar eclipse was on February 26, 1979. My brother Chris and I traveled to Manitoba, Canada to view it. Under incredible odds, adversity, and good humor, we witnessed the total solar eclipse in all its glory. The story of our trip was worthy of committing it to paper. Working from handwritten notes at the time and personal recollections later on, I wrote a short memoir about that adventure not long ago. In an age where personal histories are valued by historians to learn "the story behind the story", you too can provide a unique visualization of your experiences now and for future generations to read. Consider what you write to be your own personal, historic heirloom for the future, for your descendants and others to read.

## Inside the ALPO
# Member, section and activity news

## News of General Interest

ALPO Eclipse Section Coordinator Mike Reynolds is currently compiling his report on the August 21, 2017 "Great American Eclipse" for publication in JALPO60-1, for release in December.

### *Our Cover: The August 21, 2017 Solar Eclipse; Where Were You?*

We know where ALPO Solar Section Coordinator Rik Hill was — behind the Parkway Plaza Hotel in Casper, Wyoming, where the Astronomical League held its meeting (latitude 42.855895° N, longitude 106.327514° W).

Incidentally, it was really tough deciding which eclipse image to use on our front cover this time. But Rik's seems to catch it all -- an ethereal, soft-focus appearance that includes not only a really great view of the corona and its texture, but also flares at about the one o'clock position.

Image details right from Rik: "Coronal images were made using a 500mm Schmidt-Cassegrain lens on a Canon 20D camera using a manual bracketed series of exposures from 0.01sec to 0.1 sec. Cirrus prevented longest exposure images of the outermost corona from being useful, but inner corona images were good. This final image was made using five images from the sequence showing the prominences and inner coronal structure."

### *An Observing Site: A Great Location and a Great Price*

By Jim Lamm

As an ALPO member for many years, I wish to let you know about a unique astronomy-centered home ownership opportunity for you to consider.

I am the proud original owner of an astronomy home at Arizona Sky Village. For those of you who don't know about ASV, it's an enclave of like-minded astronomy enthusiasts who share the dark night skies of Southeast Arizona. Fred Espenak (my next-door neighbor) and Jack Newton are two of our founding residents.

Here's a recent story about ASV from a Phoenix television station: *http://www.fox10phoenix.com/news/arizona-news/266004799-story*

Recently, I have been working with two other partners on a unique fractional ownership proposal that would share my house with a small group of owners. Our goal is to find two more like-minded enthusiasts to join into a tightly controlled, privately owned LLC. Essentially it would bring all of the benefits of a time-share but WITHOUT the profit markup and high maintenance fees.

My home is fully furnished and pristinely maintained. I have a 12'x24' powered observing pad close to the home that is ready to accept either a domed or roll-off observatory. The opportunity to develop a remote observing facility is likewise a definite possibility, along with other observing activities, including my favorite -- multiple weeks per year at the site.

We have some of the most incredibly clear, DARK skies that yield wonderful observing conditions. Frankly, while observatory viewing is a mainstay at ASV, I personally enjoy just being on the pad under the full dome of the sky.

If this opportunity sounds interesting to you or if you know someone who would be interested, please review the full-page ad on the inside front cover of this Journal. Additionally, I can provide other documents with much more detail on how the LLC would work, with pictures, etc."

### *Attendance Requested: ALPO-GRA Annual Meeting*

*(Editor's Note: While the following announcement has been and will be again distributed to our membership electronically, this restatement is for those who do not have or use e-mail.)*

This year's Assn of Lunar & Planetary Observers annual conference will be held as part of the Georgia Regional Astronomers Meeting (GRAM) at the University of Georgia in Athens, Georgia, the weekend of October 27 and 28, 2017. THERE IS NO REGISTRATION FEE and only a very minimal prepaid charge for meal

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arrangements for the ALPO awards dinner.

Amateur astronomers are especially urged to attend and participate in this event. While you are not required to give an oral presentation or submit a poster for display, please consider this an excellent opportunity to enlighten other participants regarding your own recent astronomical activities.

The ALPO annual board meeting will be at 2 p.m., on Friday, October 27, at the UGA Physics Building. An informal reception with light refreshments will follow later that afternoon, with viewing through the UGA 24-inch Fecker telescope (weather permitting) that evening.

The conference astronomy talks will be held from 9 a.m. to 5 p.m. on Saturday, October 28 (with a break for a free lunch). In addition, poster presentations will be set up on tables just outside the conference room. There is no limit as to the number of astronomy posters for display.

The grand finale of the weekend will be the ALPO awards dinner beginning at 6:30 p.m., October 28, at the nearby University of Georgia Center for Continuing Education & Hotel. All who attend this event are also invited to attend the ALPO awards dinner, where official presentation of this year's ALPO Walter H. Haas Observers Award and the ALPO Peggy Haas Service Award will take place. Afterwards, Dr. Loris Magnani, professor astronomy at UGA and organizer of the GRAM event, will be our keynote speaker.

There is a very minimal charge required in advance for the dinner, which makes the event very affordable considering that there is no registration fee.

Please note that our agreement with the UGA Center specifies NO WALK-INS for the awards dinner, thus prepayment is required.

The dinner meal will be a buffet of the following:

- Drag Through the Garden Salad with Lemon House Vinaigrette
- Marinated Five Bean Salad
- Southern Fried Chicken
- Shrimp and Grits
- Yankee Pot Roast
- Collard Greens with Smoked Ham Hocks
- Whipped Potatoes
- Macaroni and Cheese
- Cheddar Biscuits and Corn bread with Honey Butter
- Apple Berry Crisp with Vanilla Sauce
- Chocolate Cake with Double Cream

Non-alcoholic beverages (water, coffee, ice-tea, etc.) will also be available.

Finally, the UGA Center, site of the ALPO awards dinner, graciously offers a steeply discounted room rate for those who wish to spend Friday, Saturday and even Sunday in Athens.

The UGA Physics Building, site of this year's ALPO-GRA meeting in Athens, Georgia.

There are two ways to complete prepayment ($30) for your ALPO awards dinner:

- Use the PayPal method available at

https://store.astroleague.org/index.php?main_page=product_info&cPath=10&products_id=121

- Send a check (payable to the ALPO) to:

  The ALPO
  c/o Matt Will
  P.O. Box 13456
  Springfield, IL 62791-3456

Deadlines are as follows:

- Sunday, October 1 – Lodging at the University of Georgia Center for Continuing Education & Hotel (voluntary). Complete booking arrangements directly with the hotel; phone 706-542-2134.

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The UGA Center for Continuing Education & Hotel, site of this year's ALPO Awards Dinner in Athens, Georgia.

State that you are part of Event No. 88950. If the original block of rooms is filled, our arrangement with the hotel is for the same rate to be extended to all who are attending this event, as long as hotel rooms are available.

- Friday, October 6 – ALPO Awards dinner payment. Payment methods stated directly above. Contact Ken Poshedly for details at *ken.poshedly@alpo-astronomy.org*
- Friday, October 13 – Conference oral presentation registration (no charge). Contact Dr. Loris Magnani at *loris@physast.uga.edu*; phone 706-542-2876.
- Friday, October 20 – Conference attendance registration (no charge). Contact Dr. Loris Magnani at loris@physast.uga.edu; phone 706-542-2876.

*Conference Registration Info*

For our planning purposes, and because the oral presentations are limited to Saturday, October 28, please note that we may not be able to accommodate all requestors. Therefore, please print out and return this completed form as soon as possible to *loris@physast.uga.edu*

Registration deadline for submitting poster presentations abstracts is Friday, October 13, and should include the following.

- Your Name
- Institution or Affiliation
- Your e-mail address
- Preference (talk, poster, neither)
- Title of your poster
- Do you have any special audiovisual requirements for your presentation?
- Abstract (200 words or less)
- I will arrive on Friday / Saturday (please indicate).
- If you are arriving on Friday, would you like to get together for an informal dinner after an lecture that evening?
- Do you have any dietary restrictions or preferences for the Saturday lunch? If yes, describe.

Directions to UGA and a campus map are given at *https://www.architects.uga.edu/maps/current* . On Friday evening (after 5 p.m.) and all day Saturday, you can park in the parking lots adjacent to the Physics Building.

### Galilean Satellite Eclipse Catalog

**By John Westfall**

The coordinator of the ALPO Galilean Satellite Eclipse Timing Program can make available an Excel catalog of the program's observations from the 1975/76 through the 2000/01 Jupiter apparitions. The read-only file contains the results of 10,308 visual timings, with 20 entries for each timing. The data are more detailed than given in the reports published in this journal over the years, and include observed UT, delta-t, the predicted event time based on the Lieske E-2 ephemeris, as well as the observer name, instrument aperture, and observing conditions. Contact the coordinator,

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John Westfall, at *johnwestfall@comcast.net* to obtain a copy of the 2 mb file.

### *Reminder: The ALPO Publications Section Gallery*

The ALPO Publications Section Gallery has been updated to include all ALPO Journals from 2015 back to 2001 and various indexes to the Journals.

The pre-2001 Journals back to issue No. 1 (1947) and additional indexes will be posted in the coming weeks and months.

These Journals are available to all to access, with no password required to open them.

The ALPO Publications Section gallery replaces the old online repository where some Journals were still password-protected. That online location will be deleted.

The Journals for calendar year 2016 remain available only to ALPO members and will be posted to the new location as their individual one-year anniversaries of release are reached.

Besides the ALPO journals, the Publications Section Gallery also includes various observing forms and monographs, all of which will be upgraded as new versions are made available.

To begin your own exploration of the Publications Gallery:

## Inside the ALPO
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1. Go to the ALPO home page at *http://www.alpo-astronomy.org/*, then click on the "ALPO Section Galleries" link at the top-right of the screen.
2. Click on the icon for the "Publications Section".
3. Click on the icon for the "Digital Journals of the ALPO."
4. Click on the icon for any of the various years.
5. Click on the icon for any of the Journals in the chosen year.
6. Click on the "Download document" link near the center of the screen.

Then either save the document to your own computer or just read it online without saving it. Saving the document to your own terminal allows you to access it at any time, even if online access is not available.

### Call for JALPO Papers

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

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

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

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

## ALPO Interest Section Reports

### ALPO Online Section

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

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

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

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

### Computing Section

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

Important links:

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

### Lunar & Planetary Training Program

**Tim Robertson, program coordinator**
*cometman@cometman.net*

*Podcast Update*

The following Observers Notebook podcasts and their release dates have been released as of September 1.

- A history of the ALPO, February 3, 2017
- The ALPO Lunar Section, February 20.
- The Journal of the ALPO, March 3.
- The ALPO Training Program, March 14.
- The ALPO Solar Section, March 26.
- The Great American Total Solar Eclipse of 2017, April 3.
- The ALPO Venus Section, April 16.
- The ALPO Meteors Section, April 28.

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- The ALPO Lunar Topographical Studies Program, May 11.
- A History of Amateur Astronomy in the U.S., May 18.
- The ALPO Saturn Section, May 26.
- The 2017 Solar Eclipse in Stapleton, Nebraska, May 30.
- The 2017 Solar Eclipse in Casper, Wyoming, May 31.
- The 2017 Solar Eclipse in Madras, Oregon, June 1.
- The 2017 Solar Eclipse in St. Joseph, Missouri, June 2.
- The 2017 Solar Eclipse in Columbia, South Carolina, June 6.
- The ALPO Minor Planets Section, June 9.
- The ALPO Jupiter Section, June 17.
- The ALPO Comets Section, July 1.
- The ALPO Lunar Transient Phenomena Program, July 18.
- The 2017 ALPO Conference, August 1.
- Telescopes, with Scott Roberts, August 13.
- The 2017 Total Solar Eclipse Travel Log, August 24.
- The ALPO Meteorites Section, August 31.
- The State of the ALPO Observers Notebook Podcast Program, September 1.

All are available at iTunes, Stitcher, and Goggle Play. Just search for "Observers Notebook". Or you can listen to it at the link below:

https://soundcloud.com/observersnotebook

The podcast hosting service is not free, however. So to keep our podcast service alive, I've set up an online method for supporters to donate a monthly amount. The service is called "Patreon", and we currently have three supporters - two of whom are NOT even members!

You can support the podcast by giving as little as $1 a month. But for $5 monthly, you'd receive early access to the podcast before it goes public; for a $10 monthly donation, you'd receive a copy of the ALPO Lunar & Planetary Training Section's "Novice Observer's Handbook"; and for a $35 monthly donation, you'd receive producer credits on the podcast and a year's membership in the ALPO. You can help us out by going to the link below:

https://www.patreon.com/ObserversNotebook

Finally, suggestions for future podcasts are always welcome. So please let me know if you have any breaking news or topic that you want covered.

For more information on the ALPO Training Program, contact

Timothy J. Robertson
ALPO Training Program
195 Tierra Rejada #148
Simi Valley, California 93065

Or send e-mail to me at: cometman@cometman.net

For more information about the ALPO Lunar & Planetary Training Program, go to: *www.cometman.net/alpo/*

## ALPO Observing Section Reports

### *Eclipse Section*

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

We expect to have a full report on the August 21, 2017 total solar eclipse ready for the winter issue of this Journal (DJALPO60-1).

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

### *Mercury / Venus Transit Section*

**John Westfall, section coordinator**
*johnwestfall@comcast.net*

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

### *Meteors Section*

**Robert Lundsford, section coordinator**
*lunro.imo.usa@cox.net*

The last of our major meteor showers for this year focuses on the Orionids While this shower is active from September 23 through November 27, some studies have extended the activity period from late August through November. This shower is

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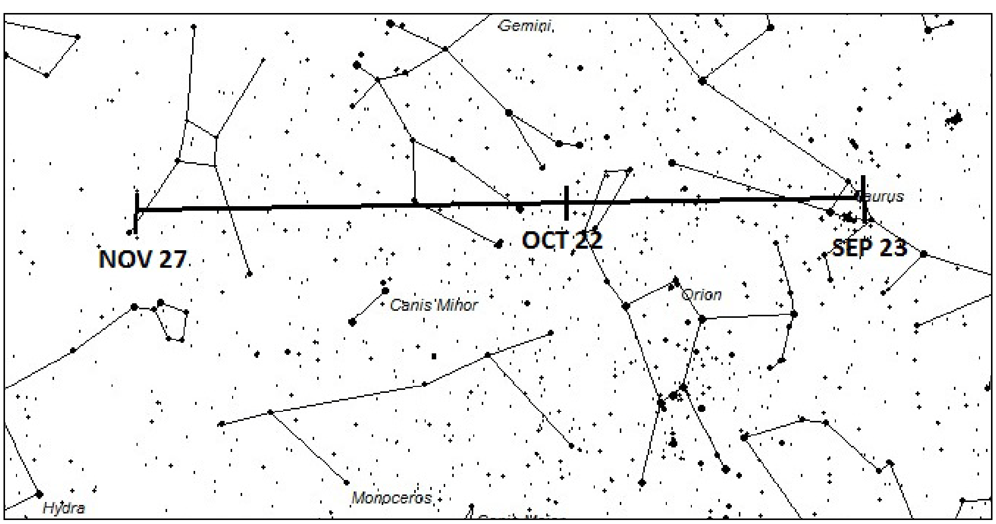
the most active radiant in the sky during the last half of October and the first few days of November. The plateau-like peak is centered on October 22, but strong Orionid rates may be seen for a week centered on this date. This is reminiscent of the eta Aquariids of May, which is actually the same shower, only the outbound particles of Halley's Comet rather than the inbound.

When this shower first becomes noticeable in late September, it lies in Taurus, just west of the bright orange star Aldebaran (alpha Tauri). With each passing night, the radiant marches eastward by 1 degree and ends up near the “club of Orion” during the time of maximum activity. This area of the sky is well-placed on October nights, as it rises near 22:00 UT local daylight time and is just right for viewing from midnight onward. As November arrives, the radiant lies in Gemini and will enter the constellation of Cancer before activity ceases in late November.

The Orionid radiant lies highest in the sky between 4 and 5 a.m. local daylight time, the best time to see the Orionids. Hourly rates are expected to be near 15-20 Orionids per hour at maximum. New Moon occurs on October 19, so that will not be a factor at all near maximum activity. To see the most activity it is advisable to face southward with your field of view centered half-way up in the sky. Orionid meteors will shoot in all directions and appear in all portions of the sky, but they will all trace back to the club of Orion near maximum activity.

There are also other showers active during the Orionid maximum. Most notable are the slow Taurids from western Taurus and the swift Leonis Minorids, from the constellation of Leo Minor.

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.




Radiant Drift for the Orionids. This chart was created using SkyChart III, Version 3.5.1, from Carina Software.

### Meteorites Section

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

This report includes information about ALPO member contributions, meteorite highlights and new meteorite approvals from April 27, 2017 to July 25, 2017 from the Meteoritical Society’s Nomenclature Committee.

The ALPO Meteorite Section confers with members about meteorites to educate and promote research. ALPO members who collect meteorites are encouraged to report unusual features in their meteorite samples. ALPO member Randy Tatum continues to pursue possible impact sites and is providing the research community with valuable images, samples and thin sections. He is currently working with Ludovic Ferriére at the Natural History Museum of Vienna and consults regularly with other impact researchers around the world. We received email inquiries of several suspected Arizona meteorites, all of which were terrestrial (magnetite). One in-person evaluation required further analysis.

The Meteoritical Bulletin records officially recognized, classified meteorites of the world’s inventory. As of July 25, 2017, it contains a total of 56,622 meteorites (some with many individual pieces). There were 317 new meteorites approved or revised since the last ALPO

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Meteorite Section Report. Newly approved meteorites include 245 ordinary chondrites, 16 carbonaceous meteorites, 2 enstatite chondrites, 2 R chondrites, 4 irons, 5 ureilites, 1 meosiderite, 2 pallasites, 21 HEDs, 12 lunar and 7 Martian. For more information and details: *https://www.lpi.usra.edu/meteor/metbull.php* Note that the abundance of each meteorite type listed is based on which ones are *submitted and approved*. Witnessed falls are given high priority.

Recent additions to the Meteoritical Bulletin include three witnessed falls from 2016: Dishchii'bikoh (LL7) from Arizona, USA, weighing 79.46g; Hradec Králové (LL5) from the Czech Republic, weighing 134 g; and Oudiyat Sbaa (EH5) from Western Sahara/Morocco, weighing 23.85 kg. In addition, one classified meteorite from Sri Lanka was changed from a find to a fall: Kalugalatenna (L6), weighing 5 kg.

Revised classifications include status of Elbogen IID iron (changed to a find); mass was corrected for the L6 chondrite from Chile El Médano 098 (1305g) and description for lunar meteorite Sayh al Uhaymir 169 was revised to omit “anorth”.

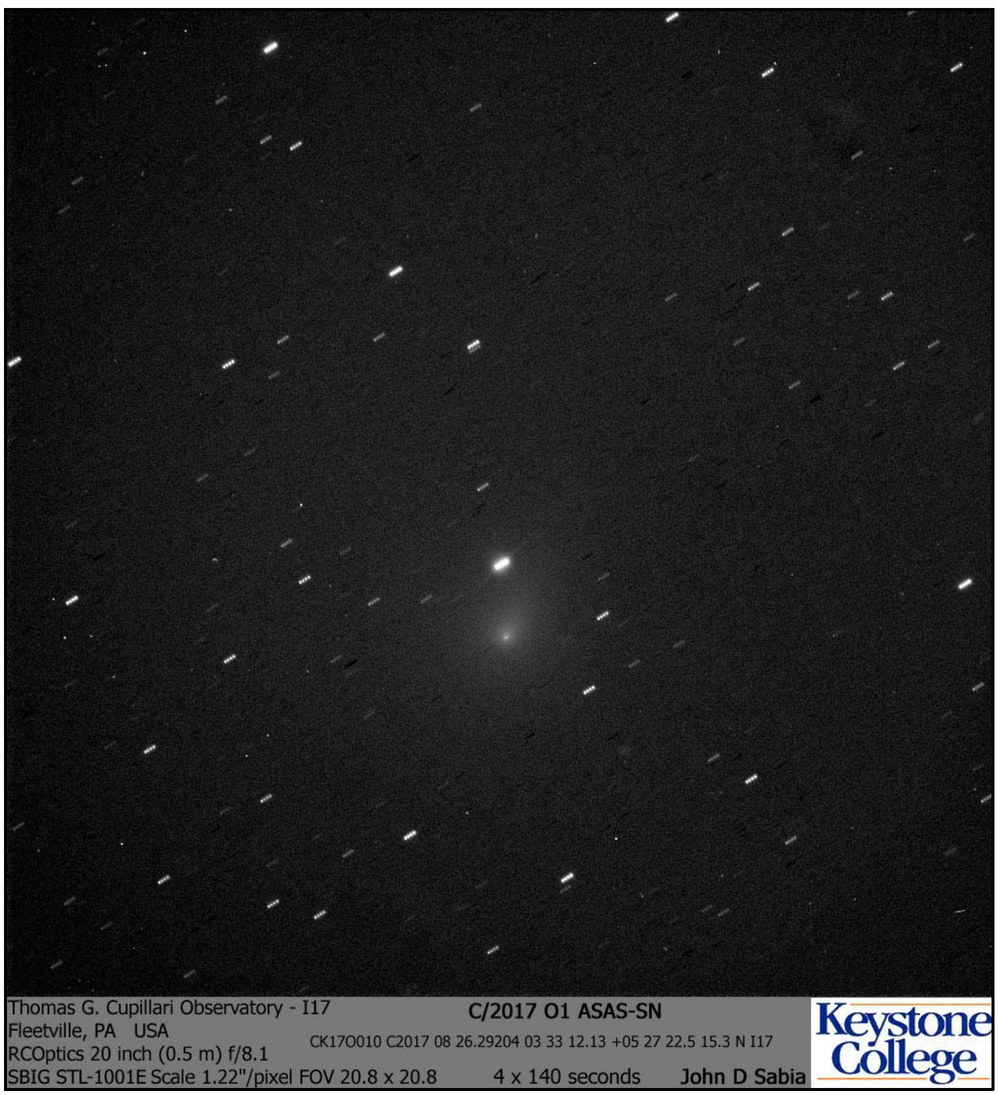
The Dishchii'bikoh (LL7) fireball was witnessed by many observers in the southwest U.S. on June 2, 2016. It is Arizona’s $4^{th}$ recovered fall and is noteworthy in that it fell on White Mountain Apache tribal (WMAT) lands and could not have been recovered without their assistance and authorization. A total of 15 stones totaling 79.46g were recovered with the aid of weather Doppler radar, seismic sensors and other monitors. The first stone found was only 0.93 grams! These have become indispensable tools in the search for fresh falls.

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

### Comets Section

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

The ALPO Comets Section was busy this year with no less than 8 comets becoming brighter than 10th magnitude. The rest of year will be a little slower with no comets guaranteed to get brighter than 10th




John Sabia used a 0.5-m telescope and STL-1001E CCD at the Thomas G. Cupillari Observatory in Fleetville, PA, to image C/2017 O1 on August 26.

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magnitude. A few comets will come close and two may even break 10th magnitude, though by how much is uncertain.

It is possible C/2016 R2 (PANSTARRS) will reach 10th magnitude though it has recently been observed to be fainter than expected. The same can be said for newly discovered C/2017 O1 which may brighten to 7th magnitude but may also be experiencing a temporary outburst and could fade rapidly. Short-period comets 24P/ Schaumasse and 62P/Tsuchinshan are consistent performers and should brighten to between 10th and 11th magnitude and 11th and 12th magnitude, respectively. Another object that will get up to 10th-11th magnitude is the "Rock Comet"3200 Phaethon. This object is the parent of the Geminid meteor shower and will pass within 0.07 au in mid-December. It is not often that one can observe a meteor shower and its parent on the same night. Phaethon's close approach will provide an excellent opportunity to search for any cometary activity.

C/2017 O1 (ASASSN) may be the brightest comet of the second half of 2017. Discovered on July 17 by the All-Sky Automated Survey for Supernovae (ASAS-SN), the comet appears to be experiencing a major outburst to around 10th magnitude. As we go to press, there are still questions as to how bright it will get. If its current 10th magnitude is indicative of its true brightness (and not just the result of a short-lived outburst), the comet may brighten to

**Ephemerides for Comets 24P/Schaumasse, 62P/Tsuchinshan, 96P/Machholz, C/2016 R2 (PANSTARRS), C/2017 O1 and 3200 Phaeton**

| Date | R.A. | Decl. | r (au) | d (au) | Elong (degrees) | m1 | Max El (40°N) | Max El (40°S) |
|---|---|---|---|---|---|---|---|---|
| **24P/Schaumasse** | | | | | | | | |
| 2017 Oct 01 | 09 03.95 | +19 30.4 | 1.350 | 1.645 | 55 | 13.0 | 35 | 5 |
| 2017 Oct 11 | 09 44.68 | +17 42.8 | 1.298 | 1.576 | 55 | 12.1 | 36 | 3 |
| 2017 Oct 21 | 10 25.78 | +15 24.9 | 1.256 | 1.523 | 55 | 11.4 | 36 | 1 |
| 2017 Oct 31 | 11 06.51 | +12 42.0 | 1.226 | 1.487 | 55 | 10.9 | 36 | 0 |
| 2017 Nov 10 | 11 46.22 | +09 42.3 | 1.210 | 1.467 | 54 | 10.6 | 36 | 0 |
| 2017 Nov 20 | 12 24.38 | +06 35.3 | 1.207 | 1.460 | 55 | 10.5 | 36 | 0 |
| 2017 Nov 30 | 13 00.61 | +03 30.6 | 1.219 | 1.463 | 55 | 10.7 | 35 | 0 |
| 2017 Dec 10 | 13 34.68 | +00 35.9 | 1.244 | 1.473 | 56 | 11.1 | 35 | 0 |
| 2017 Dec 20 | 14 06.45 | -02 03.0 | 1.282 | 1.485 | 58 | 11.7 | 35 | 4 |
| 2017 Dec 30 | 14 35.82 | -04 22.6 | 1.330 | 1.497 | 60 | 12.5 | 35 | 8 |
| **62P/Tsuchinshan** | | | | | | | | |
| 2017 Oct 01 | 08 25.56 | +18 41.5 | 1.477 | 1.620 | 63 | 12.6 | 42 | 12 |
| 2017 Oct 11 | 09 00.53 | +17 34.1 | 1.442 | 1.543 | 65 | 12.2 | 44 | 10 |
| 2017 Oct 21 | 09 35.60 | +16 07.9 | 1.415 | 1.475 | 66 | 11.9 | 46 | 9 |
| 2017 Oct 31 | 10 10.32 | +14 26.4 | 1.396 | 1.418 | 68 | 11.6 | 47 | 8 |
| 2017 Nov 10 | 10 44.30 | +12 34.3 | 1.386 | 1.369 | 69 | 11.4 | 49 | 8 |
| 2017 Nov 20 | 11 17.15 | +10 37.3 | 1.384 | 1.328 | 71 | 11.4 | 50 | 8 |
| 2017 Nov 30 | 11 48.49 | +08 41.3 | 1.393 | 1.293 | 73 | 11.4 | 51 | 9 |
| 2017 Dec 10 | 12 18.04 | +06 52.0 | 1.410 | 1.262 | 76 | 11.5 | 51 | 11 |
| 2017 Dec 20 | 12 45.49 | +05 14.4 | 1.435 | 1.234 | 79 | 11.7 | 52 | 14 |
| 2017 Dec 30 | 13 10.54 | +03 52.5 | 1.468 | 1.206 | 83 | 11.9 | 52 | 19 |
| **96P/Machholz** | | | | | | | | |
| 2017 Oct 01 | 13 43.96 | -50 10.6 | 0.848 | 1.015 | 49 | 11.9 | 0 | 24 |
| 2017 Oct 11 | 13 38.87 | -42 15.8 | 0.607 | 0.954 | 36 | 10.0 | 0 | 12 |
| 2017 Oct 21 | 13 30.92 | -28 33.0 | 0.316 | 0.885 | 18 | 6.4 | 0 | 0 |
| **C/2016 R2 (PANSTARRS)** | | | | | | | | |
| 2017 Oct 01 | 05 36.16 | -01 54.9 | 3.462 | 3.097 | 102 | 11.8 | 48 | 50 |
| 2017 Oct 11 | 05 36.83 | -01 18.9 | 3.397 | 2.899 | 111 | 11.6 | 49 | 51 |
| 2017 Oct 21 | 05 35.35 | -00 33.2 | 3.334 | 2.711 | 121 | 11.4 | 49 | 50 |
| 2017 Oct 31 | 05 31.47 | +00 26.6 | 3.273 | 2.536 | 130 | 11.2 | 50 | 50 |
| 2017 Nov 10 | 05 25.04 | +01 44.6 | 3.213 | 2.380 | 141 | 11.0 | 52 | 48 |
| 2017 Nov 20 | 05 16.09 | +03 24.5 | 3.155 | 2.249 | 151 | 10.8 | 53 | 47 |
| 2017 Nov 30 | 05 04.95 | +05 28.0 | 3.099 | 2.149 | 161 | 10.6 | 55 | 45 |
| 2017 Dec 10 | 04 52.29 | +07 54.0 | 3.044 | 2.084 | 164 | 10.4 | 58 | 42 |
| 2017 Dec 20 | 04 39.07 | +10 37.8 | 2.993 | 2.055 | 158 | 10.3 | 61 | 39 |
| 2017 Dec 30 | 04 26.44 | +13 32.5 | 2.943 | 2.063 | 147 | 10.3 | 64 | 36 |
| **C/2017 O1** | | | | | | | | |
| 2017 Oct 01 | 04 23.53 | +34 48.1 | 1.518 | 0.772 | 117 | 7.8 | 85 | 15 |
| 2017 Oct 11 | 04 35.33 | +46 02.7 | 1.507 | 0.732 | 120 | 7.6 | 84 | 4 |
| 2017 Oct 21 | 04 44.73 | +57 21.3 | 1.509 | 0.726 | 121 | 7.6 | 72 | 0 |
| 2017 Oct 31 | 04 49.41 | +67 32.9 | 1.524 | 0.751 | 121 | 7.7 | 62 | 0 |
| 2017 Nov 10 | 04 44.07 | +75 47.5 | 1.552 | 0.801 | 119 | 7.9 | 54 | 0 |
| 2017 Nov 20 | 04 14.55 | +81 43.2 | 1.591 | 0.869 | 117 | 8.2 | 48 | 0 |
| 2017 Nov 30 | 02 52.41 | +85 6.3 | 1.641 | 0.947 | 116 | 8.5 | 45 | 0 |
| 2017 Dec 10 | 00 57.36 | +85 55.9 | 1.699 | 1.033 | 114 | 8.9 | 44 | 0 |
| 2017 Dec 20 | 00 07.54 | +85 31.1 | 1.766 | 1.124 | 113 | 9.2 | 44 | 0 |

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7th-8th magnitude in October. Perihelion occurs on October 14 at 1.51 au from the Sun and closest approach to Earth on October 17 at 0.72 au. At that time, it will also be a northern circumpolar object.

C/2016 R2 (PANSTARRS) doesn't reach perihelion until May 2018 at 2.60 au from the Sun. Extrapolating forward from its brightness in early 2017 suggests the comet may climb to 10th magnitude in December of this year. December also marks the time of its minimum geocentric distance (2.06 au), hence why its peak apparent brightness occurs 5 months prior to perihelion. Predicting the brightness of a new comet months into the future is always problematic. It is very possible that this object may not get as bright as 10th magnitude. Then again it appears to be dynamically old, so perhaps it will brighten faster than expected. Either way, C/2016 R2 is a nice distant comet worth keeping an eye on.

Three short-period comets will be observable between 10th and 12th magnitude.

- 24P/Schaumasse was discovered visually by French astronomer Alexandre Schaumasse in 1911. Its perihelion on Nov 16 at 1.21 au from the Sun will mark its 11th observed return. The comet last passed perihelion in 2009 but no observations were reported for that poorly placed return. The comet has been recovered at 19th magnitude in late July so it is still with us. The comet won't come very close to Earth this time with a minimum geocentric distance of 1.46 au. Schaumasse will be a morning object and should reach magnitude 13 by Oct 1, magnitude 12 by Oct 10, and magnitude 11 by Oct 30 and peak at magnitude 10.5 in late November. It will fade back to magnitude 12.5 by the end of the year.
- The second short-period comet is 62P/Tsuchinshan (Chinese for "Purple Mountain", the observatory were it was discovered photographically in 1965). This year marks its 9th observed return. Similar to Schaumasse, 62P was not seen during its previous return. This year, it should reach magnitude 11.5 in mid-November. Schaumasse and Tsuchinshan are both morning objects and will be located within 10-20 degrees of each other during October and November. Tsuchinshan reaches perihelion on Nov 16 at 1.38 au when it will be 1.34 au from Earth.
- The last short-period comet is one of former ALPO Comet Section coordinator Don Machholz's discoveries. 96P/Machholz will not be visible to northern observers this time around, but southern observers will have a short window of opportunity to see it in early October before it moves too close to the Sun. For a few days around its October 27 perihelion (q = 0.12 au), the comet should be visible in the LASCO C3 coronographic instrument on the SOHO spacecraft. During the last apparition in 2012, SOHO detected at least 2 secondary components of 96P. It will be interesting to see if new components are visible this time. The breaking up is not new for 96P as it is a member of a large family of related objects including asteroid 2003 EH1, the Marsden and Kratcht family of sun-skimming comets, and the Southern d-Aquariid, Daytime Arietid and Quadrantid meteor showers.

**Ephemerides for Comets 24P/Schaumasse, 62P/Tsuchinshan, 96P/Machholz, C/2016 R2 (PANSTARRS), C/2017 O1 and 3200 Phaeton (Continued)**

| 3200 Phaeton | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Date | R.A. | Decl. | r (au) | d (au) | Elong (degrees) | m1 | Max El (40°N) | Max El (40°S) |
| 2017 Nov 15 | 07 06.13 | +35 37.8 | 1.455 | 0.622 | 127 | 15.8 | 86 | 14 |
| 2017 Nov 20 | 07 04.88 | +36 18.4 | 1.395 | 0.522 | 132 | 15.3 | 86 | 13 |
| 2017 Nov 25 | 07 00.56 | +37 14.5 | 1.332 | 0.423 | 138 | 14.6 | 87 | 13 |
| 2017 Nov 30 | 06 50.83 | +38 36.3 | 1.266 | 0.327 | 144 | 13.9 | 89 | 11 |
| 2017 Dec 05 | 06 29.46 | +40 44.1 | 1.196 | 0.234 | 151 | 12.9 | 89 | 9 |
| 2017 Dec 10 | 05 34.08 | +44 06.3 | 1.122 | 0.146 | 158 | 11.6 | 86 | 6 |
| 2017 Dec 15 | 02 25.93 | +41 25.2 | 1.043 | 0.078 | 137 | 10.7 | 87 | 10 |
| 2017 Dec 20 | 22 29.50 | +00 49.6 | 0.960 | 0.089 | 71 | 13.0 | 38 | 10 |
| 2017 Dec 25 | 21 13.47 | -17 33.8 | 0.870 | 0.163 | 42 | 16.1 | 14 | 4 |

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The final object is not really a comet in the traditional sense. Asteroid 3200 Phaethon is the parent body of the Geminid meteor shower. Whether the shower was produced by cometary activity or a series of splitting events, the Geminids are now one of the strongest annual showers. Recently Phaethon has been observed to display comet-like activity around perihelion. Due to intense heating (perihelion is 0.14 AU from the Sun or 7 times closer than the Earth is) some of the rocks on the surface may have fractured producing a cloud of dust which was knocked off the surface by solar radiation pressure. In effect, it is a acting like a "rock comet". Still these sort of events are very short-lived and produce a minimal amount of debris, hence they are not large enough to create the Geminids by themselves. The ephemeris table contains dates between November 15 when it will be magnitude 15.8 through its close approach on December 17 at 0.07 au (peak brightness is at V = 10.7 on December 15) and the very end of the year when it will be too close to the Sun for easy observation.

Over the past three months, the Comet Section received comet magnitude estimates for comets 41P/Tuttle-Giacobini-Kresak, 71P/ Clark, C/2015 ER61 (PANSTARRS) and C/2015 V2 (Johnson) from Salvador Aguirre, Carl Hergenrother, John Sabia and Willian Souza over the past three months.

CCD images were also received for comets (457175) 2008 GO98, 45P/ Honda-Mrkos-Pajdusakova, 71P/ Clark, C/2015 ER61 (PANSTARRS) and C/2015 V2 (Johnson) from Gianluca Masi, Richard Owens, Efrain Morales Rivera, John D. Sabia, Chris Schur and Michael Schwartz.

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

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

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

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

### *Solar Section*

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

Solar activity continues at a low level with a few notable exceptions (like ARs 2673 and 2674!). We had one new member this last quarter: Christian Viladrich in Nattages, France. We welcome his excellent imaging and hope he will teach us all by example!

Theo reports that as of July 4, the ALPO Solar Section Archive contained nearly 34,135 reports and images in 516 folders. For the period reported on in this Journal (CR 2188 through CR2190), 1,172 images had been submitted, And 975 of those by e-mail (to *solarimages@alpo-astronomy.org*) and uploaded by the staff after filenames were modified to conform with our standard image nomenclature while others were uploaded by the members themselves who complied with this standard.

Also, thanks to the work of Theo Ramakers, assistant coordinator of this section, the ALPO Solar Section Archive now has a folder for eclipse images and it is filling up fast, however we need more observations from Casper, WY! For the thousands of people there for the Astronomical League meeting, hundreds of whom were imaging, only one observer has so far submitted anything…my own humble self.

In addition to the above, Theo continues to provide the short activity summaries for each Carrington Rotation on the ALPOSS website, as well as on the ALPO-Facebook page. These give observers and people just interested in the Sun a quick look at activity just past.

Pam Shivak continues to do regular postings of solar observations and news on FaceBook page SOLARACTIVITY (that she co-owns and manages with John O'Neal). Besides getting settled in her new home in Florida (and hurricane watching!) with Randy, her husband, she has had her hands full with

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eclipse articles and observations that people are posting. During the eclipse, she was in Idaho and handed out NASA materials as a NASA/JPL Solar System Ambassador.

Rick Gossett maintains the e-mail list where members can post daily observations and images. All are again invited to do so and should add their solar observations to the ALPO Solar Section Archive by e-mailing them to: *solarimages@alpo-astronomy.org*.

So thanks to all these efforts Solar Section observers have four avenues to promulgate their images with the ALPO, through the Solar Section Archive, the Solar Section email list, the ALPO FaceBook page and the Solar Activity Face Book page!

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

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

### Mercury Section

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

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

### Venus Section

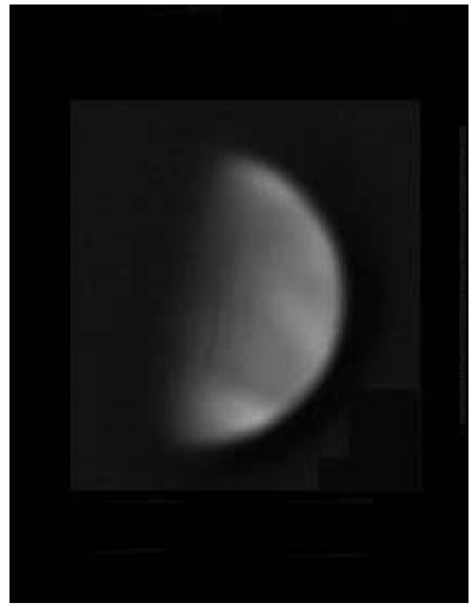
**Report by Julius Benton, section coordinator**
*jlbaina@msn.com*

Venus remains in the morning sky before dawn having reached greatest elongation west of 46° back on June 3, 2017 just a day before theoretical dichotomy on June 4th. During the current 2017-18 Western (Morning) Apparition observers are witnessing Venus as it passes 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 by the time it reaches superior conjunction on January 9, 2018.

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

During the 2017-18 Western (Morning) Apparition, observers have found it useful to wait until the planet gains altitude and the background sky has brightened a bit, allowing Venus to be followed into daylight. It is often desirable to observe Venus during daylight hours when most of the prevailing glare associated with the planet is gone or reduced, but observing Venus too far into the daylight hours can become a problem as solar heating produces turbulent air and poor seeing.

While it may seem difficult to look for Venus in daylight, it should be recalled that the planet is relatively



Frank J. Melillo of Holtsville, NY submitted this excellent UV image taken at 13:05 UT on June 25, 2017 employing at a 25.4 cm (10.0 in.) SCT in good seeing conditions (S=6.0). This image depicts a shaded and slightly irregular terminator with hints of horizontal V, Y, or ψ (psi)-shaped dusky clouds that are frequently aligned along the planet's equator at UV wavelengths. The south cusp and cusp band is visible, as well as a brighter region toward the northern cusp area along the northern limb. The apparent diameter of Venus is 19.2", gibbous phase (k) 0.604 (60.4% illuminated), and visual magnitude -4.1. South is at top of image.

**Geocentric Phenomena of the 2017-18 Western (Morning) Apparition of Venus in Universal Time (UT)**

| | | |
|---|---|---|
| Inferior Conjunction | 2017 | Mar 25$^d$ 10$^h$ (angular diameter = 59.8 arc-seconds) |
| Greatest Illuminated Extent | | Apr 30 04 UT ($m_v$ = –4.8) |
| Greatest Elongation (West) | | Jun 03 13 (46°) |
| Predicted Dichotomy | | Jun 04.26 (Venus is predicted to be exactly half-phase) |
| Superior Conjunction | 2018 | Jan 09 10 (angular diameter = 9.7 arc-seconds) |

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bright and in practice, the observer can usually find Venus if knowledge of exactly where to look is obtained before the observing session. It is worth mentioning that observers find that the presence of a slight haze or high cloud often stabilizes and reduces glare conditions while improving definition.

So far this apparition, observers have submitted a considerable number of well-executed visual drawings and digital images of Venus taken in integrated light, with color filters, and at UV wavelengths.

Regular readers of this Journal are probably acquainted with our on-going collaboration with professional astronomers as exemplified by our sharing of visual observations and digital images at various wavelengths during ESA's Venus Express (VEX) mission that began in 2006 and ended in 2015. It was a tremendously successful Pro-Am effort involving ALPO Venus observers around the globe. Despite the fact that the mission has already concluded, it is still not too late during 2017-18 for those who want to send their images to the ALPO Venus Section and the VEX website (see below) to do so. These observations remain important for further study and will continue to be analyzed for several years to come as a result of this endeavor.

The VEX website is at:

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

A follow-up effort on Pro-Am effort is underway with Japan's (JAXA) *Akatsuki* mission that began full-scale observations back in April 2016, and although the mission is continuing in 2017-18, the website for *Akatsuki* mission has "gone live" so that interested and adequately equipped ALPO observers can register and start submitting images.

More information will emerge in forthcoming reports in this Journal.

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

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

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

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

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

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

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

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

Venus observers should monitor the dark side of Venus visually for the Ashen Light and use digital imagers to capture any illumination that may be present on the plane as a cooperative simultaneous observing endeavor with visual observers. Also, observers should undertake imaging of the planet at near-IR wavelengths (for example, 1,000 nm), whereby the hot surface of the planet becomes

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**Lunar Calendar for October thru December 2017**

| | | | |
|---|---|---|---|
| Oct | 05 | 18:40 | Full Moon |
| | 09 | 05:51 | Moon Perigee: 366900 km |
| | 09 | 18:05 | Moon-Aldebaran: 0.6° S |
| | 11 | 18:21 | Moon Extreme North Dec.: 19.6° N |
| | 12 | 12:25 | Last Quarter |
| | 15 | 10:54 | Moon-Regulus: 0.2° S |
| | 17 | 10:04 | Moon-Mars: 1.9° S |
| | 18 | 00:21 | Moon-Venus: 2.1° S |
| | 19 | 19:12 | New Moon |
| | 24 | 11:54 | Moon-Saturn: 3.6° S |
| | 25 | 02:25 | Moon Apogee: 405200 km |
| | 25 | 18:13 | Moon Extreme South Dec.: 19.7° S |
| | 27 | 22:22 | First Quarter |
| Nov | 04 | 05:23 | Full Moon |
| | 06 | 00:09 | Moon Perigee: 361400 km |
| | 06 | 02:19 | Moon-Aldebaran: 0.7° S |
| | 08 | 01:28 | Moon Extreme North Dec.: 19.8° N |
| | 10 | 20:37 | Last Quarter |
| | 10 | 22:40 | Moon Ascending Node |
| | 11 | 16:07 | Moon-Regulus: 0.4° S |
| | 15 | 00:40 | Moon-Mars: 3.4° S |
| | 18 | 11:42 | New Moon |
| | 21 | 00:34 | Moon-Saturn: 3.3° S |
| | 21 | 18:52 | Moon Apogee: 406100 km |
| | 22 | 02:06 | Moon Extreme South Dec.: 20° S |
| | 26 | 17:03 | First Quarter |
| Dec | 03 | 13:00 | Moon-Aldebaran: 0.8° S |
| | 03 | 15:47 | Full Moon |
| | 04 | 08:42 | Moon Perigee: 357500 km |
| | 05 | 11:43 | Moon Extreme North Dec.: 20° N |
| | 08 | 22:25 | Moon-Regulus: 0.7° S |
| | 10 | 07:51 | Last Quarter |
| | 13 | 16:27 | Moon-Mars: 4.5° S |
| | 14 | 14:26 | Moon-Jupiter: 4.7° S |
| | 18 | 06:31 | New Moon |
| | 19 | 01:27 | Moon Apogee: 406600 km |
| | 19 | 09:31 | Moon Extreme South Dec.: 20.1° S |
| | 26 | 09:20 | First Quarter |
| | 31 | 00:25 | Moon-Aldebaran: 0.7° S |

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

apparent and occasionally mottling shows up in such images attributable to cooler dark higher-elevation terrain and warmer bright lower surface areas in the near-IR.

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

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

### *Lunar Section*

*Lunar Topographical Studies / Selected Areas Program*

**Report by Wayne Bailey, program coordinator**
*wayne.bailey@alpo-astronomy.org*

The ALPO Lunar Topographical Studies Section (ALPO LTSS) received a total of 59 new observations from 12 observers during the April-June quarter.

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

The *Focus-On* series continued, under Jerry Hubbell, with an article on Concentric Craters. Upcoming *Focus-On* subjects will be Messsier & Messier A-Oblique Craters, and Lunar Domes

Beginning in November, the *Focus-On* series will include discussions of observing and analysis techniques in addition to concentrating on specific targets.

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A descriptive article is planned for the September issue of *The Lunar Observer*.

Thanks to Assistant Coordinator Bill Dembowski, *The Lunar Observer* now includes lunar libration diagrams at 5 day intervals. These should be useful for planning near limb observations.

All electronic submissions should now be sent to both me and Assistant Coordinator Jerry Hubbell (*jerry.hubbell@alpo-astronomy.org*). Hard copy submissions should continue to be mailed to me.

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

### *Lunar Meteoritic Impacts*

**Brian Cudnik, program coordinator**
*cudnik@sbcglobal.net*

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

### *Lunar Transient Phenomena*

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

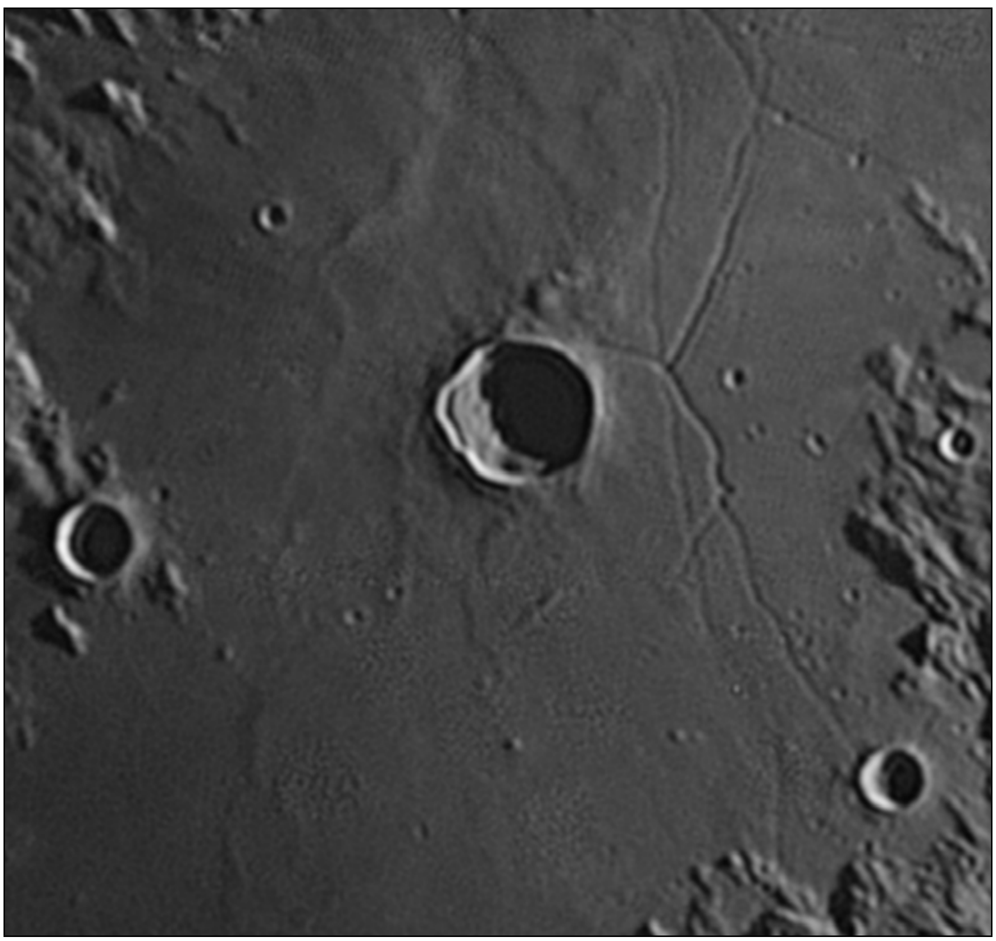
Only one LTP has been detected so far this year, and my thanks to Alexandre Amonrim for alerting me to this report:

West of Herodotus: 2017 Feb 08 at 01:45 UT Antonio Martini Jr (Botucatu, Sao Paulo, Brazil), using a 10" SCT & ASI 120 MC camera (with IR filter), noticed on the computer screen a 0.5-second duration flash of a relative brightness of 7 to Aristarchus (10) and the blackness of the terminator (0). Unfortunately he was not recording at the time, but noted its position to be at 23.5N, 54.5W. This has been assigned an ALPO/BAA weight of 2.

We welcome new observers, whether they are experienced visual observers, or high resolution lunar imagers, in order to solve some past historical lunar observational puzzles.

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

Finally, please visit the ALPO Lunar Transient Phenomena site online at



From the October issue of *The Lunar Observer* newsletter, an image of a lunar dome near Triesnecker taken by Rik Hill of Tucson, AZ, on June 13, 2016, 02:36 UT. Equipment specs, Celestron C-14 (35-cm) SCT, Wratten 21 filter, SPC900NC webcam. North/up, east/right. The image is one of many included in an article about lunar domes.

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http://users.aber.ac.uk/atc/alpo/ltp.htm

### Mars Section

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

The 2017-2019 perihelic apparition of Mars is now underway, the best since 2003. Look for an introductory article about this apparition in this issue of your Journal.

With the new apparition in progress, please join more than 1,400 interested persons on the Yahoo Mars observers list at https://groups.yahoo.com/neo/groups/marsobservers/info .

Be sure to browse the posted observations of other observers while you are there. When you make an observation, please either share it with the group by posting it in the photos section of the Yahoo list, or send it directly to me at rjvmd@hughes.net

Also, drop in to the Mars Section online and explore the Mars Section's recent observations at www.alpo-astronomy.org/mars . Be sure to check out the Mars Observers' Cafe — look for the link in the list on the right side of the Mars page on the ALPO website.

### Minor Planets Section

**Frederick Pilcher, section coordinator**
pilcher35@gmail.com

A reprint of the paper "319 Leona and 341 California – Two Very Slowly Rotating Asteroids", which was first published in the *Minor Planet Bulletin*, Volume 44, No. 2, 2017 April-June, appears later in this Journal.

Its re-publication here is meant to demonstrate the good work being done by the ALPO Minor Planets Section and to inspire and recruit others to likewise participate.

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

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

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

### Jupiter Section

**Report by Ed Grafton, section coordinator**
ed@egrafton.com

Jupiter Section Assistant Coordinator John McAnally is coordinating central meridian (CM) transit timings of Jupiter's atmospheric features. Measuring CM transit times is an excellent way to become familiar with Jupiter's features and adds to the data base of when particular features or visible. Transit timing observations may be sent to John directly at CPAjohnM@aol.com

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

### Galilean Satellite Eclipse Timing Program

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

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

### Saturn Section

**Report by Julius Benton, section coordinator**
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Saturn reached opposition back on June 15, 2017, when it became reasonably well-placed for viewing and digital imaging despite its southerly declination of about -22° for northern hemisphere observers. The 2016-17 apparition of Saturn continues throughout the fall as it progresses toward conjunction with the Sun on December 21, 2017.

The accompanying Table of Geocentric Phenomena for the 2016-17 Apparition in Universal Time (UT) is included here for the convenience of observers.

## *Inside the ALPO*

# Member, section and activity news

Detailed image of Saturn taken by Christopher Go of Cebu City, The Philippines, on June 14, 2017 at 14:55 UT, roughly a day before opposition that occurred on June 15, 2017. His RGB image was captured in excellent seeing using a 35.6 cm (14.0 in.) SCT. His image shows small white spots within the NTrZ as well as numerous other belts and zones in Saturn's northern hemisphere. Easily seen is Cassini's division (A0 or B10) clearly running all the way around the circumference of the rings except where the globe blocks our view of the rings. Also visible are Keeler's gap (A8) and Encke's “complex” (A5), as well as other “intensity minima” at the ring ansae. The north polar hexagon is clearly shown. The Seeliger “opposition effect” is quite obvious, which is a ring-brightening due to coherent back scattering of sunlight by μ-sized, icy particles in the rings that scatter light far more efficiently than the particles of Saturn's atmosphere. Seeing = 9.0 and Tr = 5.0 on the usual ALPO rating scales. The apparent diameter of Saturn's globe was 18.3" with a ring tilt of +26.6º. CMI = 259.1°, CMII = 174.2°, CMIII = 340.6°. S is at the top of the image.

As of this writing, the ALPO Saturn Section has received numerous images of Saturn at visual and infrared wavelengths. Observers are continuing to report and image discrete atmospheric phenomena in Saturn's northern hemisphere atmosphere, such as a white spot at saturnigraphic latitude +6.5° EZn (northern half of the Equatorial Zone), as well as a small white spot in the NEBZ (North Equatorial Belt Zone) at +24.0°, both best seen in images at 685nm IR wavelength, plus several small recurring white spots in the NTrZ (North Tropical Zone) and NTeZ (North Temperate Zone). Observers have also imaged a vague diffuse dark spot within the Equatorial Belt (EB). As the apparition winds down toward conjunction, it will be extremely worthwhile to continue to monitor the aforementioned features and determine their longevity and limits of visibility. Observers are also alerted to be watchful for any new atmospheric phenomena that might suddenly appear. With the rings now reaching a maximum of +27° toward our line of sight from Earth by mid-October 2017, observers have been experiencing near-optimum views of the northern hemisphere of the globe and north face of the rings during the 2016-17 apparition.

Pro-Am cooperation with the Cassini mission has continued during the 2016-17 apparition as NASA's unprecedented close-range surveillance of the planet for nearly 13 years, which started back on April 1, 2004, entered the final year of its epic voyage this observing season. By the time this report appears, the Cassini spacecraft will have already concluded its remarkable odyssey on September 15, 2017 when it will have plunged into Saturn's atmosphere.

**Geocentric Phenomena for the 2016-17 Apparition of Saturn in Universal Time (UT)**

| | |
|---|---|
| Conjunction | 2016 Dec 10$^d$ UT |
| Opposition | 2017 Jun 15$^d$ |
| Conjunction | 2017 Dec 21$^d$ |
| **Opposition Data:** | |
| Equatorial Diameter Globe | 18.3 arc-seconds |
| Polar Diameter Globe | 16.3 arc-seconds |
| Major Axis of Rings | 41.5 arc-seconds |
| Minor Axis of Rings | 18.5 arc-seconds |
| Visual Magnitude ($m_v$) | 0.0 |
| B = | +26.5° |
| Declination | -22.0° |
| Constellation | Ophiuchus |

## Inside the ALPO
# Member, section and activity news

For years to come, however, planetary scientists will be carefully studying the vast database of images and data gleaned from the Cassini mission, and ALPO Saturn observers who have been participating in our on-going Pro-Am activities are reminded that observations and images obtained prior to the time the spacecraft entered Saturn's atmosphere should be submitted for comparative analysis with Cassini results.

Moreover, our conscientious Pro-Am efforts will not cease hereafter as we regularly monitor atmospheric phenomena on Saturn and actively share our results and images with the professional community. Thus, anyone else who wants to join us in our observational endeavors are highly encouraged to submit systematic observations and digital images of the planet at various wavelengths throughout the remainder of 2016-17 apparition as well as during the next observing season.

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

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

The ALPO Saturn Section thanks all observers for their dedication and perseverance in regularly submitting so many excellent reports and images. *Cassini* mission scientists, as well as other professional specialists, continue to request drawings, digital images, and supporting data from amateur observers around the globe in an active Pro-Am cooperative effort.

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

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

### Remote Planets Section

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

Uranus and Neptune will be well-placed in the late evening sky in October. Uranus will reach opposition in mid-October and Neptune will have just passed its early September opposition date. The best way to find each planet is to either use a GPS mount or to star-hop. When I star-hop, I use a star chart and binoculars.

I am currently writing the 2016-17 Remote Planets apparition report and hope to send it to the editor of this Journal by early fall. Marc Delcroix has already recorded the first images of Uranus and Neptune for the 2017-18 apparition, recording albedo features on both planets. If you record images of Uranus and Neptune, be sure to include at least one moon in one of the images so that one can properly orient the image.

This section coordinator also carried out V-filter brightness measurements of Uranus on July 14, 2017. The data suggests that Uranus is growing a little brighter.

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

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

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

### Feature Story: ALPO Solar Section

# A Report on Carrington Rotations 2188 through 2190 (2017 03 06.0597 to 2017 05 26.8542)

**By Richard (Rik) Hill,**
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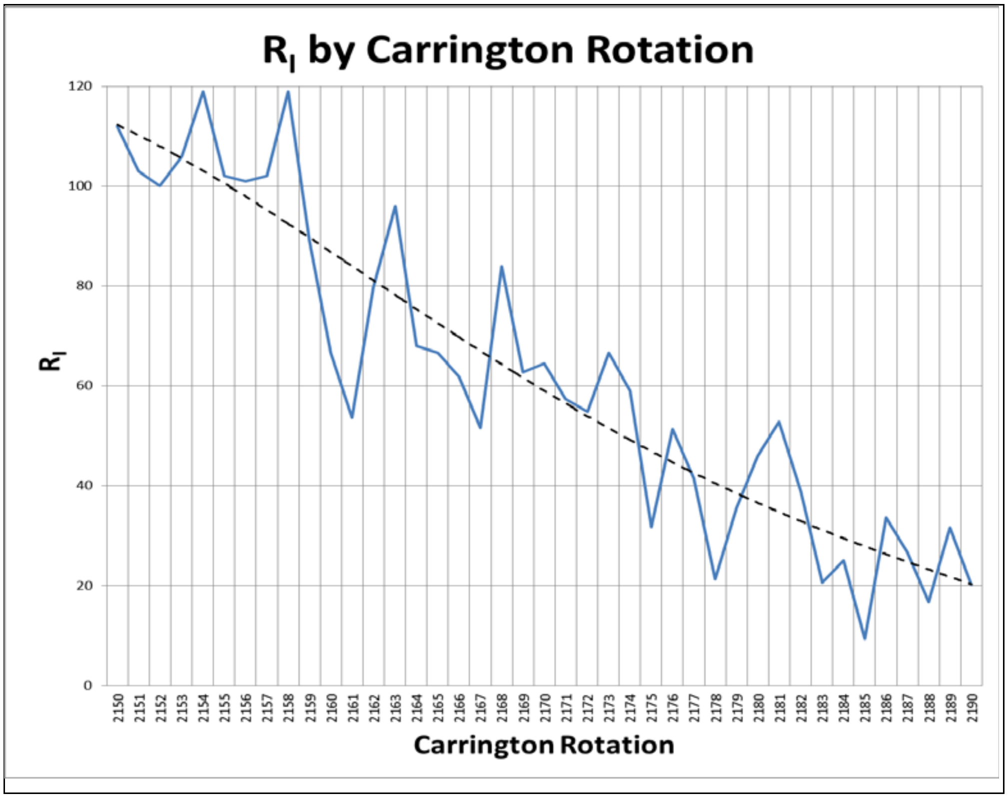
**ALPO Solar Section**
*rhill@lpl.arizona.edu*

## Overview

Solar activity continued to decline in this reporting period, though at a slower pace than a year or two ago. Plot 1 shows the activity for the last 40 rotations, that is, from 2014 05 04.61528 to the end of this report. A third order polynomial trendline has been plotted through the data, demonstrating how the activity has been, for the most part, declining the whole time, but has begun to flatten out towards a minimum. Predicted minimum is now sometime around 2020. The last minimum (in 2008) was very low, with 266 spotless days in that year (Spaceweather.com). The current cycle, Cycle 24, is the smallest cycle since Cycle 14 (1901-12). The maximum-smoothed sunspot number for the current cycle was 116.4 in Apr. 2014 (NASA-Marshall Space Flight Center).

This reporting period saw only two regions that were large, AR2644 and 2645, but even these did not attain naked-eye visibility (with proper solar filtration).




## Terms and Abbreviations Used In This Report

This short section is similar to the same in earlier reports but should be at least briefly scanned. As always, the ALPO Solar Section will be referred to as "the Section" and Carrington Rotations will be called "CRs". Active Regions are designated by the National Oceanic and Atmospheric Administration (NOAA) and will refer to all activity in all wavelengths for that region and will be abbreviated "AR" with only the last four digits of the full number being used. The term "groups" refers to the visible light or "white light" sunspots associated with an active region. Statistics compiled by the author have their origin in the finalized daily International Sunspot Number data published by the WDC-SILSO (World Data Center - Solar Index and Long Term Solar Observations) at the Royal Observatory of Belgium. All times used in this report are Coordinated Universal Time and dates are reckoned from that. Dates will be expressed numerically with month/day such as "9/6" or "10/23". Carrington Rotation commencement dates are from the table listed on the Section web page on the ALPO website under the link "Solar Ephemerides and Rotations" located in the sidebar on the right side of the screen.

The terms "leader" and "follower" are used here instead of "east" or "west" on the Sun to avoid confusion. The abbreviation to indicate white-light observations is "w-l", while hydrogen-alpha is "H-a" and calcium K-line is "CaK". Though there were no reports of naked-eye sunspots during this period, it is nevertheless important to point out that this term means the ability to see a feature on the Sun through **proper and safe** solar filtration with no other optical aid. You should never look at

**Table 1. Contributors to This Report**

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

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

the Sun, however briefly, without such filtration. Orientation of images shown here will be north up and celestial west to the right (northern hemisphere chauvinism). The cardinal directions (north, south, east and west) will often be abbreviated as N, S, E, and W.

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 modified Zurich classifications used here are the ones defined by Patrick McIntosh of National Oceanic and Atmospheric Administration (referred to in this report as "NOAA") (McIntosh 1981, 1989) and detailed in an article in the JALPO Volume 33 (Hill 1989). This classification system is also detailed by the author on the Section website at: *http://www.alpo-astronomy.org/solarblog/?page_id=200* in an article on white light flare observation. Lastly, the magnetic class of regions is assigned by NOAA and will be abbreviated as "mag. class".

Included here is a table of Section observers, most of whom contributed to this report. The table summarizes their modes of observing as well as their locations. It will be used as a reference throughout this report rather than repeating this information on every image or mention.

## References

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

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

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

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

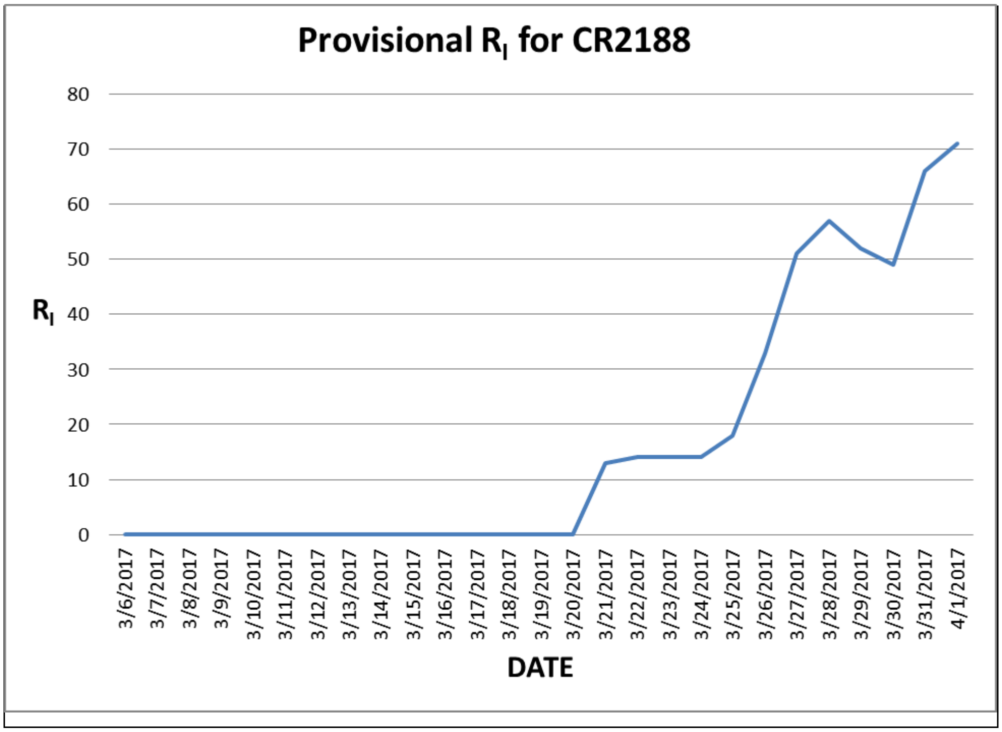
Additional references used in the preparation of this report:

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

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

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

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




## Carrington Rotation 2188

### *Dates: 2016 12 14.0521 to 2017 01 10.3840*

Avg. $R_I$= 9.4
High $R_I$ = 30 (12/21)
Low $R_I$ = 0 (11 days)

This report begins with a rotation with the lowest average RI since CR2185. The first 15 days of the rotation had no spots at all. Still this was the rotation that produced the most activity of the report.

AR 2644 was first listed on the disk on 3/26 but Teske was first to note it in his w-l observation the day before at 20:00 UT and was shortly followed by an H-a observation by Leventhal at 21:25 UT, listing it as an Aax group. Grassmann and Ty had recorded activity in H-a at the site that would become this active region several days before it was designated.

On the 26th, AR 2644 was a Dao group of 50 millionths and had already produced around 20 flares. Ramakers made a good w-l timeline of this region showing its odd evolution (Figure 1). On this date, the leader was a line of spots with all the umbrae elongated in the direction of the line, with no clear penumbra. This was followed by an irregular umbra with a small bit of rudimentary penumbra and a scattering of pores and umbral bits between. At 15:12 UT, he caught the region in flare in H-a (Figure 2).

The next day, 3/27, the leader was consolidating and becoming round with a nicely organized radial penumbra and the remnants of that line of spots following like a tail pointing back at the follower spot. The follower spot was now two larger umbrae in a fairly regular radial penumbra and a tail of spots to the N pointing to the leader. The class was now Dai, with an area of 150 millionths (mag. class beta-gamma). Flare production was about one every two hours. This was well-shown in a Tyler w-l and H-a image pair where the H-a image shows the complex interaction between the spots and their "tails" where the flaring was taking place.

Over the next few days, the two spots became more circular and lost their tails. The penumbrae were now very regular, radially organized as shown in another Tyler w-l/H-a montage (Figure 3). The area peaked at 240 millionths with a class of Dsi on the 29th, the day of central meridian passage, but the mag. class dropped to beta as AR 2645 now became the major flare producer on the disk. On the 30th, the class was Eso with slightly decreased area. This situation held as AR 2644 headed for the limb. An Eskildsen w-l image on 4/1 showed it to be an Eao sunspot group (mag. class beta) of 190 millionths that was decreasing in area

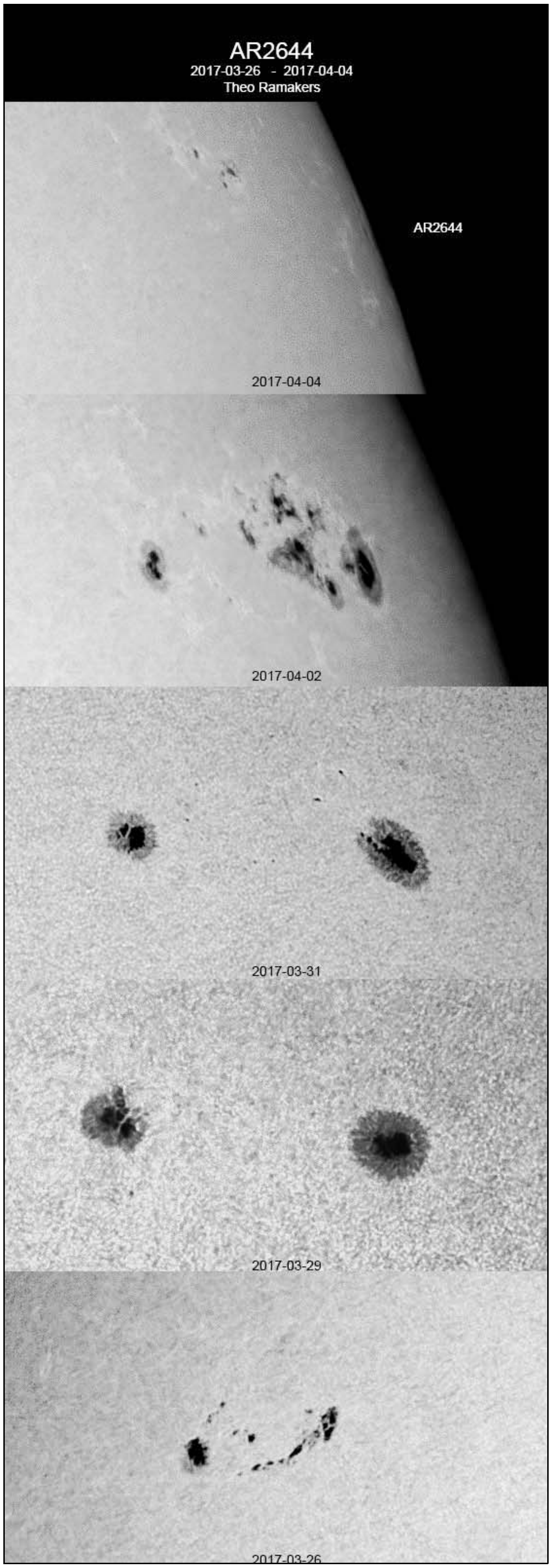



Figure 1 - Multi-day composite of AR2644 from 3/26-4/4, by Ramakers. Dates shown on the individual panes.

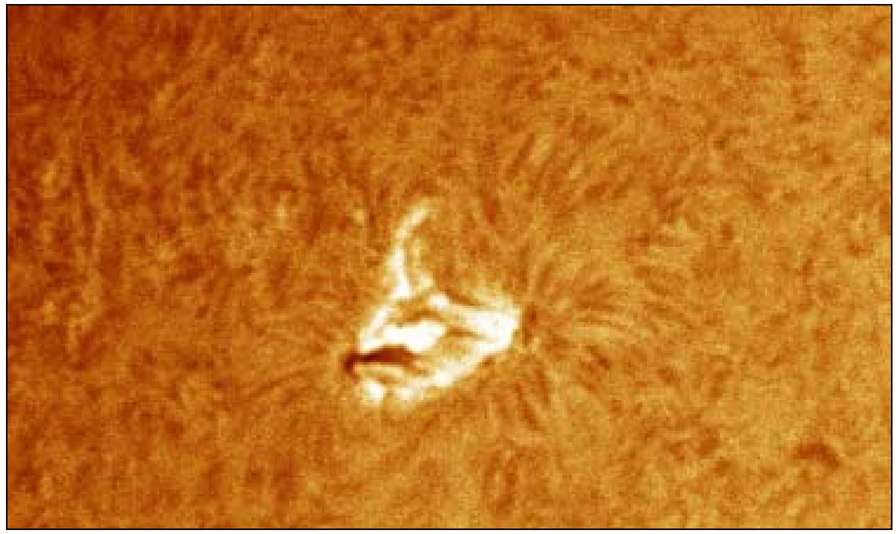


Figure 2 - AR 2644 in H-a showing flares by Ramakers on 3/26 at 15:12 UT.

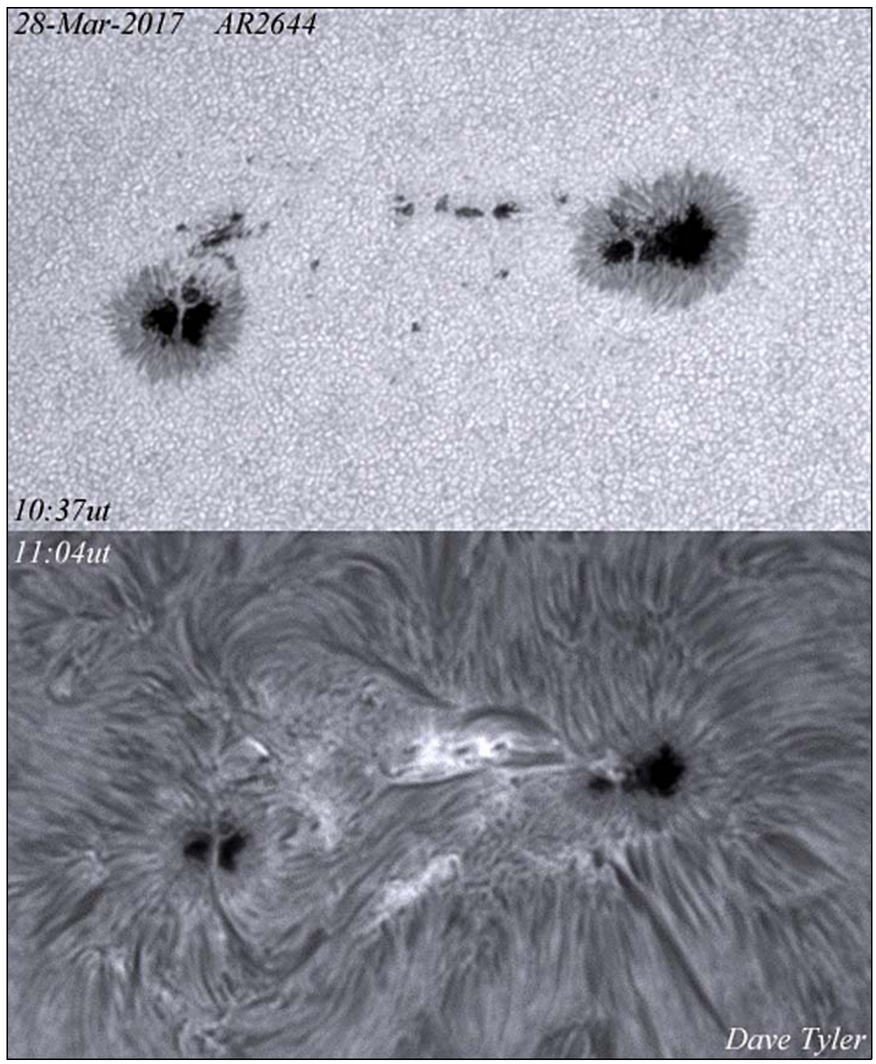



Figure 3 - AR 2644 in w-l (above) and H-a (below) by Tyler at the times shown on the images.

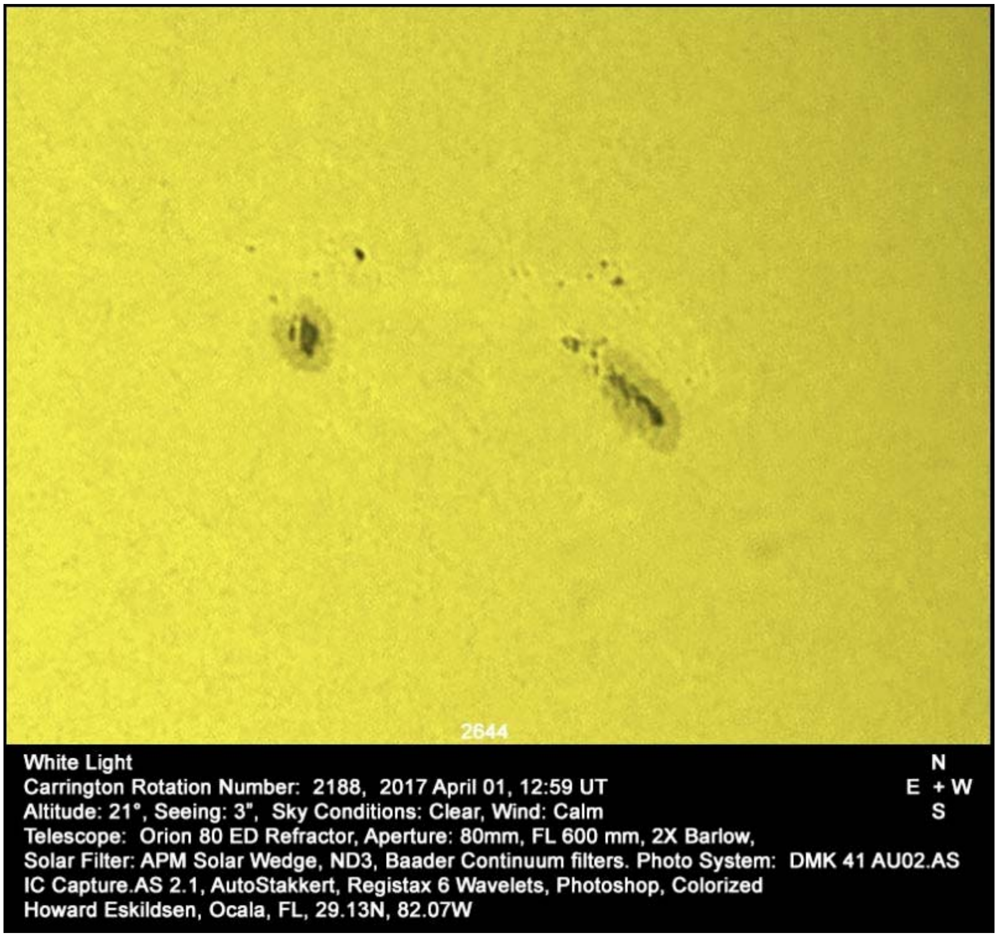



Figure 4 - W-L view of AR2644 by Eskildsen on 4/1 at 12:59 UT.

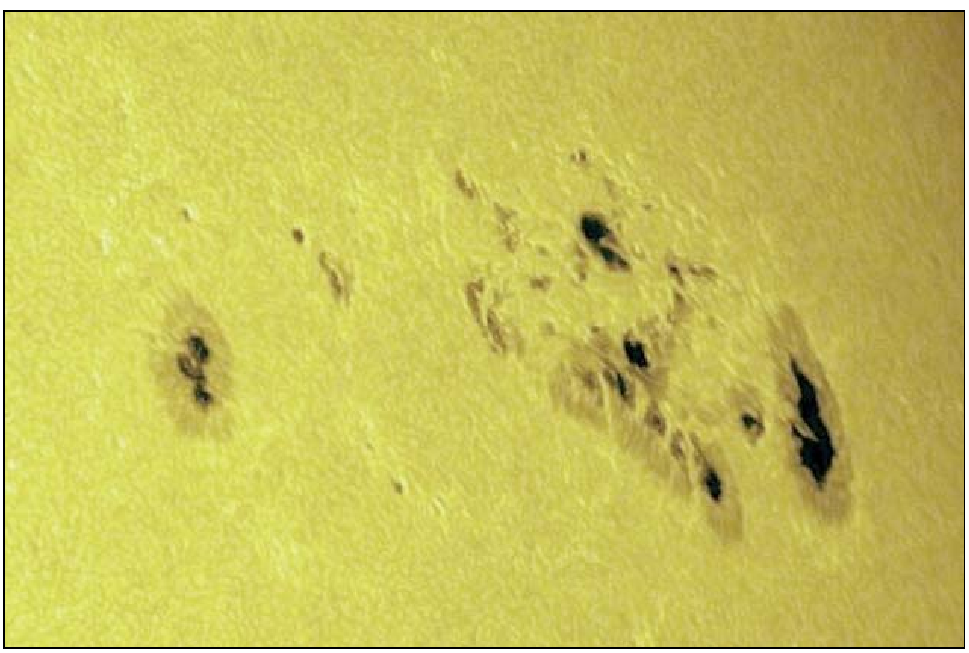


Figure 5 - AR 2644 near the limb by Tyler on 4/2 at 13:20 UT.

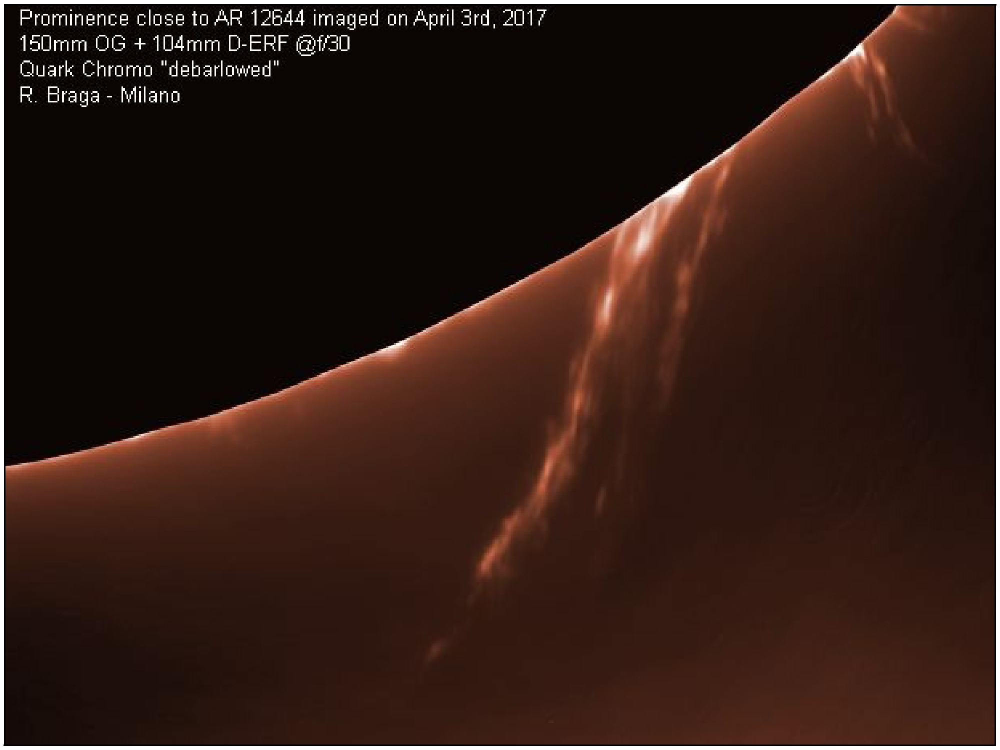



Figure 6 - Large prominence over AR 2644 by Braga on 4/3 at 15:45 UT.

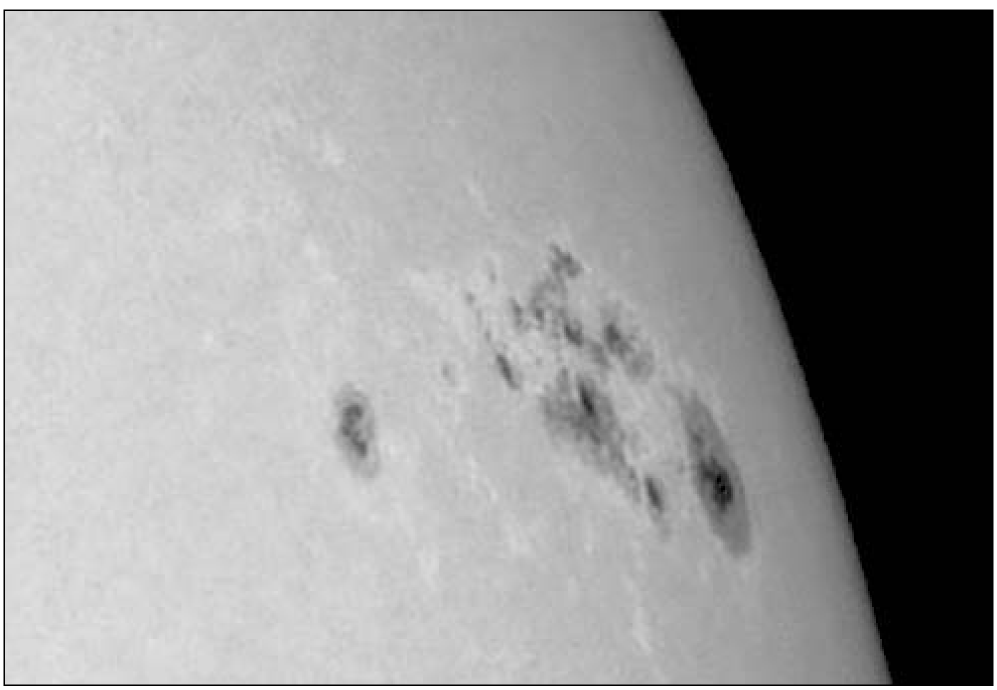
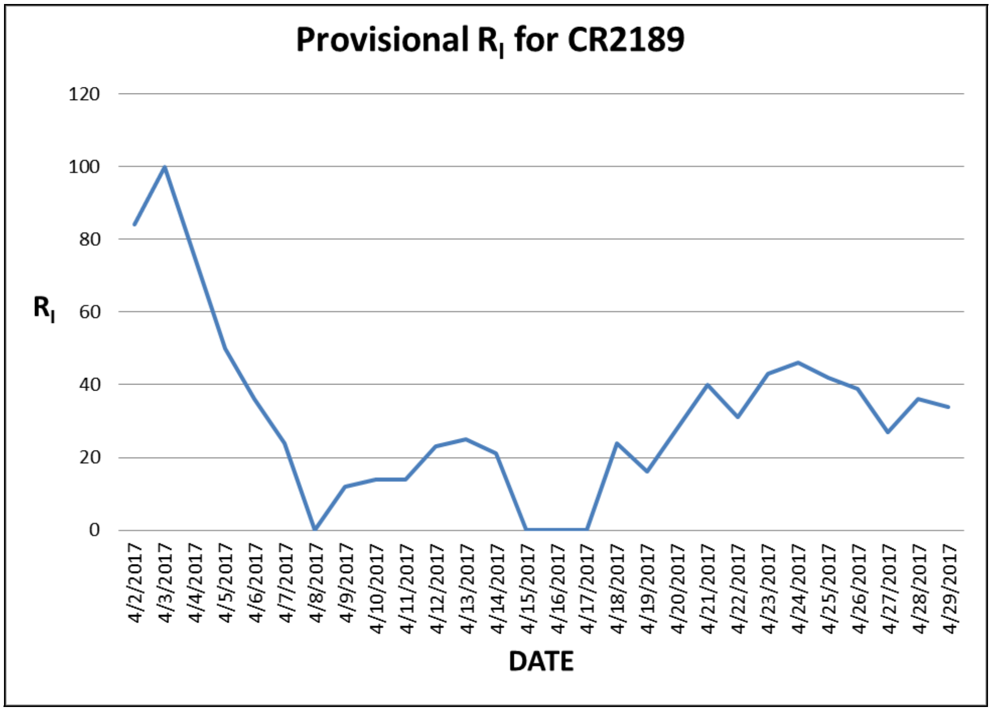


Figure 7 - AR 2644 near the limb as imaged in w-l by Ty on 4/3 at 00:38 UT.




and flare production (many M-class flares) one every three hours or so (Figure 4).

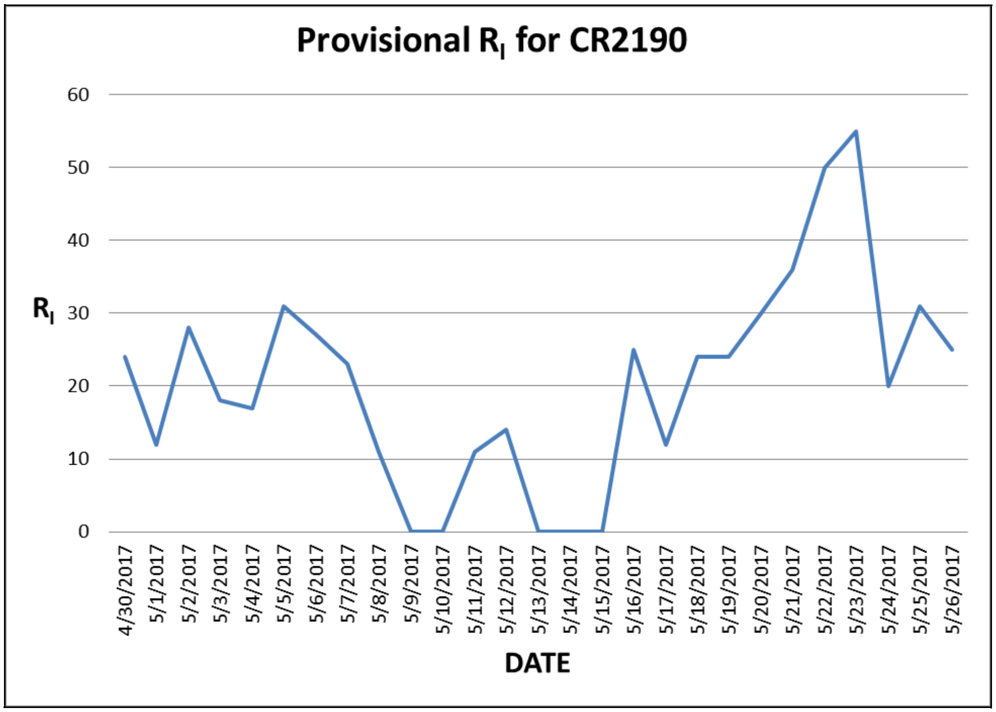
Then on 4/2, AR 2644 put on an explosive spurt of growth going to Fkc, with an area of 450 millionths (mag. class beta-gamma again) but no increase in flare production over the previous day. This situation is again shown well in Fig. 1 and in an image by Tyler at 13:20 UT on that day (Figure 5). The leader was now a large collection of spots, most with at least rudimentary penumbra with the leading leader being fairly round and having radial penumbra. The follower was reduced to a small two-lobed umbra with a well-organized penumbra. The whole region was wreathed in faculae. Braga got a nice image of a large prominence hovering over this region on 4/3 at 15:45 UT (Figure 6). In w-l, things remained largely unchanged as seen in an image by Ty (Figure 7). The area had jumped further to 520 millionths, still Fkc (mag. class beta-gamma-delta), but flare production was a little less. The follower spot was breaking down and would likely be gone in another day or two. In fact, Ty's image on 4/4 showed the remnants of it though most the rest of the group was no longer visible.

The other region of interest during CR 2188 was AR 2645. It formed on the disk on 3/27 without so much as a hint in any wavelength the day before. Broxton was first to spot it at 08:17 UT on that day, as a single spot that he classified as Hrx. By the next day, it was classed Cso at 30 millionths area (mag. class beta) and had developed into a nice bipolar sunspot group with an obvious neutral line where flares were forming as shown in a Tyler montage (Figure 8). In only 24 hours, a clear leader and follower had formed, each with penumbrae. A collection of a half-dozen umbrae and pores between these was the site for the 30 flares (all B- and C-class) that erupted in the first 48 hours of this region. It was already out-producing AR 2644 which was 5 times the area.

On 3/29, the region was classed Dai at 70 millionths area mag. class now beta-gamma having produced 32 flares in the preceding 48 hours. A Braga image on this date (Figure 9) shows a leader spot of a penumbra enclosing one large and a half-dozen smaller umbrae followed by a collection of a dozen or so middle spots that were umbrae and pores with rudimentary penumbra on a couple of them. The follower spot was one medium-sized umbra with rudimentary penumbra on the following side only. A Grassmann H-a image later the same day shows the likely site for flares to be the middle spots (Figure 10). On this date, we have the start of a Ramakers w-l evolutionary montage (Figure 11). The reader can follow along in this montage as the rest of this region's passage is described.

The next day, 3/30, the middle spots had begun to coalesce with the follower or leader spots leaving only a couple pores in the center seen in w-l by Ty (Figure 12). While the area increased a little, the classes and flare production was largely unchanged. At this time, we were treated to the sight of two sunspot groups on the Sun of approximately the same area and complexity and about the same distance from the central meridian, though in different hemispheres both longitudinally and latitudinally. It made for an interesting low-power view!

This situation reversed itself on 3/31 and the old middle spots returned as a continuous bridge of spots from leader to follower. By 4/2, AR 2645 had grown to 520 millionths with a class of Ekc (mag. class again beta-gamma). Flare production was about the same but still all B- and C-class flares (in contrast to AR 2644 which was similar classes and area, but producing about 20% less flares, many of which were M-class). A Ramakers CaK image showed both the active regions nicely (Figure 13).




Growth continued on the 3rd, with the class now Ehc, area 700 millionths and mag. class increased to beta-gamma-delta. The leader spot was now a large, elongated (N-S) umbra in a radial penumbra followed by about a dozen umbrae in rudimentary penumbrae. The follower was a couple medium-sized irregular umbrae in fairly well-organized penumbrae preceded by about a dozen umbrae and pores, some with rudimentary penumbrae. This is shown in a Ty image on that day (Figure 14).

Things were largely unchanged on 4/4, but on 4/5 the class was increased to Fkc while the area was reduced to 500 millionths (mag. class remained the same at beta-gamma-delta). Flare production was cut to half of the previous rate and still no M-class flares. Then on 4/6, the classes were reduced to Ekc (mag. class beta-gamma) and the area had fallen to 380 millionths as the region neared the limb. The last look we have of this region was on 4/7, when it was unchanged on the limb as seen in the Ramakers montage (Figure 11).

## Carrington Rotation 2189

***Dates: 2017 01 10.3840 to 2017 02 06.7250***

Avg. $R_I$= 33.6
High $R_I$ = 74 (1/21)
Low RI = 0 (1/10, 1/11)

Activity levels were moderate at the beginning of the rotation due to carryover of the two larger regions, AR 2644 & 2645, from the previous rotation. They quickly dropped to a low of 0 on 4/15-16 but rose towards the end of the rotation.

The only region worth mentioning was AR 2651 which came on the disk as a Dso group of 20 millionths area (mag. class beta the whole passage). It grew to 150 millionths and a reduced class of Cso as it approached the meridian on 4/24. Then the next day, it quickly broke down to Hsx class of 110 millionths and continued to decay until it left the disk on 4/30. It never produced better than one minor flare every 4 hours. A Grassmann image serves to show this region at its maximum development (Figure 15).

## Carrington Rotation 2190

***Dates: 2017 02 06.7250 to 2017 03 06.0597***

***Avg. $R_I$ = 26.7***
***High $R_I$ = 59 (2/28, 3/1)***
***Low $R_I$ = 0 (3/4)***

Activity in this rotation dropped back to the very low levels seen in the first half of the first rotation of this report with the peak in activity seen on 5/23 being due entirely to a number of small groups. No groups attained 100 millionths during this rotation and no regions were classified above "D". Five days had an official count of zero. The only region that showed any promise for activity was AR 2659 which attained an area of 220 millionths on 5/28 CR 2191 as it was leaving the disk shown in two spectacular images by Viladrich (figures 16 and 17).

## Conclusion

As you can see, we are rapidly bottoming out in solar activity, but as CR 2188 showed, there still can be some interesting activity worth mentioning (like ARs 2673 and 2674 as this report is being written). This requires diligent monitoring of solar activity. I particularly would point out the good synoptic drawings by Broxton, Gianninoto, Levinthal and Teske. They frequently observe emerging regions and class them before the professional observatories. Well done!

Again a reminder that there is division in the professional solar community on whether this will be just a deep solar minimum or a more extended minimum in some ways analogous to The Maunder Minimum. So keep your eye on the Sun and let's see what happens!

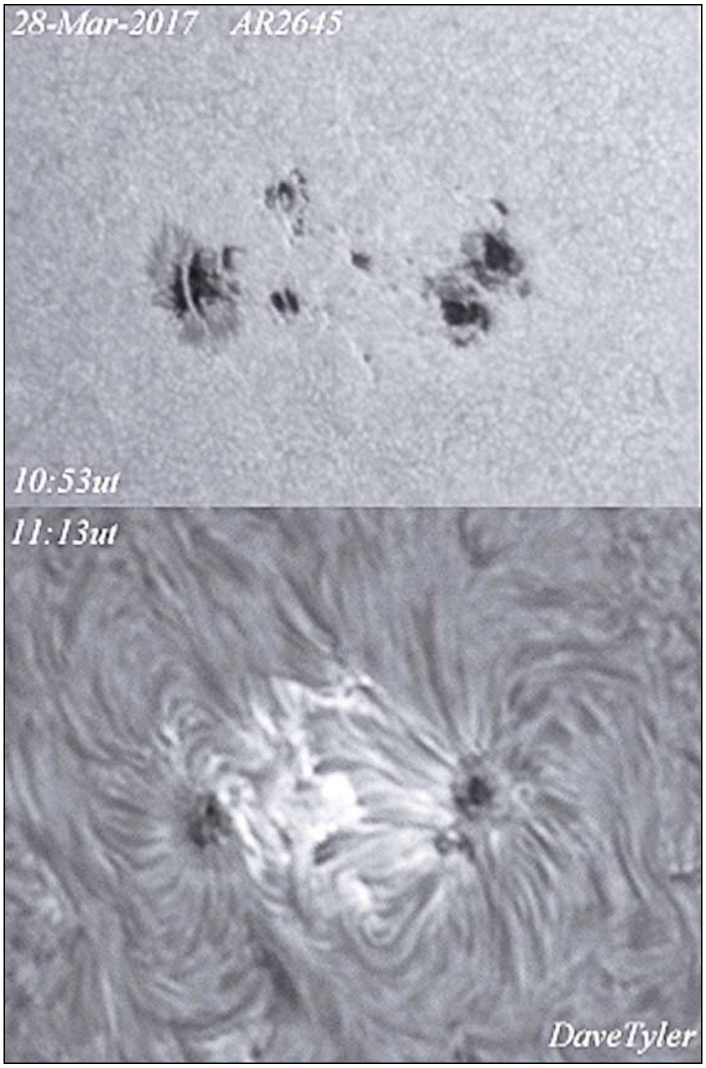



Figure 8 - A w-l and H-a composite of AR 2645 by Tyler showing the site for flaring.

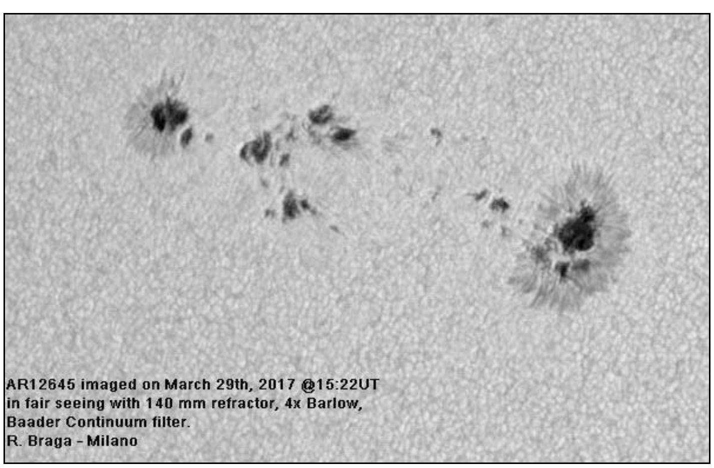



Figure 9 - AR 2645 in w-l by Braga on 3/29 at 15:22 UT.

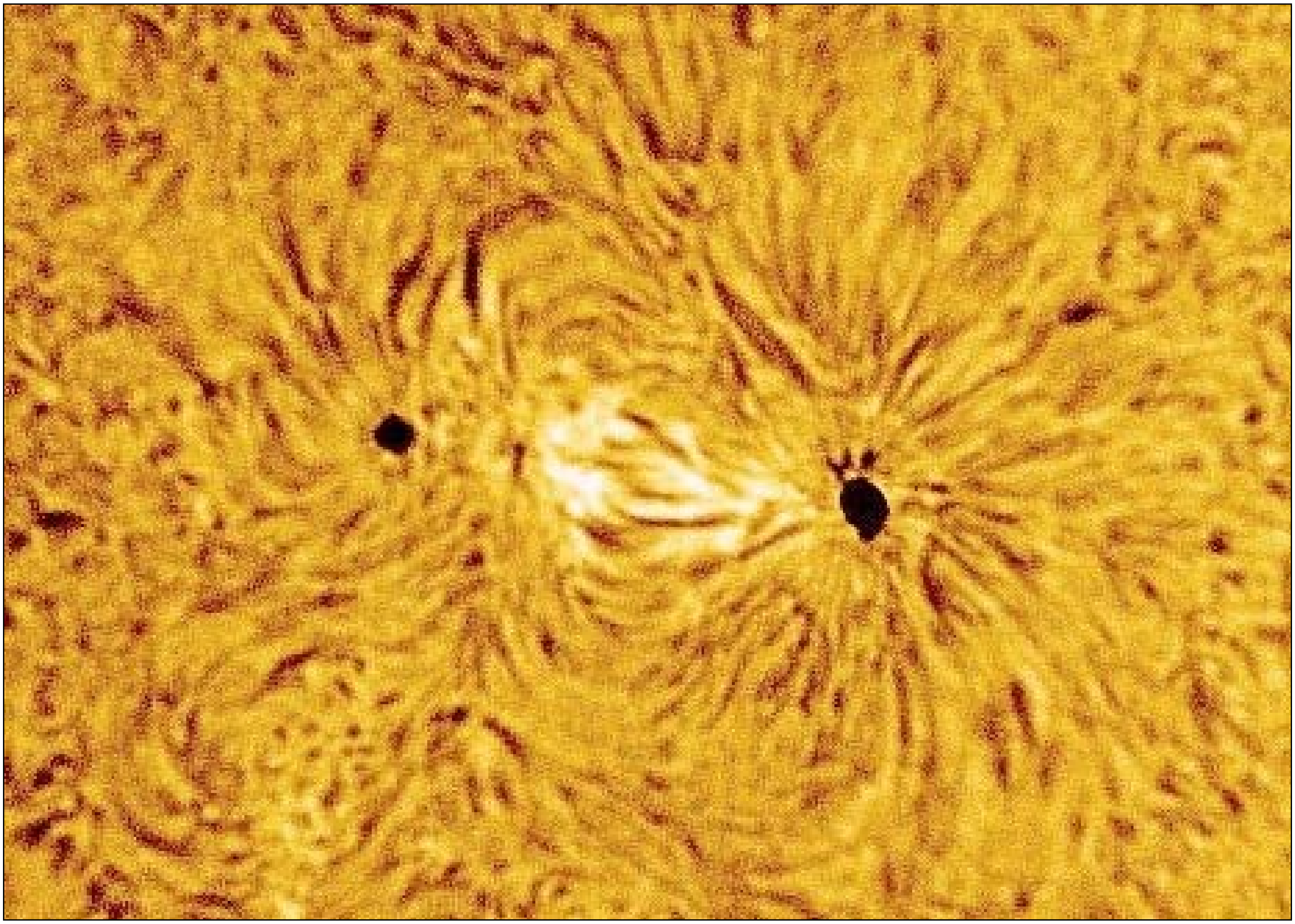
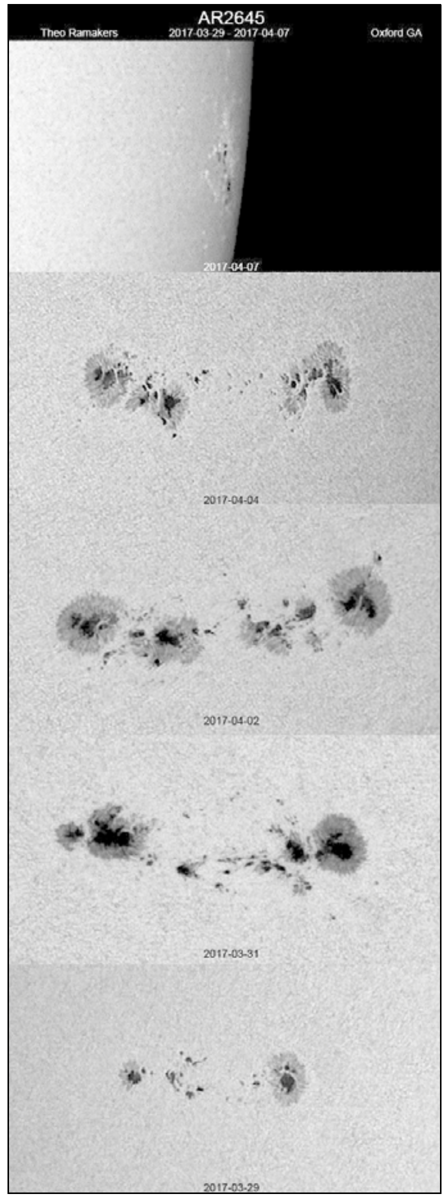


Figure 10 - A Grassmann H-a image of AR 2645 on 3/29 at 11:54 UT showing the site of flaring activity.

Figure 11 - Another Ramakers evolutionary composite, this time of AR 2645 on five dates and times shown on the images



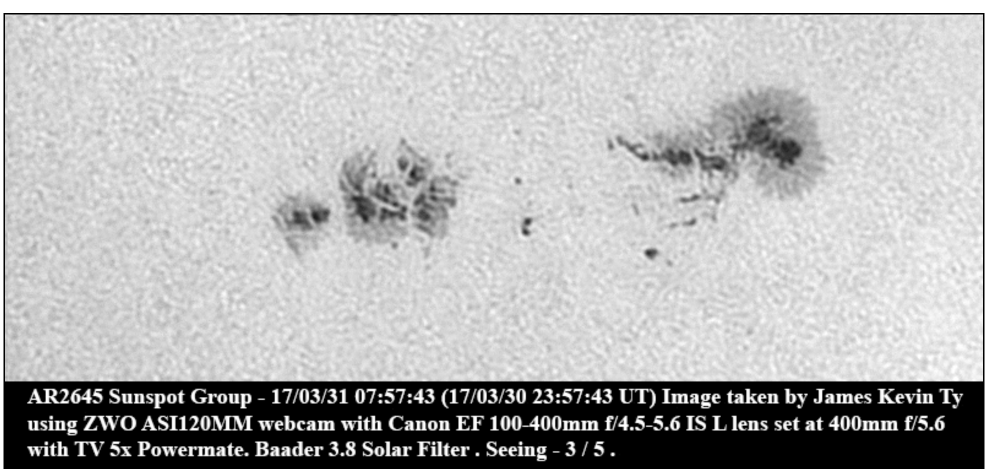




Figure 12 - AR 2645 in w-l on 3/31 at 23:57 UT by Ty.

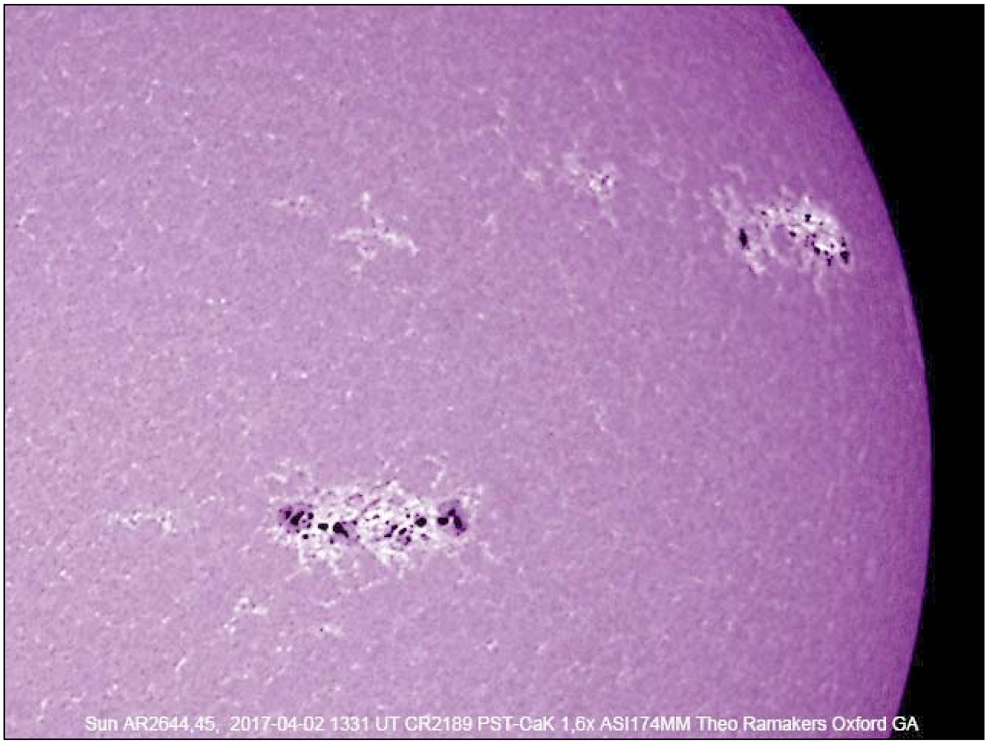



Figure 13 - A Ramakers CaK image showing both AR 2644 and 2645 on 4/2 at 13:31 UT.

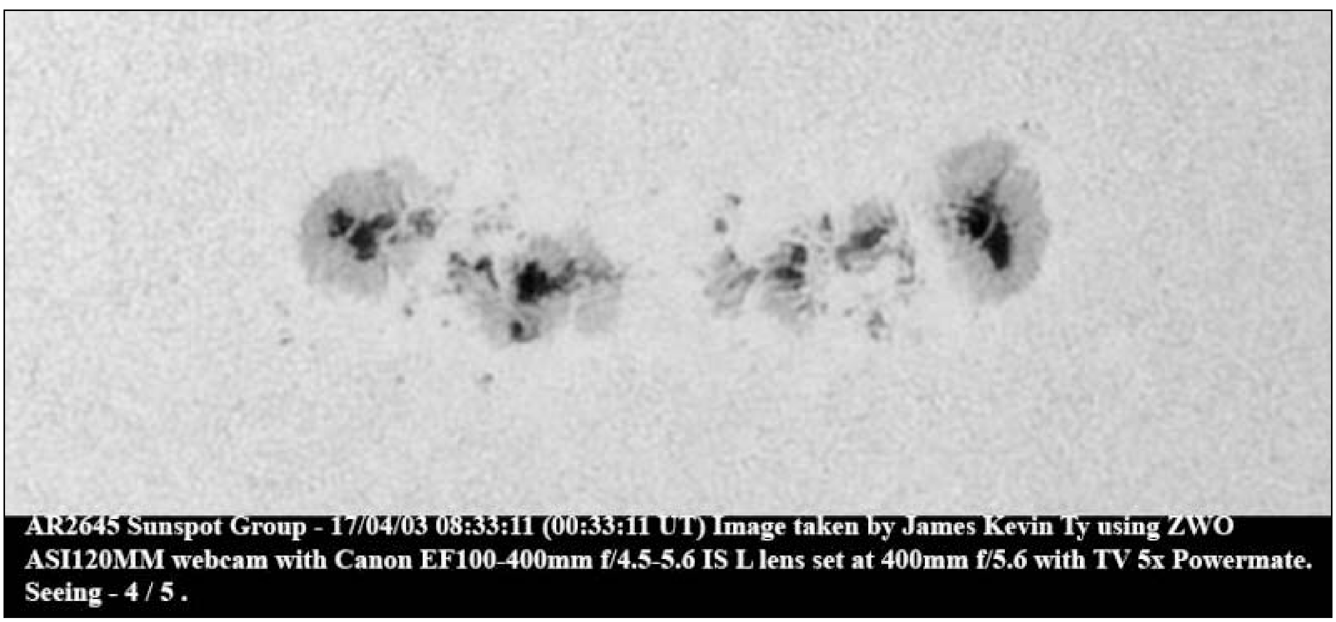



Figure 14 - A w-l view of AR 2645 on 4/3 at 00:33 UT by Ty.

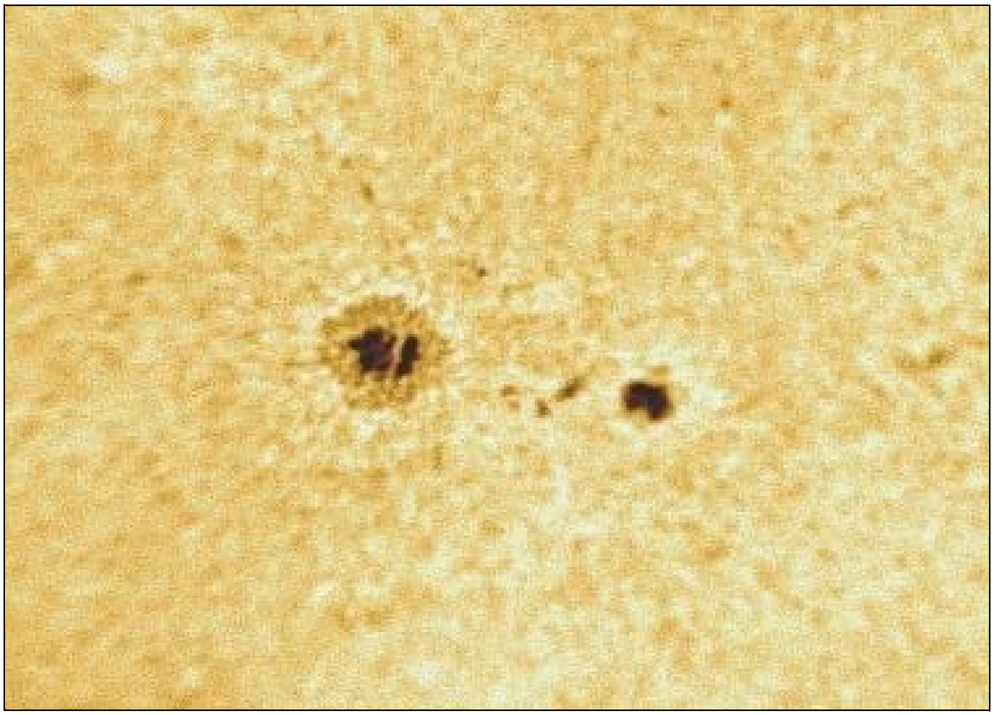


Figure 15 - A Grassmann H-a image of AR 2651 on 4/24 at 12:20 UT.


Figure 16 - A spectacular w-l image of AR 2659 by Viladrich on 5/28 at 08:55 UT.

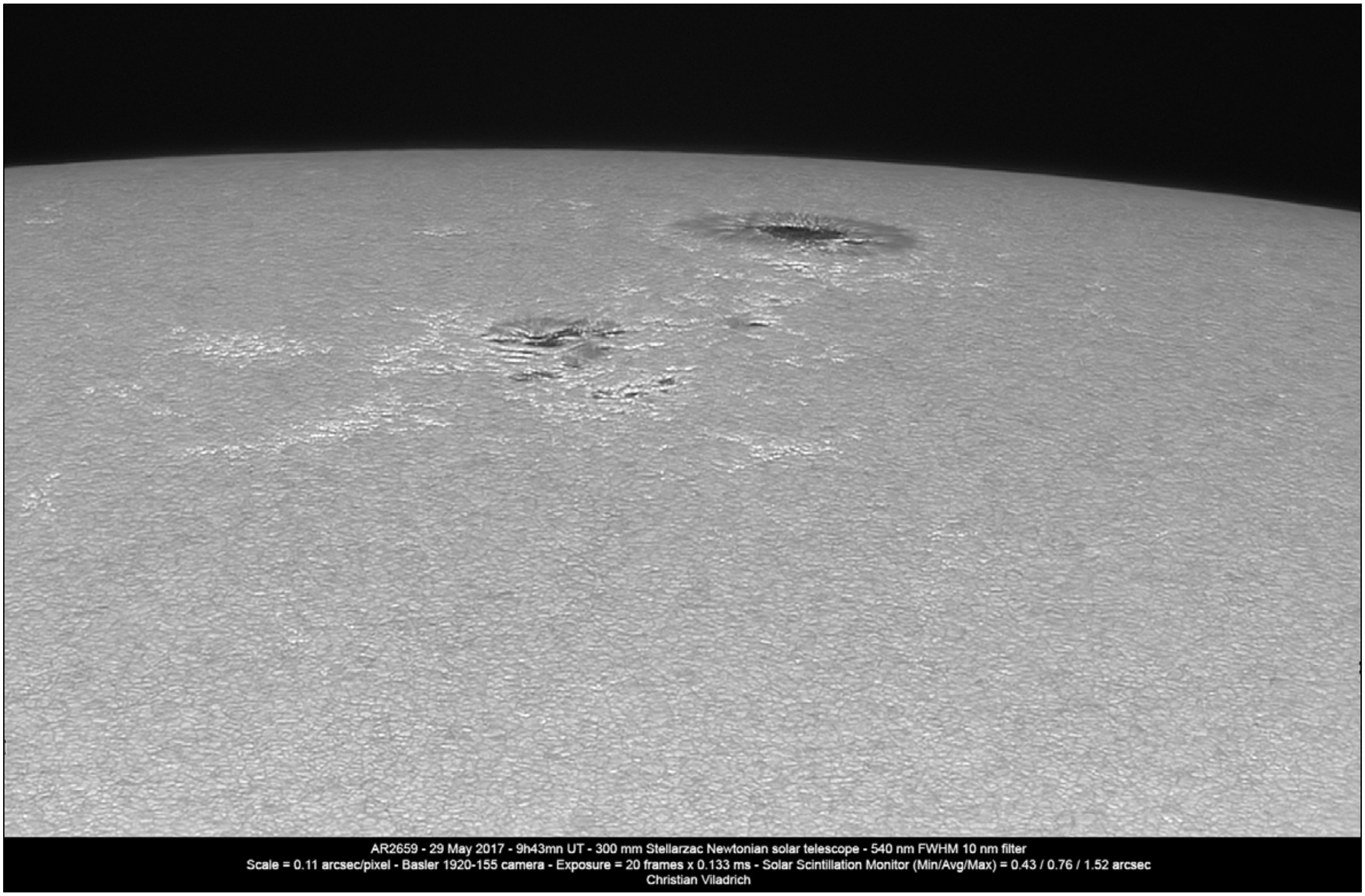



Figure 17 - AR2 2659 on 5/29 using all the same equipment and software procedures of the previous image.

# A.L.P.O. Solar Section

**OBSERVER**______________________________________________

**ADDRESS**_______________________________________________

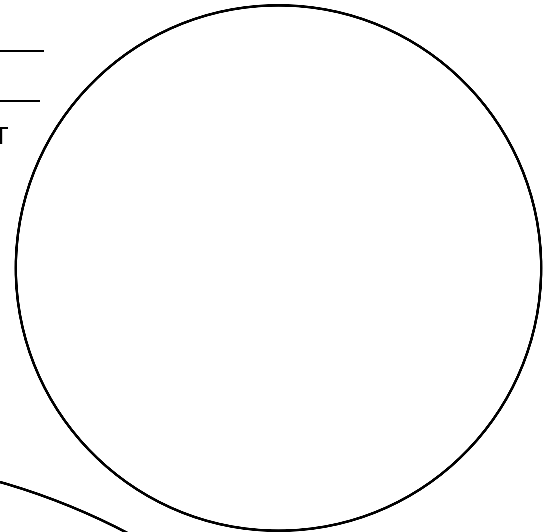
DATE/TIME____________________________________________UT

SEEING_______________  CLOUDS_______________  WIND_______________

APERTURE____________mm  FOCAL LENGTH____________mm  TYPE________

EYEPIECE________mm  FILTRATION____________________________

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



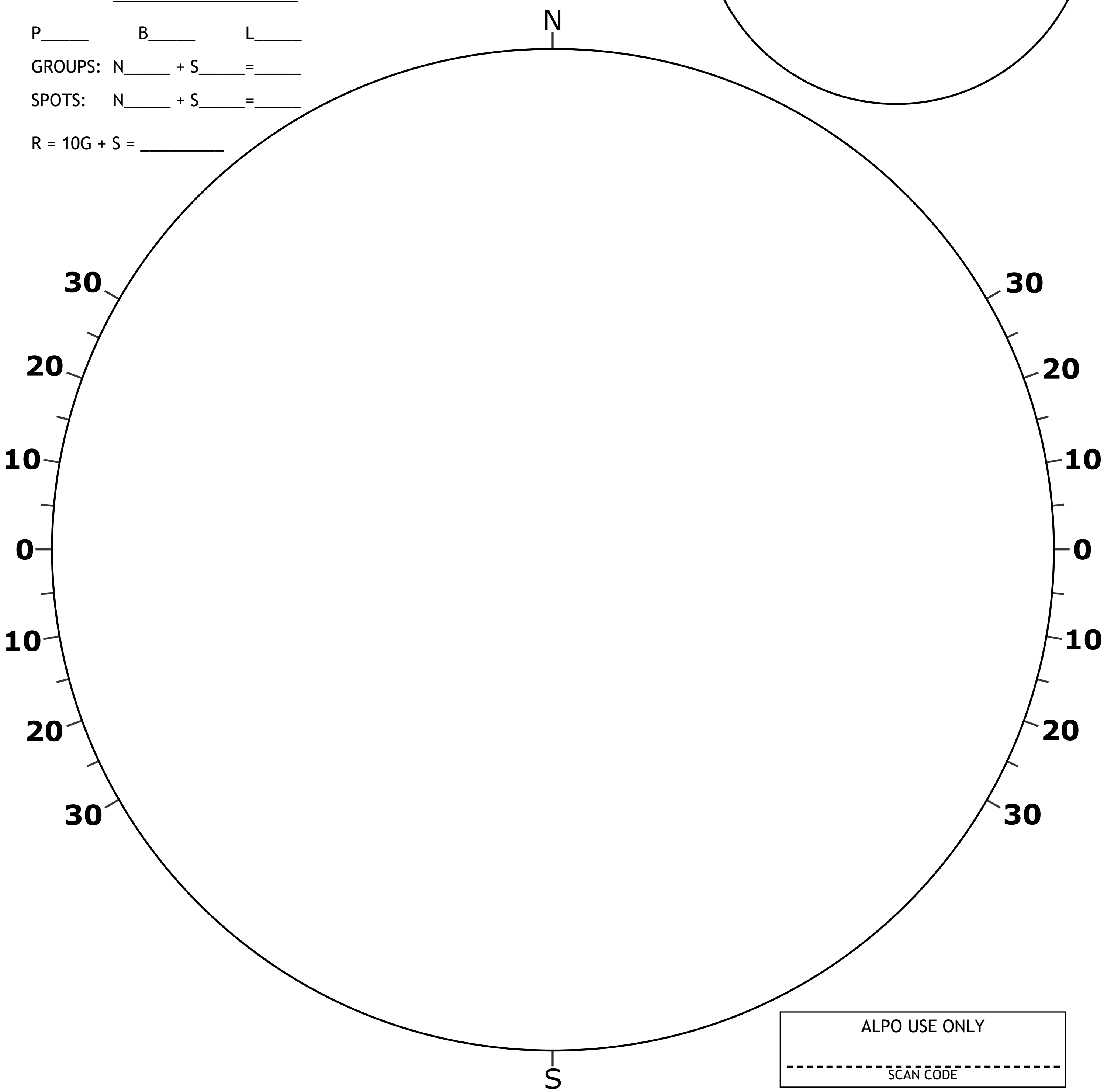
ROTATION__________________

P_____ B_____ L_____

GROUPS: N_____ + S_____=_____

SPOTS: N_____ + S_____=_____

R = 10G + S = _________

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***Feature Story***

# *ALPO Observations of Mercury During the 2015 Apparitions*

**By Frank J Melillo, coordinator, ALPO Mercury Section**
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## Abstract

There were seven apparitions of Mercury in 2015. During the course of the year, there were only four observers, who submitted a total of 21 drawings and images. They used telescopes ranging from 20 to 27.5 centimeters (8 to 11 inches) aperture. The albedo features they detected show good correlation with images made during the MESSENGER flybys and with the 1971 albedo chart prepared by Murray, Smith and Dollfus.

## Background

There were four evening and three morning apparitions during the year 2015 (Table 1). The ALPO Mercury Section received fewer observations than in previous years. The 2015 observations were made by four observers, and consisted of 14 drawings, five stacked "lucky" images obtained by webcam, and two images made by regular CCD cameras (Table 2). Michel Legrand of France contributed the most observations, which are all drawings. The drawings are important because they show what is seen through an eyepiece. John Boudreau of Massachusetts and Stephane Gonzales of France sent in their webcam images, while this author made two CCD images. The webcam and CCD images can provide more accurate localization of albedo features, verifying the actual positions of any features that are seen visually. The observations are all discussed and presented in the present article.

In 1972, Murray, Smith, and Dollfus published an albedo map derived from Earth-based, telescopic observations of Mercury (Murray, Smith, and Dollfus, 1972). This map is used in comparison with current images to identify known and suspected albedo features.

In April 2015, the MESSENGER spacecraft completed its mission after four years of orbiting Mercury. The probe proved to be more hardy than its design specifications required, and the scientists extended the mission twice before it ran out of fuel. They decided to end the mission by crashing the spacecraft onto the surface. This was not a sad moment, but a time of celebration. The craft had delighted everyone by returning many thousands of images and other data, and proving to be one of the most cost-effective interplanetary missions. With the final crash, the scientists said "Thank you" for the wonderful mission. They will now have years to study the results. It is said that MESSENGER was the most successful space probe ever implemented.

The ALPO Mercury Section seeks more observers making all types of observations to further compare the

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## Special Note

East is defined as the direction toward which a planet rotates, and in the case of Mercury, east on the planet is approximately the same direction as west on the sky. With north up as it is in the images in this paper, this east-west convention is the same as it would be if you were looking at a globe of Earth. When referring to east and west on Mercury, the author is using planetary map directions, not sky directions.

In this paper, the planetographic longitude convention, with increasing longitude toward planetary west, is used exclusively. This is the convention that ALPO Mercury and Mars observers have long used, and it differs from the planetocentric longitude system, in which longitude increases to the east.

**Table 1. Characteristics of the Apparitions of Mercury in 2015 (all dates UT)**

| No. & Type | Beginning Conjunction* | Greatest Elongation | Final Conjunction* | Aphelion | Perihelion |
|---|---|---|---|---|---|
| 1. Evening | 8 Dec 2014 (s) | 14 Jan | 30 Jan (i) | 8 Dec 2014 | 21 Jan |
| 2. Morning | 30 Jan (i) | 24 Feb | 9 Apr (s) | 6 Mar | |
| 3. Evening | 9 Apr (s) | 7 May | 30 May (i) | | 19 Apr |
| 4. Morning | 30 May (i) | 24 Jun | 23 Jul (s) | 2 Jun | 16 Jul |
| 5. Evening | 23 Jul (s) | 4 Sep | 30 Sep (i) | 29 Aug | |
| 6. Morning | 30 Sep (i) | 16 Oct | 17 Nov (s) | | 12 Oct |
| 7. Evening | 17 Nov (s) | 29 Dec | 14 Jan 2016 (i) | 25 Nov | 8 Jan 2016 |

* (s) designates superior conjunction, (i) designates inferior conjunction.
All dates are in 2015 unless otherwise indicated.

**Table 2. Observers of Mercury in 2014**

| Observer | Location | Instrument* | Number & Type of Observation** | Apparition(s) Observed |
|---|---|---|---|---|
| John Boudreau | Saugus, MA, USA | 27.5 cm SCT | 1 W | 4 |
| Stephane Gonzales | Surgeres, France | 25.0 cm RL | 4 W | 3 |
| Michel Legrand | La Baule-Escoublac, France | 21.0 cm RL | 14 D | 2, 3, 4, 5 |
| Frank Melillo | Holtsville, NY, USA | 25.0 cm SCT | 2 CCD | 3 |

* RL = Newtonian reflector, SCT = Schmidt-Cassegrain.
** CCD = integrating CCD camera imaging, D = Drawing, W = Webcam lucky imaging.

Earth-based observations with the MESSENGER images. This is an ongoing project that is by no means complete. Some of the features in MESSENGER images, including bright-rayed craters and large dark areas, are clearly depicted in drawings and images made by ALPO observers, but other features remain elusive. It is apparent that the observing techniques of modern amateur astronomers are better than they were in the past, and progress towards the detection of features on Mercury has been made (e.g., Boudreau, 2009). The author extends his gratitude to those who contributed observations in 2015 (Table 2), who made this report possible. This report is one of a series of yearly reports of observations of Mercury (Melillo, 2010b, 2011a, 2011b, 2013, 2014, 2015, and 2016)

Perhaps the best way to see Mercury clearly is to find it during the morning twilight and then follow it into daylight hours when it is higher in the sky (Melillo, 2004). This procedure yields a good chance that the seeing will be above average. Mercury has a high surface brightness so that it bears high magnification well even when using filters. For daylight visual observations, an orange filter such as the Wratten 21 is advisable, while for imaging, a red filter like the Wratten 25 or a 610 nm longpass is recommended. These colored filters increase the contrast, so that the details can be better captured.

Figure 1. A drawing made during apparition 2 by Michel Legrand, 25 Mar at 10:30 UT, with CM = 112°. Contrast enhanced by the author. In this and all other figures in this article, north is up and planetary east is to the right.

## Apparition 1: Evening, 8 Dec (2014) – 30 Jan

After superior conjunction with the Sun on 8 December 2014, Mercury became an evening object. It was early- to mid-winter in the northern hemisphere and no observations were received during this apparition. The tiny planet went through inferior conjunction with the Sun on 30 January.

## Apparition 2: Morning, 30 Jan – 9 Apr

This morning apparition lasted more than two months, but it was under poor conditions as seen from the northern hemisphere. Only one observer made an observation.

On 25 March (CM = 112°), Michel Legrand made his first drawing **(Figure 1)**. The fat gibbous disk he drew shows a large band across the southern hemisphere. At this face, the dark features Solitudo Helii, Solitudo Jovis and Solitudo Martis dominate the southern hemisphere. It is probable that the conspicuous dark area depicted by Legrand is a low resolution view of these three features together. The ALPO Mercury Section archives include many observations of the same features when this side is presented toward the Earth.

Mercury ended the morning apparition on 9 April.

## Apparition 3: Evening, 9 Apr – 30 May

This was perhaps the best evening apparition of the year, and it was early- to mid-spring in the northern hemisphere. Of all the apparitions of 2015, the most observations were received of this one. See Figure 2.

Stephane Gonzales started with his first image on 13 April (CM = 192°), showing Mercury as a full disk **(Figure 2A)**. In fact, it was a mere four days after superior conjunction with the Sun! This is perhaps the earliest observation ever received of Mercury during an evening apparition. With such a small disk diameter of only 4.8 arc seconds, Mercury showed a blank face.

Michel Legrand made six drawings from 19 April (CM = 217°) to 28 April (CM = 254°) **(Figure 2B thru D, F thru H)**. Meanwhile, Gonzales made an image on 21 April **(Figure 2E)** that appears to show Solitudo Phoenicis as a dark band oriented nearly north-to-south in the northern hemisphere. This image is nearly simultaneous with the 21 April drawing by Legend, and both show a large bright area in the northeast, an east-to-west-oriented dark feature in the south, a bright eastern limb, and possible terminator shading.

The Solitudo Phoenicis feature may never have been imaged before, and merits follow-up observations. The difficulties of identifying albedo

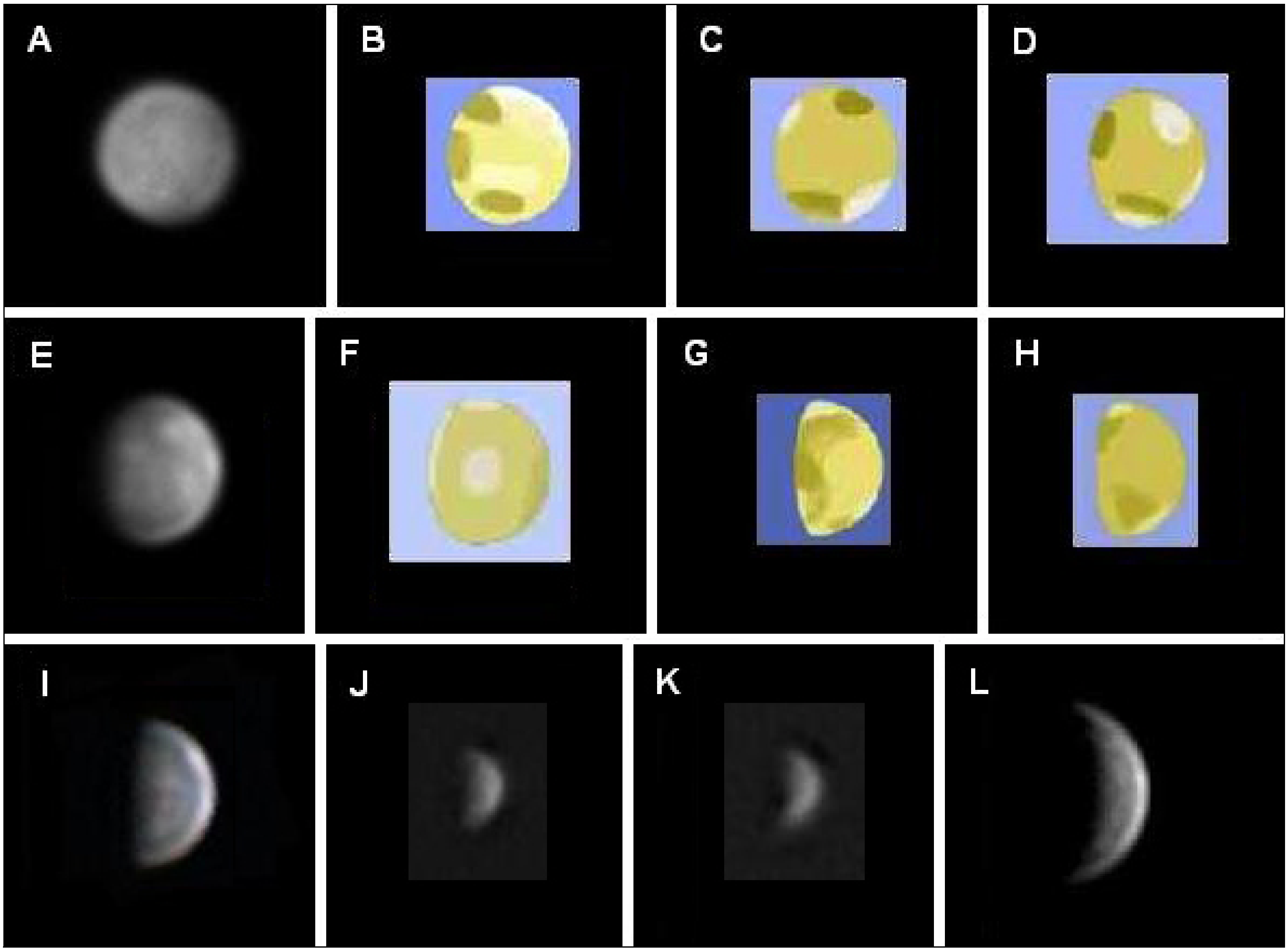


Figure 2. Six images and six drawings made during apparition 3.
A. Image by Stephane Gonzales on 13 Apr 2015 at 16:08 UT, with CM = 192°.
B. Drawing by Michel Legrand on 19 Apr 2015 at 16:16 UT, with CM = 217°.
C. Drawing by Michel Legrand on 20 Apr 2015 at 13:00 UT, with CM = 220°.
D. Drawing by Michel Legrand on 21 Apr 2015 at 15:50 UT, with CM = 225°.
E. Image by Stephane Gonzales on 21 Apr 2015 at 16:28 UT, with CM = 225°.
F. Drawing by Michel Legrand on 22 Apr 2015 at 9:30 UT, with CM = 228°.
G. Drawing by Michel Legrand on 27 Apr 2015 at 14:30 UT, with CM = 250°.
H. Drawing by Michel Legrand on 28 Apr 2015 at 12:15 UT, with CM = 254°.
I. Image by Stephane Gonzales on 29 Apr 2015 at 17:42 UT, with CM = 260°.
J. Image by Frank J Melillo in red light on 02 May 2015 at 23:00 UT, with CM = 275°.
K. Image by Frank J Melillo in red light on 09 May 2015 at 0:10 UT, with CM = 306°.
L. Image by Stephane Gonzales on 10 May 2015 at 14:15 UT, with CM = 315°.

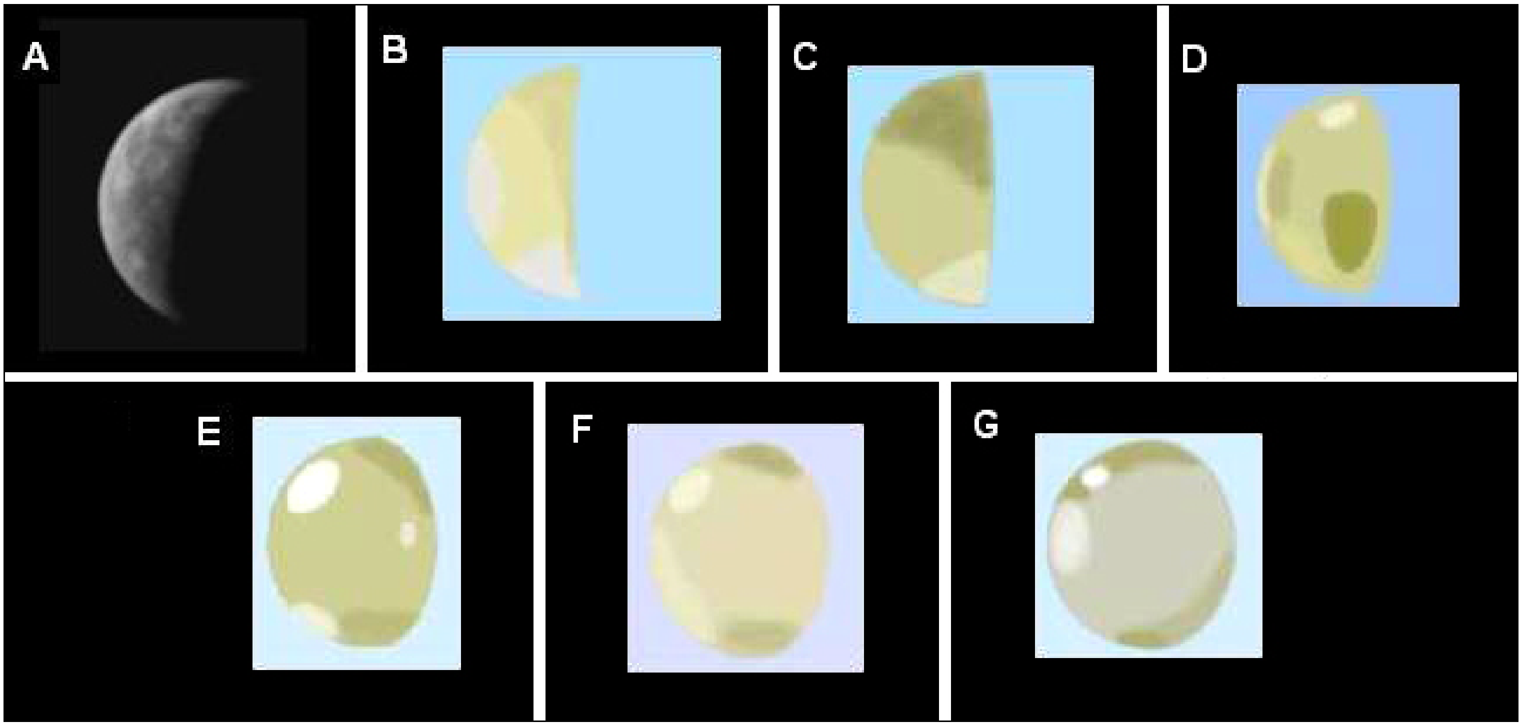


Figure 3. One image and six drawings made during apparition 4. Contrast in the drawings was enhanced by the author.
A. Image by John Boudreau on 24 Jun 2015 at 11:33 UT, with CM = 231°.
B. Drawing by Michel Legrand on 28 Jun 2015 at 10:40 UT, with CM = 251°.
C. Drawing by Michel Legrand on 02 Jul 2015 at 15:00 UT, with CM = 271°.
D. Drawing by Michel Legrand on 06 Jul 2015 at 10:15 UT, with CM = 288°.
E. Drawing by Michel Legrand on 10 Jul 2015 at 9:40 UT, with CM = 305°.
F. Drawing by Michel Legrand on 11 Jul 2015 at 15:40 UT, with CM = 311°.
G. Drawing by Michel Legrand on 15 Jul 2015 at 15:00 UT, with CM = 327°.

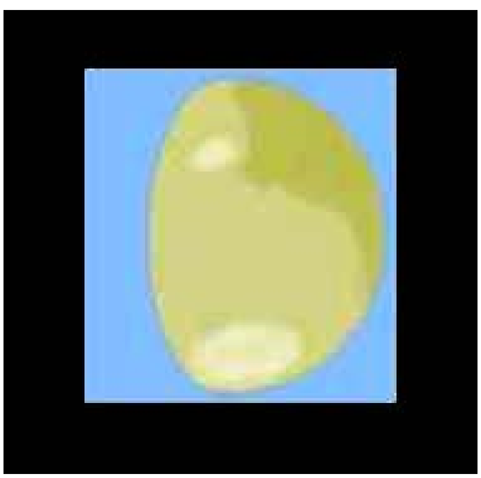

Figure 4. A drawing made during apparition 5 by Michel Legrand, on 21 Aug at 11:00 UT, with CM = 124°.

features on Mercury are illustrated by the noncorrespondences among Legrand's drawings of the 19th through the 22nd of April, which were over a CM range of only 11 degrees; though the drawing of the 21st has good correspondence to Gonzales's image. Legrand's drawing of the 19th has the best correspondence to his drawing of the 21st (and to Gonzales's image of that date).

Two more drawings were made by Legrand, on 27 and 28 April (CM's 250° and 254°, respectively), and Gonzales took his second image on 29 April (CM = 260°) **(Figure 2I)**.

This author took two CCD red light images on 2 May (CM = 275°) and 9 May (CM = 306°) **(Figure 2J and K)**. Gonzales made his final image on 10 May (CM = 315°) **(Figure 2L)**. All of these show the phase well, ranging from gibbous to crescentic, but the albedo features are too subtle to be sure about. Mercury ended this evening apparition on 30 May.

## Apparition 4: Morning, 30 May – 23 Jul

This was perhaps the second-best morning apparition of the year, but only two persons submitted observations.

John Boudreau made an excellent image of Mercury on 24 June (CM = 231°) **(Figure 3A)** showing what appears to be Solitudo Aphrodites as a dark feature at the limb in the north. Some nearby bright features correspond to previously identified markings, such as Pentas to the southeast of Aphrodites. (Aphrodites has been seen many times before and is the most conspicuous feature on the surface.) Many other albedo markings are also visible, but work is ongoing to ascertain their constancy in images, and their correspondences to known surface structures. Boudreau's work of the past can be compared with many images that were taken by the MESSENGER spacecraft (Melillo, 2010a).

Michel Legrand made six more drawings from 28 June (CM = 251°) to 15 July (CM = 327°) **(Figure 3B thru G)**. He drew a large bright region which could be Pentas near the northern part of the limb, on 6 July (CM = 288°), 10 July (CM = 305) and 11 July (CM = 311°), and possibly on 15 July (CM = 327°).

Mercury went through superior conjunction with the Sun on 23 Jul.

## Apparition 5: Evening, 23 Jul – 30 Sept

This was a rather poor apparition as seen from the northern hemisphere. Only one report was received.

Michel Legrand made a drawing on 21 Aug (CM =124°). The features he drew are difficult to associate with previously identified features. Mercury went through inferior conjunction with the Sun on 30 Sept.

## Apparition 6: Morning, 30 Sept – 17 Nov

This was the best morning apparition of the year. Surprisingly, no observations were received.

## Apparition 7: Evening, 17 Nov – 14 Jan (2016)

This was a mediocre evening apparition and no observations were received.

## Conclusions

The surface of Mercury is now well-known, as the MESSENGER probe has imaged it in great detail. However, as with Earth's moon, the best view of broad albedo features is to be had by views made from a great distance rather than by the close-up views made by spacecraft. Years of Earth-based observations have given us albedo maps of the entire surface, such as that by Murray, Smith, and Dollfus, and another by Frassati, but there are many uncertainties in such maps. Part of the difficulty in matching observations to existing maps arises from the challenges of making the observations of this difficult planet (Boudreau, 2009; Melillo, 2004). However, part of the difficulty arises from the insufficiencies of the maps. Therefore, observers should never be chagrined by the difficulties and uncertainties of these observations. Years of observations will be needed before we know the best way to compile those observations into finalized albedo maps of Mercury. The observers who accepted the challenge and submitted their work in 2015 are to be congratulated for their fine efforts.

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ALPO MERCURY SECTION

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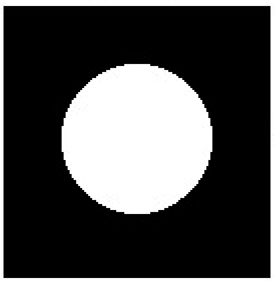


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Image 1

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Image 2

Central Meridian Longitude______°

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Camera Type___________________
Exposure______________________
f/ratio________________________
Filter_________________________

Comments:

Send all observations to: Frank J Melillo
ALPO Mercury Coordinator
14 Glen-Hollow Dr., E-#16
Holtsville, NY 11742

E-mail for questions, special observations and alerts: frankj12@aol.com

### *Feature Story*

# *A Preview of the 2017 – 2019 Perihelic Apparition of Mars*

**By Roger Venable,**
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**and Jeff Beish**
*afja_lm139@comcast.net*

## Introduction

Mars is fascinating not only because it is the most colorful of the planets, or because it is the only one on which we can observe weather and polar cap phenomena, or because its periods of fruitful observation are separated by a year and a half of drought. The red planet has a romance all its own, engendered by imaginative novelists and fostered by equally imaginative scientists of more than a hundred years ago. Mars will soon renew its old mystique, enchanting us with its closest approach to Earth since 2003. At such favorable times, observers spy features that they have not detected in years, and imagers open views of long-closeted detail. You will want to make Mars a priority in your observing plans in 2018.

## The Apparition

Salient dates of the apparition, together with magnitude and apparent diameter on those dates, are listed in Table 1. Traditionally, the observing season has been considered to start when the apparent diameter of Mars rises to 6 arc seconds, and to end when it declines to that size. The beginning and end of the observing season given in Table 1 reflect that tradition. For many visual observers, six arc seconds remains a reasonable limit, but some imagers have been making useful observations of dust storms, clouds, and polar cap changes when Mars is as small as 4 arc seconds. Furthermore, many modern amateurs use instruments larger than those available to previous generations, so that the 6-arc-second limit may seem obsolete.

Notice that the brightness at opposition will be -2.78, which is nearly twice as bright as it was at opposition in 2016 — 0.72 magnitudes brighter, a factor of 1.94 times. Note that when Jupiter is at opposition on May 9, 2018, it will be of magnitude -2.5, so Mars will outshine it in 2018.

Table 1 indicates that the closest approach to Earth will occur three days after opposition. This is due to the opposition's occurrence somewhat before Mars's perihelion. For the same reason, Mars will appear larger and brighter at eastern quadrature than it will at western quadrature. (The nomenclature of quadrature can be confusing. Quadrature occurs only with planets whose orbits are farther from the Sun than Earth's. The times of quadrature are designated by the direction of the planet from the Sun in the sky. Thus, a planet goes through western

**Table 1. Important Dates of the 2017 – 2019 Apparition**

| yyyy-mm-dd* | Event | Mag | Diam** |
|---|---|---|---|
| 2017-07-27 | Opening conjunction | 1.69 | 3.53 |
| 2018-02-12 | Observing season begins | 1.04 | 6.00 |
| 2018-03-24 | Western quadrature | 0.42 | 7.96 |
| 2018-06-28 | Retrograde motion begins | -2.08 | 20.41 |
| 2018-07-28 | Opposition | -2.78 | 24.29 |
| 2018-07-31 | Closest approach | -2.77 | 24.33 |
| 2018-08-28 | Retrograde motion ends | -2.20 | 21.46 |
| 2018-12-03 | Eastern quadrature | 0.00 | 9.14 |
| 2019-02-04 | Observing season ends | 0.92 | 6.00 |
| 2019-09-03 | Ending conjunction | 1.74 | 3.50 |

* Dates are in universal time.
** “Diam” is the apparent subtended diameter in arc-seconds.

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Left-click your mouse on:

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

**Table 2. Recent Opposition Distance and Sizes ǂ**

| Year | Mmm DD | Km x $10^6$ | A.U.* | Diam** |
|---|---|---|---|---|
| 1969 | May 31 | 72.6 | 0.485 | 19.2 |
| 1971 | Aug 10 | 55.9 | 0.374 | 24.9 |
| 1973 | Oct 25 | 66.0 | 0.441 | 21.2 |
| 1975 | Dec 15 | 85.2 | 0.570 | 16.4 |
| 1978 | Jan 22 | 97.7 | 0.653 | 14.3 |
| 1980 | Feb 25 | 101.2 | 0.676 | 13.8 |
| 1982 | Mar 31 | 95.3 | 0.637 | 14.6 |
| 1984 | May 11 | 80.4 | 0.537 | 17.4 |
| 1986 | Jul 10 | 60.6 | 0.405 | 23.0 |
| 1988 | Sep 28 | 59.1 | 0.395 | 23.6 |
| 1990 | Nov 27 | 78.2 | 0.523 | 17.8 |
| 1993 | Jan 07 | 93.8 | 0.627 | 14.9 |
| 1995 | Feb 12 | 100.9 | 0.674 | 13.8 |
| 1997 | Mar 17 | 98.7 | 0.660 | 14.1 |
| 1999 | Apr 24 | 87.2 | 0.583 | 16.0 |
| 2001 | Jun 13 | 68.1 | 0.455 | 20.5 |
| 2003 | Aug 28 | 55.5 | 0.371 | 25.2 |
| 2005 | Nov 07 | 70.3 | 0.470 | 19.9 |
| 2007 | Dec 24 | 88.6 | 0.592 | 15.8 |
| 2010 | Jan 29 | 99.2 | 0.663 | 14.1 |
| 2012 | Mar 03 | 100.7 | 0.673 | 13.9 |
| 2014 | Apr 08 | 92.8 | 0.620 | 15.1 |
| 2016 | May 22 | 76.2 | 0.509 | 18.3 |
| 2018 | Jul 27 | 57.5 | 0.384 | 24.3 |

ǂ Source: *Guide 9* sky chart software by Bill Gray.
* A.U. = astronomical units.
** Diam = apparent angular diameter in arc seconds.

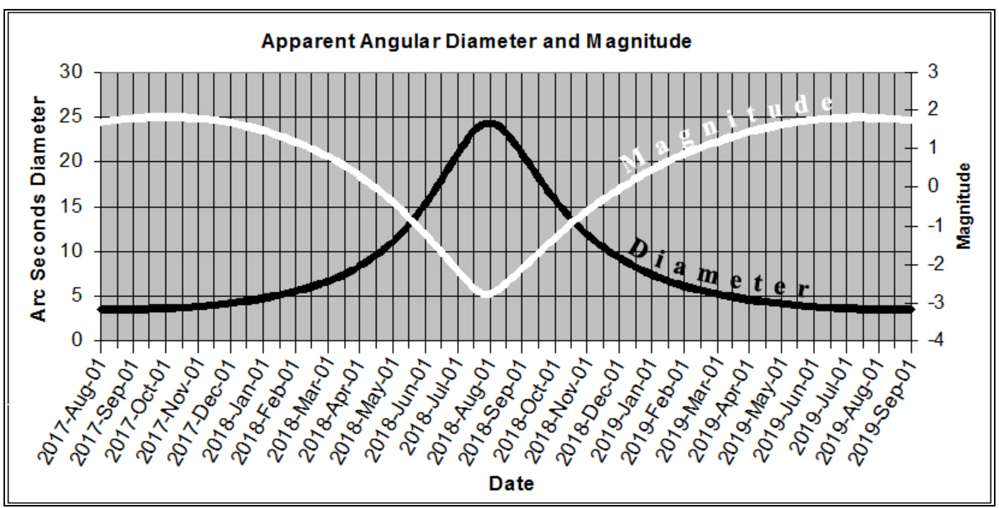


Fig. 1. Apparent diameter and visual magnitude of Mars as a function of date in the 2017-2019 apparition.

quadrature when it is west of the Sun in the sky and is therefore visible in the eastern sky before sunrise. A planet goes through eastern quadrature when it is east of the Sun in the sky and is therefore visible in the western sky after sundown.)

The size and Earth-distance of Mars is compared in Table 2 to those of recent oppositions. Note that the 2018 opposition is closer than any except those of 1971 and 2003. Not until 2035 will there be another opposition closer than that of 2018, and it will be only slightly closer, with an apparent diameter of 24.43 arc seconds.

Figure 1 graphs the diameter and magnitude as they change with the progression of this apparition. Notice that Mars will spend about 6 months with an apparent size greater than that at the 2016 opposition (which is 18.3 arc seconds, as listed in Table 2). At close apparitions such as this one, the observing season is substantially longer – 358 days in 2018, as compared to 341 days in the last apparition and only 262 days in the aphelic opposition of 2012.

## Mars in the Sky

At close oppositions, the planet usually has a southerly declination in Earth's sky. This apparition, Mars will be south of the Celestial Equator from October 27, 2017, to January 2, 2019, a period that includes all the times of large apparent diameter. Its declination will be -25.60 degrees at its opposition on July 27, 2018, but the most southerly declination of -26.55 degrees will not occur until August 16. The changes in declination as the apparition progresses are graphed in Figure 2. For observers in Earth's Northern Hemisphere, the southerly declination detracts from the otherwise very advantageous nature of the apparition, while observers in the Southern Hemisphere are especially favored.

Although Mars will already be at a declination of -21.5 degrees at the start of the observing season, when it moves northward across the Celestial Equator on January 2, 2019, it will have an apparent diameter of 7.4 arc seconds, with about a month left in the observing season.

Figure 3 is a graph of the opposition distance data of Table 2 versus the declination of the planet at each of those oppositions. Even these limited data show the relationship clearly. As the opposition cycle of 15.8 years progresses, the oppositions plot along an oval, and move clockwise along that oval to make a complete circuit in about 7.3 oppositions. The cycle comes back to within 5 days of its starting point in 79 years (5 opposition cycles), and over a period of 284 years it repeats itself even more closely. The change in distance from one opposition to another is largely a function of the orbital eccentricities of Earth (0.017) and especially of Mars (0.093). The change in declination is a function of the inclination of Mars's orbit to the ecliptic (1.85 degrees) and especially of the obliquity of Earth (23.45 degrees). The interplay of these factors during each 2.2-year opposition interval creates the oval plot when extended over the opposition cycle of 15.8 years.

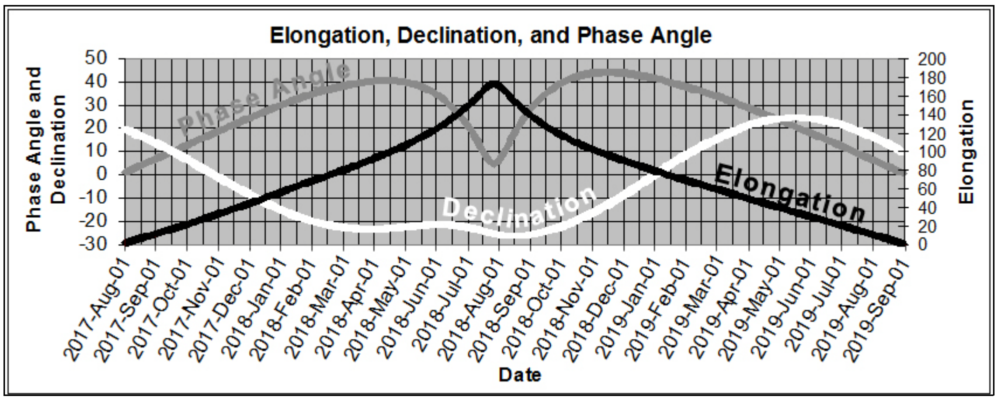


Fig. 2. Elongation, declination, and phase angle of Mars as a function of date, in the 2017 - 2019 apparition.

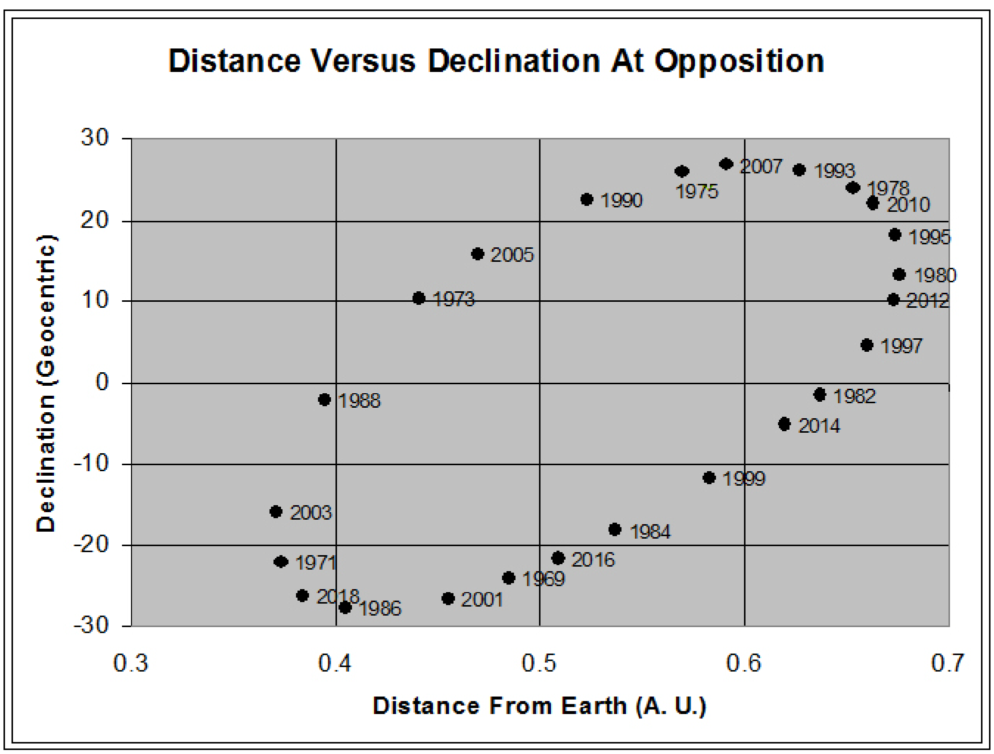


Figure 3. Declination at opposition as a function of distance from Earth at opposition.

## Mars in the Telescope

After the apparent size of the planet's disc, the next most important characteristic of the planet's appearance is its oval shape. The phase angle will peak at 40.2 degrees before opposition, and at 44.3 degrees after opposition, as graphed in Figure 2. The fraction of the planet's disc that appears to be illuminated by the Sun is calculated as

$$(1 + \cos(\text{phase angle}))/2$$

where the phase angle varies between 0 and 180 degrees, so that its cosine is negative between 90 and 180. Thus, the fraction illuminated is lowest when the phase angle is highest. The fraction illuminated begins and ends the apparition with values near 1.0, and has a similar value at opposition. The lowest values of fraction illuminated are at quadrature: 0.882 before opposition and 0.858 after opposition. The illumination defect is on the preceding side of the planet before opposition, and on the following side of the planet after opposition. The unilluminated crescent of the planet cannot be seen or imaged, though very high clouds rarely have been imaged over it.

Knowledge of the location of the illumination defect helps the observer interpret what he is seeing. The declinations of the Earth and Sun in the Martian sky are graphed in Figure 4. Thoughtful interpretation of this graph will tell the observer whether his view of the polar caps is affected by the location of the illumination defect. For example, on January 15, 2018, the Earth has a northern declination in the Martian sky, so that one might see the North Pole if it is illuminated by the Sun. The Sun also has a northern declination, indicating that the North Pole is illuminated, and so can be seen. However, on April 15, 2018, the Earth has moved into a southern declination in the Martian sky, so that an observer cannot see the North Pole even though it is illuminated by the still northern Sun. On that date, the observer cannot see the South Pole either, because it is not illuminated by the northerly positioned Sun, and is hiding in the illumination defect. The polar caps are often partially obscured by the illumination defect, and thus often seem to have peculiar shapes that an observer can understand by knowing the location of the illumination defect.

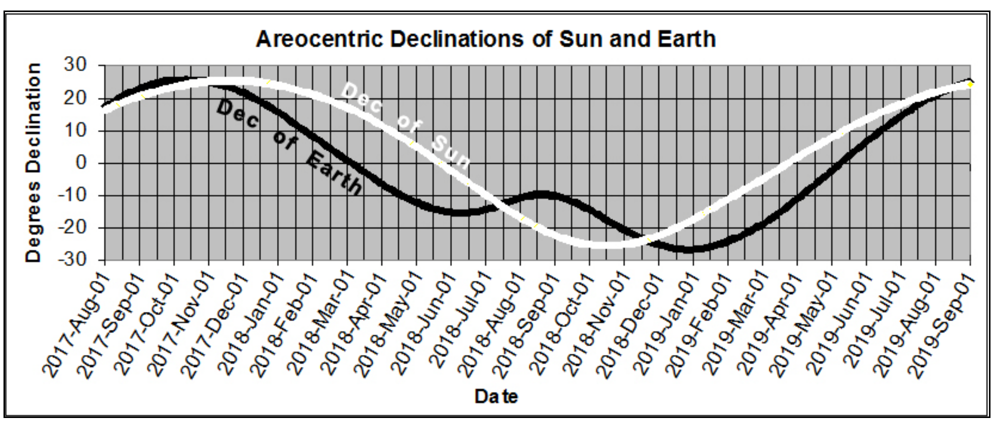


Fig. 4. Declinations of Earth and Sun in the Martian sky as functions of date, in the 2017 - 2019 apparition.

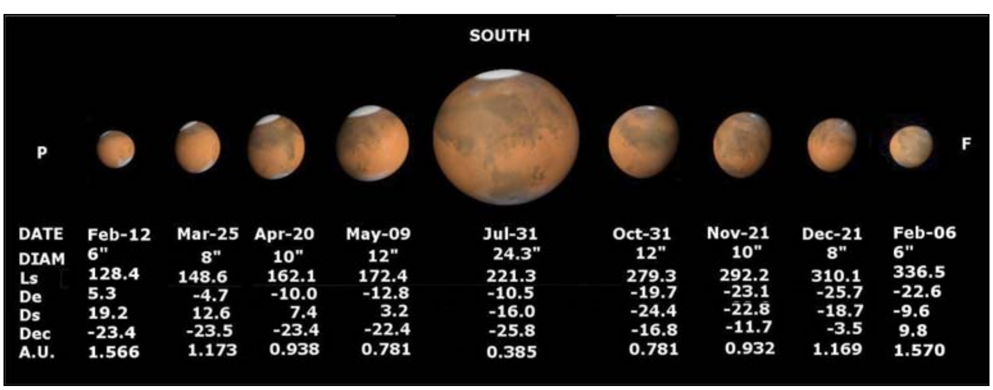


Figure 5. Jeff Beish's diagrams of expected appearances of Mars during the observing season of 2018.

The seasons of Mars are the next important characteristic of the planet that observers should witness. The seasons of the Martian year can be understood simply by following the areocentric declination of the Sun in Figure 4. Northern summer and southern winter begin in late November 2017, and last until late May 2018, when northern autumn and southern spring begin. Northern winter and southern summer then begin in mid-October 2018, and last until late March 2019, when northern spring and southern autumn begin. We use the areocentric longitude of the Sun to describe the Martian season, a variable that has the abbreviation, "Ls" or "$L_S$". Zero degrees Ls is the start of northern spring, when the Sun, as seen from Mars, crosses the plane of Mars's orbit from south to north – completely analogous to the start of spring in the Northern Hemisphere of Earth, but using the parameters of Mars's orbit rather than Earth's. Northern summer begins at 90° Ls, autumn at 180° Ls, and winter at 270° Ls, while the seasons in Mars's Southern Hemisphere are opposite to those in the north.

Jeff Beish has compiled pictures that show the expected appearance of the planet at intervals during the coming apparition. See Figure 5. Celestial south is up, and celestial west (the preceding side) is to the left, in these depictions. Notice how the apparent axial tilt of the planet changes during the apparition as the Earthly perspective on it changes.

As Figure 5 shows, the SPC (South Polar Cap) is large early in the observing season but is partly hidden by the illumination defect. The SPC has shrunken by the time of closest approach, and thereafter shrinks rapidly and becomes fully illuminated and fully visible from Earth. As the

**Table 3. Deimos' Maximal Elongations Near Opposition**

| Date | Hr:Min | PA | Long | | Date | Hr:Min | PA | Long | | Date | Hr:Min | PA | Long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2018-Jun-27 | 9:00 | 91 | 97 W | | 2018-Jul-20 | 17:20 | 272 | 111 E | | 2018-Aug-13 | 1:20 | 96 | 38 W |
| 2018-Jun-28 | 0:10 | 271 | 34 E | | 2018-Jul-21 | 8:30 | 92 | 117 W | | 2018-Aug-13 | 16:30 | 276 | 94 E |
| 2018-Jun-28 | 15:20 | 91 | 166 E | | 2018-Jul-21 | 23:30 | 273 | 17 E | | 2018-Aug-14 | 7:40 | 96 | 134 W |
| 2018-Jun-29 | 6:30 | 271 | 62 W | | 2018-Jul-22 | 14:40 | 93 | 149 E | | 2018-Aug-14 | 22:50 | 276 | 2 W |
| 2018-Jun-29 | 21:40 | 90 | 70 E | | 2018-Jul-23 | 5:50 | 273 | 79 W | | 2018-Aug-15 | 13:50 | 97 | 132 E |
| 2018-Jun-30 | 12:50 | 270 | 158 W | | 2018-Jul-23 | 21:00 | 93 | 53 E | | 2018-Aug-16 | 5:00 | 277 | 96 W |
| 2018-Jul-01 | 3:50 | 91 | 24 W | | 2018-Jul-24 | 12:10 | 273 | 176 W | | 2018-Aug-16 | 20:10 | 97 | 35 E |
| 2018-Jul-01 | 19:00 | 271 | 108 E | | 2018-Jul-25 | 3:10 | 93 | 42 W | | 2018-Aug-17 | 11:20 | 277 | 167 E |
| 2018-Jul-02 | 10:10 | 91 | 120 W | | 2018-Jul-25 | 18:20 | 273 | 90 E | | 2018-Aug-18 | 2:30 | 97 | 61 W |
| 2018-Jul-03 | 1:20 | 271 | 12 E | | 2018-Jul-26 | 9:30 | 94 | 138 W | | 2018-Aug-18 | 17:40 | 277 | 71 E |
| 2018-Jul-03 | 16:30 | 91 | 144 E | | 2018-Jul-27 | 0:40 | 274 | 6 W | | 2018-Aug-19 | 8:50 | 97 | 157 W |
| 2018-Jul-04 | 7:40 | 271 | 85 W | | 2018-Jul-27 | 15:50 | 94 | 125 E | | 2018-Aug-19 | 23:50 | 277 | 23 W |
| 2018-Jul-04 | 22:50 | 91 | 47 E | | 2018-Jul-28 | 7:00 | 274 | 103 W | | 2018-Aug-20 | 15:00 | 97 | 109 E |
| 2018-Jul-05 | 14:00 | 271 | 179 E | | 2018-Jul-28 | 22:00 | 94 | 31 E | | 2018-Aug-21 | 6:10 | 277 | 120 W |
| 2018-Jul-06 | 5:00 | 91 | 46 W | | 2018-Jul-29 | 13:10 | 274 | 163 E | | 2018-Aug-21 | 21:20 | 97 | 12 E |
| 2018-Jul-06 | 20:10 | 271 | 85 E | | 2018-Jul-30 | 4:20 | 94 | 65 W | | 2018-Aug-22 | 12:30 | 277 | 144 E |
| 2018-Jul-07 | 11:20 | 91 | 143 W | | 2018-Jul-30 | 19:30 | 274 | 66 E | | 2018-Aug-23 | 3:40 | 97 | 84 W |
| 2018-Jul-08 | 2:30 | 271 | 11 W | | 2018-Jul-31 | 10:40 | 94 | 162 W | | 2018-Aug-23 | 18:50 | 277 | 48 E |
| 2018-Jul-08 | 17:40 | 91 | 121 E | | 2018-Aug-01 | 1:40 | 275 | 28 W | | 2018-Aug-24 | 9:50 | 97 | 178 W |
| 2018-Jul-09 | 8:50 | 271 | 108 W | | 2018-Aug-01 | 16:50 | 95 | 104 E | | 2018-Aug-25 | 1:00 | 277 | 46 W |
| 2018-Jul-10 | 0:00 | 91 | 24 E | | 2018-Aug-02 | 8:00 | 275 | 124 W | | 2018-Aug-25 | 16:10 | 97 | 86 E |
| 2018-Jul-10 | 15:00 | 271 | 159 E | | 2018-Aug-02 | 23:10 | 95 | 7 E | | 2018-Aug-26 | 7:20 | 277 | 142 W |
| 2018-Jul-11 | 6:10 | 91 | 70 W | | 2018-Aug-03 | 14:20 | 275 | 139 E | | 2018-Aug-26 | 22:30 | 97 | 11 W |
| 2018-Jul-11 | 21:20 | 271 | 62 E | | 2018-Aug-04 | 5:20 | 95 | 87 W | | 2018-Aug-27 | 13:40 | 277 | 121 E |
| 2018-Jul-12 | 12:30 | 91 | 166 W | | 2018-Aug-04 | 20:30 | 275 | 45 E | | 2018-Aug-28 | 4:50 | 97 | 107 W |
| 2018-Jul-13 | 3:40 | 271 | 34 W | | 2018-Aug-05 | 11:40 | 95 | 177 E | | 2018-Aug-28 | 20:00 | 277 | 25 E |
| 2018-Jul-13 | 18:50 | 91 | 97 E | | 2018-Aug-06 | 2:50 | 275 | 52 W | | 2018-Aug-29 | 11:10 | 97 | 157 E |
| 2018-Jul-14 | 9:50 | 272 | 128 W | | 2018-Aug-06 | 18:00 | 95 | 80 E | | 2018-Aug-30 | 2:10 | 277 | 69 W |
| 2018-Jul-15 | 1:00 | 92 | 3 E | | 2018-Aug-07 | 9:10 | 275 | 148 W | | 2018-Aug-30 | 17:20 | 97 | 63 E |
| 2018-Jul-15 | 16:10 | 272 | 135 E | | 2018-Aug-08 | 0:10 | 96 | 14 W | | 2018-Aug-31 | 8:30 | 277 | 165 W |
| 2018-Jul-16 | 7:20 | 92 | 93 W | | 2018-Aug-08 | 15:20 | 276 | 118 E | | 2018-Aug-31 | 23:40 | 97 | 33 W |
| 2018-Jul-16 | 22:30 | 272 | 39 E | | 2018-Aug-09 | 6:30 | 96 | 111 W | | 2018-Sep-01 | 14:50 | 277 | 99 E |
| 2018-Jul-17 | 13:40 | 92 | 170 E | | 2018-Aug-09 | 21:40 | 276 | 21 E | | 2018-Sep-02 | 6:00 | 97 | 129 W |
| 2018-Jul-18 | 4:40 | 272 | 55 W | | 2018-Aug-10 | 12:50 | 96 | 153 E | | 2018-Sep-02 | 21:10 | 277 | 3 E |
| 2018-Jul-18 | 19:50 | 92 | 76 E | | 2018-Aug-11 | 4:00 | 276 | 75 W | | 2018-Sep-03 | 12:20 | 97 | 135 E |
| 2018-Jul-19 | 11:00 | 272 | 152 W | | 2018-Aug-11 | 19:00 | 96 | 59 E | | 2018-Sep-04 | 3:30 | 277 | 93 W |
| 2018-Jul-20 | 2:10 | 92 | 20 W | | 2018-Aug-12 | 10:10 | 276 | 169 W | | 2018-Sep-04 | 18:40 | 97 | 39 E |

SPC shrinks, look for Novus Mons, a white frosty area left behind as the SPC recedes, centered at longitude 315 and latitude 72 south. Novus Mons means "new mountain", and its other name is "the Mountains of Mitchel." These names were given because early observers considered it likely that frost would linger in a mountainous area as the SPC receded. (It is now known that the area is not particularly mountainous.) The small, residual SPC is not centered exactly on the South Pole. This can be discerned by comparing its visibility from night to night, as it will be nearer the southern limb of the planet on some nights than on others.

Another interesting feature of the Southern Hemisphere is the white frost that is often seen in Hellas and Argyre. In the Northern Hemisphere, it will be interesting to watch the development of the NPH during the northern autumn of Mars.

## Clouds

There are relatively few clouds visible on Mars during southern spring and summer, the seasons that will constitute most of the coming observing season. Nevertheless, a few discreet clouds and occasional morning limb hazes are likely. Clouds are best detected by looking or imaging with a blue filter. Ground hazes and frosts are often best seen with a green filter. (With a red filter, most clouds are hard to see, but surface albedo features stand out strongly.)

## Dust Storms

It is exciting to detect a dust storm and to monitor its development. They can be seen at any season of the Martian year. With the improvements in instruments and imaging methods in the last few decades, we have been detecting more dust storms than we did in the past. For example, in the 2007-08 apparition, Earth-based observers not only detected and monitored the great planet-encircling dust storm of that apparition, but also detected 7 other dust storms, of which 5 were well-monitored.

It has been said that we are due for another planet-encircling dust storm. There have been 11 apparitions that had such a storm since that in 1908, so that the mean interval between such large storms has averaged about 10 years. As of this writing, it has been 10 years since the last one. However, we are skeptical that a longer than average interval increases the chance of an occurrence in the next apparition. Indeed, the planet has been well observed since 1893, and the first planet-encircling storm was not seen until 1908, a period of 15 years without such a storm. A 32-year period with no such large storm lasted from 1923 to 1955. In contrast, during the 1970's, there were four planet-encircling storms: 1970, 1972, 1974, and 1975 (McKimm, 1999).

During each apparition there are some reports of dust storms that are not borne out by follow-up observations. It is important to remember the three cardinal features of dust storms:

- They are bright in red light.
- They obscure the usual albedo features.
- They move, from sol to sol.

Unless these characteristics are seen, one might refer to a suspected dust feature as a "possible" dust storm. Occasionally, exceptional dust features can be seen that do not meet these criteria. For example, narrow streaks of dark dust stand out prominently against the NPC (Northern Polar Cap), and so can be unambiguously identified as dust deposits. It is now thought that the Rima Tenuis of the NPC is a dust streak that recurs in some apparitions. Rarely, a dust storm will be composed of dark dust that is not bright in red light, but can be seen to obscure albedo features and change from sol to sol. Such dark dust storms are generally small and transient (Venable, 2017).

To identify and monitor a dust storm, the use of a red filter is very helpful. Changes in the storm's obscurations of underlying albedo features should be recorded as the observer studies the region's appearance from night to night.

## The Moons of Mars

At a favorable apparition such as this one, it is likely than many observers will be able to detect the moons of Mars visually. Detecting Phobos and Deimos is very difficult during unfavorable apparitions. The problem, of course, is not due to the intrinsic faintness of the moons, but rather to the brightness of the nearby planet. There are two ways in which visual observations of the moons are impaired by the brightness of Mars. First, the sky is bright very near the planet, due to scattering in the Earth's atmosphere. Second, the eye's sensitivity to faint light is down-regulated by the bright field of view when it includes the planet. Attempts to image the moons are not affected by the second of these factors, and so we receive more images of them than we do visual reports.

Most visual sightings are made near opposition during favorable apparitions. The difference in brightness between the planet and the moons does not change from apparition to apparition, which indicates that the limitation on observability is not due solely to the difference in brightness. The magnitude difference between Mars and Phobos is 13.2, while between Mars and Deimos it is 14.3, regardless of the magnitude of the planet. The visibility of the moons decreases rapidly as their angular separation from the planet diminishes. This phenomenon can be witnessed by anyone who manages to detect one. It appears to be the explanation for the difficulty in detecting the moons at unfavorable apparitions, as the angular separation is then smaller.

High magnification is essential. A motor-driven mounting with a hand controller for fine telescope movements may be necessary in order to accurately place the disc of Mars slightly beyond the edge of the field of view. An occulting bar placed at the focal plane of the eyepiece is another tool that some have used to good advantage.

Both moons have nearly circular orbits – Phobos has eccentricity of 0.0151, while that of Deimos is 0.0003. Consequently, at maximal elongations, their respective distances from the planet are always about the same. Furthermore, both rotate synchronously with their revolutions, so that they present the same side to us at every eastern elongation, and the opposite side at every western elongation, regardless of where Earth and Mars are in their orbits.

Generally, success in seeing the moons depends on planning to observe when they are at greatest elongation from the planet. Deimos is far easier to see than Phobos, even though it is intrinsically fainter, as it is farther from the edge of the planet's disc. Many persons have seen Deimos using telescopes with apertures as small as 200 mm (8 in.), while Phobos is likely to require 300 mm (12 in.) or more. Using a Newtonian of 400 mm (16 in.) aperture at 450 magnifications, one of us (RV) has found that Phobos in the glare of Mars seems about as bright as a star of magnitude 14 appears in a dark sky.

The striking characteristic that makes their detection difficult is how very close they are to Mars. The easier of the two, Deimos, is 2.95 diameters-of-Mars from the edge of the planet's disc when at greatest elongation. It may be detectable for one to three hours before and after the time of greatest elongation, depending on the observing conditions and the telescope aperture. Phobos will be only 0.86 diameters-of-Mars from the edge of the planet's disc when at greatest elongation. It is seldom detectable 30 minutes before or after the time of greatest elongation.

Table 3 gives the UT dates and times of greatest elongations of Deimos during the period around Mars's opposition in which the planet has an apparent diameter of greater than 20 arc seconds. Table 4 gives the same information for Phobos, for the same period. In both tables, the times are rounded to the nearest 10 minutes.

Only a fraction of these elongation events will be observable from any one longitude of Earth. ALPO observers are scattered around the world, so the table includes all elongations. To find events observable from your longitude, use the fourth column in the listing of each event. It gives the Earth longitude at which the elongation will occur on the meridian of the night sky. Southern hemisphere observers may find that any event within 60 degrees of their longitude may be observable. However, at latitude 35 degrees north, an observer might wisely limit his efforts to events within 30 degrees of the optimal longitude, and at 45 degrees north, a limit of 15 degrees might be chosen.

To earn a feather for your cap, observe Phobos at an eastern and a western elongation in the same night, one before the meridian and one after it. One of us (RV) succeeded with this in 1988 (see di Cicco, 1989). You will certainly be mentioned in the JALPO if you accomplish it!

## Reporting Your Observations

The ALPO Mars Section is eager to receive your reports of your observations, whether you make images, drawings, or written descriptions. It is easiest for us if you send them directly to coordinator Roger Venable at *rjvmd@hughes.net* , and you may also wish to post them on the ALPO Mars observers list's file section so that members of that message list can view them. You can join that list to obtain posting privileges, at *https://groups.yahoo.com/neo/groups/marsobservers/info* . The message list currently has 1,437 members.

There are observing forms available online, for those who would benefit from assistance in compiling a report. Find them on the ALPO website, at www.alpo-astronomy.org . On that page, click on "Mars Section" in the list of ALPO sections on the left side of the page. Then, on the Mars Section page, look in the list on the right side of the page, under "Mars Observing Form." (There is no more direct link to it.)

With your report, be sure to include your name, location, the universal time of your observation (not your local time), simple descriptions of your instrument(s), filters used, and estimates of the quality of seeing and transparency. Your interpretations of your findings are also welcome.

## References


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**Table 4A. Phobos' Maximal Elongations Near Opposition.**

| Date | Hr:Min | PA | Long | | Date | Hr:Min | PA | Long | | Date | Hr:Min | PA | Long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2018-Jun-27 | 2:40 | 274 | 2 W | | 2018-Jul-05 | 2:00 | 274 | 0 W | | 2018-Jul-13 | 1:20 | 275 | 1 E |
| 2018-Jun-27 | 6:30 | 95 | 60 W | | 2018-Jul-05 | 5:50 | 95 | 58 W | | 2018-Jul-13 | 5:10 | 95 | 57 W |
| 2018-Jun-27 | 10:20 | 274 | 117 W | | 2018-Jul-05 | 9:40 | 274 | 116 W | | 2018-Jul-13 | 9:00 | 274 | 115 W |
| 2018-Jun-27 | 14:10 | 94 | 175 W | | 2018-Jul-05 | 13:30 | 95 | 173 W | | 2018-Jul-13 | 12:50 | 95 | 172 W |
| 2018-Jun-27 | 18:00 | 273 | 127 E | | 2018-Jul-05 | 17:20 | 274 | 129 E | | 2018-Jul-13 | 16:40 | 274 | 130 E |
| 2018-Jun-27 | 21:50 | 94 | 70 E | | 2018-Jul-05 | 21:10 | 94 | 71 E | | 2018-Jul-13 | 20:30 | 95 | 72 E |
| 2018-Jun-28 | 1:40 | 273 | 12 E | | 2018-Jul-06 | 1:00 | 274 | 14 E | | 2018-Jul-14 | 0:20 | 274 | 15 E |
| 2018-Jun-28 | 5:30 | 94 | 46 W | | 2018-Jul-06 | 4:50 | 94 | 44 W | | 2018-Jul-14 | 4:10 | 95 | 43 W |
| 2018-Jun-28 | 9:20 | 273 | 103 W | | 2018-Jul-06 | 8:40 | 274 | 102 W | | 2018-Jul-14 | 8:00 | 274 | 101 W |
| 2018-Jun-28 | 13:10 | 94 | 161 W | | 2018-Jul-06 | 12:30 | 94 | 159 W | | 2018-Jul-14 | 11:50 | 95 | 158 W |
| 2018-Jun-28 | 17:00 | 273 | 141 E | | 2018-Jul-06 | 16:20 | 273 | 143 E | | 2018-Jul-14 | 15:40 | 274 | 144 E |
| 2018-Jun-28 | 20:50 | 94 | 84 E | | 2018-Jul-06 | 20:10 | 94 | 85 E | | 2018-Jul-14 | 19:30 | 95 | 86 E |
| 2018-Jun-29 | 0:40 | 273 | 26 E | | 2018-Jul-07 | 0:00 | 273 | 28 E | | 2018-Jul-14 | 23:10 | 276 | 31 E |
| 2018-Jun-29 | 4:30 | 94 | 32 W | | 2018-Jul-07 | 3:50 | 94 | 30 W | | 2018-Jul-15 | 3:10 | 95 | 29 W |
| 2018-Jun-29 | 8:10 | 275 | 87 W | | 2018-Jul-07 | 7:30 | 275 | 85 W | | 2018-Jul-15 | 6:50 | 276 | 84 W |
| 2018-Jun-29 | 12:10 | 94 | 147 W | | 2018-Jul-07 | 11:30 | 94 | 145 W | | 2018-Jul-15 | 10:50 | 95 | 145 W |
| 2018-Jun-29 | 15:50 | 274 | 158 E | | 2018-Jul-07 | 15:10 | 275 | 159 E | | 2018-Jul-15 | 14:30 | 275 | 160 E |
| 2018-Jun-29 | 19:50 | 93 | 98 E | | 2018-Jul-07 | 19:10 | 94 | 99 E | | 2018-Jul-15 | 18:20 | 96 | 103 E |
| 2018-Jun-29 | 23:30 | 274 | 43 E | | 2018-Jul-07 | 22:50 | 275 | 44 E | | 2018-Jul-15 | 22:10 | 275 | 45 E |
| 2018-Jun-30 | 3:20 | 95 | 15 W | | 2018-Jul-08 | 2:40 | 95 | 14 W | | 2018-Jul-16 | 2:00 | 96 | 13 W |
| 2018-Jun-30 | 7:10 | 274 | 73 W | | 2018-Jul-08 | 6:30 | 275 | 71 W | | 2018-Jul-16 | 5:50 | 275 | 71 W |
| 2018-Jun-30 | 11:00 | 95 | 130 W | | 2018-Jul-08 | 10:20 | 95 | 129 W | | 2018-Jul-16 | 9:40 | 96 | 128 W |
| 2018-Jun-30 | 14:50 | 274 | 172 E | | 2018-Jul-08 | 14:10 | 274 | 173 E | | 2018-Jul-16 | 13:30 | 275 | 174 E |
| 2018-Jun-30 | 18:40 | 95 | 114 E | | 2018-Jul-08 | 18:00 | 95 | 116 E | | 2018-Jul-16 | 17:20 | 96 | 116 E |
| 2018-Jun-30 | 22:30 | 274 | 57 E | | 2018-Jul-08 | 21:50 | 274 | 58 E | | 2018-Jul-16 | 21:10 | 275 | 59 E |
| 2018-Jul-01 | 2:20 | 95 | 1 W | | 2018-Jul-09 | 1:40 | 95 | 0 E | | 2018-Jul-17 | 1:00 | 96 | 1 E |
| 2018-Jul-01 | 6:10 | 274 | 59 W | | 2018-Jul-09 | 5:30 | 274 | 57 W | | 2018-Jul-17 | 4:50 | 275 | 57 W |
| 2018-Jul-01 | 10:00 | 95 | 116 W | | 2018-Jul-09 | 9:20 | 95 | 115 W | | 2018-Jul-17 | 8:40 | 96 | 114 W |
| 2018-Jul-01 | 13:50 | 274 | 174 W | | 2018-Jul-09 | 13:10 | 274 | 173 W | | 2018-Jul-17 | 12:30 | 275 | 172 W |
| 2018-Jul-01 | 17:40 | 94 | 128 E | | 2018-Jul-09 | 17:00 | 95 | 130 E | | 2018-Jul-17 | 16:20 | 96 | 130 E |
| 2018-Jul-01 | 21:30 | 274 | 71 E | | 2018-Jul-09 | 20:50 | 274 | 72 E | | 2018-Jul-17 | 20:10 | 275 | 73 E |
| 2018-Jul-02 | 1:20 | 94 | 13 E | | 2018-Jul-10 | 0:40 | 95 | 14 E | | 2018-Jul-18 | 0:00 | 95 | 15 E |
| 2018-Jul-02 | 5:10 | 273 | 45 W | | 2018-Jul-10 | 4:30 | 274 | 43 W | | 2018-Jul-18 | 3:50 | 275 | 43 W |
| 2018-Jul-02 | 9:00 | 94 | 102 W | | 2018-Jul-10 | 8:20 | 95 | 101 W | | 2018-Jul-18 | 7:40 | 95 | 101 W |
| 2018-Jul-02 | 12:50 | 273 | 160 W | | 2018-Jul-10 | 12:10 | 274 | 159 W | | 2018-Jul-18 | 11:20 | 276 | 156 W |
| 2018-Jul-02 | 16:40 | 94 | 142 E | | 2018-Jul-10 | 16:00 | 94 | 144 E | | 2018-Jul-18 | 15:20 | 95 | 144 E |
| 2018-Jul-02 | 20:30 | 273 | 85 E | | 2018-Jul-10 | 19:50 | 274 | 86 E | | 2018-Jul-18 | 19:00 | 276 | 89 E |
| 2018-Jul-03 | 0:20 | 94 | 27 E | | 2018-Jul-10 | 23:40 | 94 | 28 E | | 2018-Jul-18 | 23:00 | 95 | 29 E |
| 2018-Jul-03 | 4:00 | 275 | 28 W | | 2018-Jul-11 | 3:20 | 275 | 27 W | | 2018-Jul-19 | 2:40 | 276 | 27 W |
| 2018-Jul-03 | 8:00 | 94 | 88 W | | 2018-Jul-11 | 7:20 | 94 | 87 W | | 2018-Jul-19 | 6:30 | 97 | 84 W |
| 2018-Jul-03 | 11:40 | 275 | 144 W | | 2018-Jul-11 | 11:00 | 275 | 142 W | | 2018-Jul-19 | 10:20 | 276 | 142 W |
| 2018-Jul-03 | 15:40 | 94 | 156 E | | 2018-Jul-11 | 15:00 | 94 | 157 E | | 2018-Jul-19 | 14:10 | 97 | 160 E |
| 2018-Jul-03 | 19:20 | 275 | 101 E | | 2018-Jul-11 | 18:40 | 275 | 102 E | | 2018-Jul-19 | 18:00 | 276 | 103 E |
| 2018-Jul-03 | 23:20 | 93 | 41 E | | 2018-Jul-11 | 22:30 | 96 | 45 E | | 2018-Jul-19 | 21:50 | 96 | 45 E |
| 2018-Jul-04 | 3:00 | 274 | 14 W | | 2018-Jul-12 | 2:20 | 275 | 13 W | | 2018-Jul-20 | 1:40 | 276 | 13 W |
| 2018-Jul-04 | 6:50 | 95 | 72 W | | 2018-Jul-12 | 6:10 | 96 | 71 W | | 2018-Jul-20 | 5:30 | 96 | 70 W |
| 2018-Jul-04 | 10:40 | 274 | 130 W | | 2018-Jul-12 | 10:00 | 275 | 129 W | | 2018-Jul-20 | 9:20 | 276 | 128 W |
| 2018-Jul-04 | 14:30 | 95 | 173 E | | 2018-Jul-12 | 13:50 | 95 | 174 E | | 2018-Jul-20 | 13:10 | 96 | 174 E |
| 2018-Jul-04 | 18:20 | 274 | 115 E | | 2018-Jul-12 | 17:40 | 275 | 116 E | | 2018-Jul-20 | 17:00 | 276 | 117 E |
| 2018-Jul-04 | 22:10 | 95 | 57 E | | 2018-Jul-12 | 21:30 | 95 | 58 E | | 2018-Jul-20 | 20:50 | 96 | 59 E |

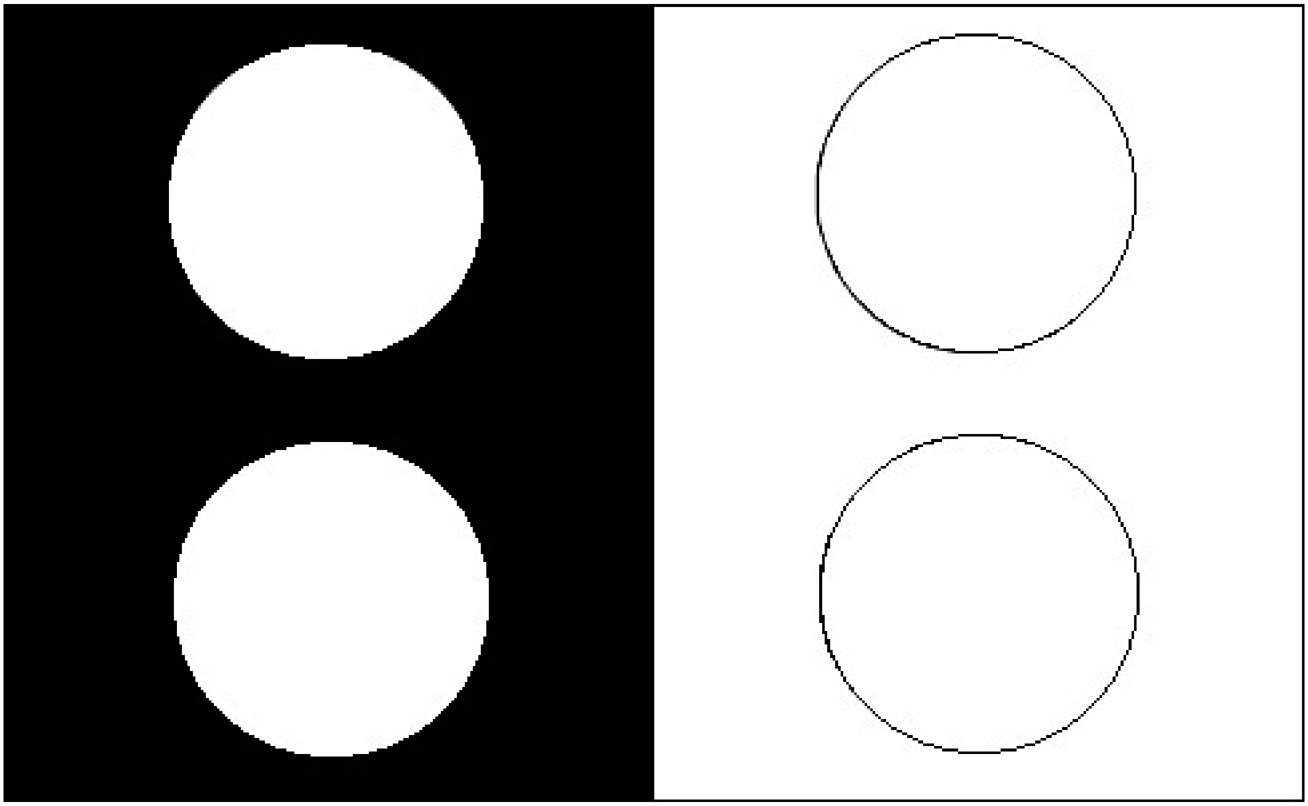
**Table 4B. Phobos' Maximal Elongations Near Opposition (Cont'd.)**

| Date | Hr:Min | PA | Long | | Date | Hr:Min | PA | Long | | Date | Hr:Min | PA | Long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2018-Jul-21 | 0:40 | 275 | 1 E | | 2018-Jul-29 | 0:00 | 277 | 1 E | | 2018-Aug-05 | 23:10 | 279 | 3 E |
| 2018-Jul-21 | 4:30 | 96 | 57 W | | 2018-Jul-29 | 3:50 | 97 | 57 W | | 2018-Aug-06 | 3:10 | 98 | 57 W |
| 2018-Jul-21 | 8:20 | 275 | 114 W | | 2018-Jul-29 | 7:40 | 277 | 114 W | | 2018-Aug-06 | 6:50 | 279 | 112 W |
| 2018-Jul-21 | 12:10 | 96 | 172 W | | 2018-Jul-29 | 11:30 | 97 | 172 W | | 2018-Aug-06 | 10:50 | 98 | 172 W |
| 2018-Jul-21 | 16:00 | 275 | 130 E | | 2018-Jul-29 | 15:10 | 278 | 133 E | | 2018-Aug-06 | 14:30 | 279 | 133 E |
| 2018-Jul-21 | 19:50 | 96 | 73 E | | 2018-Jul-29 | 19:10 | 97 | 73 E | | 2018-Aug-06 | 18:20 | 99 | 75 E |
| 2018-Jul-21 | 23:40 | 275 | 15 E | | 2018-Jul-29 | 22:50 | 278 | 17 E | | 2018-Aug-06 | 22:10 | 279 | 17 E |
| 2018-Jul-22 | 3:30 | 96 | 43 W | | 2018-Jul-30 | 2:50 | 97 | 43 W | | 2018-Aug-07 | 2:00 | 99 | 40 W |
| 2018-Jul-22 | 7:10 | 277 | 98 W | | 2018-Jul-30 | 6:30 | 278 | 98 W | | 2018-Aug-07 | 5:50 | 279 | 98 W |
| 2018-Jul-22 | 11:10 | 96 | 158 W | | 2018-Jul-30 | 10:20 | 98 | 156 W | | 2018-Aug-07 | 9:40 | 99 | 156 W |
| 2018-Jul-22 | 14:50 | 277 | 147 E | | 2018-Jul-30 | 14:10 | 278 | 147 E | | 2018-Aug-07 | 13:30 | 279 | 146 E |
| 2018-Jul-22 | 18:50 | 96 | 86 E | | 2018-Jul-30 | 18:00 | 98 | 89 E | | 2018-Aug-07 | 17:20 | 99 | 89 E |
| 2018-Jul-22 | 22:30 | 277 | 31 E | | 2018-Jul-30 | 21:50 | 278 | 31 E | | 2018-Aug-07 | 21:10 | 279 | 31 E |
| 2018-Jul-23 | 2:20 | 97 | 26 W | | 2018-Jul-31 | 1:40 | 98 | 27 W | | 2018-Aug-08 | 1:00 | 99 | 27 W |
| 2018-Jul-23 | 6:10 | 276 | 84 W | | 2018-Jul-31 | 5:30 | 278 | 84 W | | 2018-Aug-08 | 4:50 | 279 | 84 W |
| 2018-Jul-23 | 10:00 | 97 | 142 W | | 2018-Jul-31 | 9:20 | 98 | 142 W | | 2018-Aug-08 | 8:40 | 99 | 142 W |
| 2018-Jul-23 | 13:50 | 276 | 160 E | | 2018-Jul-31 | 13:10 | 277 | 160 E | | 2018-Aug-08 | 12:30 | 279 | 160 E |
| 2018-Jul-23 | 17:40 | 97 | 103 E | | 2018-Jul-31 | 17:00 | 98 | 103 E | | 2018-Aug-08 | 16:20 | 99 | 103 E |
| 2018-Jul-23 | 21:30 | 276 | 45 E | | 2018-Jul-31 | 20:50 | 277 | 45 E | | 2018-Aug-08 | 20:10 | 279 | 45 E |
| 2018-Jul-24 | 1:20 | 97 | 13 W | | 2018-Aug-01 | 0:40 | 98 | 13 W | | 2018-Aug-09 | 0:00 | 99 | 13 W |
| 2018-Jul-24 | 5:10 | 276 | 70 W | | 2018-Aug-01 | 4:30 | 277 | 71 W | | 2018-Aug-09 | 3:50 | 278 | 71 W |
| 2018-Jul-24 | 9:00 | 97 | 128 W | | 2018-Aug-01 | 8:20 | 98 | 128 W | | 2018-Aug-09 | 7:40 | 99 | 128 W |
| 2018-Jul-24 | 12:50 | 276 | 174 E | | 2018-Aug-01 | 12:10 | 277 | 174 E | | 2018-Aug-09 | 11:30 | 278 | 174 E |
| 2018-Jul-24 | 16:40 | 97 | 117 E | | 2018-Aug-01 | 16:00 | 98 | 116 E | | 2018-Aug-09 | 15:20 | 99 | 116 E |
| 2018-Jul-24 | 20:30 | 276 | 59 E | | 2018-Aug-01 | 19:50 | 277 | 59 E | | 2018-Aug-09 | 19:00 | 280 | 61 E |
| 2018-Jul-25 | 0:20 | 97 | 1 E | | 2018-Aug-01 | 23:40 | 98 | 1 E | | 2018-Aug-09 | 23:00 | 99 | 1 E |
| 2018-Jul-25 | 4:10 | 276 | 57 W | | 2018-Aug-02 | 3:30 | 277 | 57 W | | 2018-Aug-10 | 2:40 | 280 | 54 W |
| 2018-Jul-25 | 8:00 | 97 | 114 W | | 2018-Aug-02 | 7:20 | 98 | 114 W | | 2018-Aug-10 | 6:40 | 99 | 114 W |
| 2018-Jul-25 | 11:50 | 276 | 172 W | | 2018-Aug-02 | 11:00 | 278 | 170 W | | 2018-Aug-10 | 10:20 | 280 | 170 W |
| 2018-Jul-25 | 15:40 | 97 | 130 E | | 2018-Aug-02 | 15:00 | 98 | 130 E | | 2018-Aug-10 | 14:10 | 100 | 133 E |
| 2018-Jul-25 | 19:30 | 276 | 73 E | | 2018-Aug-02 | 18:40 | 278 | 75 E | | 2018-Aug-10 | 18:00 | 279 | 75 E |
| 2018-Jul-25 | 23:20 | 96 | 15 E | | 2018-Aug-02 | 22:30 | 99 | 17 E | | 2018-Aug-10 | 21:50 | 100 | 17 E |
| 2018-Jul-26 | 3:00 | 277 | 40 W | | 2018-Aug-03 | 2:20 | 278 | 40 W | | 2018-Aug-11 | 1:40 | 279 | 40 W |
| 2018-Jul-26 | 7:00 | 96 | 100 W | | 2018-Aug-03 | 6:10 | 99 | 98 W | | 2018-Aug-11 | 5:30 | 100 | 98 W |
| 2018-Jul-26 | 10:40 | 277 | 156 W | | 2018-Aug-03 | 10:00 | 278 | 156 W | | 2018-Aug-11 | 9:20 | 279 | 156 W |
| 2018-Jul-26 | 14:30 | 98 | 147 E | | 2018-Aug-03 | 13:50 | 99 | 146 E | | 2018-Aug-11 | 13:10 | 100 | 147 E |
| 8-Jul-26 | 18:20 | 277 | 89 E | | 2018-Aug-03 | 17:40 | 278 | 89 E | | 2018-Aug-11 | 17:00 | 279 | 89 E |
| 2018-Jul-26 | 22:10 | 98 | 31 E | | 2018-Aug-03 | 21:30 | 99 | 31 E | | 2018-Aug-11 | 20:50 | 100 | 31 E |
| 2018-Jul-27 | 2:00 | 277 | 27 W | | 2018-Aug-04 | 1:20 | 278 | 27 W | | 2018-Aug-12 | 0:40 | 279 | 27 W |
| 2018-Jul-27 | 5:50 | 98 | 84 W | | 2018-Aug-04 | 5:10 | 99 | 84 W | | 2018-Aug-12 | 4:30 | 100 | 84 W |
| 2018-Jul-27 | 9:40 | 277 | 142 W | | 2018-Aug-04 | 9:00 | 278 | 142 W | | 2018-Aug-12 | 8:20 | 279 | 142 W |
| 2018-Jul-27 | 13:30 | 98 | 160 E | | 2018-Aug-04 | 12:50 | 99 | 160 E | | 2018-Aug-12 | 12:10 | 100 | 160 E |
| 2018-Jul-27 | 17:20 | 277 | 103 E | | 2018-Aug-04 | 16:40 | 278 | 103 E | | 2018-Aug-12 | 16:00 | 279 | 103 E |
| 2018-Jul-27 | 21:10 | 97 | 45 E | | 2018-Aug-04 | 20:30 | 99 | 45 E | | 2018-Aug-12 | 19:50 | 100 | 45 E |
| 2018-Jul-28 | 1:00 | 277 | 13 W | | 2018-Aug-05 | 0:20 | 278 | 13 W | | 2018-Aug-12 | 23:40 | 279 | 13 W |
| 2018-Jul-28 | 4:50 | 97 | 70 W | | 2018-Aug-05 | 4:10 | 98 | 71 W | | 2018-Aug-13 | 3:30 | 99 | 70 W |
| 2018-Jul-28 | 8:40 | 277 | 128 W | | 2018-Aug-05 | 8:00 | 278 | 128 W | | 2018-Aug-13 | 7:20 | 279 | 128 W |
| 2018-Jul-28 | 12:30 | 97 | 174 E | | 2018-Aug-05 | 11:50 | 98 | 174 E | | 2018-Aug-13 | 11:10 | 99 | 174 E |
| 2018-Jul-28 | 16:20 | 277 | 116 E | | 2018-Aug-05 | 15:40 | 278 | 116 E | | 2018-Aug-13 | 14:50 | 280 | 119 E |
| 2018-Jul-28 | 20:10 | 97 | 59 E | | 2018-Aug-05 | 19:30 | 98 | 59 E | | 2018-Aug-13 | 18:50 | 99 | 59 E |

**Table 4C. Phobos' Maximal Elongations Near Opposition (Cont'd.)**

| Date | Hr:Min | PA | Long | | Date | Hr:Min | PA | Long | | Date | Hr:Min | PA | Long |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2018-Aug-13 | 22:30 | 280 | 4 E | | 2018-Aug-21 | 14:10 | 281 | 120 E | | 2018-Aug-29 | 6:00 | 280 | 125 W |
| 2018-Aug-14 | 2:20 | 101 | 54 W | | 2018-Aug-21 | 18:10 | 100 | 60 E | | 2018-Aug-29 | 9:50 | 100 | 177 E |
| 2018-Aug-14 | 6:10 | 280 | 112 W | | 2018-Aug-21 | 21:50 | 281 | 5 E | | 2018-Aug-29 | 13:30 | 281 | 122 E |
| 2018-Aug-14 | 10:00 | 100 | 169 W | | 2018-Aug-22 | 1:40 | 101 | 53 W | | 2018-Aug-29 | 17:30 | 100 | 62 E |
| 2018-Aug-14 | 13:50 | 280 | 133 E | | 2018-Aug-22 | 5:30 | 281 | 111 W | | 2018-Aug-29 | 21:10 | 281 | 7 E |
| 2018-Aug-14 | 17:40 | 100 | 75 E | | 2018-Aug-22 | 9:20 | 101 | 168 W | | 2018-Aug-30 | 1:10 | 100 | 54 W |
| 2018-Aug-14 | 21:30 | 280 | 18 E | | 2018-Aug-22 | 13:10 | 281 | 134 E | | 2018-Aug-30 | 4:50 | 281 | 109 W |
| 2018-Aug-15 | 1:20 | 100 | 40 W | | 2018-Aug-22 | 17:00 | 101 | 76 E | | 2018-Aug-30 | 8:40 | 101 | 166 W |
| 2018-Aug-15 | 5:10 | 280 | 98 W | | 2018-Aug-22 | 20:50 | 280 | 19 E | | 2018-Aug-30 | 12:30 | 281 | 136 E |
| 2018-Aug-15 | 9:00 | 100 | 155 W | | 2018-Aug-23 | 0:40 | 101 | 39 W | | 2018-Aug-30 | 16:20 | 101 | 78 E |
| 2018-Aug-15 | 12:50 | 280 | 147 E | | 2018-Aug-23 | 4:30 | 280 | 97 W | | 2018-Aug-30 | 20:10 | 281 | 21 E |
| 2018-Aug-15 | 16:40 | 100 | 89 E | | 2018-Aug-23 | 8:20 | 101 | 154 W | | 2018-Aug-31 | 0:00 | 101 | 37 W |
| 2018-Aug-15 | 20:30 | 280 | 31 E | | 2018-Aug-23 | 12:10 | 280 | 148 E | | 2018-Aug-31 | 3:50 | 281 | 95 W |
| 2018-Aug-16 | 0:20 | 100 | 26 W | | 2018-Aug-23 | 16:00 | 101 | 90 E | | 2018-Aug-31 | 7:40 | 101 | 152 W |
| 2018-Aug-16 | 4:10 | 280 | 84 W | | 2018-Aug-23 | 19:50 | 280 | 33 E | | 2018-Aug-31 | 11:30 | 280 | 150 E |
| 2018-Aug-16 | 8:00 | 100 | 142 W | | 2018-Aug-23 | 23:40 | 101 | 25 W | | 2018-Aug-31 | 15:20 | 101 | 92 E |
| 2018-Aug-16 | 11:50 | 279 | 161 E | | 2018-Aug-24 | 3:30 | 280 | 83 W | | 2018-Aug-31 | 19:10 | 280 | 35 E |
| 2018-Aug-16 | 15:40 | 100 | 103 E | | 2018-Aug-24 | 7:20 | 101 | 140 W | | 2018-Aug-31 | 23:00 | 101 | 23 W |
| 2018-Aug-16 | 19:30 | 279 | 45 E | | 2018-Aug-24 | 11:10 | 280 | 162 E | | 2018-Sep-01 | 2:50 | 280 | 81 W |
| 2018-Aug-16 | 23:20 | 100 | 12 W | | 2018-Aug-24 | 15:00 | 100 | 104 E | | 2018-Sep-01 | 6:40 | 101 | 138 W |
| 2018-Aug-17 | 3:10 | 279 | 70 W | | 2018-Aug-24 | 18:50 | 280 | 47 E | | 2018-Sep-01 | 10:30 | 280 | 164 E |
| 2018-Aug-17 | 7:00 | 100 | 128 W | | 2018-Aug-24 | 22:40 | 100 | 11 W | | 2018-Sep-01 | 14:20 | 101 | 106 E |
| 2018-Aug-17 | 10:40 | 281 | 177 E | | 2018-Aug-25 | 2:30 | 280 | 69 W | | 2018-Sep-01 | 18:10 | 280 | 49 E |
| 2018-Aug-17 | 14:40 | 100 | 117 E | | 2018-Aug-25 | 6:20 | 100 | 126 W | | 2018-Sep-01 | 22:00 | 100 | 9 W |
| 2018-Aug-17 | 18:20 | 280 | 62 E | | 2018-Aug-25 | 10:00 | 281 | 178 E | | 2018-Sep-02 | 1:50 | 280 | 66 W |
| 2018-Aug-17 | 22:20 | 100 | 2 E | | 2018-Aug-25 | 14:00 | 100 | 118 E | | 2018-Sep-02 | 5:40 | 100 | 124 W |
| 2018-Aug-18 | 2:00 | 280 | 54 W | | 2018-Aug-25 | 17:40 | 281 | 63 E | | 2018-Sep-02 | 9:30 | 280 | 178 E |
| 2018-Aug-18 | 5:50 | 101 | 111 W | | 2018-Aug-25 | 21:40 | 100 | 3 E | | 2018-Sep-02 | 13:20 | 100 | 121 E |
| 2018-Aug-18 | 9:40 | 280 | 169 W | | 2018-Aug-26 | 1:20 | 281 | 52 W | | 2018-Sep-02 | 17:00 | 281 | 65 E |
| 2018-Aug-18 | 13:30 | 101 | 133 E | | 2018-Aug-26 | 5:10 | 101 | 110 W | | 2018-Sep-02 | 21:00 | 100 | 5 E |
| 2018-Aug-18 | 17:20 | 280 | 76 E | | 2018-Aug-26 | 9:00 | 281 | 167 W | | 2018-Sep-03 | 0:40 | 281 | 50 W |
| 2018-Aug-18 | 21:10 | 101 | 18 E | | 2018-Aug-26 | 12:50 | 101 | 135 E | | 2018-Sep-03 | 4:40 | 100 | 110 W |
| 2018-Aug-19 | 1:00 | 280 | 40 W | | 2018-Aug-26 | 16:40 | 281 | 77 E | | 2018-Sep-03 | 8:20 | 281 | 165 W |
| 2018-Aug-19 | 4:50 | 101 | 97 W | | 2018-Aug-26 | 20:30 | 101 | 20 E | | 2018-Sep-03 | 12:10 | 101 | 137 E |
| 2018-Aug-19 | 8:40 | 280 | 155 W | | 2018-Aug-27 | 0:20 | 281 | 38 W | | 2018-Sep-03 | 16:00 | 281 | 80 E |
| 2018-Aug-19 | 12:30 | 101 | 147 E | | 2018-Aug-27 | 4:10 | 101 | 96 W | | 2018-Sep-03 | 19:50 | 101 | 22 E |
| 2018-Aug-19 | 16:20 | 280 | 90 E | | 2018-Aug-27 | 8:00 | 280 | 153 W | | 2018-Sep-03 | 23:40 | 281 | 36 W |
| 2018-Aug-19 | 20:10 | 100 | 32 E | | 2018-Aug-27 | 11:50 | 101 | 149 E | | 2018-Sep-04 | 3:30 | 101 | 93 W |
| 2018-Aug-20 | 0:00 | 280 | 26 W | | 2018-Aug-27 | 15:40 | 280 | 91 E | | 2018-Sep-04 | 7:20 | 280 | 151 W |
| 2018-Aug-20 | 3:50 | 100 | 83 W | | 2018-Aug-27 | 19:30 | 101 | 34 E | | 2018-Sep-04 | 11:10 | 101 | 151 E |
| 2018-Aug-20 | 7:40 | 280 | 141 W | | 2018-Aug-27 | 23:20 | 280 | 24 W | | 2018-Sep-04 | 15:00 | 280 | 94 E |
| 2018-Aug-20 | 11:30 | 100 | 161 E | | 2018-Aug-28 | 3:10 | 101 | 82 W | | 2018-Sep-04 | 18:50 | 101 | 36 E |
| 2018-Aug-20 | 15:20 | 280 | 104 E | | 2018-Aug-28 | 7:00 | 280 | 139 W | | 2018-Sep-04 | 22:40 | 280 | 22 W |
| 2018-Aug-20 | 19:10 | 100 | 46 E | | 2018-Aug-28 | 10:50 | 101 | 163 E | | 2018-Sep-05 | 2:30 | 101 | 79 W |
| 2018-Aug-20 | 23:00 | 280 | 12 W | | 2018-Aug-28 | 14:40 | 280 | 105 E | | 2018-Sep-05 | 6:20 | 280 | 137 W |
| 2018-Aug-21 | 2:50 | 100 | 69 W | | 2018-Aug-28 | 18:30 | 101 | 48 E | | 2018-Sep-05 | 10:10 | 101 | 166 E |
| 2018-Aug-21 | 6:30 | 281 | 125 W | | 2018-Aug-28 | 22:20 | 280 | 10 W | | 2018-Sep-05 | 14:00 | 280 | 108 E |
| 2018-Aug-21 | 10:30 | 100 | 175 E | | 2018-Aug-29 | 2:10 | 100 | 68 W | | 2018-Sep-05 | 17:50 | 100 | 50 E |

# A.L.P.O. Mars Section Observation



**Top:** **Time (UT):**______________________ **Bottom:** **Time (UT):**______________________
**CM:**______________° W **CM:**______________° W
**Filter:**____________________ ( W / S ) **Filter:**____________________ ( W / S )

**Date (UT):**______________________
**Time (UT):**__________ - __________
**CM:** __________° W - __________° W
**$D_E$:**__________° - **$L_S$:**__________°
**Dia. (''):**__________ **k (phase):** __________
**Telescope:**______ **f/**______ ( in. / cm. ; RL , RR , SC )
**Magnification:**______x ______x ______x
**Filters:**____________________ ( W / S )
**Seeing (0-10):**________ **Antoniadi (I-V):**________
**Transparency (1-6):**______( Clear / Haze / Int. Clouds)
**Blue (Violet) Clearing (0-3):**__________

**Observer:**______________________
**Address:**______________________
**Observing Station:**______________________
**E-mail (optional):**______________________

**Notes**

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**(Continue on back if needed)**

## *Feature Story: Minor Planets*

# *319 Leona and 341 California – Two Very Slowly Rotating Asteroids*

Originally published in *The Minor Planet Bulletin* Vol. 44, No. 2 (April -June 2017), its re-publication here is meant to demonstrate the good work being done by the ALPO Minor Planets Section and to inspire and recruit others to likewise participate. $5 contributions are most welcome; you may access *The Minor Planet Bulletin* at no charge online at http://www.minorplanet.info/mpbdownloads.html.

**319 LEONA AND 341 CALIFORNIA – TWO VERY SLOWLY ROTATING ASTEROIDS**

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(Received: 2016 Dec 20)

An observing strategy for asteroids suspected of being very slowly rotating is described and recommended to all observers. For 319 Leona the synodic rotation period is 430 ± 2 hours, amplitude 0.7 magnitudes, a second tumbling period is 1084 ± 10 hours, color index V-R = 0.43, H=10.46 ± 0.08 and G=0.11 ± 0.09 at mean light. For 341 California the synodic rotation period is 318 ± 2 hours, amplitude 0.9 magnitudes, a second tumbling period is 250 ± 2 hours, color index V-R = 0.53, H=11.53 ± 0.06 and G=0.18 ± 0.05 at mean light.

For very slowly rotating asteroids the most productive observing strategy is to obtain a short session 15 to 20 minutes every clear night except when the Moon is very close in the sky for several months before and after opposition. Solar colored comparison stars with Sloan r’ magnitudes from the CMC15 catalog (VizieR web site) should be used to measure all CCD frames. The internal consistency of the CMC15 catalog is usually within 0.05 magnitudes over the entire sky. The r’ magnitudes read off the CMC15 catalog may be converted to the standard Cousins R magnitudes system by R=r’-0.22 (Dymock and Miles, 2009). Lightcurves from all sessions are then composited with no adjustment of instrumental magnitudes. A search should be made for possible tumbling behavior. This is revealed whenever successive rotational cycles show significant variation, and quantified with simultaneous 2 period software. In addition, it is useful to obtain a small number of all-night sessions for each object near opposition to look for possible small amplitude short period variations.

Observations to obtain the data used in this paper were made at the Organ Mesa Observatory with a 0.35-meter Meade LX200 GPS Schmidt-Cassegrain (SCT) and SBIG STL-1001E CCD. Exposures were 60 seconds, unguided, with a clear filter. All measurements were calibrated from CMC15 r’ values to Cousins R magnitudes for solar colored field stars. Photometric measurement is with MPO Canopus software. To reduce the number of points on the lightcurves and make them easier to read, data points on all lightcurves constructed with MPO Canopus software have been binned in sets of 3 with a maximum time difference of 5 minutes between points in each bin.

Twenty images in both R and V filters were obtained alternately on 2016 September 10 for 319 Leona and 341 California. The same solar colored comparison stars with Sloan r’, J, and K magnitudes read from the CMC15 catalog (VizieR web site) were used to measure both image sets. For the R filter images, conversions to Cousins R magnitudes are by R=r’-0.22. For the V filter images conversions to Johnson V magnitudes are by V=0.9947*r’+0.6278*(J-K). Both conversion procedures are from Dymock and Miles (2009). The magnitudes thus converted for each color are shown together. The V magnitude data points can be adjusted upward to obtain the best fit between R magnitude and V magnitude overlapping sessions. The amount of the adjustment is then the color index V-R. For each session R magnitudes were estimated at maximum, mid, and minimum light for the rotational cycle. Each measured R magnitude was converted to its corresponding V magnitude by adding V-R. The H-G calculator function of *MPO Canopus* then drew the phase diagram for H and G at maximum, mid, and minimum light, respectively, in the Johnson V magnitude system.

319 Leona. Previous published rotation periods and amplitudes are by Behrend (2006), 9.6 hours, 0.03 magnitudes; and by Alkema (2013), 14.9 hours, 0.10 magnitudes. A total of 82 sessions, most of them about 15 minutes, were obtained 2016 Aug. 4 – Dec. 6. A single period lightcurve was constructed with *MPO Canopus* software with best fit to a period 430.66 ± 0.18 hours (Fig. 1). The small formal error is unrealistic because for tumbling asteroids systematic errors are much larger than formal errors. A fit with the 2nd order 2 period Fourier series (Fig. 2) finds a main period 430 ± 2 hours, amplitude 0.7 magnitudes, and candidate second period 1084 ± 10 hours. This fit is done in flux units, not magnitudes. The strongest signals are in the frequencies 2/P_1 and 1/P_2 with their flux amplitude ratio 1:0.22. Use of higher orders is not justified by the data limitations for the very long second period. A raw lightcurve of 319 Leona fitted to the 2 period Fourier model is shown in Fig. 3. Individual rotational cycles and their changes in successive cycles due to tumbling are clearly perceived. Raw lightcurves are also shown for the intervals 2016 Sept. 23-25 on the descending branch of the lightcurve (Fig. 4) and 2016 Sept. 27-29 on the ascending branch (Fig. 5). Within the ± 0.05 magnitude internal consistency of the CMC15 catalog, the all-night lightcurve of the middle night has a slope that fits the slope defined for all three nights. No short period variation is seen. Fig. 6 shows alternating R and V filter magnitudes separated by V-R = 0.43 magnitudes. Fig. 7 shows the V magnitude H-G plot for 319 Leona at maximum light, mid light, and minimum light, respectively.

341 California. Previous published rotation periods and amplitudes are by Behrend (2005), 8.74 hours, 0.07 magnitudes; Behrend (2008), 8.74 hours, 0.02 magnitudes; and Skiff (2014), 317 hours, 0.75 magnitudes. A total of 117 sessions, most of them about 15 minutes, were obtained 2016 June 3 – Dec. 7. A

| Number | Name | 2016 mm/dd | Pts | Phase | LPAB | BPAB | Period(h) | P.E | Amp | A.E. | P2 | P.E. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 319 | Leona | 08/04-12/06 | 3193 | 17,1,20 | 4 | 0 | 430. | 2. | 0.5 | 0.1 | 1084 | 10 |
| 341 | California | 06/03-12/07 | 3793 | 34,1,26 | 12 | -4 | 318. | 2. | 0.5 | 0.1 | 250 | 2 |

Table I. Observing circumstances and results. Pts is the number of data points. The phase angle is given for the first date, minimum value, and last date. LPAB and BPAB are the approximate phase angle bisector longitude and latitude at mid-date range (see Harris *et al.*, 1984). P2 is the second period of tumbling.

single period lightcurve was constructed with *MPO Canopus* software with best fit to a period of 317.88 ± 0.06 hours (Fig. 8). The small formal error is again unrealistic for a tumbling asteroid. A fit with the 4th order 2 period Fourier series (Fig. 9) finds a main period 318 hours, amplitude 0.9 magnitudes, candidate second period 250 hours, both ± 2 hours. Again in flux units, the strongest signals are in the frequencies 2/P_1 and 2/P_2 with flux amplitude ratio 1:0.21. A raw lightcurve of 341 California fitted to the 2 period Fourier model is shown in Fig. 10. Individual rotational cycles and their changes in successive cycles due to tumbling are clearly perceived. Raw lightcurves are also shown for the intervals 2016 Oct. 3-5 (Fig. 11) and 2016 Oct 9-11 (Fig. 12), both on descending branches of the lightcurve. Within the ± 0.05 magnitude internal consistency of the CMC15 catalog, the all-night lightcurve of the middle night has a slope that fits the slope defined for all three nights. No short period variation is seen. Fig. 13 shows alternating R and V filter magnitudes separated by V-R = 0.53 magnitudes. Fig. 14 shows the V magnitude H-G plot for 341 California at maximum light, mid light, and minimum light, respectively.

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Harris, A.W., Young, J.W., Scaltriti, F., Zappala, V. (1984). "Lightcurves and phase relations of the asteroids 82 Alkmene and 444 Gyptis." *Icarus* **57**, 251-258.

Skiff, B. (2014). Posting on CALL website *http://www.minorplanet.info/call.html*.

VizieR (2016). *http://vizier.u-strasbg.fr/viz-bin/VizieR*.


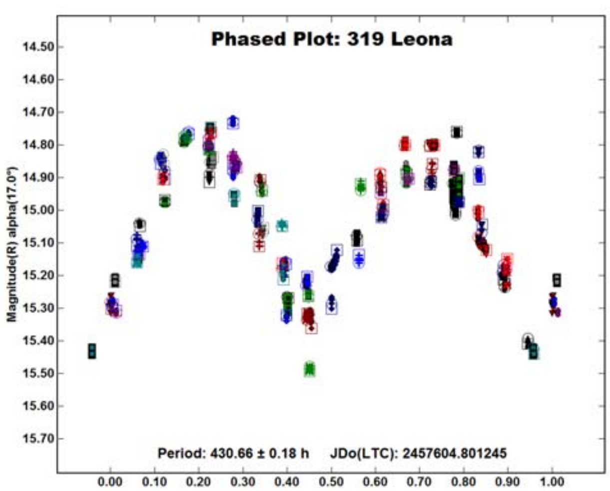


Figure 1. Single period lightcurve of 319 Leona based on 82 sessions 2016 Aug. 4 - Dec. 6 in R band magnitudes, corrected for changes in phase angle and geocentric and heliocentric distances and prepared by MPO Canopus software.

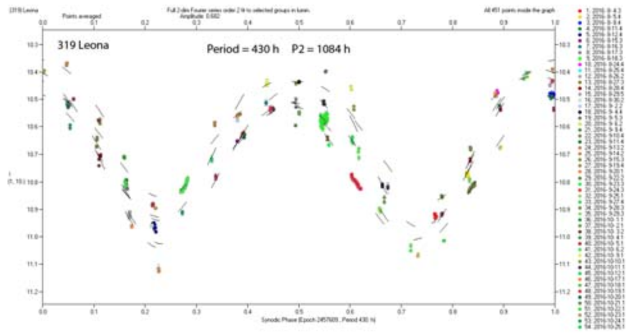


Figure 2. Second order 2 period Fourier series lightcurves of 319 Leona.

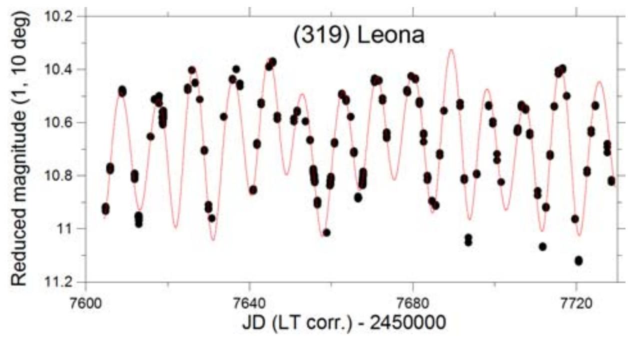


Figure 3. Raw lightcurve of all sessions of 319 Leona fit to a 2 period Fourier model.

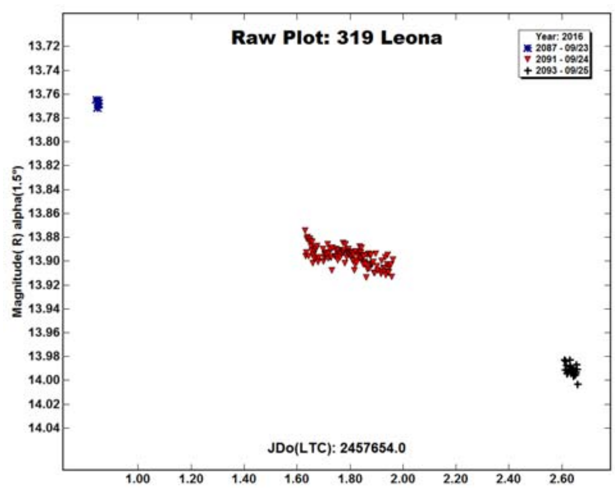


Figure 4. Raw lightcurve of 319 Leona for the interval 2016 Sept. 23-25.

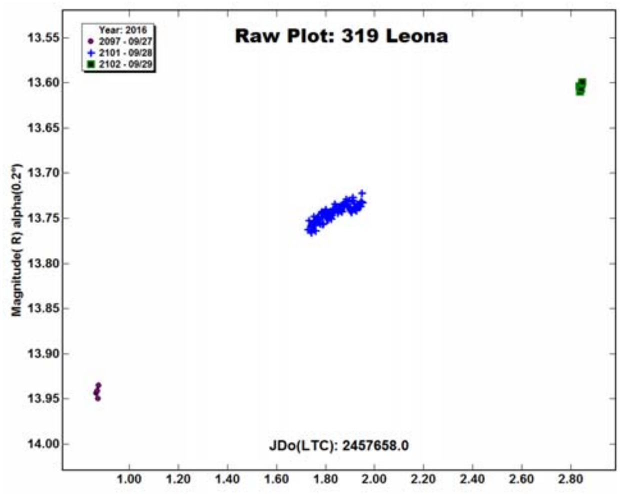


Figure 5. Raw lightcurve of 319 Leona for the interval 2016 Sept. 27-29.

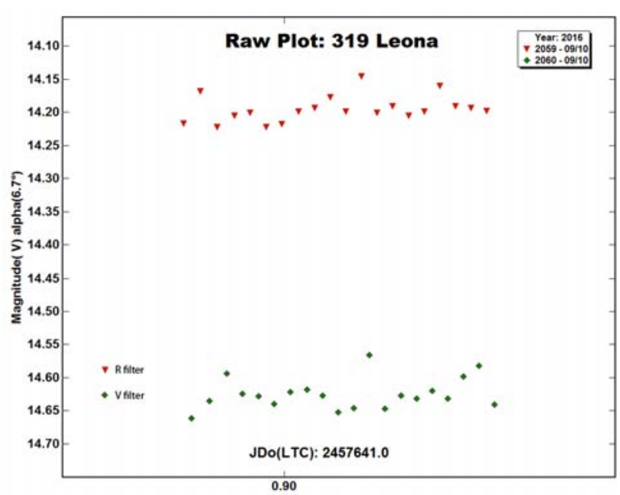


Figure 6. Observations of 319 Leona 2016 Sept. 10 in R and V magnitudes.

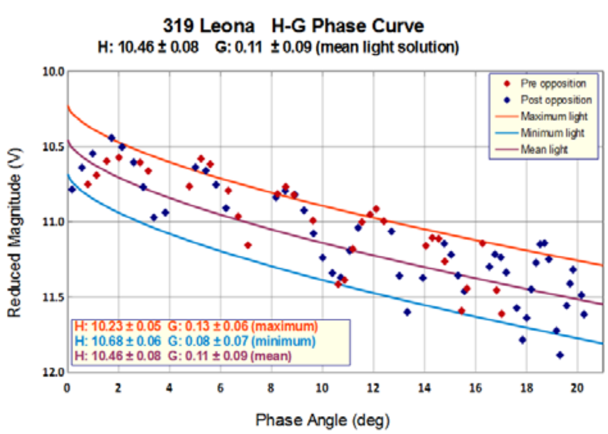


Figure 7. H-G plots for 319 Leona for maximum, mean, and minimum light data points, respectively.

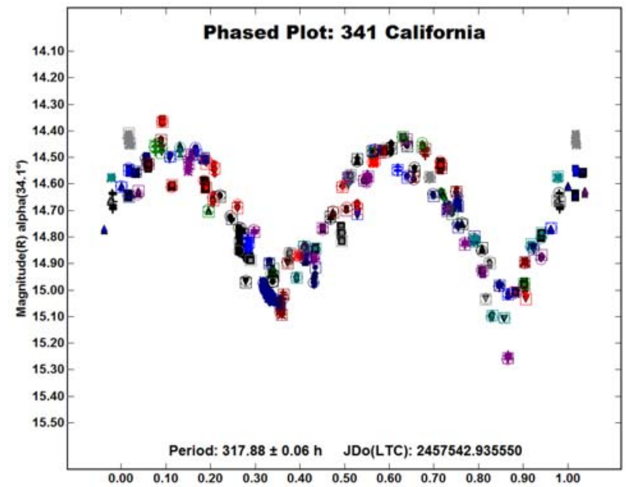


Figure 8. Single period lightcurve of 341 California based on 117 sessions 2016 June 3 - Dec. 7 in R band magnitudes, corrected for changes in phase angle and geocentric and heliocentric distances and prepared by MPO Canopus software.

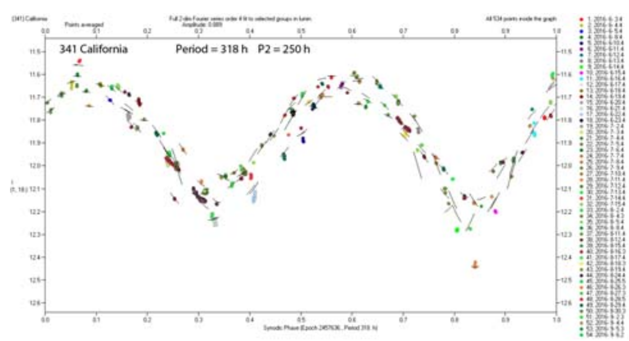


Figure 9. Fourth order 2 period Fourier series lightcurves of 341 California.

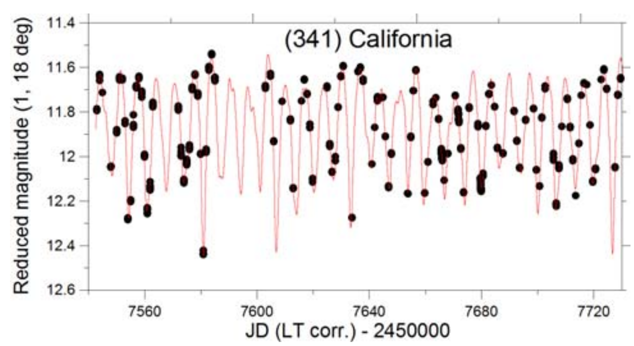


Figure 10. Raw lightcurve of all sessions of 341 California fit to a 2 period Fourier model.

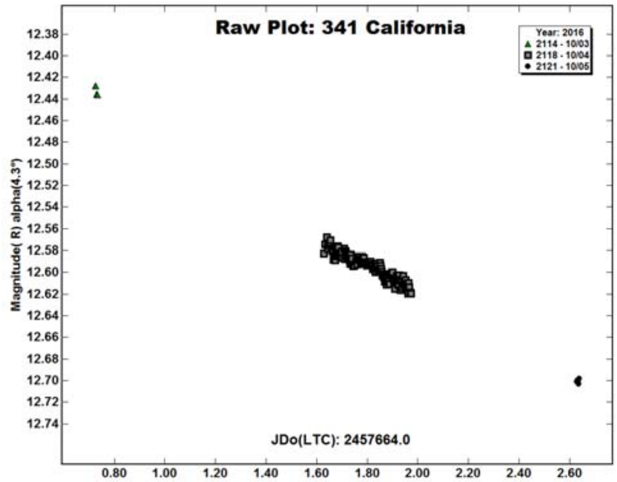


Figure 11. Raw lightcurve of 341 California for the interval 2016 Oct. 3-5.

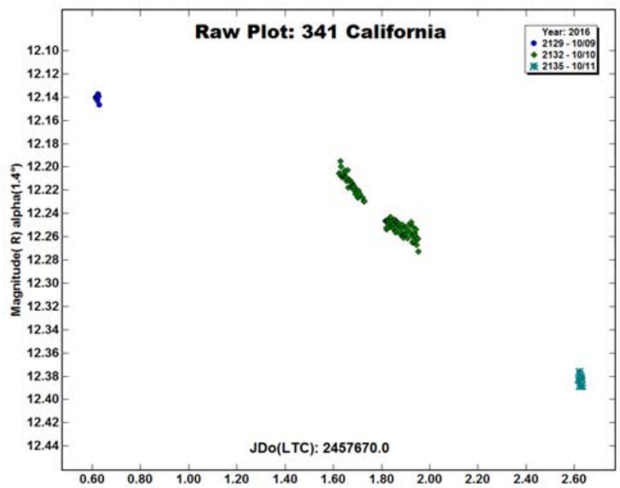


Figure 12. Raw lightcurve of 341 California for the interval 2016 Oct. 9-11.

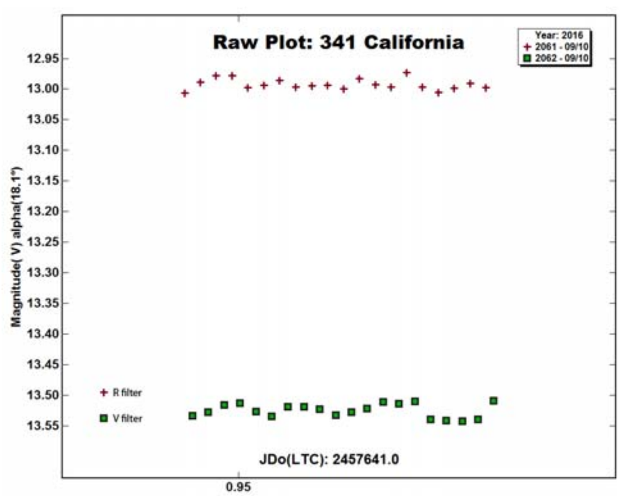


Figure 13. Observations of 341 California 2016 Sept. 10 in R and V magnitudes.

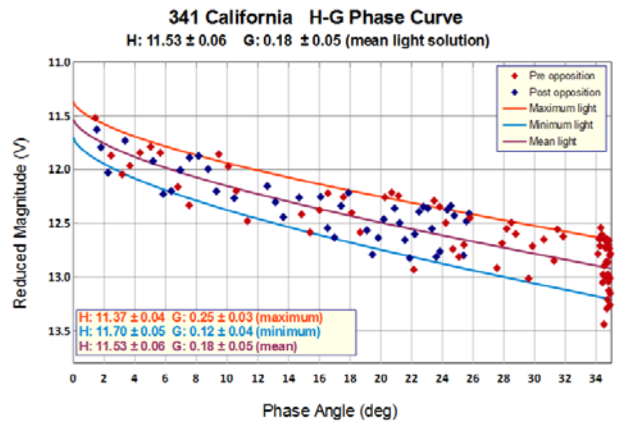


Figure 14. H-G plots for 341 California for maximum, mean, and minimum light data points, respectively.

### Feature Story:

# Galilean Satellite Eclipse Timings: The 2007-09 Apparition

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## Abstract

*During the 2007 - 2009 Jupiter apparition, three observers made 53 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 31st observed by the ALPO Jupiter Section's Galilean Satellite Eclipse Timing Program, consisting of visual timings of the eclipses by Jupiter of the four Galilean satellites Io, Europa, Ganymede and Callisto. Our observers timed the "last speck" visible when a satellite entered Jupiter's shadow (disappearance) and the "first speck" visible when it emerged from eclipse (reappearance). Each satellite's mean disappearance and reappearance timings were then averaged to determine if its position corresponded to its ephemeris. (Our 1998 - 1999 Apparition report described in detail our method of reduction, which also cited the reports for the previous apparitions. [Westfall 2009: 40, 42, 48; see also Westfall 2012, 2015, 2016a and 2016b.]) We have compared our reduced timings with the Institut de Méchanique Céleste et de Calcul des Éphémérides (IMCCE) predictions, using the INPOP13C planetary theory and Lieske E-5 satellite theory.

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- The references in blue text to jump to source material or information about that source material (Internet connection must be ON).

**Table 1. Circumstances of the 2007-2009 Jupiter Apparition**

| Apparition | | Observing Season | |
|---|---|---|---|
| Initial solar conjunction | 2007 DEC 23, 06h | First eclipse timing§ | 2008 MAR 03 (+71d) |
| First maximum phase angle | 2008 APR 12, 01h (11.09°) | Last eclipse timing§ | 2008 NOV 14 (-71d) |
| Opposition to the Sun* | 2008 JUL 09, 07h (δ = -22.5°) | Duration | 256d |
| Closest approach to Earth† | 2008 JUL 10, 11h (D = 47.3") | Solar Elongation Range | 057°W-057°E |
| Second maximum phase angle | 2008 OCT 05, 20h (11.20°) | Sources: Meeus 2015; *Astronomical Almanac*, 2009 and 2010 issues; JPL *HORIZONS* website. Dates and times throughout this report are in Universal Time (UT). | |
| Final solar conjunction | 2009 JAN 24, 06h | | |

* 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 (-).

Table 1 lists the pertinent dates and other circumstances of the 2007 - 2009 Apparition.

Jupiter was far to the south throughout the observing season, thus somewhat unfavorable for our observers, all of whom observed from the Earth's northern hemisphere.

## Observations and Observers

The 53 timings received for 2007/09 brought our 31-apparition total to 10,791 observations, but reflect an unwelcome decrease from the 80 received for the 2006/07

**Table 2. Number of Eclipse Timings, 2007 - 2009 Apparition**

| | |
|---|---|
| Number of Timings | 53 |
| Timings before Opposition | 24 (45%) |
| Timings after Opposition | 29 (55%) |
| Disappearance Timings | 23 (43%) |
| Reappearance Timings | 30 (57%) |

Apparition. Table 2 gives descriptive statistics for the 2007/09 observations.

Compared with 2006-07, there is a more even balance between the number of observations made following opposition and of those made before. Still, a bias remains, as well as for more reappearance timings than disappearance timings, which has held throughout the history of our program. This time 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 2007-09, with their nationalities, instrument apertures and number of timings, both short-term and long-term.

It is pleasing to see that all our observers, although small in number, have continued with our program for 20 or more apparitions.

The contributors all used moderate-size telescopes in the aperture range 13 - 35.6 cm (5 - 14 in.). The mean aperture, weighted by number of observations, was 28.2 cm (11 in.).

**Table 3. Participating Observers, 2007 - 2009 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 |
| 1 | Haas, W.H. | USA (NM) | 31 | 4 | 20 | 152 |
| 2a | Hays, R.H., Jr. | USA (IL) | 13 | 2 | 21 | 274 |
| 2b | | | 15 | 16 (18) | | |
| 3 | Westfall, J. | USA (CA) | 35.6 | 31 | 30 | 488 |
| Mean Number of Timings per Observer | | | | 17.7 | | |

**Table 4. Timing Residual Statistics, 2007 - 09 Apparition**

| Satellite and Event | Quantity | Satellite and Event | Quantity |
|---|---|---|---|
| **Io** | | **Ganymede** | |
| 1D: No. of Timings | 11 (9) | 3D: No. of Timings | 3 |
| 1D: Mean | +91.7±3.0s | 3D: Mean | +298.0±14.5s |
| 1D: Median | +92.0 | 3D: Median | +300.0s |
| 1R: No. of Timings | 15 (10) | 3R: No. of Timings | 5 |
| 1R: Mean | -96.2±1.6s | 3R: Mean | -223.6±10.3s |
| 1R: Median | -96.5s | 3R: Median | -248.0s |
| (1D+1R)/2: Means | -2.3±1.7s | (3D+3R)/2: Means | +37.2±8.9s** |
| (1D+1R)/2: Medians | -2.2 | (3D+3R)/2: Medians | +38.5s |
| **Europa** | | **Callisto** | |
| 2D: No. of Timings | 8 (5) | 4D: No. of Timings | 1 |
| 2D: Mean | +90.6±6.6s | 4D: Mean | +336.0±-s |
| 2D: Median | +92.0s | 4D: Median | +336.0s |
| 2R: No. of Timings | 7 | 4R: No. of Timings | 3 |
| 2R: Mean | -122.1±7.0s | 4R: Mean | -353.7±18.8s |
| 2R: Median | -128.0s | 4R: Median | -338.0s |
| (2D+2R)/2: Means | -15.8±4.8s** | (4D+4R)/2: Means | -8.8±-s |
| (2D+2R)/2: Medians | -18.0s | (4D+4R)/2: Medians | -1.0s |

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

## Timings Analysis: Satellite Positions

The individual eclipse timings made by our participants in 2007-09 are listed in Table 6 at the end of this report. Table 4 summarizes the eclipse timings made during this period, with the means, standard errors of the means, and medians of the differences ("residuals") between our timings and the IMCCE E-5 ephemeris. (In one case, eclipse disappearances of Callisto, only one timing was made, so that no standard error could be computed and no significance test could be made.)

All the residuals were corrected for oblique contact with Jupiter's shadow at disappearance and reappearance, using the formula $R' = R \cos\beta'$, where R' is the corrected residual, R the original residual, and β′ is the zenographic latitude of the satellite relative to Jupiter's shadow. This correction made a difference of at

**Table 5. Comparison of Mean Residuals, Mallama *et al.* 2010 and ALPO, 2007/09 Apparition**

| Satellite | Mean Residual (sec) | |
|---|---|---|
| | Mallama *et al.* 2010 | ALPO |
| Io | -0.7±5.1 | -2.3±1.7 |
| Europa | -28.6±9.9 | -15.8±4.8 |
| Ganymede | +30.7±0.3 | +37.2±8.9 |
| Callisto | +5.3±18.7 | -8.8±– |

most a few seconds for Io and Europa, but could reach over a minute for Ganymede and several minutes for Callisto.

In 2007-09, Io appeared to closely follow the IMCCE E-5 ephemeris. Europa, however, continued its long-known deviation from the E-5 model. Rather unusually, the observed position of Ganymede was significantly different from the ephemeris, although this result is based on only eight timings. As for Callisto, as we cannot calculate an uncertainty range, thus we cannot conclude whether the fourth satellite differed significantly from its ephemeris.

The independent CCD-photometric Galilean satellite eclipse-timing program coordinated by Anthony Mallama observed 50 eclipses during the 2007-09 Jupiter apparition (Mallama *et al.* 2010). We have compared their results with the IMCCE E-5 ephemeris and have calculated residuals for each type of eclipse event, and then averaged their disappearance and reappearance residuals for each satellite, as done above for the ALPO visual observations.

The Mallama *et al.* program's disappearance and reappearance residuals were based on mid-disappearance and mid-reappearance, rather than the "last speck" and "first speck" times of the ALPO program. However, the means of the CCD disappearance and reappearance mean residuals should be comparable to ours, and the mean residuals of both programs are listed in Table 5.

**Table 6. Galilean Satellite Eclipse Timings, 2007 - 09 Apparition**

| UT | LD | Lat | ObN | STB | Dif |
|---|---|---|---|---|---|
| **Io Disappearances** | | | | | |
| 80303 | 16 | -13 | 3 | 210 | +94 |
| 80411 | 22 | -12 | 3 | 200 | +107 |
| 80427 | 22 | -12 | 2b | 100 | +99 |
| 80504 | 22 | -12 | 3 | 000 | +98 |
| 80520 | 20 | -11 | 3 | 201 | +92 |
| 80527 | 18 | -11 | 3 | 111 | +85 |
| 80612 | 13 | -11 | 3 | 100 | +99 |
| 80619 | 10 | -10 | 3 | 100 | +75 |
| 80621 | 9 | -10 | 3 | 211 | +62 |
| | | | 2b | 100 | +92 |
| 80705 | 3 | -10 | 3 | 000 | +46 |
| **Io Reappearances** | | | | | |
| 80723 | 8 | -10 | 2b | 001 | -104 |
| 80730 | 11 | -9 | 3 | 200 | -26 |
| 80808 | 14 | -9 | 2a | 000 | -99 |
| 80815 | 17 | -9 | 3 | 200 | -65 |
| | | | 2b | 000 | -100 |
| 80822 | 19 | -9 | 3 | 100 | -90 |
| 80831 | 21 | -9 | 2b | 000 | -105 |
| 80907 | 22 | -8 | 1 | 11- | -96 |

| UT | LD | Lat | ObN | STB | Dif |
|---|---|---|---|---|---|
| **Io Reappearances - continued** | | | | | |
| 80914 | 22 | -8 | 3 | 211 | +55 |
| 80923 | 23 | -8 | 1 | 110 | -94 |
| 80930 | 23 | -8 | 3 | 100 | -89 |
| 81009 | 22 | -8 | 1 | 211 | -145 |
| | | | 2b | 000 | -100 |
| 81016 | 21 | -7 | 3 | 000 | -96 |
| | | | 1 | 22- | -67 |
| **Europa Disappearances** | | | | | |
| 80331 | 32 | -22 | 3 | 200 | +99 |
| 80502 | 35 | -21 | 3 | 000 | +108 |
| 80520 | 31 | -21 | 2b | 200 | +62 |
| 80527 | 29 | -20 | 2b | 200 | +75 |
| | | | 3 | 100 | +114 |
| 80621 | 14 | -19 | 3 | 211 | +60 |
| | | | 2b | 000 | +88 |
| 80705 | 4 | -19 | 3 | 100 | +52 |
| **Europa Reappearances** | | | | | |
| 80706 | 6 | -19 | 2b | 101 | -115 |
| 80817 | 27 | -18 | 2b | 100 | -147 |
| | | | 3 | 201 | -115 |

| UT | LD | Lat | ObN | STB | Dif |
|---|---|---|---|---|---|
| **Europa Reappearances – Cont.** | | | | | |
| 80911 | 35 | -17 | 4b | 000 | -149 |
| | | | 3 | 201 | -134 |
| 81013 | 34 | -16 | 3 | 100 | -139 |
| 81114 | 26 | -15 | 3 | 101 | -96 |
| **Ganymede Disappearances** | | | | | |
| 80430 | 55 | -34 | 2b | 000 | +389 |
| 80612 | 32 | -31 | 3 | 100 | +350 |
| 80830 | 10 | -26 | 2b | 100 | +303 |
| **Ganymede Reappearances** | | | | | |
| 80318 | 16 | -38 | 3 | 100 | -241 |
| 80430 | 19 | -34 | 3 | 000 | -279 |
| 80823 | 47 | -26 | 3 | 101 | -283 |
| 80830 | 52 | -26 | 3 | 200 | -248 |
| 80928 | 57 | -24 | 2b | 001 | -241 |
| Callisto Disappearances | | | | | |
| 81003 | 63 | -32 | 2a | 000 | +396 |
| **Callisto Reappearances** | | | | | |
| 80505 | 63 | -53 | 3 | 100 | -649 |
| 80728 | 40 | -41 | 3 | 200 | -440 |
| 81019 | 92 | -29 | 2b | 000 | -387 |

***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 = jovigraphic latitude of satellite on Jupiter's shadow cone in degrees; ObN = observer number as in Table 3; STB = observing conditions, where S = seeing, T = transparency and B = field brightness, all expressed in terms of 0 = condition not perceptible, 1 = condition perceptible but does not affect accuracy and 2 = condition perceptible and does affect accuracy; and Dif = (observed – calculated) eclipse time in seconds. Underlined timings were excluded during analysis due to unusually large differences from the other observations. Note that the "raw" residual values have not been corrected for oblique contact with Jupiter's shadow.

When multiple CCD timings were made for the same event, they often agreed with each other to within a second. Thus we have high confidence in the CCD results and conclude that their residuals consistently reflect real differences between the satellites' positions and the IMCCE E-5 ephemeris. There were no statistically significant differences between the Mallama *et al*. and the ALPO results.

## Conclusion

The analysis of our program's timings made during the 2007-09 Jupiter apparition showed the following:

- The the times of eclipses by Jupiter of Io consistently did not differ significantly from the IMCCE E-5 ephemeris.
- Europa's observed timings, however, disagreed significantly from the ephemeris, its eclipse times averaging about 16 seconds earlier than predicted.
- Ganymede's eclipses averaged over a half-minute later than the ephemeris.
- Because there were too few timings made of Callisto's eclipses, we can come to no firm conclusion about the behavior of that satellite.

Our mean residuals for the four satellites did not disagree significantly with the independent CCD timings made by Anthony Mallama and his associates during the 2007/09 Apparition.

We thank the observers who contributed timings during 2007-09, and hope that they continue with our program. We also invite others who are interested in this visual observing program, which requires only modest-sized telescopes, to contact the program coordinator (John Westfall at johnwestfall@comcast.net, 5061 Carbondale Way, Antioch, CA 94531 USA). He will be happy to furnish interested observers with a copy of observing instructions, a timing report form, and a table of Galilean satellite eclipse predictions for the coming apparition.

## References


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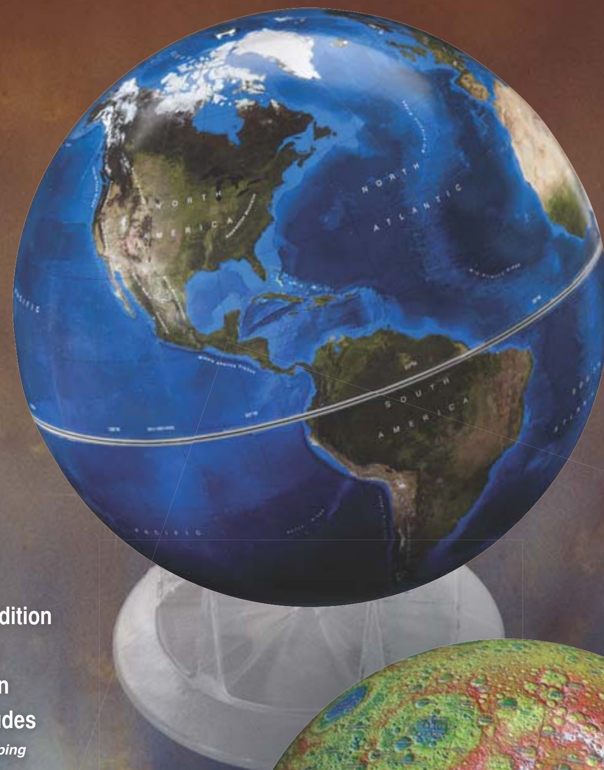

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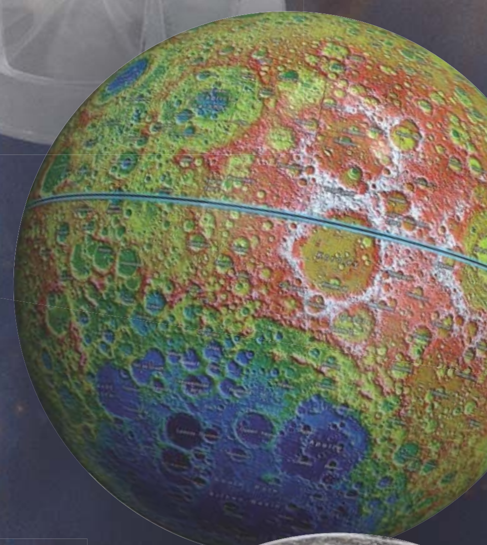

## *S&T*'s Topographic Moon Globe

The Topographic Moon Globe shows our home planet's constant companion in greater detail than ever before. Color-coded to highlight the dramatic differences in lunar elevations, deep impact basins show up clearly in blue, whereas the highest peaks and rugged terrain show up as white, red, and orange.

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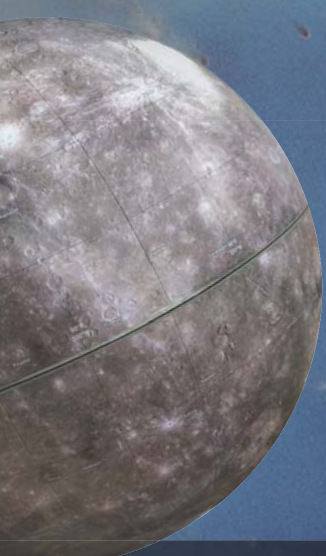
## *Sky & Telescope*'s Moon Globe

A beautiful and extremely accurate globe of the Moon. Unlike previous Moon globes based on artistic renderings, this globe is a mosaic of digital photos taken in high resolution by NASA's Lunar Reconnaissance Orbiter. The globe shows the Moon's surface in glorious detail, and how the nearside actually appears when viewed through a telescope. ***Item #MOONGLB*** ***$99.***95 ***plus shipping***



## *Sky & Telescope*'s Mercury Globe

To create this dramatic portrayal, the editors of *Sky & Telescope* worked with scientists on NASA's Messenger mission to produce the globe's custom base map. Special image processing has preserved the natural light and dark shading of Mercury's surface while allowing the labels to stand out clearly. The names of more than 350 craters and other features are shown. ***Item #MERCGLB*** ***$99.***95 ***plus shipping***

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