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The Strolling Astronomer

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Founded in 1947

Comet NEOWISE: In all its glory

(See pages 3 and 24)

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

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

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http://www.alpo-astronomy.org

Founded in 1947

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Point of View:

30 Years of Remote Planets Studies

By Richard Schmude, Remote Planets Section coordinator

It was in 1988 when Bill Winkler showed me his photometer. This was the first time I had seen one. Little did I know that much of my own research would be based on the use of this instrument. The Voyager spacecraft gave us our first close-up views of Neptune in 1989 and a year later, ALPO Executive Director John Westfall, appointed me as the Remote Planets Recorder. With this appointment, along with my new position as a Graduate Research Assistant at the Los Alamos National Laboratory, I purchased an SSP-3 photometer from Optec. I made this decision because I felt that the best way to contribute to our knowledge of Uranus and Neptune was through making accurate brightness measurements of these planets.

In January 1991, my photometer arrived. At that time I owned a 10-inch Dobsonian telescope (obviously without a clock drive). Therefore, I could use only one-second integration times to carry out brightness measurements. In June 1991, I carried out my first brightness measurements of Uranus. And shortly afterwards, I succeeded in measuring the brightness of Neptune.

During the last decade of the 20th century, a few others contributed brightness of Uranus and Neptune. During that time, I also attended at least one photometry workshop at Vanderbilt University under the direction of Dr. Doug Hall. Dr. Hall was very helpful. During the 1990s, drawings and images of the remote planets were scarce and did not show much detail.

During the first decade of the 21st century, Jim Fox began contributing high quality B and V filter brightness measurements of Uranus and Neptune. I also received a few brightness measurements of Pluto. In 2008, my first book “Uranus, Neptune and Pluto and How to Observe them” was released.

During the 2010s, several individuals began imaging Uranus and Neptune with red and near-infrared filters. The images revealed albedo features on both planets. The most common feature on Uranus was the bright polar area. Neptune was different. It displayed bright spot at different latitudes. Frank Melillo also contributed photographs showing Pluto on different nights.

I wrote the 2019-2020 remote planets report while much of the country was “sheltering in place”. The National Crises continues. Hopefully, the third decade of the 21st century will enable us to make more interesting observations of Uranus, Neptune and Pluto.

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News of General Interest

Our Cover: Surprise! This One Came Through!

Comets can be fickle creatures. This year saw not one, but two comets hyped as the next big thing only to see both fall apart before reaching perihelion. After that double disappointment, hopes weren't too high for newly discovered C/2020 F3 (NEOWISE). But as we said, comets are fickle creatures and NEOWISE went on to develop into the most spectacular comet for northern observers since Hale-Bopp in 1997. While not a Great Comet like Hale-Bopp, NEOWISE did brighten to 1st magnitude and sprouted dust and gas tails with lengths of 10s of degrees.

As this issue contains a preliminary apparition report for NEOWISE, it is fitting that the comet graces this issue's front cover. The image by John D. Sabia shows the comet on the evening of July 17, 2020 (July 18, 2020 at 2:09 UT) from Fleetville, Pennsylvania USA. John used a Canon T5 DSLR at ISO 400 and a Samyang 135 mm f/2 lens to capture the comet in a 65-second exposure. The camera was piggybacked on a Celestron C-11 in the Lackawanna Astronomical Society's roll-off roof observatory on the grounds of the Thomas G. Cupillari Observatory at Keystone College.

ALPO 2020 Conference to Feature International 'Astronomy Populizer' Pranvera Hyseni

(Editor's Note: Due to various external matters, this issue of your Journal is several weeks late in being distributed. The following conference material has already been distributed to all via direct e-mails)

Pranvera Hyensi, keynote speaker for the 2020 ALPO Conference.

The Assn of Lunar & Planetary Observers (the ALPO) is most pleased to announce that its keynote speaker for this year's conference will be Ms. Pranvera Hyseni. Further, we have two full days of astronomy presentations scheduled as well as presentation of the annual Walter Haas Observing Award.

Due to the continuing nearly worldwide quarantining caused by the Covid-19 pandemic and another wave of infections, the 2020 Conference of the ALPO will be held online via Zoom on Friday and Saturday, October 2 and 3, 2020. The conference times will be:

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

Ms. Hyseni's appearance will follow presentation of the annual Walter Haas Observer Award after the last talk on Saturday afternoon.

The ALPO Conference is free and open to all. Digital ALPO memberships start at only $18 a year. To join online, go to *http://www.astroleague.org/store/index.php?main_page=product_info&cPath=10&products_id=39*, then scroll to the bottom of that page, select your membership type, click on "Add to Cart" and proceed from there.

Ms. Hyseni is currently pursuing a master's degree in Planetary Science at the University of California, Santa Cruz (California) and is the founder and director of "Astronomy Outreach of Kosovo". She – along with her organization's team, consisting of two hundred volunteers – is dedicated to rebuilding her home country through the stars. Ms. Hyseni was recently was selected as one of the five most influential women in Kosovo and was also recognized as a distinguished student

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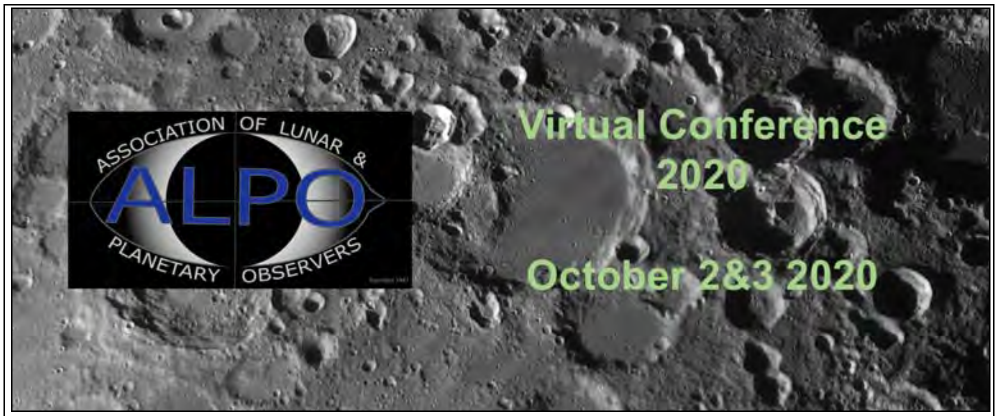

The official 2020 ALPO Conference logo.

by the Municipality Assembly of Vushtrri. Besides working towards attaining her master's degree, her current effort is to develop the first observatory and planetarium in Kosovo.

Ms. Hyseni was honored by the International Astronomical Union and the Minor Planet Center with the naming of an asteroid, 45687 Pranverahyseni. The Municipal Assembly of Vushtrri (Kosovo) named her a distinguished student, and she was also honored with the "24Under24" award by the Mars Generation as a young leader in STEM education. She received the “Master Outreach” award in 2019 from the Astronomical League, and was named as Slooh’s Space Ambassador by the robotic telescope service "Slooh."

Besides access via Zoom, the ALPO conference will also be live-streamed as follows:

- On the ALPO Facebook page at *https://www.facebook.com/search/top?q=2020%20alpo%20virtual%20conference*
- On the ALPO YouTube channel at *https://www.youtube.com/channel/UCEmixiL-d5k2Fx27Ijfk41A*

An advantage of Zoom access, however, is that attendees can participate with their own questions submitted via the Zoom group text chat feature. Those attendees using Zoom must already have it installed on their computer prior to the conference dates. Zoom is free and available at *https://zoom.us/*

The Zoom links for the ALPO conference will be posted on social media and e-mailed to those who wish to receive it that way on Thursday, October 1. There will be a separate Zoom meeting set up for each day. The Zoom virtual (online) meeting room will open 15 minutes prior to the beginning of each day’s activities.

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

ALPO Website Updates

Various announcements have been posted to the ALPO website home page.

Organizational Changes and Appointments

Due to unforeseen circumstances, the position of ALPO Jupiter Section Coordinator is open once again.

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

Call for JALPO Papers

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

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

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

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

ALPO Interest Section Reports

ALPO Online Section

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

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

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

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

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Table 2020 ALPO Conference Speaker Schedule

Friday	UT	ET	PT	Speaker	Topic
2-Oct	17:00	1:00	10:00	Julius Benton	Introduction and Welcome
	17:15	1:15	10:15	Pam Schvak	ALPO Youth Program
	17:40	1:40	10:40	Richard Schmude	Visibility of Martian Clouds 2003-2020
	18:05	2:05	11:05	Carl Hergenrother	Recent Observation of Comets
	18:30	2:30	11:30	Roger Venable	Canals Revisited- a Hubble and Lowell comparison
	18:55	2:55	11:55	Break	
	19:20	3:20	12:20	David Teske	ALPO Lunar Section
	19:45	3:45	12:45	Alberto Anunziato	Short duration bright spots on the Moon
	20:20	4:20	1:20	Tony Cook	A Comparison of LTP Frequency with Routine Observation Frequency
	20:45	4:45	1:45	Ken Poshedly	Closing Remarks Day 1

Saturday	UT	ET	PT	Speaker	Topic
3-Oct	17:00	1:00	10:00	Ken Poshedly	Schedule updates and welcome
	17:15	1:15	10:15	Matt Will	An introduction to the ALPO
	17:40	1:40	10:40	Roger Venable	Recent observations of Mars
	18:05	2:05	11:05	John Rogers	Current Observation of Jupiter
	18:30	2:30	11:30	Frank Melillo	Mercury Observations
	18:55	2:55	11:55	Break	
	19:20	3:20	12:20	Scott Harris	Earth Encounters with Small Asteroids and Comets
	19:45	3:45	12:45	Jerry Hubbell	Exoplanets and amateur astronomy
	20:20	4:20	1:20	Carl Hergenrother	The future of the ALPO
	20:45	4:45	1:45	Matt Will	Closing Remarks Day 2
	23:00	7:00	4:00	Awards and Keynote speaker	Pranvera Hyseni
Backup Presentors				Tim Robertson	The Observers Notebook Podcasts
				Richard Schmude	Jupiter

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Outreach Section

Lunar & Planetary Training Program

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

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

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

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

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

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

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

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

'Observers Notebook' Podcasts

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

Though not part of the podcasts, the ALPO now has a YouTube channel!!

We will post instructional videos, lectures, and also have the ability to broadcast LIVE events on the internet!

We have one video available for viewing right now, it is an introduction to the ALPO. Go to: *https://youtu.be/Oy3ajPFNDdg*

Check it out and subscribe to the channel at *https://www.youtube.com/channel/UCEmixiL-d5k2Fx27Ijfk41A?*

Did you subscribe? No? Then do it today!!

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The Observers Notebook podcast continues to go strong with over 100

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

The most recent podcasts include an interview with Greg Bragg from Celestron who talks about the latest innovations from that company, John O'Neal who tells how he plans for an evening at the telescope and ALPO Lunar Program Assistant Coordinator Jerry Hubbell who tells us how amateurs can hunt for exoplanets with our equipment. Check out the podcasts today for this an many more interesting topics.

It takes a great amount of time and money to make and produce these podcasts, thus far it has been done with the help of a service called Patreon.

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

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

- Number of downloads as of July 1, 2020 – 34,000+
- Number of Subscribers (all formats) – 240+
- Average of number daily downloads (last 3 months) – 85
- iTunes rating – 5 Stars!
- Locations of most downloads – USA, UK, Canada, Australia, Germany, and France.

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

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

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

https://www.patreon.com/ObserversNotebook

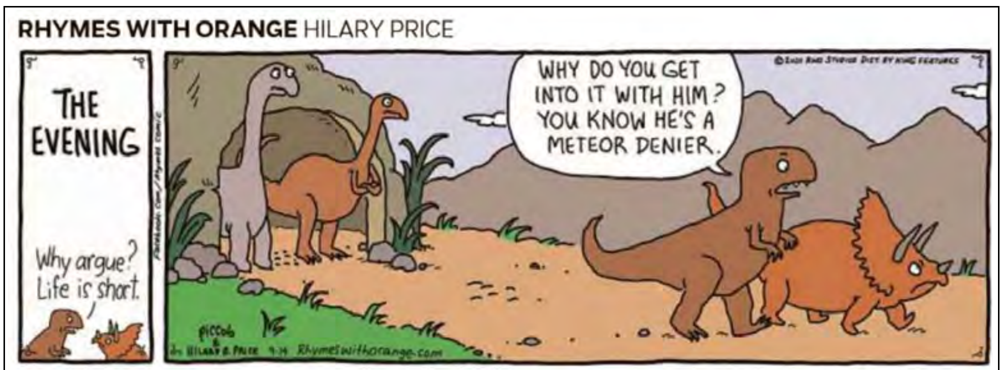
If you have an idea for a topic that you would like to hear covered on the podcast, please drop me a note. I am also looking for member profile pieces where we get to know the members of the ALPO.

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

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

Youth Activities Program

Pamela Shivak,
program coordinator
pamelashivak@yahoo.com



Topical Humor — Sometimes astro-humor makes its way even into the comic pages of the general media. For one thing, it serves to remind people that astronomy is still a going concern. And other times, it can poke fun at current political goings-on. Like this one from September 14, 2020.

ALPO Observing Section Reports

Eclipse Section

Keith Spring,
acting section coordinator
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Recent Eclipses

Recently, we experienced an eclipse triad consisting of the June 5 Penumbral Lunar, June 21 Annular Solar and the July 5 Penumbral Lunar Eclipses. The next eclipse triad will occur in 2024.

Observer Michael Amato reported on the July 5 eclipse from West Haven, CT stating: "Last night's Penumbra Eclipse was very faint. I had to use my 10x50 binoculars to see the faint shading on the upper left of the Moon. I couldn't see the shadow with my naked eyes".

We are still accepting reports for all of these eclipses.

Upcoming Eclipses

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

****

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

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- 2021 May 26; Total Lunar Eclipse; Visible from South-East Asia, Australia, Pacific, Western North and South America, Antarctica
- 2021 Jun 10; Annular Solar Eclipse; Visible from Canada, Russia; Partial in North America, Europe, North Asia
- 2021 Nov 19; Partial Lunar Eclipse; Visible from Asia, Australia, Pacific, North America, South America
- 2021 Dec 4; Total Solar Eclipse; Duration 1 minute, 54 seconds; Visible from Antarctica.

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

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

Mercury / Venus Transit Section

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

Past Transits

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

Future Mercury Transits

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

Future Venus Transits

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

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

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

Meteors Section

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

As we enter October the haze of summer is left behind, being replaced by the crystal-clear skies of autumn. This is prime time for meteor observers in the northern hemisphere. All three months are rich in meteoric activity climaxing with the Geminids in mid-December.

It has been a slow year so far with the bright Moon wreaking havoc on many of the major meteor showers so far. No such problems exist during the last quarter of 2020, so we hope you will take advantage of the situation and watch some meteor activity. If you cannot view from home remember to respect areas that have been closed due to the Covid-19 pandemic. Stay safe and healthy and we look forward to receiving your reports!

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

Meteorites Section

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

This report includes new meteorite approvals from April 19-July 4, 2020 from the Meteoritical Society's Nomenclature Committee.

The *Meteoritical Bulletin* records officially recognized, classified meteorites of the world's inventory. As of July 4, 2020, it contains a total of 63,875 meteorites. There were 175 new meteorites approved or revised from April 19-July 4. Noteworthy meteorites are 9 approved or corrected falls: Zsadany, Romania (1875) (H5); Mahadeva, India (2019) (H5); Wad Lahteyba, Western Sahara (2019) (H5); Novo Mesto, Slovenia (2020) (L5); Barcelona, Spain (1704) (L6); Kakowa, Romania (1858) (L6); Tauti, Romania (1937) (L6); Al Farciya, Western Sahara (2019) (L6); Gatuto, Central Kenya (2020) (L6).

A "Tale of Two Meteorites"?

Upon further historical investigation and new compositional analysis, the "Sologne, France" H5 chondrite found in an old wooden box, was "discredited" and determined to be a likely stone from the Pultusk, Poland, fall of 1868 (Dauphas et al. (2000); Krzesinska (2017)) and the Barcelona L6 meteorite discovered in a botanical museum glass jar, was traced to an observed fall from 1704 from which no other pieces were recovered (Llorca et al. 2020).

Newly approved meteorites include 9 iron and stony-iron meteorites identified on Mars from 2004-2009 via NASA spacecraft: Gusev Crater 001-002 and Meridiani Planum 002 and 005-008. In addition, 99 ordinary chondrites (42 H, 1 H(L)3, 39 L, 16 LL, 1 L melt rock); 1 EL7; 1 E-achondrite; 2 aubrites, 20 carbonaceous chondrites (4 CK, 1 CM, 3 CO, 1 CR, 9 CV); 2 R chondrite; 11 irons; 2 mesosiderites; 3 ureilites; 26 HEDs (3 Howardites, 22 Eucrites, 1 Diogenite); 4 achondrites; 2 Lunar; 5 Martian.

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

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

Comets Section

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

The year 2020 has seen a procession of noteworthy comets. First, C/2019 Y4 (ATLAS) was forecast to be the next big thing. After reaching 7th magnitude in late March, it began to disintegrate and proceeded to slowly fade. While ATLAS never lived up to its potential, it did allow ground-based observers a front-row seat to watch the disintegration of a cometary nucleus. Quickly following on the heels of ATLAS was C/2020 F8 (SWAN). While never predicted to be a great object, it was expected to reach 2nd-3rd magnitude in May. But it, too, fell apart as it approached perihelion and was never brighter than 5th magnitude. After the back-to-back let downs of ATLAS and SWAN, the rather unheralded C/2020 F3 (NEOWISE) overachieved to become the brightest comet since 2013's C/2011 L4 (PANSTARRS). More on this wonderful object can be found later in this Journal.

In addition to ATLAS, SWAN, and NEOWISE, 3 other comets were brighter than 9th magnitude during the three months of May through July. C/2017 T2 (PANSTARRS) has been a small telescope fixture in the northern evening sky since late 2019. It finally peaked around 8th magnitude in April and May. C/2019 Y1 (ATLAS) briefly reached 7th magnitude during a mid-April outburst. while C/2019 U6 (Lemmon) peaked at 6th magnitude in early June. The final easy-to-observe comet of the spring and summer of 2020 was frequent inner

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solar system visitor 2P/Encke. This year's return was best from the southern hemisphere, when it was seen at 7th magnitude.

Between May and mid-June, the ALPO Comets Section has received over 150 visual and CCD photometric measurements of 14 comets from Michel Deconinck, J. J. Gonzalez, Carl Hergenrother, Willian Souza and Chris Wyatt. The Section also received over 150 images and sketches of 6 comets from Sergio Babino, Andres Chapman, John Chumack, Michel Deconinck, Hugo Espina, Diego Etchevers, Ken Fiscus, Jamie Garcia, Carl Hergenrother, Laurent Lacote, Gianluca Masi, Tyson McVicar, Frank J. Melillo, Martin Mobberley, Mike Napper, Tim Robertson, Michael Rosolina, Gregg Ruppel, John D. Sabia, Chris Schur, Mark Shapiro, Tenho Tuomi and Darryl Wilson.

Looking ahead to the last three months of 2020, only one comet is expected to be an easy object for small aperture observers. Jupiter-family comet 88P/Howell is making its 9th observed return.

Table Ephemerides for Comets 88P Howell and 141P Machholz

Date	R.A.	Decl.	r (au)	d (au)	Elong (deg)	m1	Const	Max El 40N	Max El 40S
88P/Howell									
2020 Oct 01	16 46.6	-26 00	1.35	1.42	65	8.2	Sco	12	45
2020 Oct 11	17 25.3	-27 00	1.36	1.45	64	8.3	Oph	13	43
2020 Oct 21	18 05.0	-27 19	1.38	1.50	63	8.9	Sgr	14	41
2020 Oct 31	18 44.8	-26 58	1.41	1.56	62	9.1	Sgr	16	38
2020 Nov 10	19 23.7	-25 58	1.44	1.63	61	9.4	Sgr	17	34
2020 Nov 20	20 01.1	-24 23	1.48	1.71	59	9.8	Sgr	19	29
2020 Nov 30	20 36.4	-22 20	1.52	1.80	57	10.1	Cap	21	24
2020 Dec 10	21 09.5	-19 58	1.58	1.90	55	10.5	Cap	22	19
2020 Dec 20	21 40.4	-17 22	1.63	2.01	53	11.0	Cap	23	14
2020 Dec 30	22 09.2	-14 38	1.69	2.13	50	11.4	Aqr	24	10
141P/Machholz									
2020 Oct 01	17 22.9	-09 43	1.39	1.30	73	18.1	Oph	30	42
2020 Oct 11	17 39.3	-10 06	1.29	1.28	67	17.4	Ser	29	36
2020 Oct 21	17 59.2	-10 24	1.18	1.24	62	16.6	Ser	28	30
2020 Oct 31	18 23.0	-10 34	1.08	1.18	58	15.8	Sct	27	24
2020 Nov 10	18 50.7	-10 35	0.99	1.10	55	14.9	Sct	27	18
2020 Nov 20	19 22.9	-10 24	0.91	1.01	53	13.9	Aql	27	14
2020 Nov 30	20 00.0	-10 03	0.85	0.91	52	12.9	Aql	27	10
2020 Dec 10	20 42.9	-09 38	0.81	0.80	52	12.1	Aql	28	8
2020 Dec 20	21 33.5	-09 10	0.81	0.70	54	11.4	Cap	30	8
2020 Dec 30	22 33.9	-08 39	0.84	0.60	58	11.1	Aqr	32	11

88P was discovered on photographic plates taken with the 0.46-m Palomar Schmidt in August 1981 by then-Caltech student, and current University of Arizona researcher, Ellen Howell. In addition to being found in pre-discovery observations from 1955, 88P has been observed at every return since 1981. The comet's perihelion distance has steadily decreased from 1.92 au in 1955, to 1.62 au in 1981, to 1.41 au in 1993, and to its current 1.35 au. As a result, comet Howell often reaches 10th magnitude or brighter. It was at its brightest during the 2009 return when it peaked at 8th magnitude. This year, perihelion occurs on September 28 with Howell again peaking around 8th-9th magnitude.

A slightly fainter comet comes to perihelion in mid-December. 141P/Machholz was discovered by former ALPO Comets Section Recorder Don Machholz in 1994. During the discovery apparition, 141P was observed to be in 5 pieces, though only a single component has been observed during recent returns. This return sees P/Machholz reaching 11th magnitude at the very end of the year when it will be near perihelion (0.81 au) and closest to Earth (0.52 au).

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

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

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

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Solar Section

Report by Rik Hill, section coordinator & scientific advisor
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Solar activity continues to decline. Are we at minimum? Unfortunately this is something that can only be seen in the rear view mirror, after we've passed through it! Even so, our observers kept up a good pace of observing. Year-to-date (the end of Carrington Rotation 2231), we received 1,222 observations and reports for an average of 204 per rotation this year. The last two rotations each topped 300 observations thanks to some impressive prominence activity. Cycle 25 regions are regularly being observed now so the end to this lull can't be far off.

The author would like to express his gratitude for the good work of Jim Tomney, the new ALPO Online Section acting assistant coordinator, for his compiling of raw numbers for this report.

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

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

Mercury Section

Report by Frank J. Melillo, section coordinator
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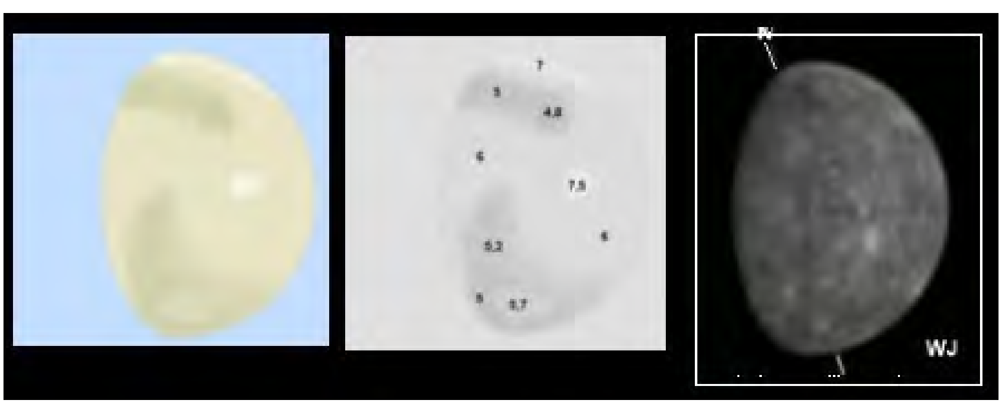
The ALPO Mercury Section has received a number of observations during the latest evening apparition (May-June 2020). What was interesting was that Mercury and Venus were together during the latter part of May. On May 30, I viewed Mercury at the latest time possible (about 9:30 p.m. local time) before it got lost in a haze. Most images received showed a rayed crater, Kuiper, just before it set over the limb. Even visually, there may be a sighting of the Kuiper crater. See drawings by Michel Legrand.

Currently, Mercury is visible — though with difficulty — after sunset due to the very shallow angle of the ecliptic. Even though the evening apparition lasts more than two months, it sets only about 45 minutes after sundown on October 1 at the greatest elongation possible, about 26 degrees southeast of the Sun.



Drawing by Michel Legrand of Pays de la Loire, France, on May 19, 2020 at 12:50 UT, of a possible sighting of the rayed crater Kuiper on Mercury located visually right of center. CM 59°. No equipment or other data provided.

I personally will save my energy for the next morning apparition, which should be the best of the year. The inferior conjunction with the Sun occurs on October 25, which is the start of the apparition. Ten days later, Mercury will rise at the start of the morning twilight. Telescopically, it will appear as a 33% illuminated crescent phase at +0.3 magnitude.

The next greatest elongation is slated to occur on November 10 at 20 degrees west of the Sun. Also, Venus will appear on the same side as Mercury. It should be an interesting naked-eye view in mid-November during the morning twilight.

The best time to view Mercury telescopically should be the third week of November. It will appear in a gibbous phase and shine at -0.7 magnitude. Most of Mercury's surface should be visible then, with some interesting features such as rayed craters. The two prominent rayed craters, Ellington and Debussy, may be visible in good seeing condition. A Wr.#25 red light or 610nm filter should be able to bring out the contrast to make them easily visible, especially during imaging.

The morning apparition should be almost the same as the last one in December 2019, just three weeks earlier. Mercury's morning apparition will end on December 20. Hopefully, most of you will have some good fall weather to view the most neglected planet of the solar system.

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

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Venus Section

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

Venus is now visible before sunrise in the morning sky as the 2020-21 Western (Morning) Apparition continues. Throughout the current 2020-21 Western (Morning) Apparition, Venus is passing through its waxing phases as it shrinks in angular diameter, slowly changing from a thin crescent to a gibbous and ultimately a fully illuminated disk as it progresses toward Superior Conjunction on March 26, 2021.

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

As of the date of this report was being prepared (June 2020) for the previous 2019-20 Eastern (Evening) Apparition observers had submitted well in excess of 280 observations in the form of digital images of the planet at UV, visual and near IR wavelengths, as well as numerous drawings in integrated light (no filter) and with different color filters.

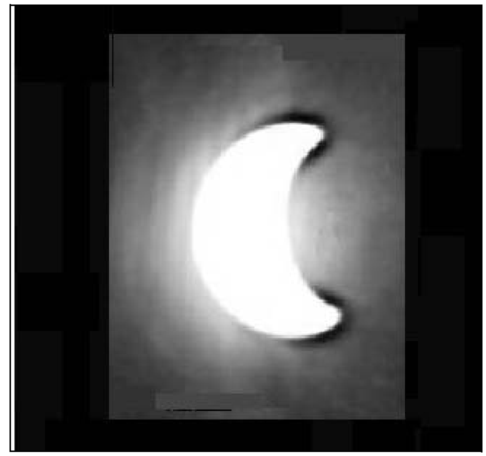
Regular readers of this Journal should be familiar with our continuing collaboration with professional astronomers as exemplified by our sharing of visual observations and digital images at various wavelengths during ESA's previous Venus Express (VEX) mission that ran for about nine years, from 2006 until the mission ended in 2015. It remains as one of the most successful Pro-Am efforts to date, involving ALPO Venus observers around the globe. Such observations will remain important for further study and will continue to be analyzed for several years to come as a result of this endeavor.

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

A follow-up collaborative Pro-Am effort remains underway during the 2020-21 Western (Morning) Apparition in continuing support of Japan's (JAXA) *Akatsuki* mission that began full-scale observations starting back in April of 2016. The website for the *Akatsuki* mission remains active so interested and adequately equipped ALPO observers can still register and start submitting images if they have not already done so.

As always, more information will continue to be provided on the progress of the mission in forthcoming reports in this Journal. It is extremely important that all observers participating in the programs of the ALPO Venus Section always first contribute their observations to the ALPO Venus Section at the same time submittals are sent to the Akatsuki mission.

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



Frank Melillo of Holtsville, NY, submitted this image of Venus using a 1000nmIR filter to capture thermal emission from the hot unilluminated surface of Venus on May 13, 2020 at 00:43 UT with a 25.4cm (10.0 in.) SCT under fair seeing conditions (S = 5.0). The image reveals cooler dark higher-elevation terrain as well as warmer bright lower surface areas in the near-IR. The crescent of Venus is intentionally overexposed to help reveal the dark side emission. The apparent diameter of Venus is 47.5", phase k=0.136 (13.6% illuminated), and visual magnitude -4.5. South is at the top of drawing.

Table Geocentric Phenomena of the 2020-21 Western (Morning) Apparition of Venus in Universal Time (UT)

Inferior Conjunction	2020 Jun 03^d 00^h UT (angular diameter = 58.3″)
Greatest Illuminated Extent	2020 July 10^d 08^h UT (-4.7m_V)
Theoretical Dichotomy	2020 August 12.88^d UT (Venus is predicted to be exactly half phase)
Greatest Elongation West	2020 August 13^d 00^h UT (46.0°)
Superior Conjunction	2021 March 26^d 00^h UT (angular diameter = 9.8″)

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

We are continuing our full coordination and strong teamwork with the *Akatsuki* mission team in collection and analysis of all observations. If anyone has questions about our Pro-Am efforts, please do not hesitate to contact the ALPO Venus Section for guidance and assistance. Those still wishing to register to participate in the coordinated observing effort between the ALPO and Japan's (JAXA) *Akatsuki* mission should utilize the following link:

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

The observation programs of the ALPO Venus Section are listed on the Venus page of the ALPO website at http://www.alpo-astronomy.org/ as well as in considerable detail in the author's *ALPO Venus Handbook* available free as ALPO Monograph 15 on the ALPO website. (Go to www.alpo-astronomy.org, click on the ALPO home page, lick on the *ALPO Section Galleries* link near the top-right corner of the page, click on Publication Section, click on ALPO Monographs, then click on "ALPO Monograph 15 - Venus Handbook (Revised Edition 2016)".)

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

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reported in addition to supporting information such as telescope aperture and type, UT date and time, magnifications and filters used, seeing and transparency conditions, etc.

Under favorable circumstances during future apparitions, Venus observers should monitor the dark side of Venus visually for the Ashen Light and use digital imagers to capture any illumination that may be present on the planet as a cooperative simultaneous observing endeavor with visual observers. Also, observers should undertake imaging of the planet at near-IR wavelengths (e.g., 1000nm) around the dates on either side of inferior conjunction, whereby the hot surface of the planet becomes apparent and occasionally mottling shows up in such images attributable to cooler dark higher-elevation terrain and warmer bright lower surface areas in the near-IR.

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

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

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

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

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

Lunar Section

Lunar Topographical Studies / Selected Areas Program

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

The ALPO Lunar Topographic Studies Section (ALPO LTSS) received a total of 318 observations from 38 observers in eight countries during the April-June 2020 quarter. The countries represented by observers were Argentina (19), USA (8), Italy (1), Columbia (1), Uruguay (4), France (2), Mexico (1) and Bolivia (2). It is most impressive to have so many high-quality lunar observations submitted from so many observers throughout the world, particularly Latin America.

Twenty-two articles were published in addition to numerous commentaries on images selected in the monthly newsletter *The Lunar Observer* which expanded in page count to over 100 pages by May 2020.

Starting in the June 2020 issue, a new section, *By the Numbers*, looked at observer's locations and telescopes used for Moon-gazing. In June 2020, Maksutov-Cassegrain telescopes were the most common used for lunar observations. *The Lunar Observer* was placed on the Cloudy Nights website and viewed an average of 180 times in each month of the quarter.

The *Focus-On* series continued under Jerry Hubbell, with the debut of the "Lunar 100" during this quarter. The Lunar 100 observing list was compiled by Charles Wood as a list of 100 targets to observe on the Moon from very easy (Lunar 100 number 1, the Moon) to very challenging (Lunar 100 number 100, Mare Marginus swirls). In May 2020, the first 10 of the Lunar 100 were featured in the *Focus-On* article. We received an incredible response from astronomers across the globe, who provided many images and drawings of these lunar subjects. The targets included easy naked-eye details such as the Moon and Earthshine, to some prominent lunar features visible in binoculars such as the craters Tycho and Copernicus and mountain ranges such as the Apennines.

Future *Focus-On* articles will highlight observations from the Lunar 100 observing list. Every other month will feature 10 of the Lunar 100 targets in the *Focus-On* series. September will feature Lunar 100 targets 21-30 and November will feature Lunar 100 targets 31-40.

Each month *The Lunar Observer* also features an in-depth article from Dr. Anthony Cook on the BAA's Lunar Geologic Change Detection Program (the basis for the ALPO Lunar Transient Phenomena program). Other articles discuss lunar features, lunar domes and images of recent lunar topographic studies.

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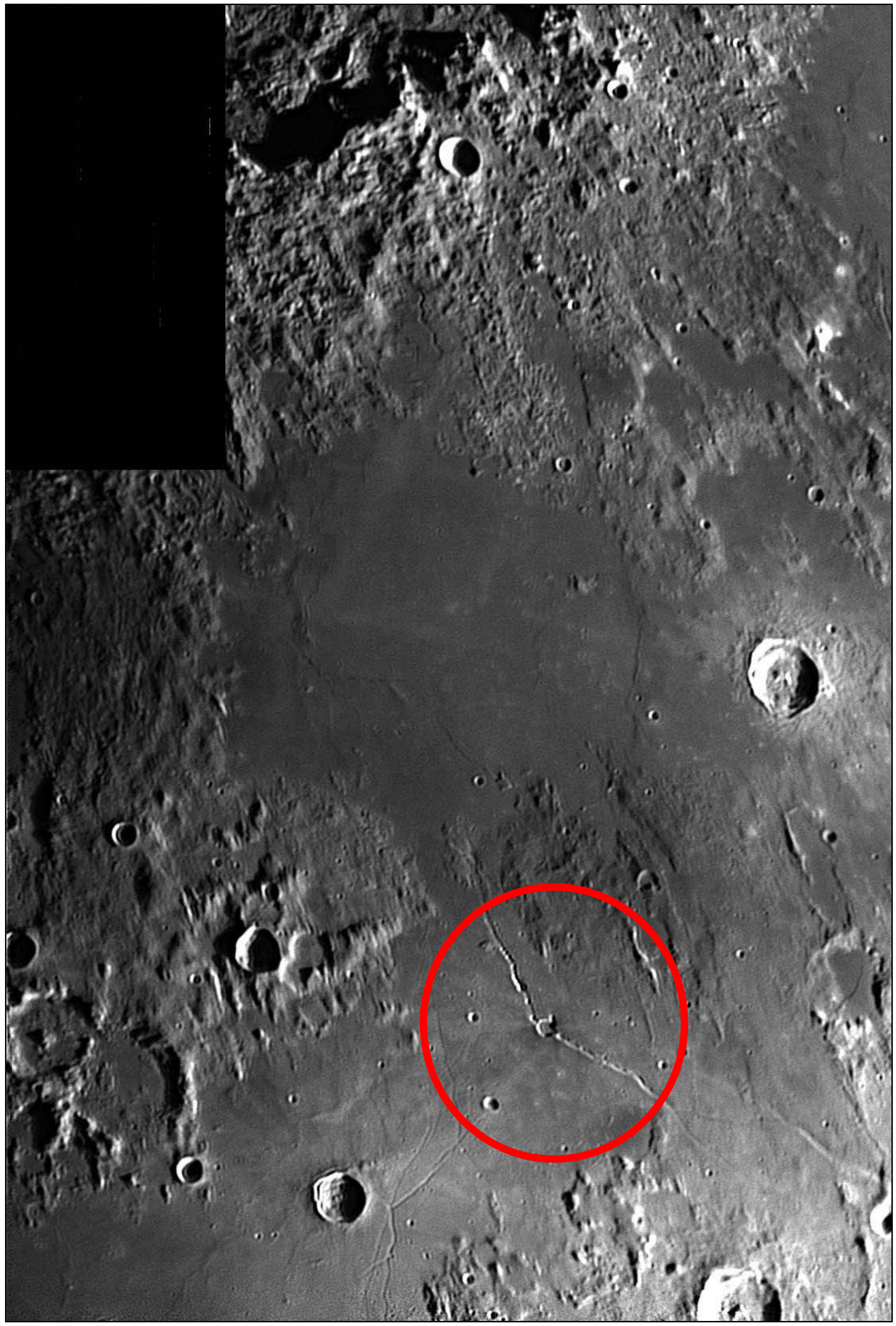
Electronic submissions can now be made through the ALPO website, (lunar@alpo-astronomy.org). The former method of submitting them directly to the coordinators will still work, but please don't submit through both the website and directly to the coordinators. See the most recent issue of *The Lunar Observer* on the ALPO website (*http://www.alpo-astronomy.org/gallery3/index.php/Lunar*) for instructions. Hard copy submissions should continue to be mailed to me at the address listed in the ALPO Resources Section of this Journal.

The lunar image gallery/archive is now active. At the time of this writing, all of the images received after December 2017 are now in the gallery. Wayne Bailey continues to submit archived images to the Lunar Gallery. This acting coordinator is now adding current lunar image submissions to the Lunar Gallery. Also, all issues of *The Lunar Observer*, including those from its beginning in 1997 as an American Lunar Society publication to June 2004 when it became the newsletter of this ALPO program, are now available on the ALPO website due to hard work by Theo Ramakers.

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



Lunar crater Hyginus, its associated rille and the nearby region as imaged taken by Marcelo Mojica Gundlach of Cochabamba, Bolivia, South America. Taken April 30, 2020 at 23:21 UT. Equipment details: 6-inch *Sky Watcher* Maksutov equipped with an ZWO ASI 178 B/W camera.

Lunar Meteoritic Impacts

Report by Brian Cudnik, program coordinator

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This coordinator recently received a report from Antonio Mercatali of the Moon Research Section of the Italian Amateur Astronomers Union (Luna-UAI) concerning five lunar impact event candidates that they recorded in 2016 and 2017. Their last one was particularly intriguing, appearing quite bright at peak and lasting 1.27 seconds. To see images

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and an animated gif of the bright (which could be as bright as 1st magnitude but more likely 2nd or 3rd), long duration impact event, visit their lunar meteor website which is presented in English: *http://luna.uai.it/index.php/Lunar_Impact_Candidates_recorded*

The image shows the impact at its peak, as recorded by Bruno Cantarella and Luigi Zanatta of Sezione Nazionale di Ricerca Luna dell'Unione Astrofili Italiani (UAI). Information about their imaging system and two telescopes used to record this impact event is given on the above-referenced website.

In addition, I received a second report of a much more recent impact event from Mohammed Fadil Talafha, research assistant of the Sharjah Academy for Astronomy, Space Sciences, and Technology, located in the United Arab Emirates. He stated that he "observed [his] first flash in 1st of March 2020" The impact was detected at 16:54:24.09 UT on 1 March 2020 and was confirmed by the NELIOTA project operating out of Greece.

(*Editors Note: NELIOTA is an activity launched by the European Space Agency (ESA) at the National Observatory of Athens in February, 2015. It aims to determine the distribution and frequency of small near-earth objects (NEOs) by monitoring lunar impact flashes.*)

The confirming images are shown here and were taken from videos recorded by NELIOTA (left) and the Sharjah Lunar Impact Observatory (right). This is, in fact, the 100th confirmed lunar impact event recorded by the NELIOTA project since it began observations in March 2017. More information can be found at *http://www.esa.int/Safety_Security/*

Figure 1. Image of a lunar impact brightest at its point as recorded on 27 September 2017 by Bruno Cantarella and Luigi Zanatta of Sezione Nazionale di Ricerca Luna dell'Unione Astrofili Italiani (UAI). See text for details.

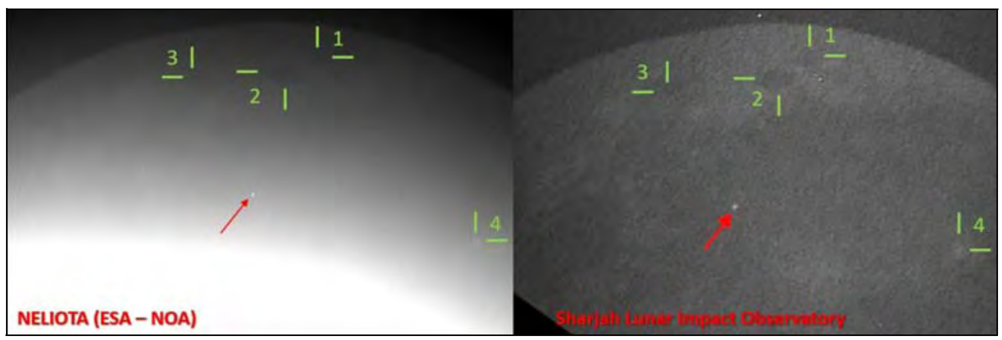

Figure 2 (above). Two confirming images of a lunar impact on 1 March 2020. At left is image taken from videos recorded by NELIOTA; at right is image by the Sharjah Lunar Impact Observatory.

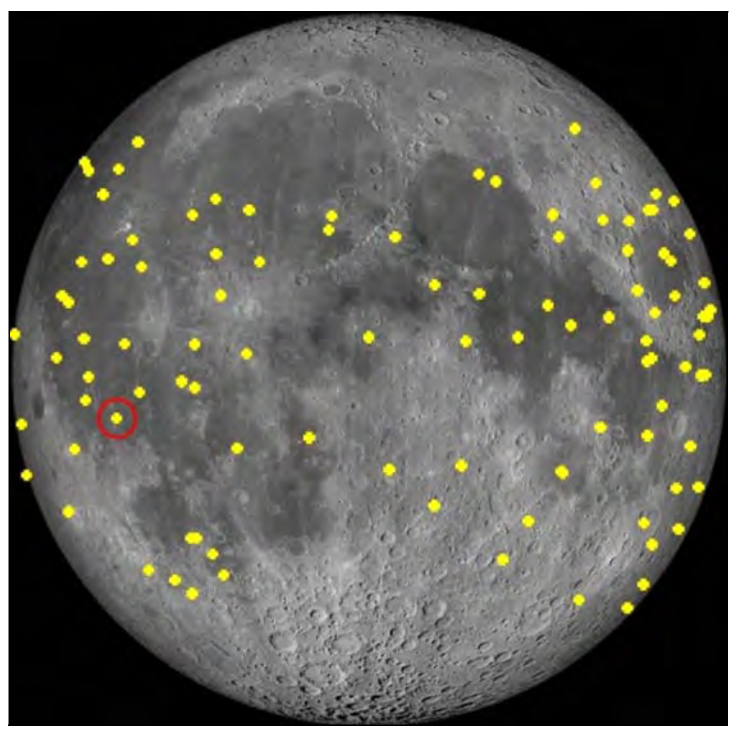

Figure 3. Full Moon image showing distribution of meteor impacts asa recorded by the NELIOTA project.

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100th_lunar_asteroid_collision_confirmed_by_second_telescope.

The full moon image from the NELIOTA website shows how the meteor impacts are distributed over the Moon's surface. The 102 events appear rather evenly distributed over the Moon, with a noticeable lack of activity near the poles, which is likely an observing bias (poles are generally not as well covered due to the presences of the cusps). The event circled in red is the same event observed by the UAE group.

No reports have been received from anywhere or anyone else for calendar year 2020. But given the timing of these latest lunar impact events, it seems that sporadic meteoroids make up a significant fraction of the observed meteoroid impacts, which is why monthly observations (not just observations during annual showers) when the Moon is favorably placed are highly encouraged.

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

Lunar Transient Phenomena

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

No LTP observations have been received since the last LTP Program report in this Journal. We continue to have success, though, in eliminating some past LTP reports via our repeat illumination program *http://users.aber.ac.uk/atc/lunar_schedule.htm*, though, interestingly, others remain unresolved.

One example of a past LTP that we easily disproved using the similar illumination observation scheduling approach was by an unknown Italian observer who on 2004 Jan 30 UT 15:52, saw what they regarded as an unusual white spot in the shadow on Mons Piton. However, as you can see from recent observations made by UAI and BAA observers (Fig. 1), the white spot is just simply highland protruding into sunlight. This former LTP has now been removed from the ALPO/BAA LTP database.

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

We receive repeat illumination reports from astronomers across the world, most notably the UAI in Italy, the BAA in the UK, the AEA and SLA in Argentina, and LIADA members in Bolivia and Uruguay. In the U.S., our most active ALPO contributors are Jay Albert, Rik Hill and Gary Varney.

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

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

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

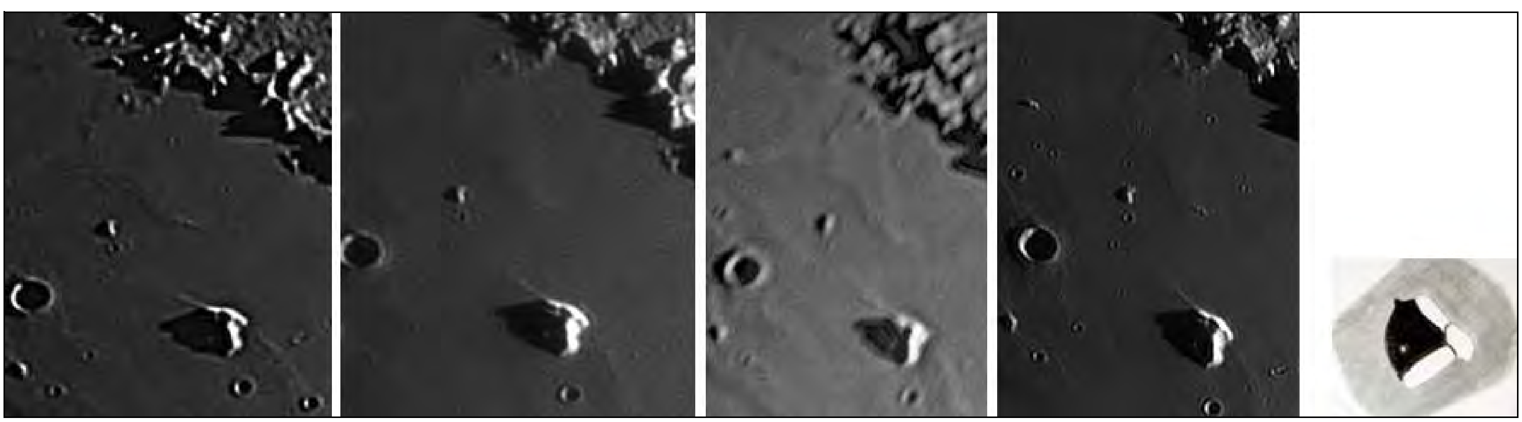

Figure 1. Mons Piton orientated with north towards the top. (Far Left) An image by Luigi Zanatta (UAI) taken on 2020 Apr 01 at 19:40 UT. (Left) An image taken by Fabio Verza (UAI) taken on 2020 Apr 01 at 29:30 UT. (Center) An image by Valerio Fontani (UAI) taken on 2020 Apr 01 at 20:36 UT. (Right) An image by Aldo Tonon made on 2020 Apr 01 at 20:50 UT. (Far Right) A sketch by Trevor Smith (BAA) made on 2019 Nov 05 at 20:10 UT.

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

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

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

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

Lunar Domes Studies

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

We have received 85 images including some by Jean Pierre Brahic, Gerard Coute, Howard Eskildsen, Guy Heinen, Richard Hill, Raffaello Lena, Luigi Morrone, Roberto Paletta, K.C. Pau, Frank Schenck, Martin Stenke, Schultz Tonkli, and 1 drawing submitted by Robert Garfinkle (regarding the dome near Mason crater). Many images are of high resolution and of great interest for our program.

Coute has imaged a small volcanic feature near Lassel D. It is a lunar cone probably originated by lava fragmentation during degassing. It was also well-imaged during the Apollo mission *https://www.hq.nasa.gov/office/pao/History/SP-362/ch4.3.htm*. The size of this lunar cone is well detectable in the AS16-120-19237 (H) picture *https://www.hq.nasa.gov/office/pao/History/SP-362/hrp97.jpg*

He also has imaged the region of Prinz and Gruithuisen highland domes.

Hill has submitted many images and has imaged Piccolomini dome under different solar illumination angles, Birt region including bisected domes and the volcanic region around Reinhold and Copernicus.

Schenck has imaged the domes near Messier crater, Gambart domes and Reinhold domes, domes in Wallace, three domes termed Huxley 1-3, Yerkes dome and Aristillus dome.

Tonkli has imaged the domes in Kies (K1-K3).

Morrone has sent many images including domes in Marius volcanic shield and the dome named Herodotus Omega, the dome in Hyginus, the dome inside Meton crater, the dome Putredinis 1 and two domes named Archytas 1-2. Further images are under investigation.

Brahic has submitted an image of the dome Laplace 1, first identified by Teodorescu (see *http://www.alpo-astronomy.org/lunarblog/wp-content/uploads/2019/10/dome-sinus-iridum-alpo.pdf*); Teneriffe 1; domes in Manilius and Hyginus region under high solar illumination angle; Archytas 1 dome; Mare Crisium and Yerkes domes; three domes in Huxley region and the dome Putredinis 1.

Heinen has imaged the Gruithuisen highland domes, Yerkes dome, the Hortensius Milichius domes field, Kies domes, the Menelaus bisected domes, Arago domes, domes in the Cauchy volcanic shield, Piccolomini dome, Autolycus 1 dome, Aristillus dome, the Valentine domes, the Birt bisected domes, Kies 1 dome, Herodotus Omega dome, the Hortensius domes, the Reinhold domes, Herodotus Omega dome and Marius Hills.

Stenke has submitted images of the Hortensius Milichius domes field, Gambart domes and the Schiller-Zucchius-Basin.

Paletta has imaged the domes in Kies (K1-K3) under oblique solar illumination angle and the domes in Hortensius Milichius domes field.

We have updated our domes maps where these domes are labeled: Kies domes (*http://kiesdomes.blogspot.com*) and the Hortensius-Milichius-T. Mayer domes field (*http://hortdomes.blogspot.com*).

Eskildsen has submitted many images under different solar illumination angles of Archytas domes, Piccolomini dome, Fracastorius dome, the Birt domes, Beer dome located in Apennine bench formation, Valentine domes, Aristillus 1 dome, Mons Rümker, Marius Hills, Arago Alpha dome and domes in the region of Cauchy, Gardner and Jansen.

Domes in Maraldi-Cauchy region have been described in previous preliminary report by us: *http://www.alpo-astronomy.org/lunarblog/wp-content/uploads/2020/01/domes-maraldi.pdf*

We encourage more high-resolution imagery of this wide lunar region so that we can have more data to better assess lunar domes and characterize their morphometric and spectral properties.

Eskildsen has also imaged the domes in Manilius, the Yangel 1 dome and the Marco Polo MD complex which has been previously studied (see *https://www.hou.usra.edu/meetings/lpsc2017/pdf/1005.pdf*). The Marco Polo MD complex is a large dome where the magma in the laccolith found its way to

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the surface in a number of vents producing low-albedo pyroclastic deposits and erupting thin low-viscosity lava flows forming the effusive domes MP1, MP3 and MP4.

Lena has imaged the domes in Cauchy, a wide volcanic shield, three domes in Lansberg D, the Gruithuisen highland domes, the Mersenius P dome, the Marius Hills, the Doppelmayer dome, Kepler dome, the M24 dome and a kipuka near Herigonius.

Pau has imaged the dome Putredinis 1 and Yerkes dome.

Garfinkle has submitted a drawing of the dome near Mason which was published in his book *Luna Cognita* (ed. Springer), and which was observed on September 16, 2000.

We now have examined the lunar dome Mason 1 using CCD terrestrial images, LROC WAC images, Clementine multispectral data, the Chandrayaan-1 Moon Mineralogy Mapper and the LROC WAC-based GLD100 Digital Terrain Map (DTM). The dome named Mason 1 lies to the south of crater Mason and has a base diameter of 8.0 km ± 0.3 km. Its height measures 190 m ± 15 m and the average slope angle is 2.6° ± 0.2°. Spectral data indicate a basaltic composition. Based on the morphometric properties, we infer the physical conditions under which the dome was formed (lava viscosity, effusion rate, magma rise speed) as well as the geometries of the feeder dikes. An article is in preparation for the publication in this Journal.

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

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

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

Mars Section

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

Mars is coming! As of this writing (mid-July) it is past its western quadrature and is high in the eastern sky late at night. With an apparent diameter of 13 arc seconds, much detail can be seen on its surface.

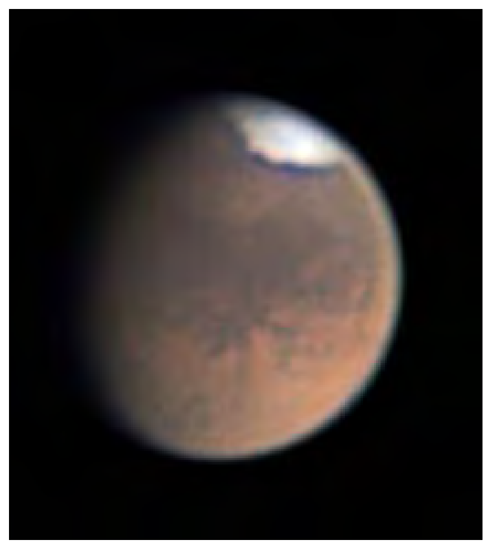
There have been dust storms in the last few months affecting Mare Erythreum, Solis Lacus, Xanthe, and Mare Acidalium. Right now, a dusty haze persists over the planet, rendering albedo features with less contrast than normal.

The seasonal South Polar Cap is receding and Novus Mons (the Mountains of Mitchel) is becoming visible. However, by the time you read this, its appearance will have changed, so please get out and observe as often as possible.

This is an excellent time to witness the shrinkage of the South Polar Cap. More and more surface features will be seen as Mars achieves a diameter of about 22.5 arc seconds in early October. Its declination will be in the northern sky for the rest of the apparition -- well suited for observing by most of us.

The Mars observers' message list is now on Groups.io at: *https://groups.io/g/marsobservers* and has more than 1,000 members. There, you can tell us what you see and post your images and drawings in the photos section. You should also send your images and drawings to *mars@alpo-astronomy.org* for inclusion in the online Mars archive.

To check the ALPO Mars image gallery on the ALPO website, first, go to *http://www.alpo-astronomy.org*, then click on the "ALPO Section Galleries" link at the



Mars image made by Peter Gorczynski on 2020-07-15 at 07:40 UT, using a Schmidt-Cassegrain telescope of 356 mm (14 in.) aperture, a Barlow lens, an ASI 290MM camera and RGB filters. Though hazy due to Martian atmospheric dust, much detail is evident in the albedo features and the South Polar Cap. Central meridian is 44 degrees.

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upper right corner of the screen. Next click on the "Mars images and observations" icon, then click on the Mars image folder for the desired year.

Minor Planets Section

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

Following here are highlights published in *The Minor Planet Bulletin*, Volume 47, No. 3, 2020 July-September. These represent the recent achievements of the ALPO Minor Planets Section.

Lorenzo Franco has published a spin-shape model of 118 Peitho. Brian Warner and Robert Stephen have published a spin-shape model of (11405) 1999 CV3. New lightcurves for both asteroids are also published. The lightcurve inversion technique of obtaining spin and shape usually provides two equally likely solutions for sidereal rotation period, celestial longitude and celestial latitude of the rotation pole. The two spin parameter sets for each asteroid are shown in Table 1 that accompanies this report.

A satellite of an asteroid may be detected photometically if a brief dip is observed in the rotational lightcurve as the secondary either transits or is occulted by the primary. Their combined light is reduced during these satellite events. Dual period software can separate the two lightcurves with separate periods from the observed combined lightcurve. Seven asteroids with satellite events were reported in the most recent issue of *The Minor Planet Bulletin*. The primary rotation period (Prot), orbital revolution period (Porb) and authors of the studies are listed in Table 2.

Asteroid 2011 CT4 was found by B. Warner and R. Stephens to have a rotation period 0.9601 hours, at which rate the centrifugal force at the equator exceeds gravitational attraction force. Any loose debris is spun off. This object is a solid rock, a monolith.

In addition to those asteroids specifically identified above, lightcurves with derived rotation periods are published for 163 other asteroids as listed below: 78, 81, 83, 86, 153, 179, 372, 445, 455, 463, 470, 504, 527, 549, 739, 749, 755, 782, 862, 914, 925, 970, 1015, 1027, 1048, 1086, 1103, 1106, 1109, 1112, 1120, 1149, 1160, 1170, 1188, 1202, 1212, 1274, 1302, 1316, 1345, 1385, 1415, 1439, 1539, 1579, 1589, 1627, 1655, 1706, 1755, 1794, 1806, 1831, 1864, 1941, 2023, 2075, 2103, 2227, 2326, 2432, 2443, 2566, 2871, 2890, 2898, 2937, 3166, 3202, 3267, 3373, 3385, 3489, 3566, 3571, 3613, 3761, 3842, 3904, 3986, 3998, 4194, 4302, 4421, 4700, 4705, 4857, 4875, 4931, 5042, 5096, 5186, 5391, 5438, 5512, 5537, 5543, 5626, 5693, 5972, 6801, 7118, 7368, 7527, 7778, 8566, 9100, 9186, 9219, 9564, 9717, 9299, 10422, 11066, 11230, 11420, 11493, 11548, 12853, 16579, 18172, 19288, 19492, 23186, 23692, 25660, 28885, 29032, 31560, 32395, 34613, 36284, 37652, 38181, 39197, 41475, 43815, 48540, 52768, 54686, 64163, 77892, 87312, 89776, 90075, 93040, 103067, 154993, 163373, 214088, 302111, 393493, 416591, 437316, 474223, 489486, 500094, 512245, 2019 CH, 2019 XG1, 2019 WB6, 2020 DD.

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

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

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

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

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

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

Jupiter Section

Report compiled by section staff members Richard Schmude, Craig MacDougal and John McAnally

Jupiter will be visible in the evening sky during October. Unfortunately its declination will be near 22° S. Those living in Earth's southern latitudes will get a better view than those living farther north.

Richard Schmude, Jr. has completed the 2017-2018 and 2018-2019 Jupiter apparition reports for future publication in this Journal. Work has begun on the 2020-2021 Jupiter report.

Preliminary drift rates (in degrees/30 days) for the following currents have been determined South Polar current

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(-1.3°), South South South Temperate Current (-13.8°), Oval BA (-16.4°), the Great Red Spot (+2.0°), the South Equatorial Belt Jetstream (+92.9°) and North North Temperate Current (-9.0°).

Assistant Coordinator Craig MacDougal reports there are 497 members subscribed to the Jupiter Yahoo e-mail discussion list. He also reports that Vlamir da Silva Junior is the most active member.

Clyde Foster discovered a new feature on Jupiter on May 31. Now named "Clyde's Spot", the JUNO spacecraft imaged it on June 2. Congratulations to Clyde Foster!

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

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

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

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

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

Saturn Section

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

The 2020-21 apparition of Saturn continues. Saturn passed opposition on July 20, 2020, and remains located in Sagittarius, and it is conveniently placed for visual observations and imaging throughout the night.

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

As of this writing, the ALPO Saturn Section has already received hundreds of visual observations and multi-wavelength images. Observers performing digital imaging have been reporting considerable discrete atmospheric phenomena in Saturn's northern hemisphere, including small white spots in the EZn (northern half of the Equatorial Zone) interacting with the adjacent EB (Equatorial Band), plus sporadic small white spots in the EZs (southern half of the Equatorial Zone, as well as a curious persistent white ripple or streak midway within the EB (Equatorial Belt).

Small white and dark spots continue to appear the NPR (North Polar Region) at saturnigraphic latitude +74.7°. The aforementioned atmospheric phenomena have shown up well in most images captured using RGB, red, 685nmIR filters. It is very important for observers during the remainder of the current 2020-21 observing season to continue to monitor Saturn and capture images with the same multi-wavelength filters to determine if the same or similar features persist and change morphologically with time. Observers should be watchful for any new atmospheric phenomena that might suddenly appear. With the rings tilted by about +22° toward our line of sight from Earth in 2020-21, observers still have favorable opportunities to view, draw, or image the northern hemisphere of the globe and north face of the rings despite Saturn's southerly declination of -21° for Northern Hemisphere observers.

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

For quite a few years to come, planetary scientists will be carefully studying the vast database of images and data gleaned from the Cassini mission, including images provided during the mission by ALPO observers.

Our ALPO Pro-Am efforts did not cease after the Cassini mission ended during September of 2017. Indeed, as in the immediately preceding 2018-19 and 2019-20 apparitions, our team of observers are routinely monitoring Saturn for atmospheric phenomena and

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we have been actively sharing our results and images with the professional community. Therefore, anyone around the globe who wants to join us in our observational endeavors is highly encouraged to submit systematic observations and digital images of the planet at various wavelengths throughout the current 2020-21 observing season.

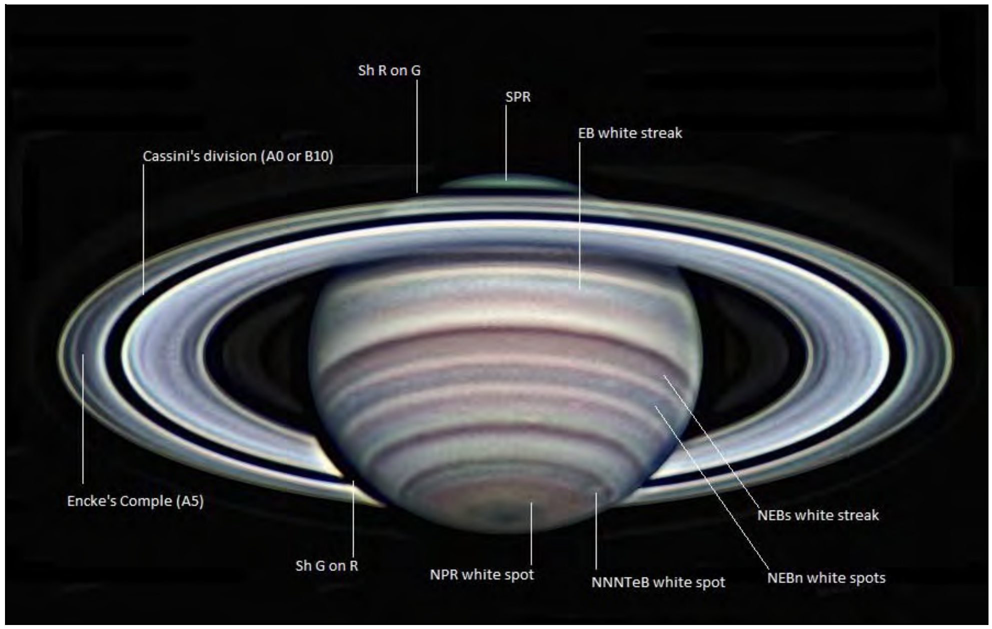
Observers are also reminded that visual numerical relative intensity estimates (also known as visual photometry) remain an extremely important part of our visual observing program and are badly needed to ascertain recurring brightness variations in the belts and zones on Saturn as well as the major ring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

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

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

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

Information on ALPO Saturn programs, including observing forms and



Detailed RGB image of Saturn taken by Christopher Go of Cebu City, Philippines on June 3, 2020 at 18:53 UT in excellent seeing conditions. His image was captured using RGB filters with a 35.6cm (14.0 in.) SCT. His image reveals the curious elongated white streak or ripple within the EB (Equatorial Belt) as well as what appears to be white streak in the NEBs (North Equatorial Belt, southern half) and white spots in the NEBn (North Equatorial Belt, northern half), as well as in the NNNTeB (North North North Temperate Belt), and the NPR (North Polar Region). The SPR (South Polar Region) is barely visible in the image just south of where the rings cross the globe of Saturn. The Sh G on R (Shadow of the Globe on the Rings) and Sh R on G (Shadow of the Rings on the Globe) are noted as well as Cassini's Division (A0 or B10) and Encke's Complex (A5). The apparent diameter of Saturn's globe in this image is 17.8" with a ring tilt of +20.6°. and CMI = 222.8°, CMII = 7.1°, CMIII = 304.70°. The apparent visual magnitude = +0.4. South is at the top of the image.

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

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

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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 will be visible in the late evening and early morning during October. It will reach opposition on October 31. Neptune will be visible as soon as it gets dark and will set in the early morning hours. It reached opposition on September 11.

The coordinator is finishing up the 2019-2020 apparition report and hopes to submit it to the editors in July of 2020. During late 2019, Uranus had a large bright, North Polar cap. It is undoubtedly a large cloud system rather than ice. This feature has been imaged for several years. Neptune had three large bright spots during late 2019. Use near infrared filters to image these albedo features.

Pluto will be visible during the evening in October. It reached opposition on July 15. There is a chance that its atmosphere may freeze-out causing a slight brightening. Therefore, I am hoping someone can measure its brightness.

(Source for opposition dates: Observer's Handbook 2020 (J. S. Edgar, editor) published by the RASC.)

To find any of the remote planets for telescopic observations, it is suggested that you first use a star chart which shows the position of the target, then use binoculars to find the target. [Note that *skyandtelescope.com* is a great source to find specific locations of sky objects.]

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

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

Finally, my usual reminder that the book *Uranus, Neptune and Pluto and How to Observe Them* is available from Springer at *www.springer.com/astronomy/popular+astronomy/book/978-0-387-76601-0* or elsewhere (such as *www.amazon.ca/Uranus-Neptune-Pluto-Observe-Them/dp/0387766014*).

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

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We (Sometimes) Get Letters

Date: July 29, 2020

To: Tim Robertson,

I love the podcast. I just listened to about 80 percent of the entire collection while driving cross-country. It is now my last night on the road and I have just purchased a membership and would like to participate in the Training Program.

I don't know my membership number but my Order Confirmation Number is 11833.

I'm looking forward to receiving the Handbook.

Thank you,

Mark Lovett

****

Date: September 14, 2020

Subject: Comet Impact on Mars?

To the Editor:

(*States Tom Dobbins*) My immediate thought after reading Jim Melka's "Probable Comet Impact on Mars in 1973" in the 2020 summer issue of the JALPO was that the discovery of a field of recent impact craters on Mars would warrant banner headlines in the popular press. I consulted Tim Parker, a planetary geologist at NASA's Jet Propulsion Laboratory and a leading expert on Mars. He replied:

(*States Tim Parker*) "My first impression, looking at the two rather regional images of the craters, is that a single impactor couldn't spread far enough apart to produce those craters, from breaking up at the top of the atmosphere to hitting the ground. But I also wonder why the author didn't use online tools like Jmars or even Google Earth (which has a Mars menu option) to look at recent data… These proposed new craters are spread over hundreds of kilometers, so if they were from a single comet it would have to have broken up into several rather large fragments before arriving at Mars. Any impactors capable of producing kilometer-size craters would have to have been very large themselves. Comets that big would have been spectacular "comets of the century." Mariner 9 resolution probably wasn't sufficient to resolve these craters clearly. (Unfortunately, Mariner 9

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data isn't easily searchable, so I can't verify this.) However, looking at modern very high resolution images from the CTX camera on Mars Reconnaissance Orbiter, all of these craters are clearly old -- they have small craters superposed on them and their ejecta blankets. The clouds are interesting, but I don't think they can be attributed to any new craters."

(*Tom Dobbins*) The alleged 1973 comet impact doesn't appear to be "probable" and may in fact be "highly unlikely."

-- Tom Dobbins

(A reply from Mr. Melka)

To the Editor:

This is my response to the letter of Tom Dobbins, in which he commented on my article in which I claimed that a probable comet impact on Mars was witnessed by a group of observers, including myself, in 1973. Dobbins quoted extensively from Tim Parker's assessment of the article.

Tim Parker stated, ". . . I also wonder why the author didn't use online tools like Jmars. . . ." I did use JMARS. I wrote, "However, the diameters of the six new craters were measured with JMARS using the Mars Orbiter Laser Altimeter (MOLA) images of the Corprates quadrangle, and were found to have diameters ranging from 4.2 km up to 10.0 km."

Tim Parker stated, "My first impression, looking at the two rather regional images of the craters, is that a single impactor couldn't spread far enough apart to produce those craters." I agree with his impression, which is why I wrote, "It is suspected that the comet had two nuclei based on the fact that the initial appearance of the cloud was of two large circular bright white clouds." The distance of the centers of the two circular white clouds plotted on the MOLA map and shown in Figure 7 were measured to be 650 km. It follows that the spread of craters should be in the hundreds of kilometers. In further support of my thesis, it is important to note that the craters are in two groups, separated by a distance similar to the centers of the clouds.

Tim Parker stated, "Any impactors capable of producing kilometer-size craters would have to have been very large themselves". However, a commonly expressed opinion in astronomical literature is that craters result from impactors that are approximately one-tenth the diameter of the crater. Accordingly, the new craters might have been produced by impactors ranging from 0.4 to 1.0 kilometers in size. This is smaller than most comets observed by ALPO observers.

Tim Parker stated, "Comets that big would have been spectacular 'comets of the century."' I think that one cannot retrospectively assess the probable brightness of a comet by the size of its impact crater. Many comets discharge very little dust and are consequently very faint.

Tim Parker stated, "Mariner 9 resolution probably wasn't sufficient to resolve these craters clearly. (Unfortunately, Mariner 9 data isn't easily searchable, so I can't verify this.)" This assertion about the Mariner 9 resolution is mistaken. In the article I wrote, "The Mariner 9 maps are believed to show identifiable features as small as 1 to 2 km in size for 70% of the Martian surface, and as small as 3 km in size for the remaining 30% of the surface". This is the opinion of Batson, who compiled the Mariner 9 maps, and it is remarkable that Parker disagrees with that author without ever having seen the Mariner 9 maps. Furthermore, as I stated in the Introduction, I compared the Mariner 9 maps of 1971 and 1972 to the Viking Orbiter images of 1975 and 1976, with attention specifically to the Coprates, Phoenicis Lacus, and Thaumasia quadrangles, and I found no craters that are exceptions to this size limit except for those that I identified as new. As I wrote, "If the new craters were smaller than 3 km size, their absence from the Mariner 9 maps might be considered to be inconsequential."

Tim Parker stated, "However, looking at modern very high resolution images from the CTX camera on the Mars Reconnaissance Orbiter (MRO), all of these craters are clearly old." Parker is well aware that it is difficult to ascertain whether small craters overlie or underlie the ejecta of nearby craters. In view of this, I am in the process of investigating his assertion further by obtaining the relevant MRO images.

Tim Parker stated, "The clouds are interesting, but I don't think they can be attributed to any new craters." In response, I say that comet nuclei typically have two major componments – rocky material and frozen ices. I am proposing that impacts of rocky material produced only the craters. The vaporized ices were responsible for the large circular white clouds.

Tom Dobbins stated, "The alleged 1973 comet impact doesn't appear to be 'probable' and may in fact be 'highly unlikely."' In the article, I compared the

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September 2 clouds to seven categories of Martian clouds, and explained that each of these types was inconsistent with the clouds that our team observed.

I appreciate the time and consideration that Dobbins and Parker gave to my article. I hope that my responses here contribute constructively to the discussion of the relevant issues.

Jim Melka

All further correspondence on this matter should be sent to:
- *tomdobbins@gmail.com*
- *jim.melka@alpo-astronomy.org*

Notable Deaths

Samuel R Whitby, 1949-2019

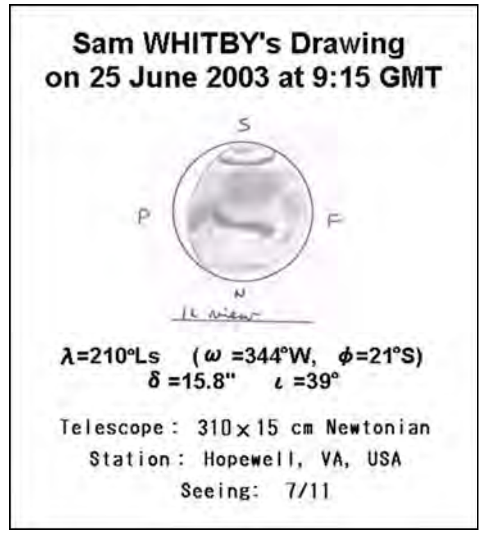
(Obituary by Randy Tatum, Henrico, VA)

Longtime amateur astronomer and member of the Assn of Lunar & Planetary Observers and the British Astronomical Assn, and contributor to the Mars Section of the Oriental Astronomical Assn. Samuel R. Whitby passed away on September 9, 2019. Sam was also a member of the Richmond (Virginia) Astronomical Society where he enjoyed many evenings observing with the 7-inch Mogey refractor at Ragland Observatory. He was also poet and historian and authored seven books. His works included reflections on life, nature and astronomy

Sam grew up on his grandparents' small farm near Brodnax, Virginia, where the dark skies there provided him with fine views of comets Ikeya-Seki and Bennett. He began observing Jupiter in 1963 at the age of 14 and developed into a fine visual observer and draftsman of the planets with his specialty being Mars, Jupiter and Saturn; his drawings are very accurate and never embellished.

Sam highly valued his friendships in the astronomical community and often mentioned his correspondence with Mars expert Matsatsugu Minami. His letters were published in the "Communications in Mars Observations" (CMO), an international journal of global Mars observations published by the International Society of the Mars Observers (ISMO). It was while he was in his late 50s when he was diagnosed with Parkinson's disease. Sam's desire to observe never waned as the disease progressed. He was delighted to travel to North Carolina to view the 2017 "Great American Solar Eclipse."

Sam's father was a barber and his mother translated for Spanish-speaking migrant farm workers who attended the local Baptist church. Sam studied psychology and philosophy at Virginia Commonwealth University, worked at a couple of factories while a student, then worked about four years for a county



Mars as sketched by Sam Whitby in June 2003.

Sam Whitby with his 6-inch reflector in December 2009.

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welfare department and 23 years for the Virginia Department of Juvenile Justice.

He is survived by his wife of 38 years, Uta Whitby; children Colleen Gorman (Jeff), David R. Whitby (Angelique) and Tyler B. Whitby; grandchildren Maxwell, Sailor, Kieran, Declan and Gavin; sister-in-law Rodessa Whitby; nephew Emmitt Whitby; and niece Juanita Howerton. Besides his parents, he was also preceded in death by his brother, Randall Whitby.

I (Randy Tatum) will miss his insight and friendship.

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Prof Jean Dragesco, 1920-2020

(This obituary is based on a written tribute about Dr. Dragesco authored by Dr. Richard McKim in observance of Dr. Dragesco's 100th birthday and previously published in the Journal of the British Astronomical Assn.)

Prof. Jean Dragesco who gained a worldwide reputation as a photographer of the microscopic scale to the macroscopic, and was a longtime member of both the ALPO and the BAA, passed away on August 26, 2020 at the age of 100 in Saint-Clément-de-Rivière, France.

Protistologist by profession and amateur astronomer by inclination, his solar, lunar, planetary and cometary photographs have been admired by a generation of BAA members. This short paper celebrates the centenary of his birth.

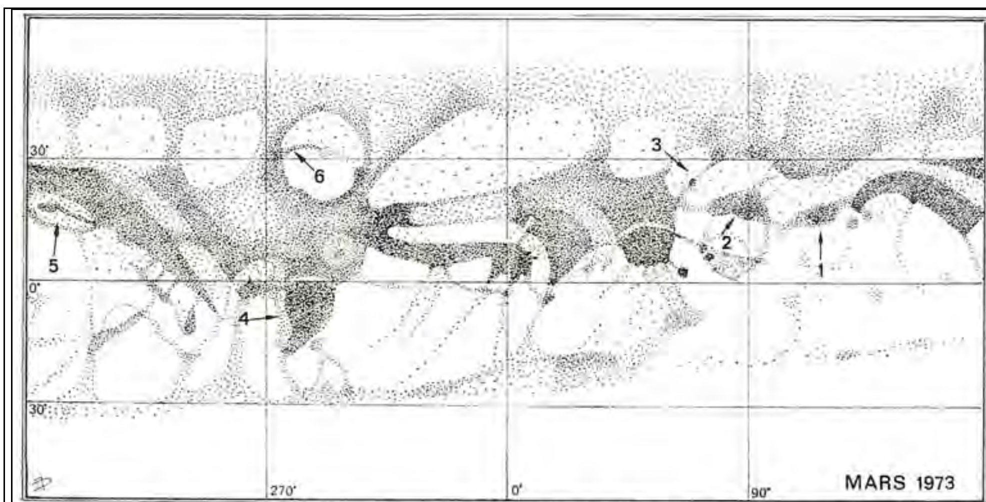
Jean was an assistant recorder (coordinator) for the ALPO Jupiter Section from April 1978 through November 1990, specializing in planetary photography.

The name of Prof Jean Dragesco will be a familiar one to older BAA members. He contributed an enormous amount of visual observational work over many decades, and was an accomplished expert in taking high-resolution photographs of the Sun, Moon and planets. A BAA member from 1961 November till the early 2000s, our subject was born Ionel Drāgescu in Cluj, Romania, on 1920 Apr 27. As 2020 marks the centenary of his birth, it is a good moment to celebrate the many achievements of his life.

Growing up in Cluj, and encouraged by his scientifically-inclined uncle Radu Drāgescu, Jean became keenly interested in astronomy in 1935. He gathered a group of fellow Romanian amateurs around him, and even published two magazines using a duplicating machine: one for astronomers, and the other for microscopists. Fate would decide that he would spend the rest of his life in France and Africa.

Jean Dragesco lecturing on the subject of scientific photography in 1978: a favorite portrait.

His father was appointed as the information and press relations officer at the Romanian Embassy in Paris in 1940. The German invasion of France caused significant problems for the family and their initial stay in Paris was brief, but in the following year Jean and his sister were living in an apartment in the city, and in 1942 Jean enrolled as a science student at the Sorbonne (at the University of Paris). He had found it hard to choose between astronomy and biology, finally opting for the latter.



Planisphère de Mars 1973 montrant (à l'aide de flèches, numérotées de 1 à 6) **les principales caractéristiques de l'opposition, concernant les variations séculaires d'albédos.**

Jean Dragesco's hand-drawn Mars map for 1973 (wth original caption), compiled by him from observations by members of the SAF. The stippling technique used was also ideal for microscopical drawings.

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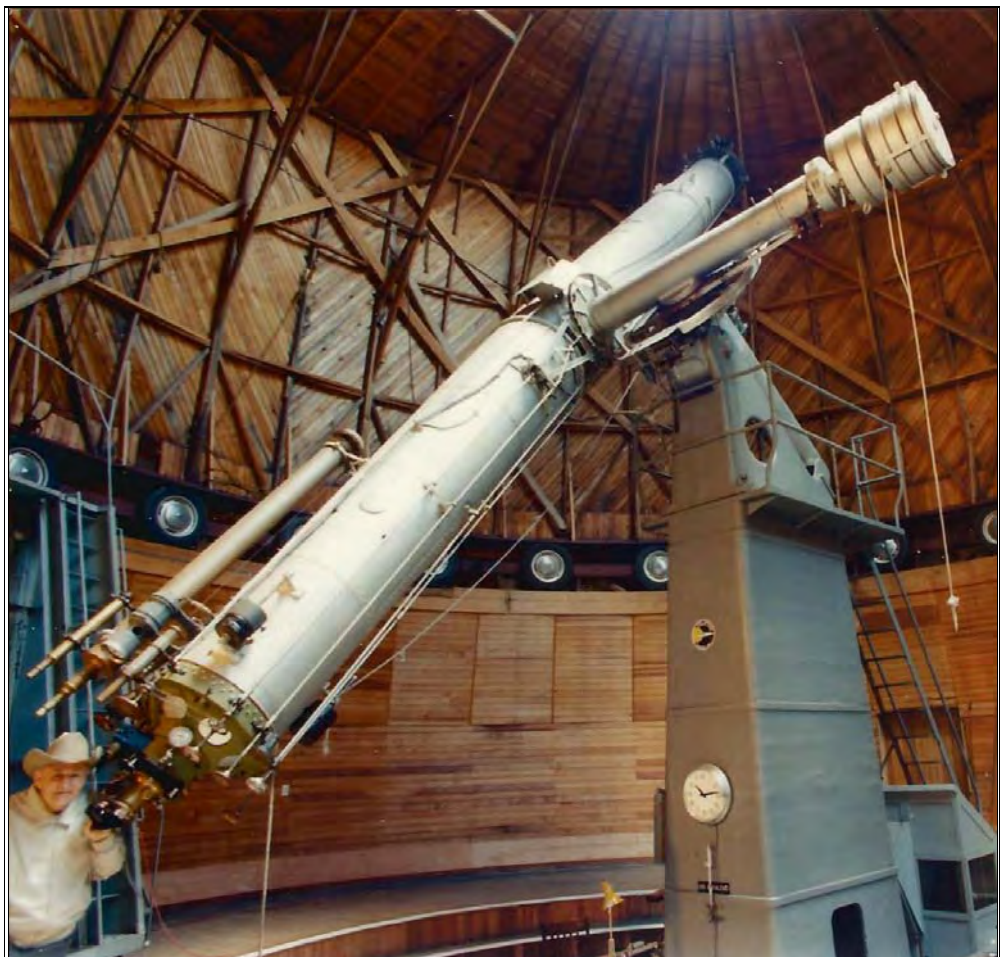
The Celestron 14 at Butare, Rwanda, with its movable shed on wheels. Note the unusual angle of the polar axis.

He was already a member of the Société Astronomique de France, and could make use of the Society's observatory atop the Sorbonne, in the rue Serpente. With the nighttime curfew, he was obliged to spend whole nights at the observatory, sleeping on a wooden table. Some of his 1941 Mars drawings were published by G. Fournier in his reports for the SAF bulletin, l'Astronomie, and he was a keen follower of Jupiter's dark South Tropical Streak during 1941-'42. Jean once told me (Dr. McKim) that the Editor, the elderly Mme Gabrielle Flammarion, had declined to publish his observation of Saturn's rings as she had experienced a different telescopic impression from him of Encke's Division.

Jean was a great collector of books, having inherited a substantial scientific library from his Uncle Radu. In wartime Paris he was able to collect many rare science books, astronomical and otherwise, for a nominal sum. Later he generously presented his Mars book collection to me: it has proved invaluable for historical research.

Out of class, Jean would study scientific photography with the equally energetic young SAF member Gérard de Vaucouleurs. They collaborated on a manual of scientific photography. A perfectionist, de Vaucouleurs held long revision sessions with his co-authors, which Jean still recalled with agony decades later. But it did result in a standard work on the subject. And in the early 1940s Jean would mentor a young French amateur, Audouin Dollfus (four years his junior), and help him to construct his own 200mm reflecting telescope from scratch. Dollfus would later rise to be the chief astronomer at Paris Observatory, and to become a legendary figure in the world of planetary science.

After the ending of hostilities in 1945, Jean decided to become a Frenchman. He once told me (with tongue-in-cheek?) that the first step was easy enough: it was just a matter of curving round the tips of the 'u' on his handwritten identity card so that it became an 'o', producing a much more French-sounding surname: Dragesco. He was naturalised in 1957. After graduating from the Sorbonne, he



Jean Dragesco wearing his Stetson in the dome of Lowell's 60cm Clark refractor, 1988.

had taken up a career as a researcher within the CNRS (Centre National de la Recherche Scientifique), and he later took his doctorate in 1956.

Comet Levy 1990 XX, photographed with a Celestron Schmidt camera. (From 1991 New Year card.)

From the start, Jean carried out his professional research in the field of protistology in general, and on ciliates in particular: his first paper was published in 1948. Later he would discover a new example of these microscopic species, which would be named after him.

He was quick to realise the value of photographic and cinematographic techniques. Keenly interested in wildlife photography, he took part in long expeditions abroad, and invented a rifle-like device (the 'Dragescotar') to hold the telephoto lens steady upon his shoulder. He made many professional films, upon subjects ranging from protozoa and termites to the birds and mammals of Africa.

As his reputation grew, he became a co-founder and editor of several international journals dealing with biology or cinematography. An early book, *Chasse d'Afrique* (1965), was well received and established him as a professional wildlife photographer. In the 1960s he moved to French Equatorial Africa to take up university appointments in Gabon and Cameroon. He gained his professorship in 1970. Most of his professional life was spent in Africa, his spiritual home.

At Yaoundé (Cameroon), he equipped himself with a fine 254mm Newtonian reflector. Later he would use a Celestron 8 for greater portability, and finally a C14. An expert in optical testing, Jean told me that he had to reject several of the early commercial instruments before getting a perfect specimen.

In 1973 he mounted his second expedition to film a total solar eclipse, travelling to Kenya for the longest eclipse of the 20th Century. In the mid-1970s he spent a few years as a professor at the French University of Clermont-Ferrand.

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But it was not long before he would return to Africa.

By 1976 he was established at Cotonou, Benin. Research continued by both day and night, with the site offering excellent seeing conditions for planetary work. Jean's final university post was at Butare, Rwanda; it was highly fortunate that before the start of the terrible genocide that would devastate that country, he had retired to France.

Attracted by our active planetary Sections at a time when those of the SAF were less prolific, Jean joined the BAA in 1961 and immediately began sending us high-quality drawings of Mars and Jupiter, accompanied by good photographs. With the advent of Kodak's fine-grained TP2415 "iracle" film two decades later (and aided by a combination of excellent technique, optics, drive and seeing), he was able to secure quite superb results that few other amateurs could match. His low-latitude location enabled him to study the planets to advantage, particularly in the years when they were at high southern declination. Jean wrote planetary reports (mostly dealing with Mars, but occasionally for Jupiter and Saturn) for the SAF's Commission des Surfaces Planétaires. Like Dollfus, whom he later succeeded as head of that Commission, he was an inspiration to young observers.

Under the dark African skies (particularly in Rwanda, where the seeing conditions were less favourable than in Benin), Jean became adept at deep sky photography. He also took many fine photos of comets, particularly 1P/Halley in 1985-'87. Purchasing a hydrogen-alpha solar filter, he captured limb prominences and solar flares. By the 1970s, he was winning prizes for his astronomical photographic work and he received three medals from the SAF, including its highest award. The BAA gave him the Steavenson Award in its centenary year (1990), and the ALPO its Walter H. Haas Observer's Award that same year. To mark his 80th birthday, the IAU named minor planet (12498) "Dragesco" in his honour.

Always a workaholic, Jean was often tired after a long night at the eyepiece. Fortunately, a solution was at hand. In his faculty laboratories he possessed a personal photographic darkroom, and was able to install a camp bed so that he could occasionally snatch a few hours' sleep - unseen! - during daytime.

Jean was an excellent protistology draftsman and took great care over the pen and ink diagrams for his papers (using a stippling effect). He told me that the preparation of these detailed diagrams gave him a lot of personal satisfaction. By 1982 he had authored over 200 publications.

I first came to know Jean through BAA correspondence in 1981, and we finally met when I visited Paris in 1984. Jean took me to Meudon to meet Audouin Dollfus (by then its most senior astronomer), and we spent an evening observing with the 83cm Grande Lunette. Over dinner at his flat I met his second wife Armelle Kernéis, a fellow biologist whom with her husband had co-authored the standard work Cilies libres de l'Afrique intertropicale.

In the summer of 1986 we had the good fortune to observe together for some 10 nights with the 1m Cassegrain at Pic du Midi (in the French Pyrenees). Jean had already used this superb telescope — funded in the 1960s by NASA for lunar photography in advance of the Moon landings — towards the end of 1975. During our stay, he secured amazing photographs of Mars, Jupiter and Saturn (all then close to opposition), despite Mars and Saturn being at high southern declination. He was greatly assisted by keeping nine fully loaded Nikon camera bodies at the ready.

He disposed of what he considered to be low-resolution photographs, but nonetheless I was amazed at the quality of some of the negatives I fished out of his waste paper bin. I made detailed telescopic drawings and much more modest photographs. We wrote several joint papers about our adventure.

One night while observing Mars, the seeing (following a mediocre start to the evening) suddenly became absolutely perfect, and I ran to fetch Jean from his room to take photos. Although he fixed up his camera quickly, he asked me to control the fine focus — I believe this was shortly before he underwent an operation for cataracts — and in spite of my assistance, the result was the sharpest single image ever taken from the Earth up to that time. Saturn was also observed in perfect seeing, and it was easy to catch the markings upon Jupiter's Galilean moons.

We were not able to return to the Pic for the next opposition of Mars in 1988, but Jean was invited to work for a month at Lowell Observatory (Flagstaff, Arizona, USA) with his old friend de Vaucouleurs. This mission was less successful than the earlier ones, due to the generally poor seeing prevailing there in September, but nonetheless he was excited to use the famous 60cm Clark refractor, which had been so skilfully adopted for the same purpose by E. C. Slipher. Like the Grande Lunette, it was a physically tiring instrument to use, being pulled around with a rope.

Jean and Armelle retired to France in 1988, and moved from Paris to the

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south of the country. Jean would enjoy an active retirement at Saint Clément de Rivière, near Montpellier, often writing numerous articles for the high-quality astronomical photography magazine Ciel et Espace. New telescopes arrived; he had owned around 40 in his lifetime. Here, as in the warm climate of Africa, he favoured simple telescope huts on wheels that could be rolled out of the way to enable observing to begin quickly. He even continued with his research into protistology in his home laboratory. And Armelle skilfully added a reflective silver lustre to the homemade pottery that she fired in her own kiln.

Following the fall from office of President Nicolae Ceauşescu in 1989, and the subsequent return to democratic government in Romania, Jean was able to give practical help to his many astronomical friends in his home country. He had always worked closely with Matei Alexescu of Bucharest. Finally the letters from his Romanian friends were no longer censored, but it was sometimes difficult to meet every request he received: posting colour films abroad was alright, but one astronomer asked for a car battery!

By 1993, Jean had completed a comprehensive manuscript in French for a book entitled “High Resolution Astrophotography,” and I was commissioned by Cambridge University Press to prepare an English translation (there was no French edition). The book was a great success, appearing as a softcover reprint in recent years. In addition to a detailed theoretical text, it contained short biographies of the world's leading solar, lunar and planetary photographers, with many examples of their state-of-the-art work. In his introductory text, Audouin Dollfus wrote that to imagine Dragesco without a telescope would be as unthinkable as Chopin without a piano. But Jean correctly predicted that it would be the last book of its sort, for by the late 1980s the CCD camera was already displacing the photographic emulsion. Had he been younger, he would have taken up the new technology.

Jean and Armelle continued to live happily with a cat and dog, and their only enemies were the voracious local mosquitoes. The summer heat on the French Riviera was hardly oppressive to those who had lived for decades in Africa, but nevertheless an afternoon siesta was essential. His final active observational work before he retired from the field in his mid-80s concerned solar activity: aided by the Riviera's clear skies he kept up the visual Wolf number counts that he had been making on a daily basis for decades.

With his first wife, Jean had a large family of six children and we only have space to mention here that his sons Alain (d. 2002) and Eric became noted wildlife photographers in their own right (see *https://www.ericdragesco.com/*).

A selection of Jean's photographs is given here, to illustrate both his amazing technical skill and the range of his scientific achievements. I thank Eric and Bernard for help with checking the accuracy of the text, and I would like to send their father my very best wishes on the occasion of his 100th birthday.

Select bibliography

With Gérard de Vaucouleurs & Pierre Selme, *Manuel de photographie scientifique*, Ed. Revue d'Optique, 1956

Chasse d'Afrique, Paris, 1965

With Pierre Bourge & Yvon Dargery, *La photographie astronomique d'amateur*, P. Montel, 1978

With Armelle Dragesco Kernéis, *Ciliés libres de l'Afrique intertropicale*, Éditions de l'Orstom, 1986

High Resolution Astrophotography, Cambridge University Press, 1995

Amintirile unuivânător de imagini în Africa, Editura CD Press, Bucharest, 2005

Both co-authored with Richard McKim: 'A Visit to the Pic du Midi Observatory', Journal of the British Astronomical Assn, 97(5), 280-287 (1987); 'Observations Planétaires a l'Observatoire du Pic du Midi', Pulsar, 78, no. 658, 22-26 (1987).

Alain Dragesco-Joffé, La vie sauvage au Sahara, Delachaux et Niestlé, Lausanne, 1993

Eric Dragesco, La vie sauvage dans les Alpes, Delachaux et Niestlé, Lausanne, 1995

Papers & Presentations

A First Look at Comet C/2020 F3 (NEOWISE)

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To Our Hard-Copy Readers

All images in this paper can viewed in full color in the online (pdf) version of this Journal.

Abstract

Long-period comet C/2020 F3 (NEOWISE) developed into a 1st magnitude object around the time of its July 3, 2020 perihelion at a distance of 0.29 astronomical units (au) (26,970,000 miles) from the Sun. It became the brightest comet for Earth-based observers since C/2011 L4 (PANSTARRS) in 2013. For observers in the northern hemisphere, it was the most aesthetically impressive comet since C/1995 O1 (Hale-Bopp) in 1997. Around the time of its closest approach to Earth at a distance of 0.69 au on July 23, the comet possessed a dust and ion tails with lengths of 10° and almost 30°, respectively. Based on current brightness trends, Comet NEOWISE may remain a visual object till October 2020 and a CCD object well into 2021.

As of August 4, 2020, the ALPO Comets Section has received 330 observations from 26 contributors. The number of submitted observations already makes Comet NEOWISE the best-observed comet by the ALPO since Hale-Bopp. Being conducted mid-apparition, this will be a first-look report containing a subset of observations and preliminary photometric results. A full report will be published in the future after the end of the apparition.

Discovery

Comet NEOWISE was discovered by the Near-Earth Object Wide-field Infrared Satellite (NEOWISE) on March 27.71, 2020 UT. At discovery, Comet NEOWISE was located in the constellation of Puppis at a distance of 2.08 au (193,440,000 miles) from the Sun and 1.70 au (158,100,000 miles) from Earth. NEOWISE reported a brightness of 17th magnitude. Ground-based follow-up observations found the comet as bright as magnitude 15.9 (Green et al., 2020a).

The NEOWISE spacecraft was originally named the Wide-field Infrared Satellite (WISE) when launched on December 14, 2009 on a United Launch Alliance Delta II 7320-10 launch vehicle from Vandenberg Air Force Base (California USA) into a Sun-synchronous polar orbit with an inclination of 97.5° and 488 x 495 km (303 x 306 miles) altitude. The mission was selected as part of NASA's Medium Explorer (MIDEX) program. Equipped with a 0.4-m (16-inch) telescope, WISE was designed to survey the entire sky over 10 months at 4 infrared wavelengths (3.4, 4.6, 12, and 22 microns). It can be considered a successor of the Infrared Astronomical Satellite (IRAS) which conducted a similar mission. IRAS, launched in 1983 and is best known to comet observers as a co-discoverer of C/1983 H1 (IRAS-Araki-Alcock) and discoverer of (3200) Phaethon, the parent body of the Geminid meteor shower.

By October 2010, the coolant on WISE had depleted, leading to the spacecraft's shutdown in February 2011. Since the lack of coolant did not adversely affect the two wavelengths at 3.4 and 4.6 microns, a proposal was made to reactivate the spacecraft and dedicate it to the discovery and physical studies of asteroids and comets. As a result, the spacecraft was reactivated in August 2013 and re-designated NEOWISE. Since launch, WISE/NEOWISE has discovered 33 comets and over 300 near-Earth asteroids.

Orbit

The following orbit was published in Central Bureau Electronic Telegram 4816 and Nakano Note 4155 from astrometric observations made between March 27 and July 19, 2020 (Green et al., 2020b; Nakano, 2020).

Date of Perihelion (T) = 2020 July 3.67924 TT

Perihelion Distance (q) = 0.2946509 au

Eccentricity (e) = 0.9991646

Argument of Perihelion = 37.27831°

Longitude of Ascending Node = 61.00908°

Inclination (i) = 128.93756°

Inverse semi-major axis (1/a) = +0.002835 au^{-1}

1/a(original) = +0.003719 au^{-1}

1/a(future) = +0.002823 au^{-1}

Epoch = 2020 July 10.0 TT

An "original" 1/a value greater than +0.0001 au^{-1} suggests a dynamically old comet having made at least one previous perihelion passage within the inner solar system (Marsden et al., 1978). The "original" value of 1/a is calculated by integrating the orbit of a comet back to a point before the gravitational effects of other large solar system objects affected the comet's orbit during the current apparition. The "future" value of 1/a is calculated by integrating the orbit forward in time to a point after the gravitational effects of other solar system objects have ceased. The "original" value of 1/a corresponds to a semi-major axis of ~270 au and a previous perihelion occurring ~4,400 years ago or around

2400 BC. The comet's future semi-major axis is ~350 au (corresponding to the next perihelion happening in ~6,700 years.

Overview of the Apparition

The comet's path in the sky from discovery to early August 2020 is shown in *Figure 1*. The comet approached the Sun from the south, resulting in most pre-perihelion observations being limited to observers in the southern hemisphere. From discovery to early June, the comet moved through Puppis, Columba, Canis Major, Lepus, Monoceros and Orion. By early June, NEOWISE's elongation dropped below 20° making ground-based observations no longer possible.

While the comet was out of view from Earth, a flotilla of Sun-watching spacecraft, including the Solar and Heliospheric Observatory (SOHO), Solar and Terrestrial Relations Observatory (STEREO) and Parker Solar Probe, were able to observe the comet. The comet was within the field-of-view of the Large Angle and Spectrometric COronagraph (LASCO) on SOHO between July 22 and 28 (Knight and Battams, 2020). A minimum solar elongation of 7° occurred on June 25.

Two days before perihelion on July 1, the comet was once again seen by Earth-based observers while at a very small elongation of 11°. For the first half of July, NEOWISE was a morning object as it moved through Taurus, Auriga and Lynx. At mid-month, the comet passed north of the Sun and moved into the evening sky. Around this time, the comet was also a circumpolar object for mid to high northern latitudes. As July progressed and the comet moved to the southeast through Ursa Major and Coma Berenices, it once again became visible to observers in the southern hemisphere. Closest approach to Earth occurred on July 23 at 0.69 au (64,170,000 miles).

Observations

As of August 4, 2020, the ALPO Comets Section has received a number

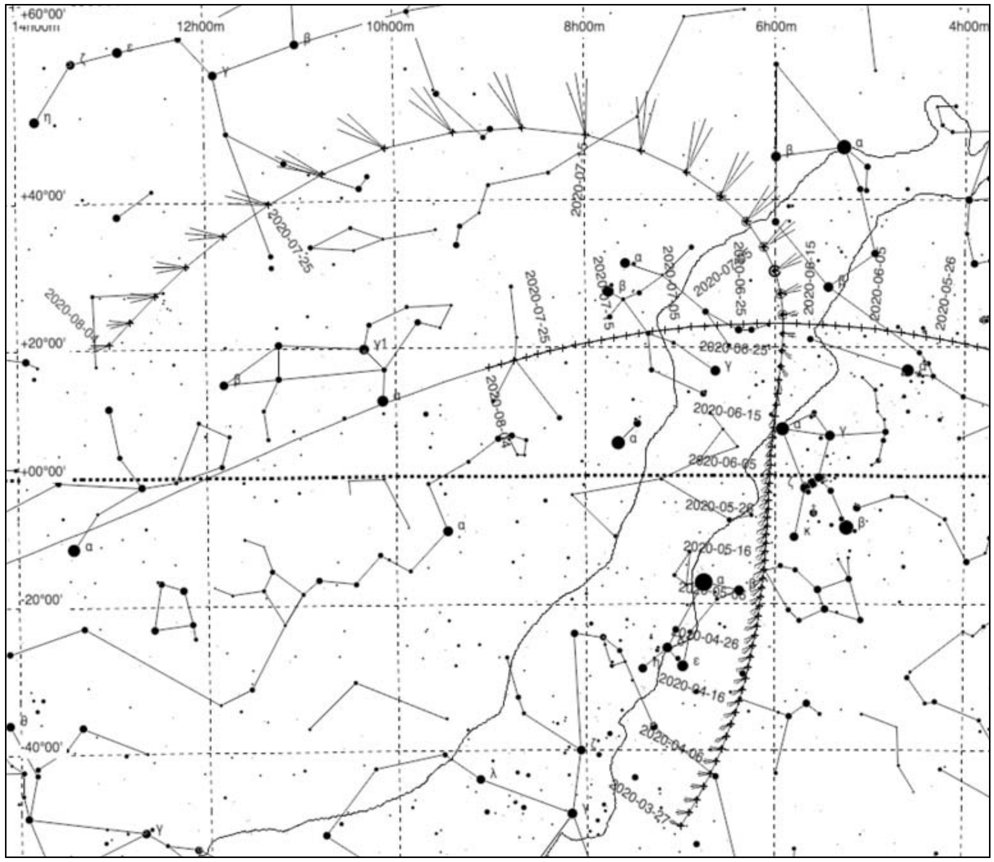

Figure 1. Star chart showing the path of C/2020 F3 (NEOWISE) and the Sun from the date of NEOWISE's discovery on March 27, 2020 through August 4, 2020. Chart was produced with the program Cartes du Ciel version 4.2.

of different types of observations from 27 different contributors in 10 countries. A total of 330 observations were submitted including 184 images and sketches, 118 magnitude estimates and 28 observing reports (*Table 1*).

The first visual observation reported to the ALPO was made on April 11, 2020 by Chris Wyatt. He used a 0.25-m (10-inch) reflector and estimated the comet's brightness at magnitude 13.5 with a 0.7 arc-minute coma. Two nights later, Carl Hergenrother remotely used a CCD-equipped iTelescope 0.11-m (4-inch) refractor to measure the comet at V magnitude 11.9 with a 5.3 arc-minute coma. On April 15, Wyatt re-observed the comet and estimated it to be magnitude 11.0 with a 4.3 arc-minute coma. This early series of observations from discovery through mid-April suggests that the comet may have rapidly brightened from ~16th magnitude to 11th magnitude in only three weeks.

From mid-April to June 6, a steady rate of brightening was observed with the comet reaching magnitude 9 by mid-May, 8 by late May, and ~7.6 on June 6 when the last ground-based observation was reported to the ALPO. The comet entered the LASCO C3 coronagraph field-of-view on June 22 when it was measured at magnitude 4.2. It was observed to brighten to magnitude 2.2 when it left the C3 field-of-view on June 28 (Knight and Battams, 2020).

Starting on July 1, the comet was reacquired by ground-based observers at around magnitude ~1.5. Over the next week, numerous observers began to observe and image the comet. While we will leave the debate as to whether NEOWISE was a "Great" or just a "Very Good" comet to the future, it did display a number of features seen only in brighter comets. Both visual and CCD observers noted a strong yellow color in early July due to Sodium D line emissions (*figures 2 and 3*). Also observed in early July was a bifurcation of the dust tail. This feature is sometimes, though incorrectly, called "the shadow of the nucleus" and was detectable both visually and via imaging (*figures 4 and 5*). Other observed inner coma features were rotating jets and expanding shells and hoods (*Figure 6)*. In addition to authoring Figure 6, Gianluca Masi also determined a rough rotation period of 7.5 ± 2.3 hours based on the expansion of the shells (Green et al., 2020b). These jets, shells and hoods were evident to visual observers (see July 20 report by Roger Venable in the "Select Observation Reports" section later in this paper).

Table 1. List of C/2020 F3 (NEOWISE) Observers for this Report through August 4, 2020

Observer Name	Location	Nights	Observations*
John Chumack	Enon, Ohio, USA	7	(C,R)
Phillip Creed	Canal Fulton, Ohio, USA	1	(C,R)
Dan Crowson	New Florence, Missouri, USA	2	(C)
Michel Deconinck	Artignosc sur Verdon, Provence, France	14	(C,M,V)
Ken Fiscus	Albert Lea, Minnesota, USA	1	(C,R)
Juan Jose Gonzalez	Various sites, Spain	7	(M)
Christian Harder	Jeersdorf, Niedersachsen, Germany	15	(M,V)
Carl Hergenrother	Tuscon, Arizona, USA	14	(C,M)
Gabriel James	Cochabamba, Bolivia	4	(C,M)
Laurent Lacote	Bordeaux, France	1	(C)
Gianluca Masi	Rome, Italy	6	(C)
Tyson McVicar	Edmonton, Alberta, Canada	4	(C,R)
Frank J Melillo	Holtsville, New York, USA	7	(C)
Jim Melka	Chesterfield, Missouri, USA	2	(C)
Martin Mobberley	Cockfield, Suffolk, UK	5	(C)
Efrain Morales	Aguadilla, Puerto Rico, USA	2	(C)
Mike Napper	Jacksonville, Florida, USA	8	(C,R)
Tim Robertson	Simi Valley, California, USA	6	(C)
Michael Rosolina	Greenbrier, West Virginia, USA	4	(C,V)
Gregg Ruppel	Tuscon, Arizona, USA	5	(C)
John D Sabia	Scranton, Pennsylvania, USA	6	(C,M)
Chris Schur	Payson, Arizona, USA	9	(C)
Mark Shapiro	Greensboro, North Carolina, USA	12	(C,R)
Willian Souza	Sao Paulo, Brazil	5	(M)
Tenho Tuomi	Lucky Lake, Saskatchewan, Canada	6	(C)
Roger Venable	Chester, Georgia, USA	2	(R)
Christopher Wyatt	Walsa, New South Wales, Australia	21	(M)
NOTE: C - CCD images, M - brightness measurements, R - textual reports, V - visual sketch.			

The full extent of both the ion and dust tails were evident around the time of closest approach to Earth on July 23. Though the comet had faded to 3rd magnitude by this time, a strongly curved dust tail was measured to a length of 10° and the ion tail out to nearly 30° (*Figure 7*). By early August, the comet has faded to between 5th and 6th magnitude though still sporting a 1-2° in bright Moonlit skies.

Photometric Analysis

The total magnitude, or brightness of a comet's coma, can be represented by the following equation:

$$m_1 = H_0 + 5\log\Delta + 2.5n \log r - 2.5 \log \psi(\alpha)$$

where m_1 is the apparent total magnitude, H_0 is absolute total magnitude, Δ is the geocentric or comet-Earth distance in au, n is an activity index (a measure of the rate of change in comet brightness relative to heliocentric distance), r is the heliocentric distance or comet-Sun distance in au, ψ is the phase function, and α is the phase, or Sun-comet-Earth angle in degrees (Meisel and Morris, 1982). In this preliminary work, no corrections were made for aperture, observer bias or phase function. These will be addressed in the final report.

Between April 11 and August 4, 116 magnitude estimates were submitted to the ALPO. Of these, 110 were visual estimates with the remaining six being CCD measurements. The two data points published in Knight and Battams (2020) were included since they partially filled a critical gap in coverage between June 6 and July 1. *Figure 8* shows the

Table 2. Magnitude Parameters for C/2020 F3 (NEOWISE) Including Their Times and Heliocentric Distance Ranges

H	2.5n	n	Days from Perihelion	Date Range (UT in 2020)	Heliocentric Distance Range (au)
7.3	11.5	4.6	-83 – 0	April 11 – July 3	1.85 – 0.29
6.5	9.8	3.9	0 – +32	July 3 – August 4	0.29 – 0.89

Figure 2. Image of Comet NEOWISE + owl and another bird on the foreground cactus on July 4 UT from near Tucson, Arizona USA by Gregg Ruppel. Image was taken with a Canon 50D and Tamron 70-200 at 70mm (EFL 112mm), f/2.8, 4 sec, ISO 100.

evolution of the comet's apparent total magnitude with time. *Figure 9* presents the heliocentric lightcurve with heliocentric total magnitude (m_1 – 5*log r) plotted against the logarithm of the heliocentric distance (log r).

The comet's rate of brightening and fading can be consistently modeled with separate pre- and post-perihelion solutions. All the perihelion magnitude observations, minus the first observation on April 11, can be fit by a solution with H_0 = 7.3, 2.5n = 11.5, and n = 4.6. All post-perihelion observations can be fit with a solution of H_0 = 6.5, 2.5n = 9.8, and n = 3.9. The comet's rate of fading is slightly slower than its rate of brightening. More information on the date, time from perihelion, and heliocentric range for the photometric solutions can be found in *Table 2*. Photometric solutions were produced with the Comets for Windows program, v1.5.0, by Seiichi Yoshida (available at *http://www.aerith.net/project/comet.html*).

Selected Observation Reports

A representative selection of observations reports is included here to show the evolution in the appearance of the comet. (See *Table 1* for observer locations. In all instances, the "'" symbol represents the term arc-minutes.)

April 19 - Christopher Wyatt — m1= 11.4; Diameter = 3.2'; 40cm L, f/4 (x59). Very diffuse coma with small opaque centre. Enhances slightly in Swan Band filter.

May 10 – Christopher Wyatt — m1= 9.9; Diameter = 4.6'; 25cm L, f/5 (x40). Enhances in Swan Band filter, very diffuse coma moderately condensed. Close to 10.3 mag star on NW edge of coma.

May 17 – Christopher Wyatt — m1= 9.2; Diameter 5.5'; 25cm L, f/5 (x40). Opaque coma fading to edges. Centre appears faintly stellar in periods

Figure 3. Chris Schur imaged NEOWISE while it was low on the horizon on July 4. Equipment: 6 inch, f/3.6 Cometracker Schmidt Newtonian and Baader MPCC coma corrector with an exposure time of 4 seconds.

of good seeing. Comet faintly visible in 10x50 monocular.

May 28 – Christopher Wyatt — m1= 8.1; Diameter 5.6’; 15x70 binoculars. Moonlight; Coma diffuse, well-condensed opaque centre. Altitude = 16.9°.

June 6 – Christopher Wyatt — m1= 7.6; Diameter 5’; 15x70 binoculars. Moonlight, Twilight; Low altitude = 7.1°. Sometimes appears to have a stellar pseudo-nucleus.

July 1 – Carl Hergenrother — m1= ~1.0. The comet was first seen after having just cleared the mountains (from my observing site) at an elevation of ~3°. The Sun wasn't too far behind at a distance of 11° and 7° below the horizon. The comet was only visible for about 5 minutes before it was lost to the rapidly brightening sky. It was an easy object in 30x125 binoculars, difficult but visible in 10x50’s and invisible to the naked eye. In appearance, the comet was small (~1'), slightly yellow, and condensed (but still non-stellar) with a hint of a fan tail pointing away from the Sun.

July 3 – Carl Hergenrother — m1= ~1.4. Not sure if I was able to see the comet without visual aid though it was easy in 10x50 and 30x125 binoculars. The inner condensation was small (~1’) and slightly diffuse. The tail extended for about 0.3° in both binoculars and was easier to follow in the smaller binoculars. The tail appears brighter on the edges, with the northern (left) edge brighter than the southern (right) edge. The comet was seen in the 10x50s until 4:50 am, or ~35 minutes before sunrise with the comet at an elevation of 7.1° and the Sun 6.6° below the horizon. In the 30x125s, the comet was visible for another 10 minutes till 5:00 a.m., with the comet elevation at 8.9° and the Sun 4.7° below the horizon.

July 9 – Mike Napper — This morning on the beach in northeast Florida was the best I have had observing C/2020 F3 NEOWISE. The comet was a very striking naked eye object with much of the tail showing. It was absolutely beautiful in 10x50 binoculars. The tail spanned about 4° in the binocular field. Comet brightness easily exceeded Beta Aurigae.

July 10 – Mike Napper — Another wonderful morning of observing Comet C/2020 F3 NEOWISE over the ocean from Jacksonville Beach, Florida USA. The comet was bright naked eye - IMHO magnitude +1. The tail extended over 4° in my 10x50 binoculars. Absolutely beautiful!

July 11 – Tyson McVicar — The hype is real! This comet was one of the best observations I have ever had in the 5 years in the hobby. It was visible to the naked eye as a faint smudge at my yellow zone dark site. With a Televue 40mm Plossl, using a Takahashi TSA 102S APO telescope looking to the north, slightly northeast I was treated to an outstanding view. I could see the dense nucleus, focused to a perfect point. There was a dark lane bisecting

Figure 4. Sketches of the inner coma of NEOWISE on July 4 by Michel Deconinck (France), showing the bifurcation of the tail. Equipment: Vixen 126mm binocular with various eyepieces.

the river of golden white tail. With 12x50 binoculars it looked basically white, but it took on the most beautiful textured golden white, almost a nebulous mottled look to it at parts closer to the nucleus. I would estimate magnitude almost identical with Beta Aurigae, which was up and a helpful estimate marker.

July 11 – Phillip Creed — My vacillating about whether or not C/2020 F3 is the best northern hemisphere comet since Hale-Bopp is over. It CLEARLY is. I gotta say – it sure makes things easy when you can see a comet in Live View! I forgot my binoculars, but even with the naked eye, I could easily make out the gently curving tail, extending 4.2° by my reckoning. The comet was simply a magnificent sight even though, to my eyes, it had faded a bit since I last saw it. I had it this morning at magnitude 1.9, and unlike previous mornings, it didn't quite appear stellar. Maybe as it's approaching its coma appears larger?

July 16 – Tyson McVicar — Observed the comet again briefly with the 12x50's. Tail is naked-eye object, definitely with averted vision looks to be almost 2° or so, getting hints of a tail almost halfway of the field of view. Dense bright nucleus, still not quite able to estimate brightness; about the same as previous binocular observations.

July 20 – Roger Venable — Binocular view (7x50's): Brightness estimate of coma: 4.1. Comparison stars: iota Ursa Majoris (mag 3.1) and kappa Ursa Majoris (mag 3.55). Dust tail 2.5° long at 01:30 UT, 3.0° long at 01:40, and 5.0° long at 01.45. . . as the sky grew darker. Ion tail first differentiable from dust tail at 01:40 UT, 2° long at 01:40, and 4° long at 01:45. Telescopic view (Newtonian telescope of 300 mm / 12 in. aperture, viewed at magnification 79x, integrated light): Outer coma detectable to a radius of 10 arc-minutes, gradually tapering in brightness with increasing distance from the center, generally faint and featureless except for becoming indistinguishable from the proximal tail in that direction.

Inner coma has peculiar, concentric shell structure, in two layers. These took the form of two concentric rings of brightness, each of the same width. They were essentially circular except that in the direction of the tail, they were slightly flattened, so that their shape was like that of a gibbous planet. I estimate the inner ring to have been 30 arc-seconds across (in diameter) and it contained no central point-like nucleus. The outer ring appeared equal in radius to the diameter of the inner ring. These two rings were crisply different from one another in brightness but nearly uniform in brightness in themselves, and of course, considerably brighter than the outer coma described above.

July 22 – Ken Fiscus — Saw the comet again tonight. I caught it naked eye without even trying as I got out of my vehicle at my dark site. The tail extends about 8° with averted vision (naked eye). In the telescope, I was surprised to see that the gold color is gone. Gone. It was notably blue tonight.

August 1 – Mark Shapiro — The comet was prettily located just above the Coma Berenices Cluster and therefore easy to locate, even sweeping with the 10x50 binoculars. The comet sported just a tiny tail, maybe 1°? Quite difficult to discern, though. Nevertheless, it was easy to immediately identify the comet as a non-stellar object. Moonlight interfered somewhat with my magnitude estimate, but sadly I can't even estimate the comet as being of 5th magnitude. I could not perceive a head. When defocusing in order to estimate the magnitude, the comet did not seem to be even as bright

Figure 5. Sketch of NEOWISE by Christian Harder (Niedersachsen, Germany) on July 07.06 UT. Equipment: 12-inch, f/4 Dobson (69x & 96x). The bifurcation of the tail is also evident in this sketch.

as the two nearby 5th magnitude stars 14 Comae Berenices and 16 Comae Berenices and nowhere near as bright as Gamma Comae Berenices (4.36).

References

Bortle, J. (1991). "Post-Perihelion Survival of Comets with Small q." *International Comet Quarterly* Vol. 13, p. 89. Available at: *https://fg-kometen.vdsastro.de/Publ/Bortle_PostPeriholSurvival.pdf*

Green, D. et al. (2020a). "C/2020 F3 (NEOWISE)." International Astronomical Union (IAU) Central Bureau Electronic Telegram (CBET) 4740, Cambridge Mass.

Green, D. et al. (2020b). "C/2020 F3 (NEOWISE)." International Astronomical Union (IAU) Central Bureau Electronic Telegram (CBET) 4816, Cambridge Mass.

Knight, M., Battams, K., (2020). "Morphology and Photometry of Comet C/2020 F3 (NEOWISE) from SOHO." Astronomer's Telegram (ATel) 13853. Available at: *http://www.astronomerstelegram.org/?read=13853*

Marsden, B., Sekanina, Z, Everhart, E. (1978). "New osculating orbits for 110 comets and analysis of original orbits for 200 comets." *Astronomical Journal* Vol. 83, pp. 64-71. Available at: *http://articles.adsabs.harvard.edu/pdf/1978AJ.....83...64M*

Meisel, D. D., Morris, C. S. (1982). "Comet head photometry: past, present, and future." In Comets, ed. L. L. Wilkening, University of Arizona Press, Tucson, Arizona, pp. 413-432. Available at: *https://books.google.com/books?hl=en&lr=&id=MHlfHcJ-Du4C&oi=fnd&pg=PA413&dq=Comet+head+photometry:+past,+present,+and+future&ots=RTExxLhIh7&sig=YG8TfcPMA3JFj-BnAS574dC7IuM*

Nakano, S. (2020). "C/2020 F3 (NEOWISE)." Nakano Note 4155. Available at: *http://www.oaa.gr.jp/~oaacs/nk/nk4155.htm*.

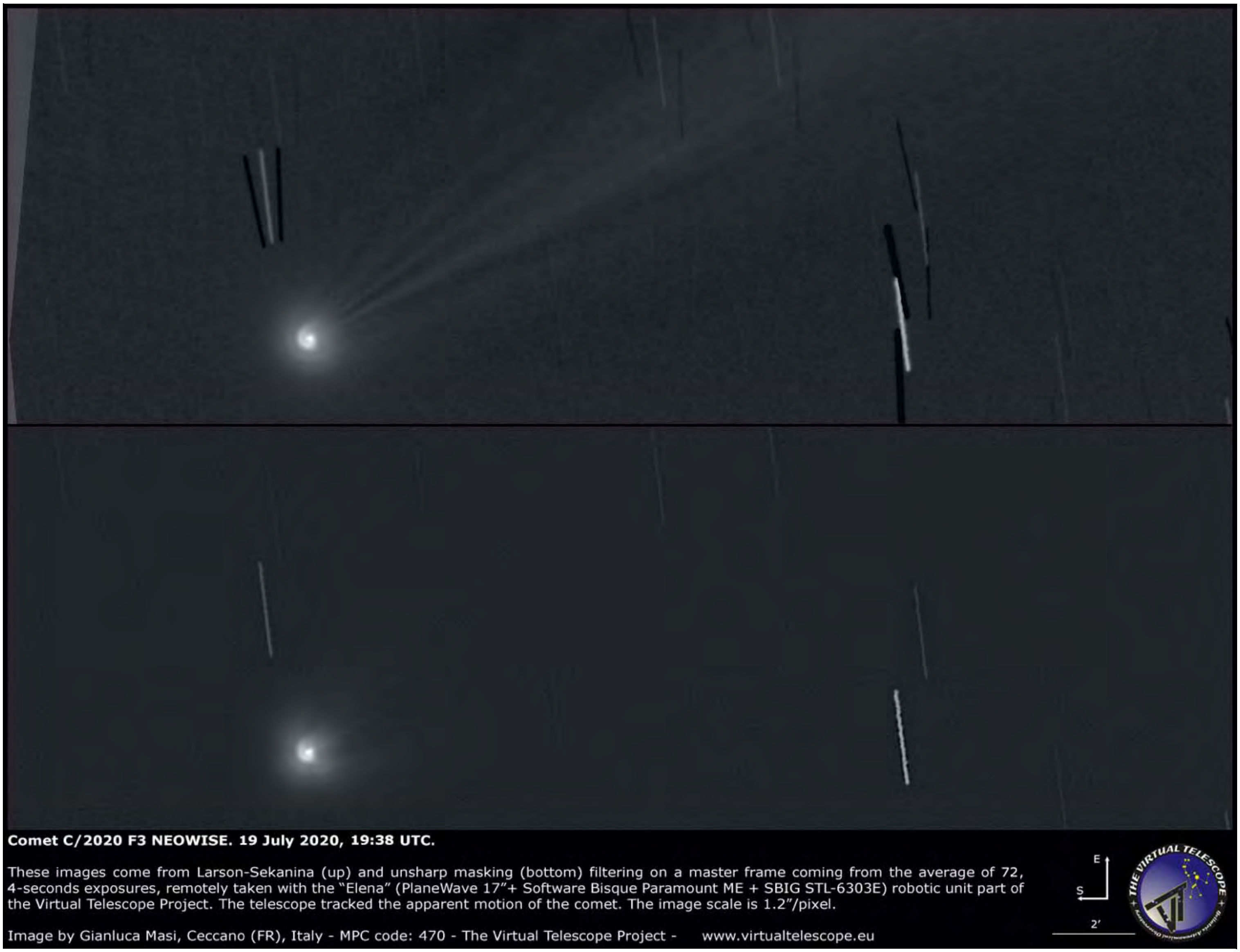

Figure 6. The inner coma of NEOWISE showing jet and hood activity in this processed image taken on July 19 by Gianluca Masi in Ceccano, Italy. Equipment: 0.43 meter telescope.

Figure 7. On the night of July 23, NEOWISE reached its closest distance to Earth. That night the full extent of the tails of NEOWISE is shown in this image take by John Chumack from near Celina, Ohio USA. A Canon 6D DSLR and Canon 24-105mm lens was used (set to 47mm @ f/4.5 and ISO 1600) to make this co-add of 12 x 60-second images. The ion tail extends for ~28° while the curving dust tail extends ~10°.

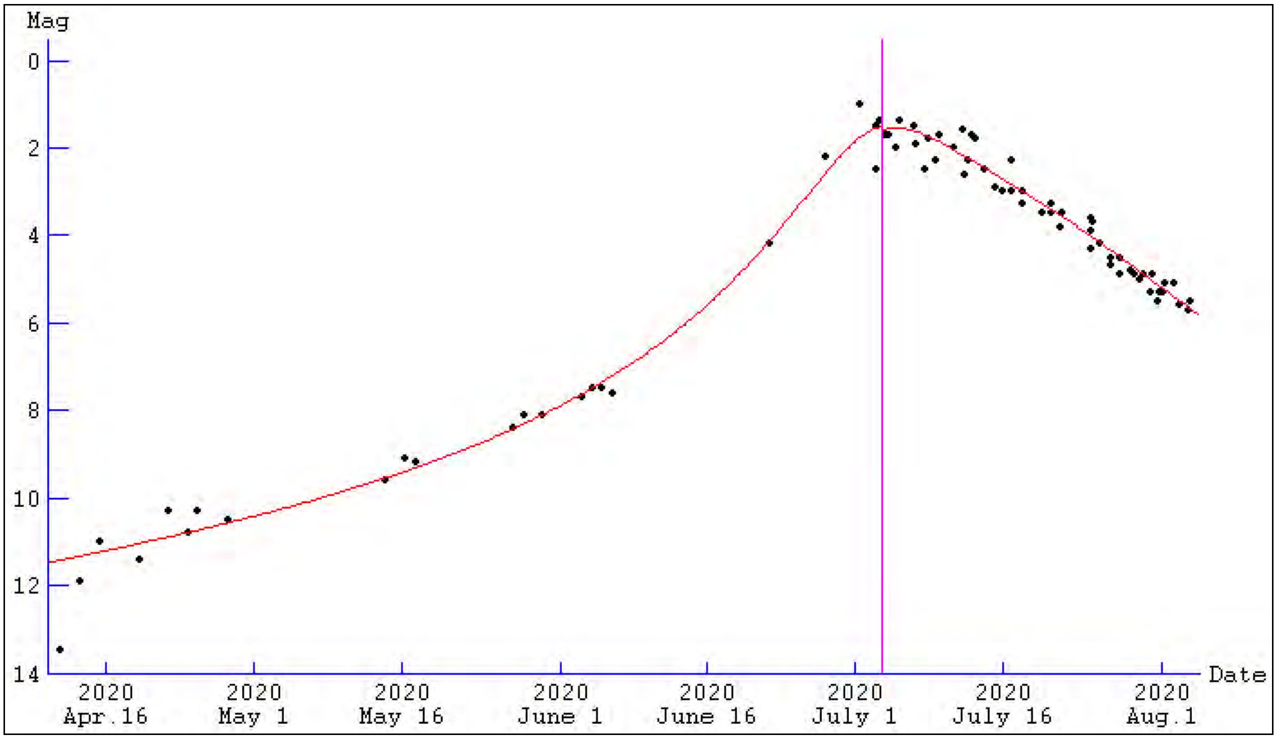

Figure 8. Lightcurve of C/2020 F3 (NEOWISE) in Figure 2 showing total magnitude (m1) vs date (UT). Photometric solution and graphic produced with the "Comets for Windows" v1.5.0 program by Seiichi Yoshida.

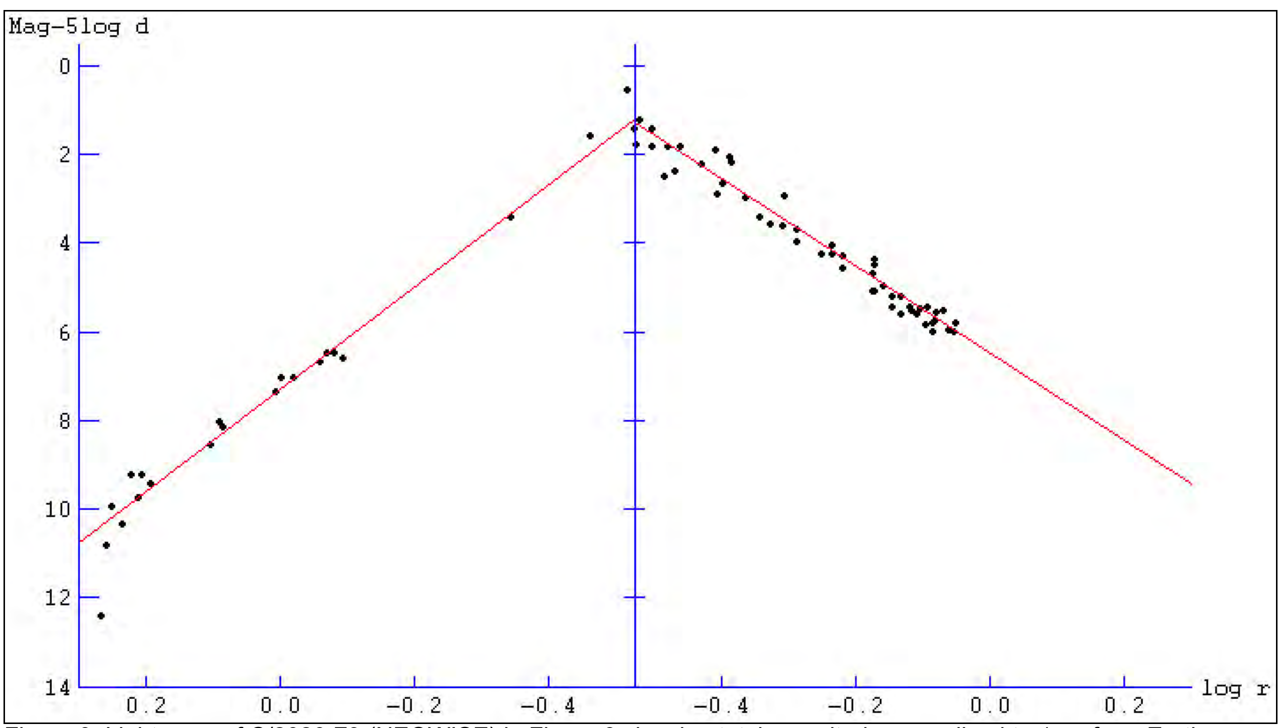

Figure 9. Lightcurve of C/2020 F3 (NEOWISE) in Figure 3 showing total magnitude normalized to 1 au from Earth versus the logarithm10 of the heliocentric distance in au. Photometric solution and graphic produced with the "Comets for Windows" v1.5.0 program by Seiichi Yoshida.

Figure 10. Image of the rising of the tail of NEOWISE on July 7 by Michel Deconinck as viewed from Sainte-Croix Lake, France. Equipment: Pentax K50 and 100m, f/2.8 lens at ISO 1600.

Figure 11. Tim Robertson took this image on the morning of July 10 from Simi Valley, California USA with a Canon EOS DSLR and 300 mm lens (8-second exposure).

Figure 12. Image taken on July 13 by Jim Melka of Chesterfield, Missouri USA. Equipment: Canon 20D at ISO 200 with a 270 mm lens.

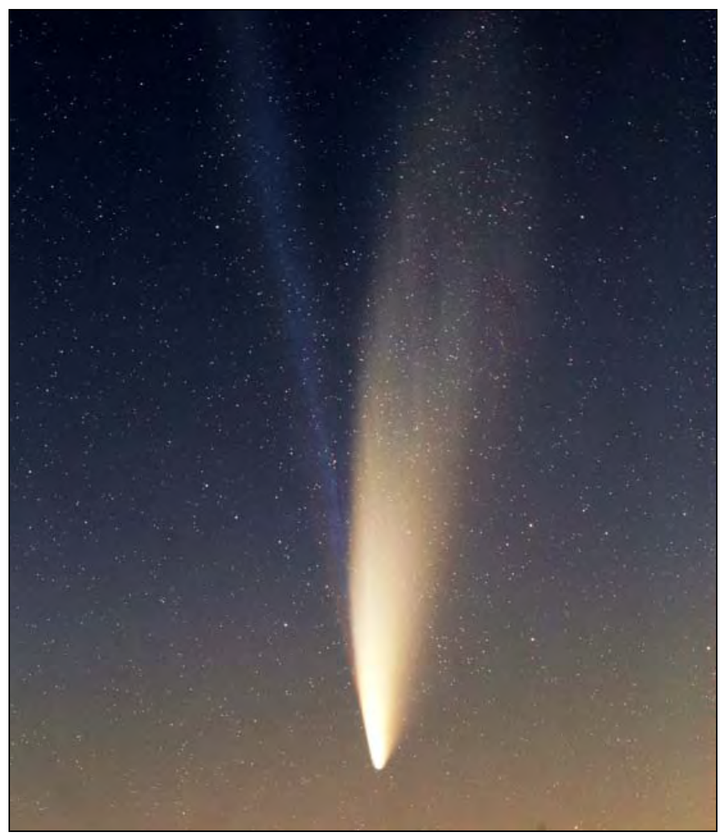

Figure 13. Note the red and blue ion tails in this image taken by Laurent Lacote of Bordeaux, France, taken on July 12. Equipment: Canon 6D DSLR and Canon EF 200mm, f2.8 lens. The image is a stack of 30 x 30-second exposures.

Figure 14. NEOWISE in all its glory as imaged by Chris Schur on July 17 from Payson, Arizona USA. Equipment: Canon XTi, Canon 10D, and Sigma 150mm, f/2.8 Macro lens. The image is a composite from 15 x 45-second images.

Figure 15. John D. Sabia of Scranton, Pennsylvania USA, caught NEOWISE on July 20 in a 60-second exposure with a Samwang 135mm, f/2 lens.

Figure 16. This image by Frank J. Melillo closely matches the visual impression of the comet in small binoculars in late July.

Figure 17. Martin Mobberley catches the comet 25 days after perihelion as it is now on its way back to the far reaches of the outer solar system. Equipment: iTelescope Takahashi FSQ106.

Papers & Presentations

ALPO Observations of Venus During the 2015-16 Western (Morning) Apparition

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

Abstract

Only seven observers from the United States, France, Germany, Slovenia, and Sweden contributed digital images and visual observations (drawings and descriptive reports) to the ALPO Venus Section during the 2015-16 Western (Morning) Apparition, which was considered to be one of the more poorly observed apparitions in recent years. This report summarizes the results of the 129 total observations. Types of telescopes and accessories used in making the observations, as well as sources of data, are discussed. Comparative studies take into account observers, instruments, visual and photographic results. The report includes illustrations and a statistical analysis of the long-established categories of features in the atmosphere of Venus, including cusps, cusp-caps, and cusp-bands, seen or suspected at visual wavelengths in integrated light and with color filters, as well as digital images captured at visual, ultraviolet (UV), and infrared (IR) wavelengths.. Terminator irregularities and the apparent phase phenomena, as well as results from continued monitoring of the dark hemisphere of Venus for the enigmatic Ashen Light are discussed.

Introduction

The ALPO Venus Section received only 129 observations for the 2015-16 Western (Morning) Apparition, comprised of visual drawings, descriptive reports, and digital images from just seven observers residing in the United States, France, Germany, Slovenia, and Sweden. Geocentric phenomena in Universal Time (UT) for this observing season are given in Table 1, while Figure 1 shows the distribution of observations by month during the apparition. Table 2 gives the location where observations were made, the number of observations submitted, and the telescopes utilized.

Observational coverage of Venus during the 2015-16 Western (Morning) Apparition was considered poor in comparison with the 2014-15 Eastern (Evening) Apparition and other recent observing seasons. Nevertheless, monitoring of the planet started very early for at least one observer, Michel Legrand, who sketched the thin crescent of Venus between 14:30UT and 11:21UT on August 17, 2015, just two days following Inferior Conjunction that occurred on August 15, 2015 [Refer to Illustration No. 001]. The observational reports upon which this report is based covered the period from August 17, 2015 through May 9, 2016 with 89.1% of the total contributions for August through December 2015. There was a noticeable gap in observational coverage for about four months between the end of December 2015 and May 9, 2016, as well as no observations for the period subsequent to May 9, 2016 until the time of superior conjunction on July 6, 2016, and several individuals commented that unusually cloudy weather and repeatedly poor seeing conditions contributed to the lapse in observational coverage during that period.

Online Features

Left-click your mouse on:

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

Observing Scales

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

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

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

IAU directions are used in all instances.

Terminology: Western vs Eastern

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

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

Table 1. Geocentric Phenomena in Universal Time (UT) for the 2015-16 Western (Morning) Apparition of Venus

Inferior Conjunction	2015 Aug 15^{d} 19^{h} 00^{m} UT
Initial Observation	Aug 17 10^{h} 30^{m} UT
Greatest Illuminated Extent	Sep 21 15^{h} 00^{m} UT ($m_v = -4.8$)
Greatest Elongation West	Oct 26 07^{h} 00^{m} UT (46.0˚)
Dichotomy (predicted)	Mar 25.27^{d} UT
Final Observation	May 09 10^{h} 45^{m} UT
Superior Conjunction	Jul 06 00^{h} 00^{m} UT
Apparent Diameter (observed range):	58.3″ (2015 Aug 17) ↔ 9.8″ (2016 May 09)
Phase Coefficient, ***k*** (observed range):	0.010 (2015 Aug 17) ↔ 0.991" (2016 May 09)

For the 2015-16 Western (Morning) Apparition of Venus observers witnessed the trailing hemisphere of Venus at the time of sunrise on Earth (a progression from crescent through gibbous phases) as the planet passed through greatest brilliancy (-4.6mv), dichotomy, and maximum western elongation from the Sun (46.0°). Observers are always encouraged to pursue systematic observations of Venus when seeing conditions permit from conjunction to conjunction, and the ALPO Venus Section is fortunate to have a team of dedicated observers who have tried very hard to meet that challenge in recent observing seasons.

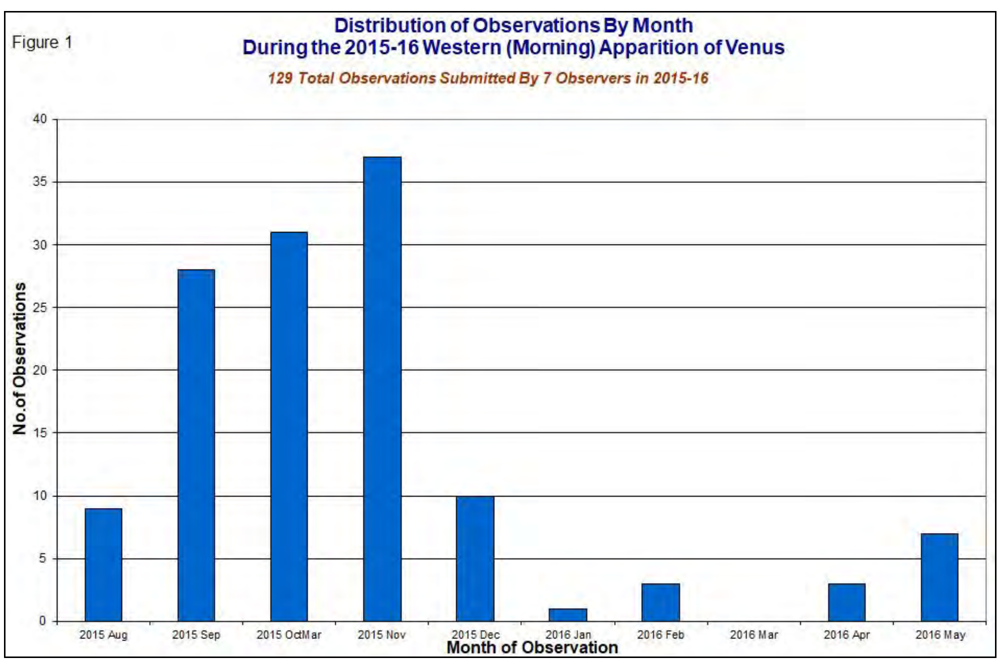
Figure 2 shows the distribution of observers and contributed observations by nation of origin for this apparition, where it can be seen that 42.9% of the participants in our programs were located with the United States, whose observations accounted for 45.7% of the total submitted. Continued international cooperation took place during this observing season, whereby 57.1% of the observers resided outside the United States and contributed 54.3% of the overall observations. The ALPO Venus Section always welcomes a widening global team of observers in the future.

The types of telescopes used to observe and image Venus are shown in Figure 3. Apertures less than 15.2 cm (6.0 in) accounted for 15.5% of all observations in 2015-16, with the remaining percentage (84.5%) were made with instruments ranging from 15.2 cm (6.0 in) to 31.5 cm (12.4 in). During the observing season the frequency of use of classical designs (refractors and Newtonians) was 16.3%, while utilization of catadioptrics (Schmidt-Cassegrains, Dall Kirjhams, and Maksutov-Cassegrains) was 83.7%. All visual and digital observations were performed under twilight or daylight conditions, generally because most experienced Venus observers are aware that viewing during twilight or in full daylight substantially reduces the excessive glare associated with the planet. Also, doing visual work or imaging Venus when it is higher in the sky markedly cuts down on the detrimental effects of atmospheric dispersion and image distortion prevalent near the horizon.

Despite the small number of observers and observations for 2015-16, the writer is grateful for the reports that were contributed in the form of drawings, descriptive reports, and digital images of Venus for the apparition. Readers who want to follow Venus in coming apparitions are urged to join the ALPO and start participating in our observational studies. The significant brightness of Venus makes it an easy object easy to find, and around the dates of greatest elongation from the Sun, the planet can be as much as fifteen times brighter than Sirius and can even cast shadows when viewed from a dark, moonless observing site. Getting started in the Venus Section programs requires only minimal aperture, ranging from 7.5 cm (3.0 in) for refractors to 15.2 cm (6.0 in) reflectors.

Observations of Atmospheric Details on Venus

The methods and techniques for visual studies of the especially faint, elusive "markings" in the atmosphere of Venus are described in detail in ***The Venus Handbook***, available from the ALPO Venus Section in printed or *.pdf format.



Readers who maintain archives of earlier issues of this Journal may also find it useful to consult previous apparition reports for a historical account of ALPO studies of Venus.

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

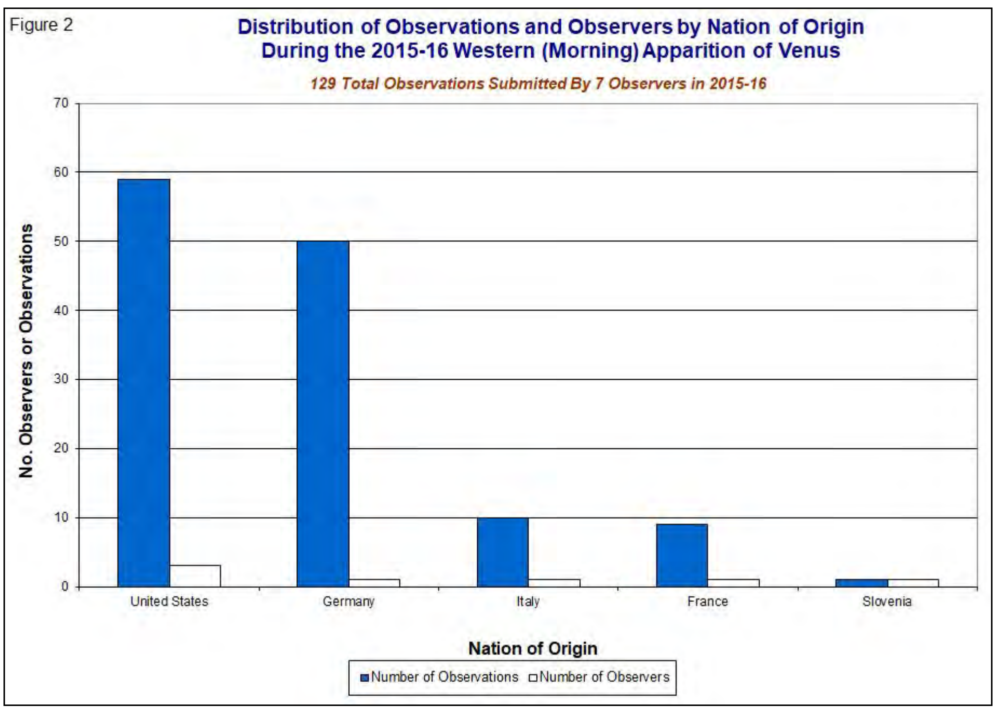
Represented in the photo-visual data for this apparition were all of the long-established categories of dusky and bright markings in the atmosphere of Venus, including a small fraction of radial dusky features, described in the literature cited earlier in this report. *Figure 4* shows the frequency of readily identifiable forms of markings seen or suspected on Venus. Most observations referenced more than one category of marking or feature, so totals exceeding 100% are not unusual. At least some level of subjectivity is inevitable when visual observers attempt to describe, or accurately represent on drawings, the variety of highly elusive atmospheric features on Venus, and this natural bias had some effect on the data represented in *Figure 4*. It is assumed, however, that conclusions discussed in this report are, at the very minimum, sensible interpretations.

The dusky markings of Venus' atmosphere are always troublesome to detect using normal visual observing methods, and this well-known characteristic of the planet is generally independent of the experience of the observer. When color filters and variable-density polarizers are utilized as a routine practice, however, views of cloud phenomena on Venus at visual wavelengths are often measurably improved. Without neglecting vital routine visual work, the ALPO Venus Section urges observers to try their hand at digital imaging of Venus at UV and IR wavelengths. The morphology of features captured at UV and IR wavelengths is frequently quite different from what is seen at visual regions of the spectrum, particularly atmospheric radial dusky patterns (in the UV) and the appearance of the dark hemisphere (in IR). Similarities do occasionally occur, though, between images taken at UV wavelengths and drawings made with blue and violet filters. The more of these

Table 2. ALPO Observing Participants in the 2015-16 Western (Morning) Apparition of Venus

Observer and Observing Site	No. Obs.	Telescope(s) Used*
Benton, Julius L. Wilmington Island, GA	4 4 3 5	8.0 cm (3.1 in.) REF 9.0 cm (3.5 in.) MAK 10.2 cm (4.0 in.)m REF 12.7 cm (5.0 in.) MAK
Braga, Raffello Milan, Italy	1 9	13.0 cm (5.1 in.) NEW 21.0 cm (8.3 in.) DAL
Legrande, Michel Le Baule, France	9	21.0 cm (8.3 in.) NEW
Paul Maxson Phoenix, AZ	10 25	21.0 cm (8.3 in.) DAL 31.5 cm (12.4 in.) DAL
Melillo, Frank J. Holtsville, NY	8	25.4 cm (10.0 in.) SCT
Niechoy, Detlev Göttingen, Germany	3 47	10.2 cm (4.0 in.) REF 20.3 cm (8.0 in.) SCT
Smrekar, Matic Ljubljana, Slovenia	1	30.5 cm (12.0 in.) SCT
Total No. of Observers	**7**	
Total No. of Observations	**129**	

*REF = Refractor, SCT = Schmidt-Cassegrain, MAK = Maksutov, NEW = Newtonian, DAL= Dall Kirkham



that the ALPO Venus Section receives during an observing season, the more interesting are the comparisons of what can or cannot be detected visually versus what is captured by digital imagers at different wavelengths.

Figure 4 illustrates that all visual observations and digital images during the 2015-16 Western (Morning) Apparition referred to the usual categories of dusky features seen or suspected on the brilliant disc of Venus, the highest percentages falling into the category of "Banded Dusky Markings" (59.7%), and "Amorphous Dusky Markings" (58.1%) followed by "Irregular Dusky Markings" (34.8%) [Refer to Illustrations No. 002, 003, 004, 005, 006, 007, 008, 010, and 012], and "Radial Dusky Markings" (25.6%), whereby the latter are normally only revealed in UV images along with the characteristic roughly horizontal V, Y, or ? (psi) shaped dusky cloud features in the atmosphere of Venus. [Refer to Illustrations No. 009 and 011, and 021].

Terminator shading was reported in 98.4% of the submitted observations in 2015-16, as shown in Figure 4. Terminator shading normally extended from one cusp of Venus to the other, and the dusky shading was progressively lighter in tone (higher intensity) from the region of the terminator toward the bright planetary limb. Many observers described this upward gradation in brightness as ending in the Bright Limb Band. A considerable number of images at visual wavelengths showed terminator shading, but it was most obvious on many UV images [Refer to Illustrations No. 002, 003, 009, 010, and 013].

The mean numerical relative intensity for all of the dusky features on Venus this apparition averaged about 8.9. The ALPO Scale of Conspicuousness (a numerical sequence from 0.0 for "definitely not seen" up to 10.0 for "definitely seen") was used regularly, and the dusky markings in Figure 4 had a mean conspicuousness of 4.0 throughout the apparition, suggesting that the atmospheric features on Venus were within the range from very indistinct impressions to fairly strong indications of their actual presence.

Figure 4 also shows that "Bright Spots or Regions," exclusive of the cusps, were seen or suspected in only 17.8% of the submitted observations [Refer to Illustrations No. 012, 014, 015, and 018]. As a customary practice, when visual observers detect such bright areas, it is standard procedure to denote them on drawings by using dotted lines to surround them.

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

Figure 3

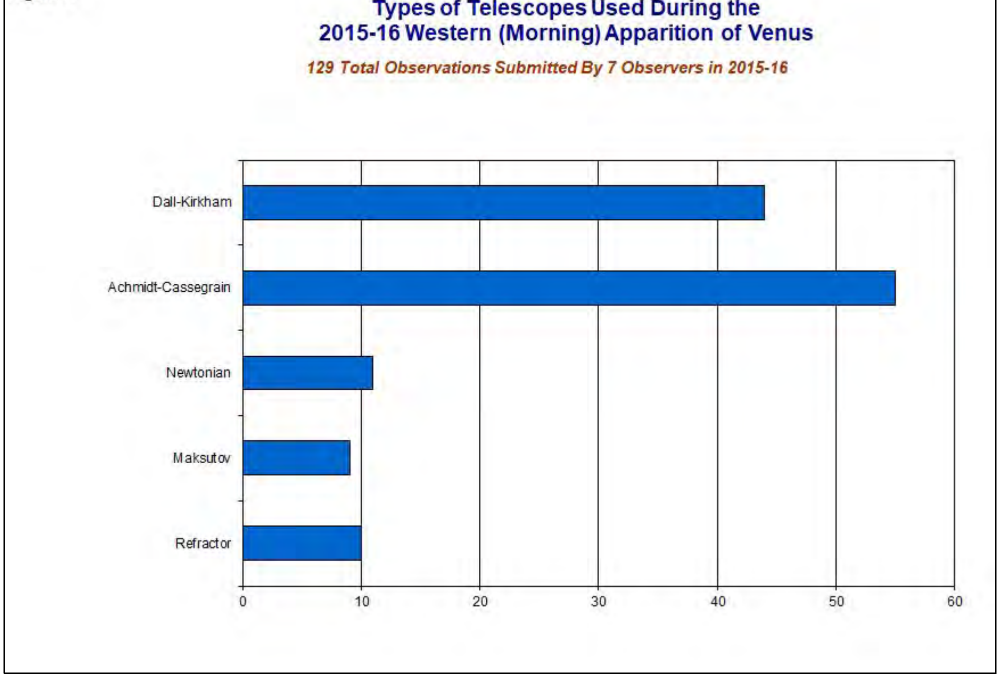
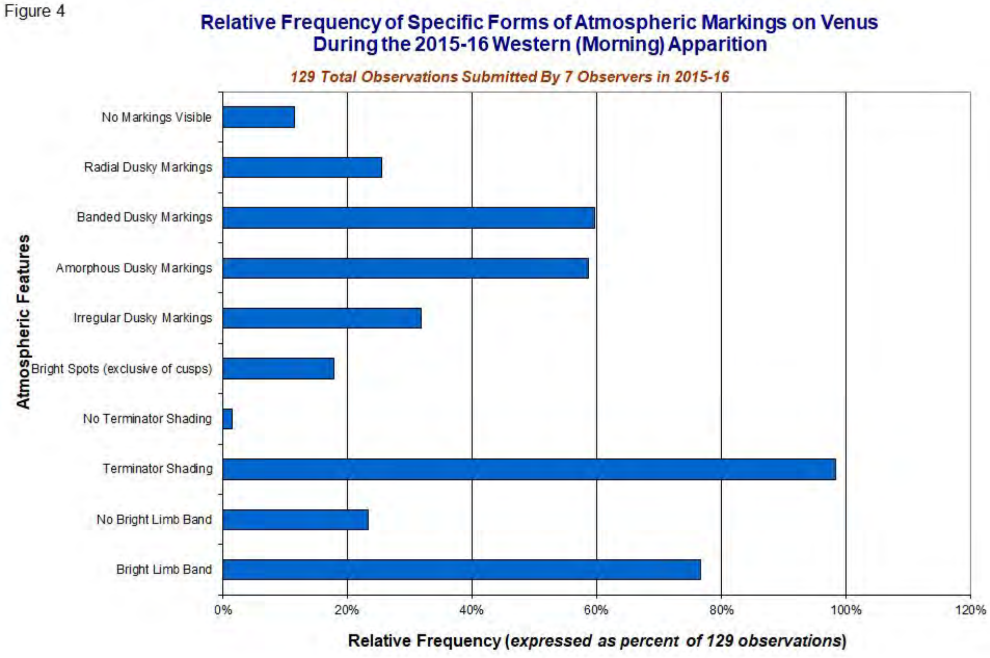


Figure 4

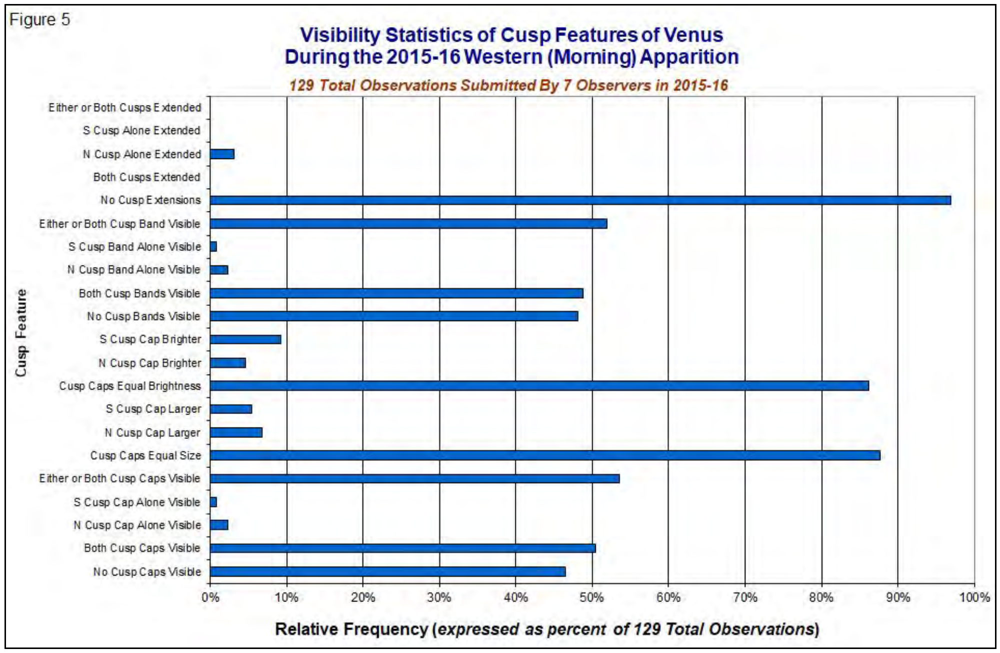


General Caption Note for Illustrations 1-24*. REF = Refractor, SCT = Schmidt-Cassegrain, CAS = Cassegrain, MAK = Maksutov, NEW = Newtonian; UV = Ultra Violet light; Seeing on the Standard ALPO Scale (from 0 = worst to 10 = perfect); Transparency = the limiting naked-eye stellar magnitude.*

of otherwise indefinite atmospheric markings on Venus.

The Bright Limb Band

Figure 4 illustrates a reasonable majority of the submitted observations (76.7%) this apparition referred to a conspicuous "Bright Limb Band" on the illuminated hemisphere of Venus. When the Bright Limb Band was visible or imaged, it appeared as a continuous, brilliant arc running from cusp to cusp 50.0% of the time, while it was interrupted or only marginally visible along the limb of Venus in 50.0% of the positive reports. The bright limb band was more likely to be incomplete in UV images than those captured at visual wavelengths as well as submitted drawings. The mean numerical intensity of the Bright Limb Band was 9.8, perhaps slightly noticeable with color filters or variable-density polarizers. This very bright feature, usually reported by visual observers this apparition [Refer to Illustration No. 002], was also seen on many of the digital images of Venus received [Refer to Illustration No. 009].



Terminator Irregularities

The terminator is the geometric curve that separates the brilliant sunlit and dark hemispheres of Venus. A deformed or asymmetric terminator was reported in 48.8% of the observations. Amorphous, banded, and irregular dusky atmospheric

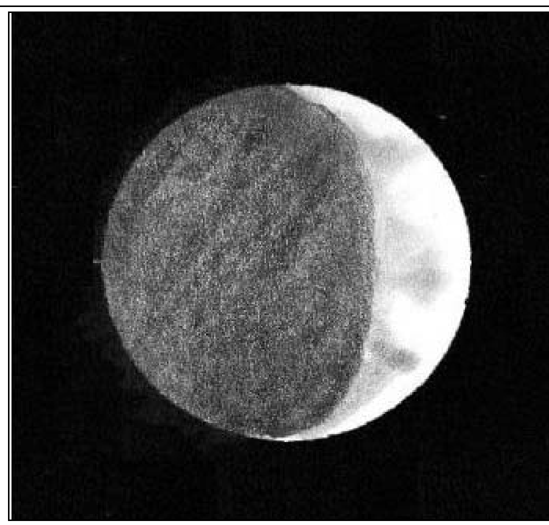


Illustration 001 2015 August 17 10:30UT. Drawing by Michel Legrand. 21.0 cm (8.3 in.) NEWT at 210X and W15 (deep yellow) filter. Seeing 5.0 (interpolated), Transparency 3.0. Phase (k) = 0.965, Apparent Diameter = 10.4". Drawing shows extremely thin crescent of Venus approximately two days following inferior conjunction (August 15, 2015). S is at the top of the drawing.

Illustration 002 2015Sep28 03:13UT Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 82X in IL (Integrated Light). Seeing 3.0, Transparency 3.0. Phase (k) = 0.0.326, Apparent Diameter = 34.7". Amorphous, banded, and radial dusky markings are seen in this very nice drawing, along with a bright limb band running from cusp to cusp. S is at the top of the drawing.

Illustration 003 2015Oct03 13:51UT. UV image by Paul Maxson. 31.5 cm (12.4 in.) DAL. Seeing (not specified), Transparency (not specified). Phase (k) = 0.366, Apparent Diameter = 32.1". Banded and amorphous dusky markings are depicted along with terminator shading. S is at the top of the image.

markings often seemed to merge with the terminator shading, possibly contributing to some of the reported incidences of irregularities. Filter techniques usually improved the visibility of terminator asymmetries and associated dusky atmospheric features. Bright features adjacent to the terminator can sometimes appear as "bulges" while darker markings may look like wispy hollows [Refer to Illustrations No. 016 and 017].

Cusps, Cusp-Caps, and Cusp-Bands

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

When the northern and southern cusp-caps of Venus were reported this observing season, Figure 5 graphically shows that these features were equal in size 87.7% of the time and 86.2% of the time in brightness. So, there were minimal instances when the southern and northern cusp-caps were larger and/or brighter than each other. Both cusp-caps were visible in 50.4% of the observational reports, and their mean relative intensity averaged 9.6 during the observing season. Dusky cusp-bands were detected flanking the bright cusp-caps in 48.8% of the observations when cusp-caps were visible, and when visible, the cusp-bands displayed a mean relative intensity of about 7.0 (see Figure 5) [Refer to Illustrations No. 019 and 020].

Cusp Extensions

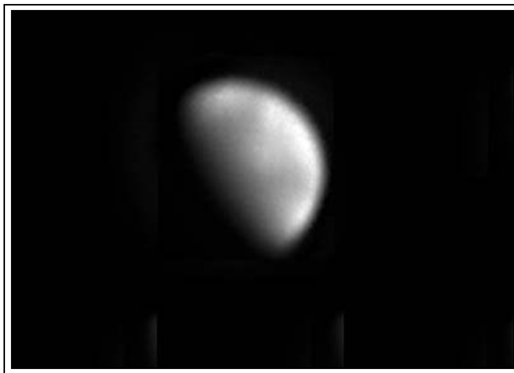
No cusp extensions were recorded in 96.9% of the observations made in integrated light or with color filters during 2015-16 called attention to obvious cusp extensions beyond the 180 expected from simple geometry (see Figure 5). While Venus was passing through its crescent phases following inferior conjunction on August 15, 2015, rare instances of cusp extensions were detected from time to time, ranging from 2 to 8 , but only vaguely evident on images contributed or rarely depicted on drawings provided during the observing season) [Refer to Illustration No. 022].. Cusp extensions are notoriously hard to image because the sunlit regions of Venus are overwhelmingly brighter than faint cusp extensions, but observers are still encouraged to try to record these features using digital imagers in upcoming apparitions.

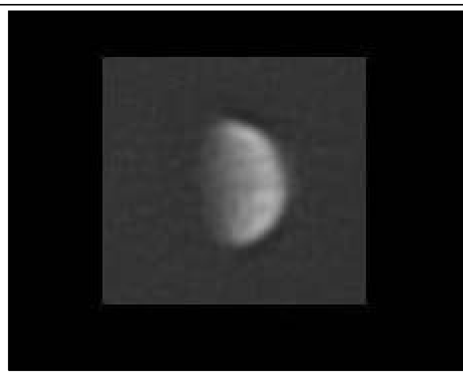
Estimates of Dichotomy

A discrepancy between predicted and observed dates of dichotomy (half-phase) is often referred to as the "Schröter Effect" on Venus. The predicted half-phase occurs when k = 0.500, and the phase angle, i, between the Sun and the Earth as seen from Venus equals 90°. Although theoretical dichotomy occurred on October 25.27^{d}, 2015, systematic visual dichotomy estimates were not received this apparition.

Ashen Light Observations and Dark Hemisphere Phenomena

The Ashen Light, reported the first time by G. Riccioli in 1643, is an extremely elusive, faint illumination of Venus' dark hemisphere. Some observers describe the Ashen Light as resembling Earthshine on the dark portion of the Moon, but the origin of the latter is





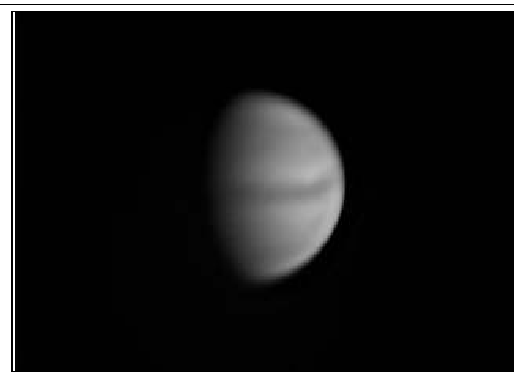


Illustration 004 2015Nov29 13:45UT. UV image by Paul Maxson. 31.5 cm (12.4 in.) DAL. Seeing (not specified), Transparency (not specified). Phase (k) = 0.662, Apparent Diameter = 17.8". Banded and radial dusky markings are visible with terminator shading. The bright limb band is incomplete from cusp to cusp. S is at the top of the image.

Illustration 005 2015Dec05 14:05UT. UV image by Frank Melillo. 25.4 cm (10.0 in.) SCT using Astrodon UV filter. Seeing 7.0, Transparency (not specified). Phase (k) = 0.684, Apparent Diameter = 17.0". Banded and irregular dusky markings are shown, including both cusp caps and cusp bands (northern cusp cap is slightly larger and brighter). S is at the top of the image.

Illustration 006 2015Dec20 07:48UT. Digital image by Raffaello Braga. 21.0 cm (8.3 in.) DAL with W47 (violet) filter. Seeing (not specified), Transparency (not specified). Phase (k) = 0.735, Apparent Diameter = 15.4". Along with terminator shading, banded dusky markings are clearly visible in this image plus both cusp caps and cusp bands as well as a portion of the bright limb band toward the northern cusp. S is at the top of the image.

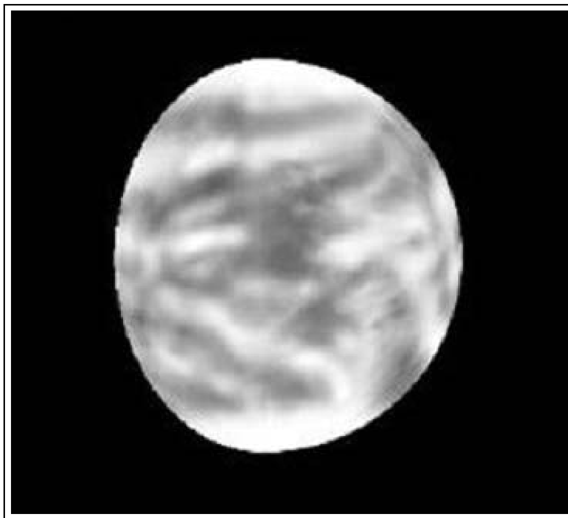
clearly not the same. It is natural to presuppose that Venus should ideally be viewed against a totally dark sky for the Ashen Light to be detectable, but such circumstances occur only when the planet is very low in the sky where poor seeing adversely affects viewing. The substantial glare from Venus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

In 2015-16, there were no digital images submitted that suggested the presence of the Ashen Light, but Detlev Niechoy strongly believed the Ashen Light was definitely visible in integrated light as depicted in his rather interesting drawing of September 23, 2015 at 04:45UT and likely present yet again on his drawing made on October 13, 2015 at 02:43UT [Refer to Illustrations No 023 and 024].

Because the instruments and methods are not that complicated, the ALPO Venus Section encouraged observers to conduct systematic imaging of the planet in the near-IR. At these wavelengths the hot surface of the planet becomes quite apparent and occasionally mottling shows up in such images, which are attributed to the presence of cooler dark higher-elevation terrain and warmer bright lower surface areas in the IR. There were no IR images of the dark hemisphere submitted during the observing season apparition, although there were several suspected instances during crescentic phases when the dark hemisphere of Venus allegedly appeared darker than the background sky during the 2015-16 Western (Morning) Apparition, a phenomenon that is probably nothing more than a spurious contrast effect.

Simultaneous Observations

The atmospheric features and phenomena of Venus are elusive, and it is not unusual for two observers looking at Venus at the same time to experience somewhat different impressions of what is seen. Our challenge is to establish which features are real on any given date of observation, and the only way to build confidence in any database is to increase observational coverage on the same date and at the same time. Therefore, the ideal scenario would be to have



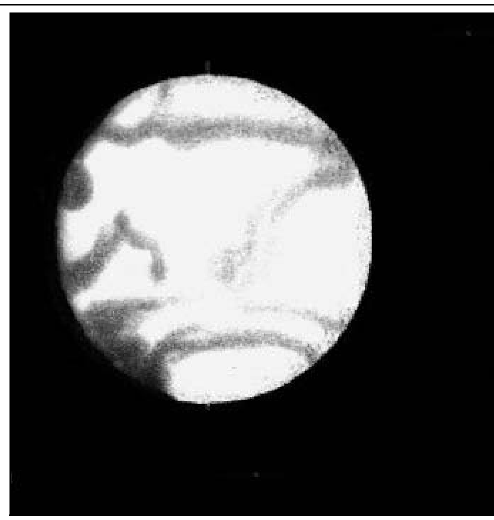


Illustration 007 2016Feb15 10:29UT. Excellent sketch by Michel Legrand. 21.0 cm (8.3 in.) DALL in integrated light (no filter), W80A (medium blue) and W38 (light blue) filters. Seeing (not specified), Transparency (not specified). Phase (k) = 0.882, Apparent Diameter = 11.8". Along with terminator shading plus banded, irregular, and amorphous dusky markings are noted in this drawing plus both cusp caps and cusp bands; observer's impression was that the southern cusp cap was brighter but the northern cusp cap was lightly larger. S is at the top of the drawing.

Illustration 008 2016May07 10:55UT. Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 82X in IL (Integrated Light). Seeing 3.0, Transparency 3.0. Phase (k) = 0.0.326, Apparent Diameter = 34.7". Banded dusky markings, as well as both cusp caps and cusp bands are seen; northern cusp is both larger and brighter. Situated toward the southern portion of the disk is a bright spot. S is at the top of the drawing.

Illustration 009 2015Nov07 07:40UT. Digital image by Raffaello Braga. 21.0 cm (8.3 in.) DAL with W47 (violet) filter. Seeing (not specified), Transparency (not specified). Phase (k) = 0.566, Apparent Diameter = 21.5". Along with obvious terminator shading, banded and radial dusky markings are shown in this image including the possible presence of roughly horizontal V, Y, or ? (psi) shaped dusky cloud features. The bright limb band is not continuous from cusp to cusp. S is at the top of the image.

simultaneous observational coverage throughout any apparition. Simultaneous observations are defined as independent, systematic, and standardized studies of Venus carried out by a large group of observers using the same techniques, similar equipment, and identical observing forms to record what is seen. While this standardized approach emphasizes a thorough visual coverage of Venus, it is also intended to stimulate routine digital imaging of the planet at visual and various other wavelengths, such as infrared and ultraviolet. By these exhaustive efforts, we would hope to be able to at least partially answer some of the questions that persist about the existence and patterns of atmospheric phenomena on Venus.

Amateur-Professional Cooperative Programs

The ALPO Venus Section continued to routinely share visual observations and digital images at various wavelengths with the professional community. As readers will recall, ESA's Venus Express (VEX) mission that started systematically monitoring Venus at UV, visible (IL) and IR wavelengths back in May 2006, ended its highly successful campaign early in 2015 as it made its final descent into the atmosphere of the planet. It was a tremendously successful Pro-Am collaborative effort involving ALPO Venus observers around the globe, and those who actively participated are commended for their perseverance and dedication. These collective data are important for further study and will continue to be analyzed for several years to come as a result of this endeavor. The VEX website is

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

A follow-on Pro-Am effort is now already underway with Japan's (JAXA) Akatsuki mission that began full-scale observations back in April 2016, and although the mission is continuing well into 2018, and the website for Akatsuki mission has already "gone live" so that interested and adequately equipped ALPO observers can register and start submitting images. More information will continue to be provided on the progress of the mission in forthcoming reports in this Journal. It is extremely important that all observers participating in the programs of the ALPO Venus Section always first send their observations to the ALPO Venus Section at the same time submittals are contributed to the Akatsuki mission. This will enable full coordination and collaboration between the ALPO Venus Section and the Akatsuki team in collection and analysis of all observations whether they are submitted to the Akatsuki team or not. If there are any questions, please do not hesitate to contact the ALPO Venus Section for guidance and assistance. Those wishing to register to participate in the coordinated observing effort between the ALPO and Japan's (JAXA) Akatsuki mission should utilize the following link: *https://akatsuki.matsue-ct.jp/*

Conclusions

Analysis of minimal collection of ALPO observations of Venus during the 2015=16 Western (Morning) Apparition revealed that vague shadings on the disc

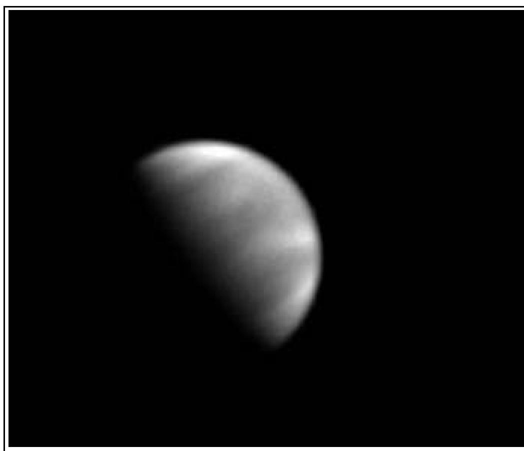
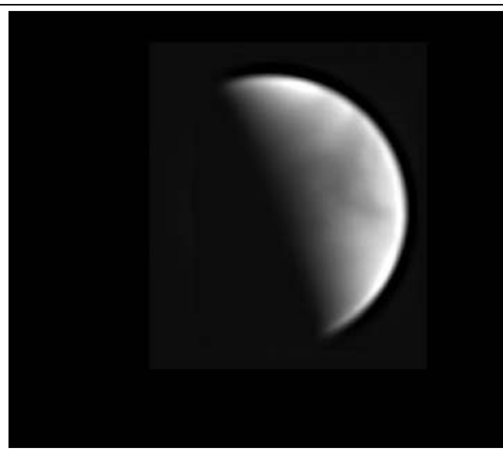
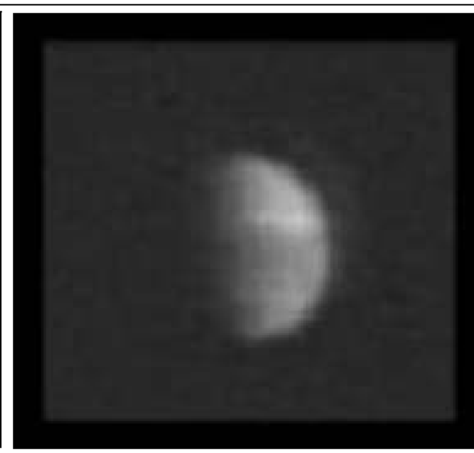




Illustration 010 2015Nov12 06:05UT. UV image by Matic Smrekar. 30.5 cm (12.0 in.) SCT. Seeing (not specified), Transparency (not specified). Phase (k) = 0.580, Apparent Diameter = 20.9". Banded and radial dusky markings as well as both cusp caps and cusp bands are depicted. Terminator shading is apparent. The southern cusp cap is larger and brighter than its northern counterpart. S is at the top of the image.

Illustration 011 2015Oct23 13:45UT. UV image by Paul Maxson. 31.5 cm (12.4 in.) DAL. Seeing (not specified), Transparency (not specified). Phase (k) = .491, Apparent Diameter = 25.0". At UV wavelength of this image, characteristic roughly horizontal V, Y, or ? (psi) shaped dusky cloud features in the atmosphere of Venus are obvious. The southern cusp cap is also visible. S is at the top of the image.

Illustration 012 2015Nov27 14:30UT. UV image by Frank Melillo. 25.4 cm (10.0 in.) SCT. Seeing 5.0, Transparency (not specified). Phase (k) = 0.654, Apparent Diameter = 18.0". Banded dusky markings are shown and terminator shading plus a brighter than usual area nearly central on the disk. S is at the top of the image.

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

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

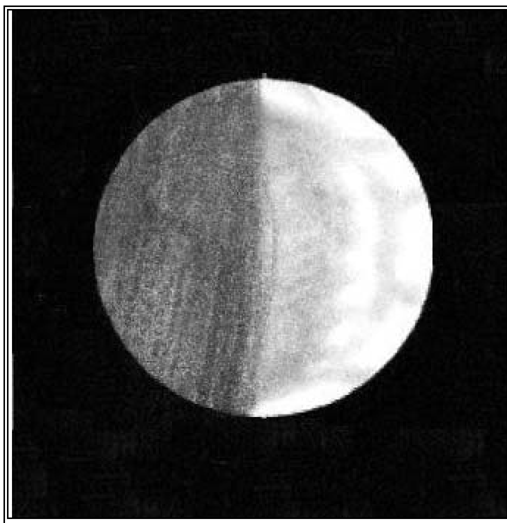
Active international cooperation by individuals making regular systematic, simultaneous observations of Venus remain our main objective, and the ALPO Venus Section encourages interested readers to join us in our many projects and challenges in the coming years.

References

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

-------------, (2011), “ALPO Observations of Venus During the 2007-08 Western (Morning) Apparition of Venus.” *Journal of the Assn of Lunar & Planetary Observers, 53,* No. 1 (Winter), 27-39. *http://alpo-astronomy.org/gallery3/var/albums/Publications-Section/ALPO-Journals/DJALPO-2011/DJALPO53-1-Winter2011.pdf?m=1521160545*

--------------, (2014), “ALPO Observations of Venus During the 2009-10 Western (Morning) Apparition of Venus.” *Journal of the Assn of Lunar & Planetary Observers, 56,* No. 3 (Summer), 19-33. *http://alpo-astronomy.org/gallery3/var/albums/Publications-Section/ALPO-Journals/DJALPO-2014/DJALPO56-3-Summer2014.pdf?m=1522686377*



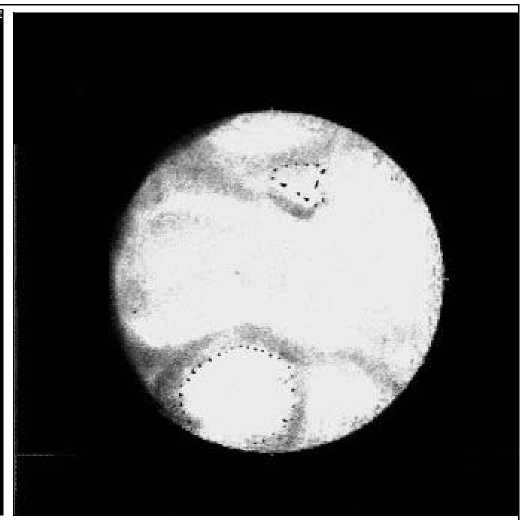


Illustration 013 2015Nov02 05:05UT. Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 82X in Integrated Light (no filter) and a W25 (red) filter. Seeing 5.0 (interpolated), Transparency (not specified). Phase (k) = 0.541, Apparent Diameter = 22.6". Drawing shows the terminator shading extending from cusp to cusp as well as irregular dusky markings and a discontinuous bright limb band. S is at the top of the drawing.

Illustration 014 2016May04 12:00UT. Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 163X in Integrated Light (no filter) and a W25 (red) filter. Seeing 5.0 (interpolated), Transparency (not specified). Phase (k) = 0.988, Apparent Diameter = 9.9". Drawing shows a bright spot along the southern limb on the gibbous disk of Venus. S is at the top of the drawing.

Illustration 015 2016May09 10:02UT. Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 263X in Integrated Light (no filter). Seeing 4.5 (interpolated), Transparency (not specified). Phase (k) = 0.991, Apparent Diameter = 9.8". Drawing illustrates the presence of two bright spots on the gibbous disk of Venus. S is at the top of the drawing.

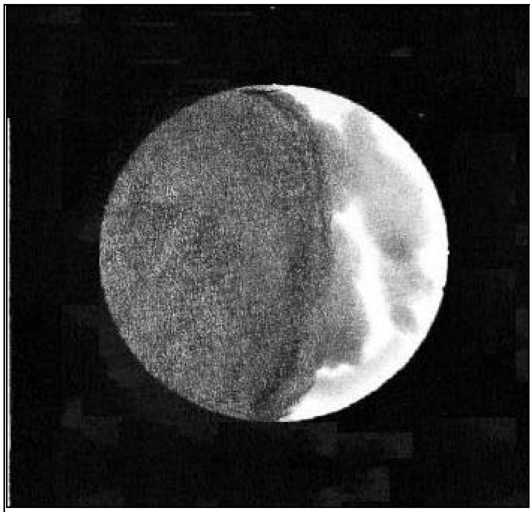
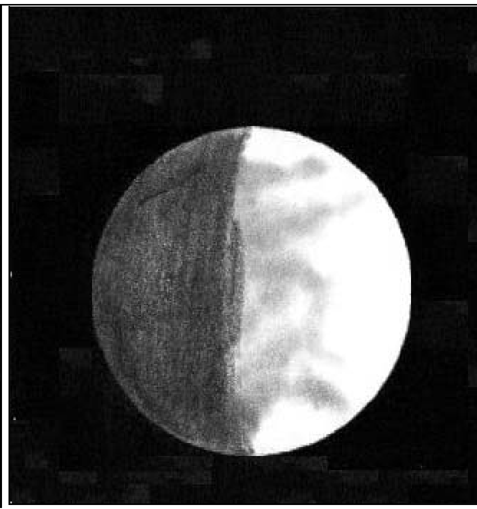
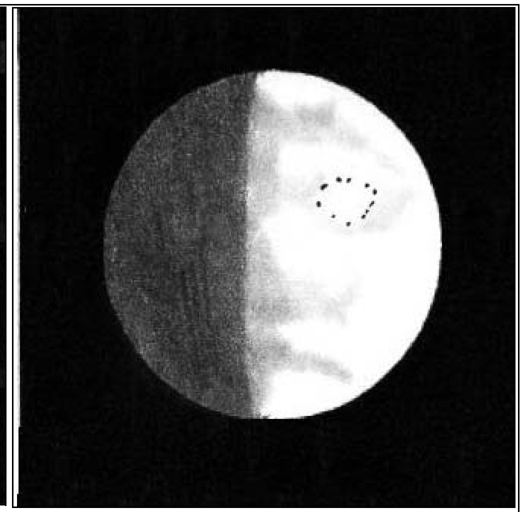




Illustration 016 2015Oct02 03:59UT Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 225X in Integrated Light (no filter). Seeing 4.5 (interpolated), Transparency (not specified). Phase (k) = 0.356, Apparent Diameter = 12.8". This drawing shows terminator shading as well as slight deformities from cusp to cusp. Amorphous dusky markings are present as well. S is at the top of the drawing.

Illustration 017 2015Nov05 05:16UT. Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 225X using W15 (deep yellow) filter. Seeing 4.5 (interpolated), Transparency (not specified). Phase (k) = 0.865, Apparent Diameter = 12.1". Terminator irregularities are seen along its extent from cusp to cusp. Irregular dusky markings are apparent also. S is at the top of the drawing.

Illustration 018 2015Nov08 06:51UT. Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 82X in Integrated Light (no filter). Seeing 4.0 (interpolated), Transparency (not specified). Phase (k) = 0.671, Apparent Diameter = 21.3". Drawing shows a bright spot on the disk of Venus as well both cusp caps and cusp bands. Irregular dusky markings are also present. S is at the top of the drawing.

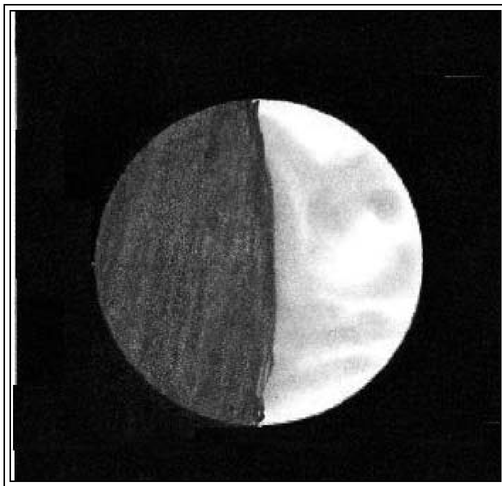
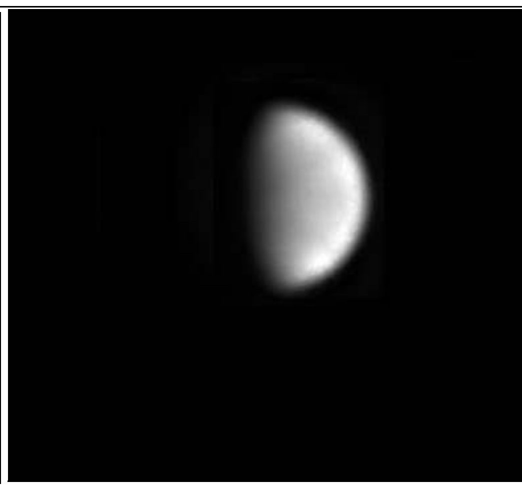
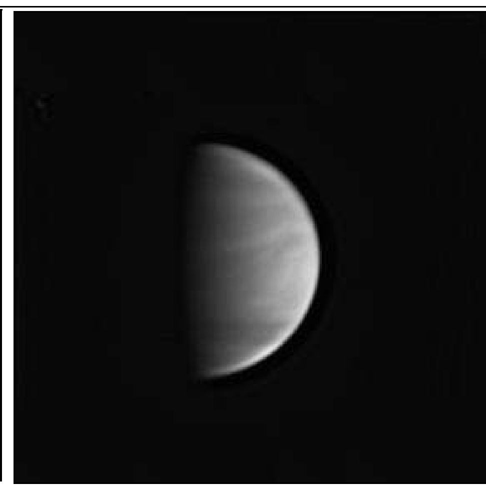
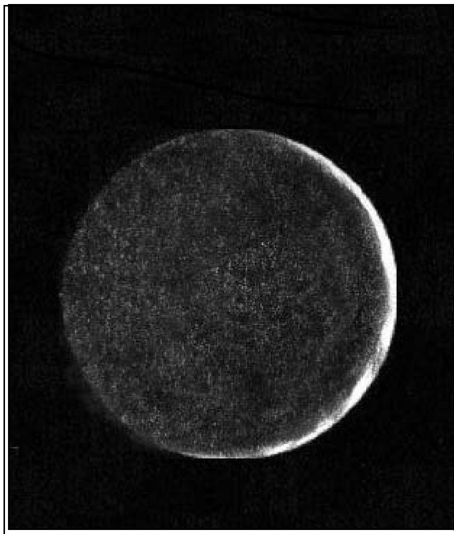
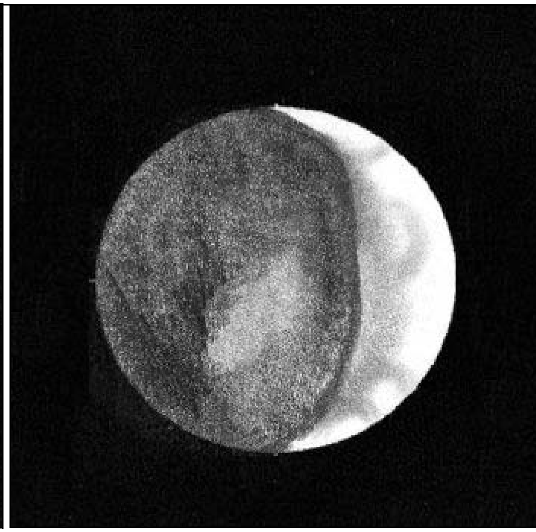




Illustration 019 2015Nov01 03:25UT. Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 225X in Integrated Light (no filter) and using a W25 (red) filter. Seeing 4.0 (interpolated), Transparency (not specified). Phase (k) = 0.536, Apparent Diameter = 22.8". Drawing shows both cusp caps and cusp bands (the southern cusp cap is larger and brighter). Banded and irregular dusky markings are present. S is at the top of the drawing.

Illustration 020 2015Dec04 3:59UT. UV image by Paul Maxson. 31.5 cm (12.4 in.) DAL. Seeing (not specified), Transparency (not specified). Phase (k) = 0.681, Apparent Diameter = 17.1". Both cusp caps stand out prominently in this image. Both cusps bands are vague but nevertheless present. S is at the top of the image.

Illustration 021 2015Nov13 06:18UT. Digital image by Raffaello Braga. 21.0 cm (8.3 in.) DAL with W47 (violet) filter. Seeing (not specified), Transparency (not specified). Phase (k) = 0.0.026, Apparent Diameter = 57.1". Along with terminator shading, banded and radial dusky markings are visible in this image as well as the possible presence of V, Y, or ? (psi) shaped dusky cloud features. S is at the top of the image.





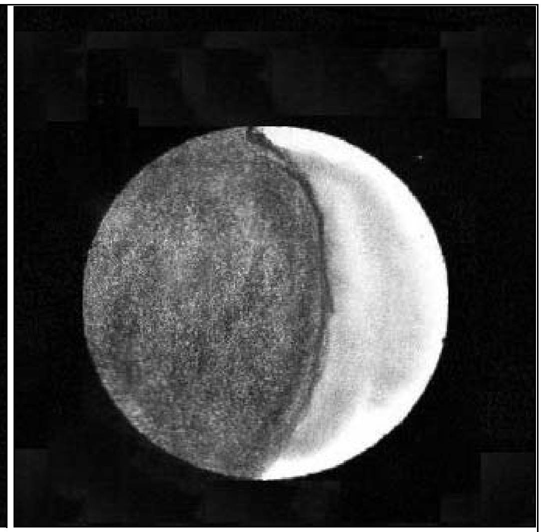


Illustration 022 2015Aug22 11:13UT. Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 82X in Integrated Light (no filter). Seeing 4.0 (interpolated), Transparency (not specified). Phase (k) = 0.683, Apparent Diameter = 16.6". The northern cusp is slightly extended by about 5o. Irregular dusky markings are visible along the bright crescent of Venus. S is at the top of the drawing.

Illustration 023 2015Sep23 04:45UT. Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 82X in Integrated Light (no filter). Seeing 4.0 (interpolated), Transparency (not specified). Phase (k) = 0.287, Apparent Diameter = 37.3". The presence of the illusive Ashen Light is considered definitely visible. Amorphous dusky marking are also present on the disk. S is at the top of the drawing.

Illustration 024 2015Oct13 02:43UT. Drawing by Detlev Niechoy. 20.3 cm (8.0 in.) SCT at 82X in Integrated Light (no filter). Seeing 4.0 (interpolated), Transparency (not specified). Phase (k) = 0.429, Apparent Diameter = 28.3". The Ashen Light is considered definitely present visually. S is at the top of the drawing.

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

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

-------------, (2018), "ALPO Observations of Venus During the 2014 Western (Morning) Apparition of Venus." *Journal of the Assn of Lunar & Planetary Observers*, 60, No. 3 (Summer), 41-52. *http://alpo-astronomy.org/gallery3/var/albums/Publications-Section/ALPO-Journals/DJALPO-2018/JALPO60-3-Summer-2018.pdf?m=1545337354*

-----------, (2018), "ALPO Observations of Venus During the 2014-15 Eastern (Evening) Apparition of Venus." Journal of the Assn of Lunar & Planetary Observers (awaiting publication).

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

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

United States Naval Observatory. The Astronomical Almanac. Washington: U.S. Government Printing Office. (Annual Publication; the 2015 and 2016 editions, which were published in late 2014 and 2015, respectively, were used for this report. *https://bookstore.gpo.gov/products/astronomical-almanac-year-2015-and-its-companion-astronomical-almanac-online-data-astronomy*

https://bookstore.gpo.gov/products/astronomical-almanac-year-2016

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

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

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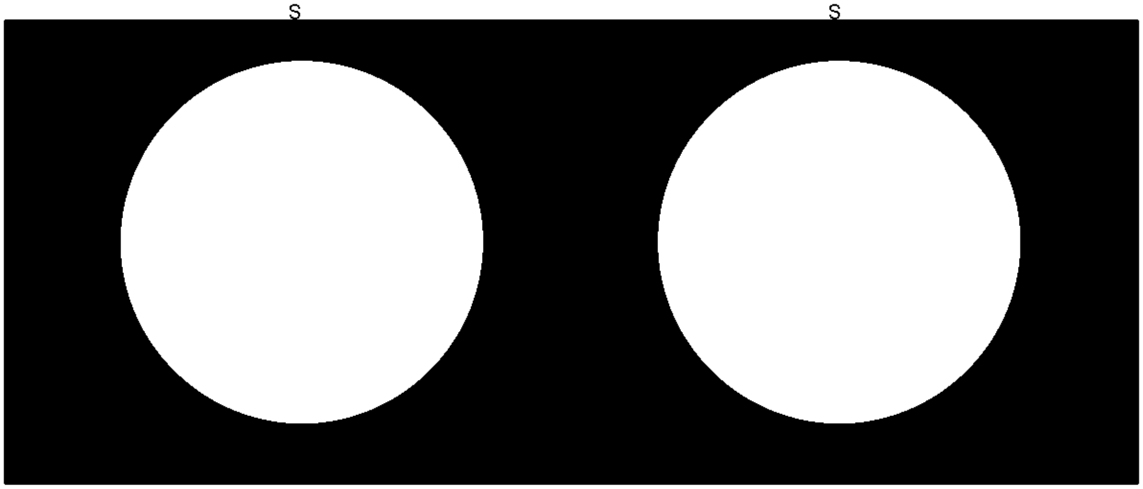

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N   (*all coordinates are IAU*)   N

Observer_______________________________Location____

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

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

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

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

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

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

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

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

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

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

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

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

IMPORTANT: Depict morphology of atmospheric detail, as well as the intensity of features, on the appropriate blanks at the tope of this form. Attach to this form all supporting descriptive information, and please __do not__ write on the back of this sheet. The intensity scale is the *Standard A.L.P.O. Intensity Scale*, where 0.0 = completely black ⇔ 10.0 = very brightest features, and intermediate values are assigned along the scale to account for observed intensity of features.

Papers & Presentations

Lunar Nighttime Thermal Analysis

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

This paper is the second of three papers by Mr. Wilson on this topic. Look for the third paper in JALPO63-1 (Winter 2021).

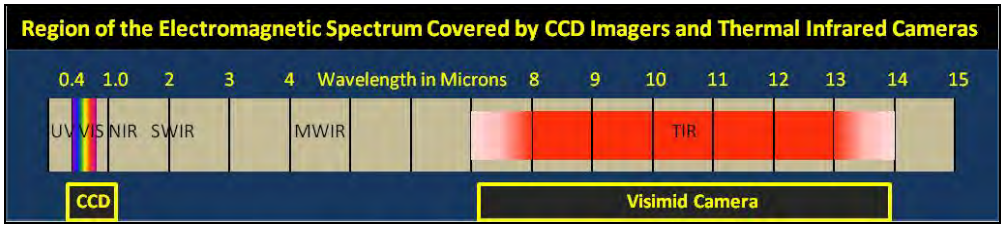

Figure 1. Visual representation of the author's Visimid thermal camera compared with a CCD.

Abstract

Thermal infrared (TIR) imaging was once the exclusive domain of professional astronomers, but dramatic price drops over the last decade are making the capability accessible to a growing number of amateurs. Developments in all aspects of the process are proceeding very rapidly, but TIR imaging has not yet reached the "plug-and-play" stage. This, the second in a series of articles, serves as an introduction to thermal imaging of the Moon for amateur observers who may have an interest in exploring data that can be acquired beyond visible range. It provides instructions for all aspects of thermal imaging including: thermal camera requirements, image acquisition software, telescope and other hardware requirements, thermal image processing and interpretation of the images.

Introduction and Background

Although there are several ways to image the Moon in TIR wavelengths, this paper makes no effort to cover them all. Instead, this is a description of the method that the author uses to generate the images that are presented in the accompanying figures. The hope is that the reader will be able to replicate these results using one of the commercially available, uncooled thermal imagers that have recently dropped in price. Designed for other uses, these devices can add an observing technique for amateur astronomers just as CCD imaging did 25 years ago.

TIR imaging cameras are commonly used by wildlife observers, home inspectors and energy audit engineers. They allow you to see heat radiated from objects that are near room temperature. The body heat generated by people and animals outdoors at night makes them appear to literally glow in the dark. Evaporative cooling causes walls and ceilings to appear darker if moisture is present due to a water leak. Warm air leaking in from outdoors during the summertime causes areas with poor insulation to appear brighter than their surroundings. TIR imagers allow us to see the world as our eyes never can - and to literally gain new insights into it. Can they show us heat emitted from the Moon as well? Before spending money on a TIR camera, it might pay off to do a simple calculation to find the answer to that question.

Wein's law relates the wavelength of electromagnetic radiation emitted by an object to its temperature. It says that the wavelength of maximum emission from a black body is equal to 2,880 divided by the absolute temperature of the object.

CCD imagers detect electromagnetic radiation with wavelengths from 0.4 microns to 1.1 microns. That covers the visible part of the spectrum and part of the near-infrared. If we use the temperature of the Sun for T (5,770 K), we calculate that the peak wavelength is 0.5 microns (500 nm), which is what we observe for the Sun.

λ (µm) = 2880 / T (Eqn. 1 Wein's Law)

TIR imagers detect radiation that is roughly 20 times longer than that. The author's camera is sensitive from 7 to 14 microns (see ***Figure 1***). If we use 14 microns for λ, then the peak wavelength, we calculate that the coldest temperature that the camera can detect is 206 K (-67° C). There is actually a broad distribution around the peak wavelength, and the precise minimum detectable temperature is also a function of the emissivity (the efficiency with which a surface emits radiation) of the object, the temperature of the sensor in the camera and other factors such as the geometric fill factor for subpixel radiant sources. For our purposes, it is accurate enough to simply use Wein's Law to say that everything warmer than about 200 K (-70° C) emits radiation that the camera can potentially see. Temperatures on the Moon range from about 90 K (-183° C) just before lunar sunrise, to almost 400 K (127° C) in the lunar afternoon. This suggests that we should be able to use a thermal imaging camera to take a picture of the heat radiated from the surface of the Moon, at least during the lunar day. Later, we will see that the lunar night holds a few surprises for our TIR cameras as well.

To collect, process and interpret TIR images, you need the following:

- Thermal imaging camera with software to capture images
- Newtonian (or Cassegrain) telescope with clock drive
- Mechanism to attach the camera to the eyepiece drawtube
- Laptop computer
- Software to process and stack the raw images (for best results)

Thermal Imaging Camera Requirements

The key piece of required equipment that you probably don't own is the thermal camera. Uncooled thermal infrared camera prices have dropped dramatically in recent years, and cameras in the $1,000+ price range, if not lower, can be used to achieve results similar to those presented in this article. The author has imaged the Moon and Venus with imagers provided by two different vendors.

He currently uses an X-640 sold by Visimid Technologies. This is a complete camera with a built-in viewer and multiple, electronic, real-time viewing options, including colorization. Although completely adequate for its intended purposes, the software currently provided with the camera was not designed for astronomy. It has limited functionality suitable for lunar imaging, but it does work with the Windows 7 operating system and it was sufficient to acquire all of the thermal images that were used for this article. It saves images in BMP format. A power cable and USB cable (shown connected in ***Figure 2***), are also included with the camera. Although lunar features are visible in the raw images, further processing, described below, significantly improved the quality. Visimid is currently developing a more complete version of control software that should allow for more camera controls and commensurately better results. Their products are available in the U.S. and internationally. For more information contact Wende Liebert (www.visimid.com, phone 469.906.2660 x103).

Figure 2. Visimid Technologies X-640 uncooled thermal camera used by the author. Note attached power and USB cables.

A few years ago, the author used a ThermalExpert QVGA_384 X 288 imager purchased from i3Systems, Inc. for $995. Unlike the X-640, the ThermalExpert is an imager and not a camera. With no built-in viewfinder or monitor, it relies on a computer connection for image display. An advantage is that it is much smaller and lighter, so it can more easily be attached to the telescope's focal plane (a piece of tape was usually adequate). Although the camera performed quite well with engineering-grade image capture software that had limited functionality, a full featured software program that was later provided could not connect the camera to a Windows 7 computer. Apparently, i3System focused their development efforts on Windows 10. If you have a Windows 10 system, you might want to consider this option for a full-featured thermal imaging system and an excellent thermal imager. They can supply in the U.S. and internationally. Contact Terry Clausing, Drysdale & Associates, (phone 513.831.9625, terry@drysdaleenergy.com).

Image Acquisition Software Requirements

Whether you choose to use one of the two systems described above or a third option, you need to ensure that the image capture software provided with the camera will satisfy your needs. Since an uncooled thermal imager will require that you stack and average raw frames for the best results, the software must support this workflow. Unfortunately, the author has found that some thermal imagers currently available come with application software that makes this practically impossible. These cameras were not developed with astronomers in mind, so be careful, ask detailed questions and perhaps insist on a demo before making a purchase.

Telescope Requirements

Another key piece of equipment is the telescope. A Newtonian reflector is almost a requirement for thermal imaging. Although a classical Cassegrain would also work, any optical design that includes glass in the light path will not. Glass is opaque to thermal infrared wavelengths. You will also want as much aperture as possible, since resolving power is inversely proportional to the wavelength of light. The author used an 18", f/4.4 Newtonian reflector from Obsession Telescopes to capture all of the images acquired with the Visimid camera. He used a 12", f/4.8 Celestron Newtonian to capture the images acquired with the i3System imager.

The resolving power equation says that resolving power of a telescope is equal to 1.22 times the wavelength of electromagnetic radiation divided by the aperture of the primary optic, as expressed by ***Equation 2***. Since the Visimid camera is sensitive to radiation from 7 to 14 microns, we can take the midpoint of 7 and 14 and use 10.5 x 10^{-6} meters (10.5 microns) for λ. Since D = 0.457 meters (18"=0.457 m), we calculate R=2.80 x 10-5 radians. Multiply that by 206,265 arcseconds per radian and we get R=5.8 arcseconds.

R = 1.22 / D

Equation 2 Resolving Power

That's right — in the TIR, an 18" scope only resolves craters down to about 6 or 7 miles in diameter on the lunar surface. The limiting resolution of an 8" scope is about 15 miles. At first this sounds less exciting than a rainy day. But let's not be too hasty. There are a couple of silver linings in that cloud. First, with a resolution of 6 arc seconds, the seeing is always diffraction limited. The image is always rock-steady, even better than it is with a 60 mm refractor. The seeing is almost always 10 in the TIR. Second, even if your primary mirror has a flawed figure, it is probably better than diffraction-limited for this application. The peak-to-valley (P-V) error standard for a diffraction-limited mirror is λ / 4. For observational astronomy,   is always assumed to be somewhere in the visible spectrum. In the TIR, the wavelengths are 20 times longer, so the error that can be tolerated before the mirror is no longer diffraction limited is 20 times larger. A large mirror with a terrible figure for visual observing will probably be excellent for thermal imaging.

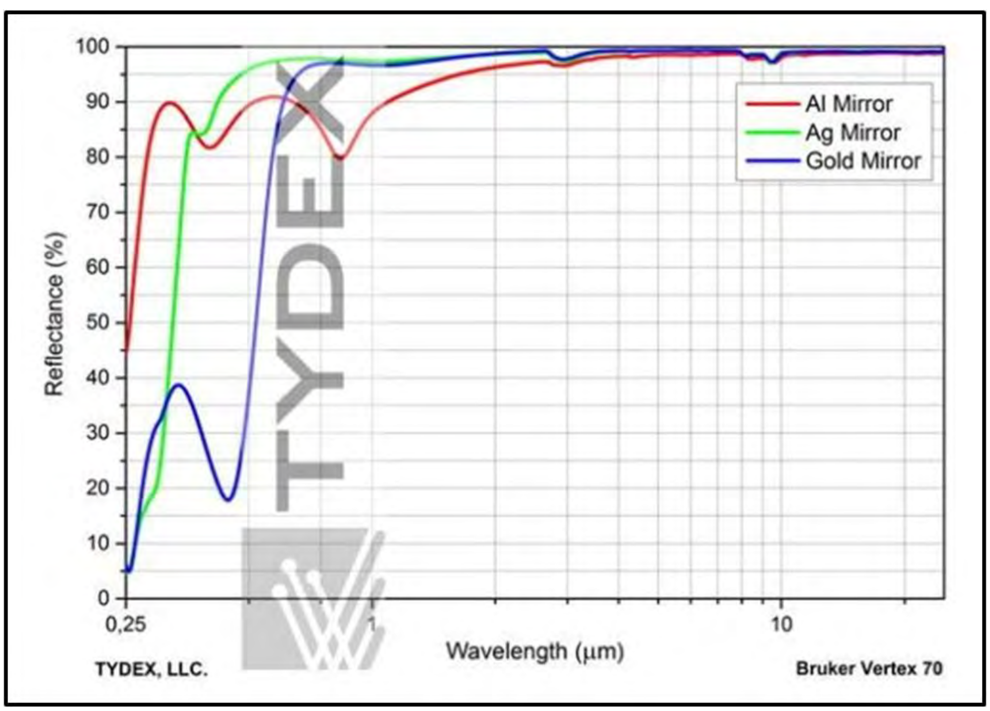

Figure 3. A comparison of mirror reflectance coating curves from the UV through the TIR for aluminum, silver and gold coatings.

What about focal length and the consequent image scale (aka “plate scale”)? What is best, a short, medium or long focal length? Well, it depends on what performance parameter you are trying to optimize. For a given aperture, if the focal length is too short, we get a brighter image with higher signal-to-noise ratio (SNR) and a wider field of view (FOV), but we fail to take full advantage of the resulting power of the telescope. If the focal length is too long, the image becomes so dim that the SNR suffers, the FOV is reduced and the spatial resolution is no better than it would be at some shorter focal length. Assuming that you want to maximize spatial resolution we would like to know what focal length will optimize the trade off.

Let's use an 8 inch (203 mm) Newtonian reflector as our example. ***Equation 2*** tells us that its resolving power is 15 arc seconds. Sampling theory provides us with the Nyquist theorem, which states that it is necessary to sample at least twice as fast as the highest frequency that you wish to recover from a signal. For our purposes, detector spacing is the sample rate. And we wish to recover image features that occur with a frequency of 1 every 15 arc seconds. So we need at least two detectors every 15 arc seconds at the focal plane. That means that the focal length must be long enough to spread 15 arc seconds over the spacing of at least two detectors, that is, 7.5 arc seconds per detector.

With one more concept, we can calculate our answer. Image scale (S) is defined in ***Equation 3***. It is a measure of the size of the image at the focal plane. Commonly expressed in units of arc seconds per micron, a large value of S is associated with a short focal length (F) and a relatively small, relatively bright image. We want an image that is not too small, but also not too large and dim.

In 2020, uncooled TIR cameras typically have detectors spaced either 12 microns or 17 microns apart. Since the 17 micron technology is older and is more likely to be found in lower cost imagers, we use that figure for our analysis. That means we need F = 7.5 arc seconds / 17 microns = 0.441 arc seconds / microns. Plugging that into Equation 3 gives 0.441 = 206,265 / F. Hence, F = 206,265 / 0.441 = 468,000 microns = 468 mm. That means that the f-ratio that just satisfies the Nyquist sampling limit is 468 mm / 203 mm = f/2.3. Note that this result applies regardless of aperture.

$$S = 1 \;/\; F \;=\; 57.3 \;/\; F \;=\; 206265 \;/\; F$$

Equation. 3 Plate Scale

For reasons beyond the scope of this discussion, instead of oversampling by a factor of 2, it may be a good idea to oversample more, perhaps by a factor of 2.8. This would increase our optimum f-ratio calculation to f/3.3. The difference is inconsequential, since both numbers are lower than commercially available Newtonian reflectors. The point here is that a commonly available f/4.5 scope will produce images that are fairly close to optimal, but an f/8 scope will give a much smaller FOV and a fainter image with lower SNR. If you have a choice, use the scope with the shortest f-ratio.

A final note on the primary optic concerns the coating. It is widely believed that gold coatings are superior for mirrors used for infrared imaging applications. This is incorrect. ***Figure 3*** shows reflectance curves from the UV through the TIR for aluminum, silver and gold mirror coatings. From 7 to 14 microns, all of the coatings are virtually identical in performance. The author has used mirrors with aluminum coatings ranging from one to eight years old, with excellent results.

Other Hardware Requirements

Unfortunately, there is currently no adapter available to mate the camera (or the i3System imager) to a 1 1/4" eyepiece tube. Borrowing a technique used by photographers, the author uses a "Bogen Magic Arm," shown alongside the X-640 in ***Figure 4*** and attached to the scope in ***Figure 5***, to position the camera at the focal plane.

The entire setup, including a Windows 7 laptop used to control the camera and collect the images, is shown in ***Figure 6***. It should be noted that the locking mechanism of the Magic Arm is not absolutely rigid, and some flexure can occur over timeframes of several minutes. This can occasionally cause loss of sharp focus, or vignetting changes due to a horizontal focal plane shift.

Procedures for Image Acquisition

Either eyepiece projection or prime-focus imaging may be used to capture the images. Eyepiece projection requires that a second thermal IR lens (i.e., germanium) be placed in the eyepiece position. The camera can then be used just as a regular 35 mm camera would be when performing eyepiece projection photography. Prime focus imaging simply requires that you unscrew the lens and place the focal plane of the camera at the focal plane of the telescope.

With the Visimid camera connected to the telescope via the Bogen Magic Arm as shown in ***Figure 5***, you look through the viewfinder as you point the scope towards the Moon. When you see a bright blob appear, you are pointed correctly. Focusing is then accomplished by first loosening the Bogen Magic Arm slightly, repositioning the camera so that sharp focus is achieved, then retightening the Magic Arm. This requires some practice and patience, but until a mechanical adapter can be found, it is the best solution available.

When you can see raw thermal images of the lunar surface on your laptop screen, you are almost ready to collect your thermal image set. At this point, it is a good idea to carefully examine the image. Do you have sharp focus? The

Figure 4 (left). The Bogen Magic Arm kit and the Visimid Technologies X-640 thermal camera.

Figure 5 (center). Bogen Magic Arm with Visimid camera attached to the author's Obsession 18-inch, f/4.5 Dobsonian reflector.

Figure 6 (right).Scope assembly and laptop computer.

Bogen Magic Arm sometimes slips slightly and it takes only a couple of millimeters of slip along the optical axis to lose sharp focus. Is the focus sharp across the entire FOV? It can be difficult to orient the camera so that the focal plane is orthogonal to the optical axis. Any error will manifest itself as loss of focus in some areas. Does the image have enough contrast and dynamic range for you to see and identify major lunar features? The raw images will probably have low contrast, but they should at least show recognizable features.

If contrast is minimal and the outdoor temperature is high, the atmosphere may be the problem. Sky temperature is a foreign concept to most people. In the TIR, it is exactly analogous to sky brightness in the visible region of the spectrum. A warm atmosphere is the same to a TIR imager as a light-polluted sky is to a visible light CCD imager. Thick clouds are opaque to the TIR imager, just as they are in the visible. Thin clouds are a little different. At low altitudes, their temperature is higher and they reduce image contrast more than they do if they are at high altitude.

A cold sky is optimal for TIR imaging. Although it most often occurs in the winter, if the humidity is low, the sky temperature can be below zero even on hot summer days. Other than discovering that your images have low contrast after you have set up your equipment, how can you know what the sky temperature is? Simple – point the thermal camera up at the sky and read the temperature from the display screen.

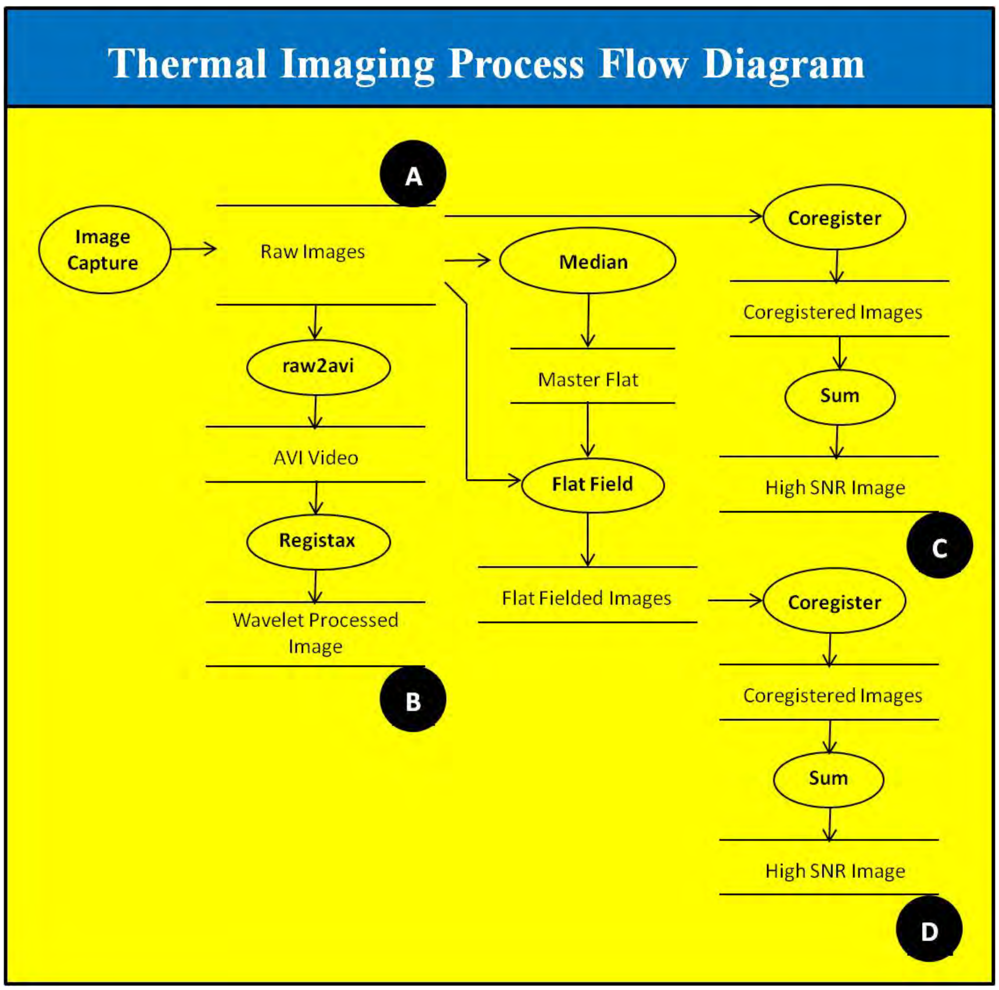

Figure 7. Process flow diagram in showing three different process chains that may be used to improve the quality of the raw images.

The Visimid image acquisition software requires that you perform two separate mouse-clicks to save each individual thermal image to disk. The first click transfers the image from the camera to the computer screen. Clicking on another button saves the image. The two image capture modes (standard and touchup) are discussed in "Image Processing Requirements."

After pointing the scope and focusing, the process of collecting an image set during the evening amounts to starting the software, entering a root filename and clicking on "increment file number". Then you simply click on one button to capture and then click on another button to save. Repeat this a few dozen times as fast as you can and you will have an image set that can be stacked and processed. Unfortunately, the current software cannot automatically collect and save a sequence of images.

Image Processing Requirements

The raw thermal images will have recognizable lunar features, but they are noisy and have low contrast. Amateur astronomers learned years ago that stacking multiple images improves the SNR and brings out low contrast details in CCD images. The same applies to thermal images. Most of the images presented in this article were processed by averaging about 35 individual frames. The noise diminishes quickly with the first several "coadds," and the Visimid camera produces no visible fixed pattern electronic noise, regardless of the size of the image stack.

Due to significant vignetting, flat-fielding is important. A full-featured software control program would provide for gain control of the camera. Unfortunately, the Visimid camera currently has an uncontrollable electronic gain setting. It automatically varies with the amount of illumination that the camera senses. This works quite well when you are using the camera as originally intended. For example, if you are sitting in your

Figure 8 (above left) and Figure 9 (above right. A comparison of i3System and Visimid raw image quality.

Figure 10 (below left) and Figure 11 (below right). A comparison of Visimid standard versus touch-up options for raw images.

backyard scanning the treeline looking for wildlife late at night, it will automatically, and immediately, adjust the viewfinder display brightness range if you pass over a hot object such as a recently parked car. That's just what you want it to do in that case.

Unfortunately, in the case of imaging the Moon, it means that the camera gain is changing constantly as you move the field of view across the lunar surface. As the gain changes, so does the degree of vignetting. Since each image has a different amount of vignetting, a single flat field image cannot solve the problem. To date, the author has not found a very good solution. One consequence is that radiometric calibration is not possible, either in absolute or relative terms. That means that the images cannot be used to derive temperature measurements, and that unless a fairly large brightness difference is obvious between two points in an image, the viewer cannot even be certain that the brighter point is warmer than the darker one. In spite of this, we can still see much useful information. The next version of the Visimid camera control software should address this problem and future results should yield results with more scientific value.

The process flow diagram in ***Figure 7*** illustrates three different process chains that may be used to improve the quality of the raw images. In it, ovals represent processes (that is, computer program functions like image coaddition) and line pairs represent data stores (e.g., disk files). The four locations labeled A, B, C and D define various stages of processing.

Example images corresponding to each of the locations are referenced in the text, as follows:

- Position A - ***Figures 8, 9***: comparison of i3System and Visimid raw image quality
- Position A - ***Figures 10, 11***: comparison of Visimid standard vs. touch-up options for raw images
- Position B - ***Figure 12***: Registax processing option
- Position C - ***Figure 13***: frame averaged processing option
- Position D - ***Figure 14***: frame averaged and flat fielded processing option

Immediately after capture, raw images are saved to disk as BMP files. This occurs at location A in ***Figure 7***. We first examine a raw image captured by the i3System imager, shown in ***Figure 8***. This is a full-frame image taken at prime focus using a 12" Celestron Newtonian with a focal length of 1.46 meters. A raw image of the same region captured with the Visimid camera at nearly the same lunar phase is shown in ***Figure 9*** for comparison. This Visimid image was cropped from ***Figure 10***.

It is noteworthy that the i3System image was taken using a 12" F/4.8 Celestron reflector, while all other images were taken using the Visimid camera and an 18" F/4.4 Obsession reflector. Even though lesser aperture was used, the i3System image is visibly richer in tonal detail than the Visimid image, suggesting that the i3System imager produces results with higher SNR. Though visibly noisier, the Visimid camera's 640 x 480 focal plane array is larger than the i3System's array of 384 x 288 detectors.

Due to reasons previously discussed, the author was not able to collect images quickly enough with the i3System software to create a coregistered image stack. For that reason, there will be no further discussion of i3System's product in this paper.

The Visimid software offers two capture options, "standard" and "touch-up". Standard seems to perform a min-max stretch on the image data before it is displayed. Touch-up seems to perform a stronger histogram stretch, which results in greater contrast and an increase in image brightness. ***Figure 10*** shows a "standard" image and ***Figure 11*** shows a "touch-up" image of the same area on the Moon at the same time. Although the raw "touch-up" images are visibly more detailed, the author learned that the histogram stretch saturates some of the pixels, which causes a loss of information later in the process chain after images have been coadded and averaged. Stacking images to increase the SNR offers far greater benefits than that given by the "touch-up" histogram stretch. The author obtains superior results using the "standard" option.

Three processing options exist from this point. First, the BMP image file set may be converted into an AVI video file for input into Registax (http://www.astronomie.be/registax/) for stacking and wavelet processing. This path leads to location B in the process flow diagram. Second, the BMP files may be coregistered, then summed in order to increase the SNR before final brightness and contrast adjustments. This path leads to location C. Third, a flat-field master image may be created and applied to each of the BMP files before coregistration and summation. This is depicted by the sequence of steps that lead to location D.

The first option requires you to convert the set of BMP files that you have captured into an AVI file for input into Registax. The author uses a third-party software program called HandyAVI (https://www.azcendant.com) to do this, and others are also available. After reading the AVI file into Registax, the author has had only limited success with

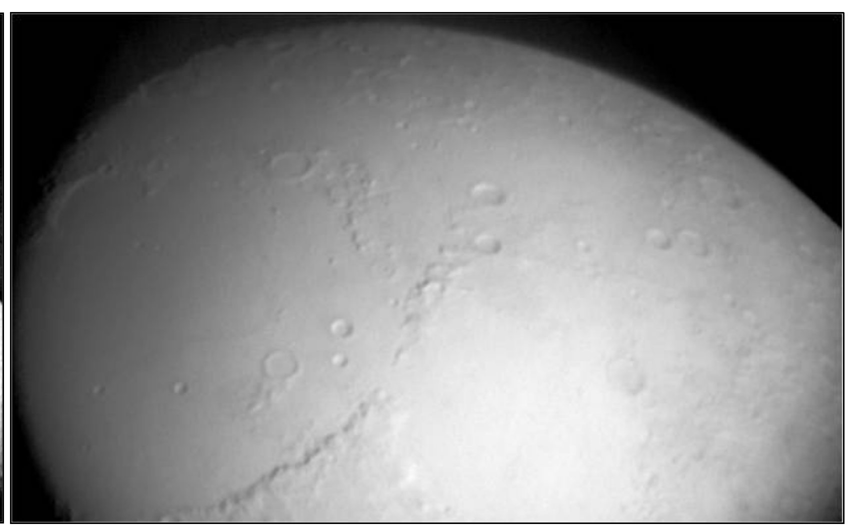

Figure 12 (left). Image using the Registax processing option.

Figure 13 (right). Image using the frame averaged processing option.

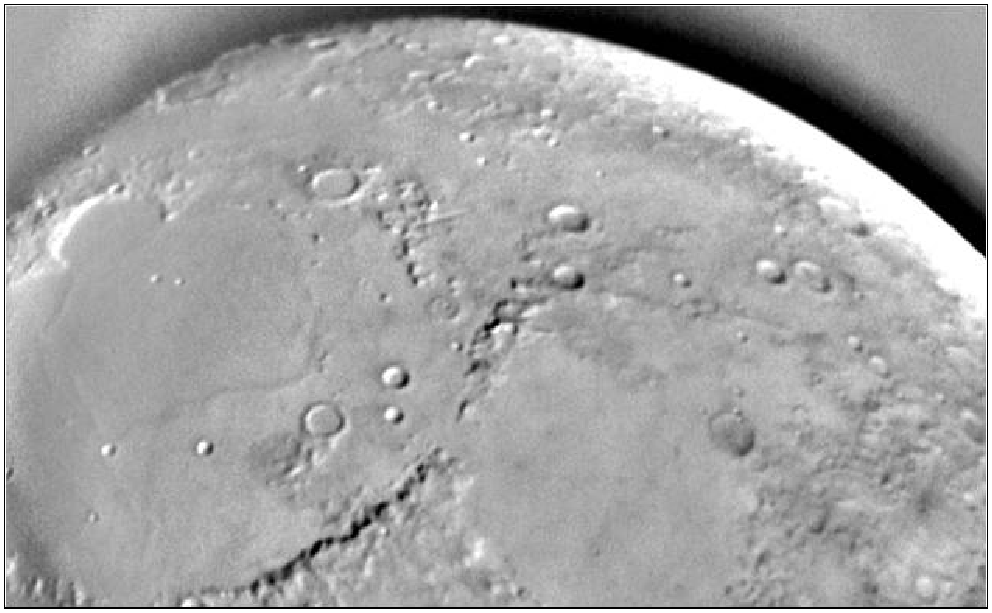

Figure 14. Image using the frame averaged and flat fielded processing option.

the first step - aligning the individual frames. Perhaps the SNR of raw Visimid frames is too low for Registax to handle. If so, it may work with other brands of thermal imagers. As for Visimid images, the software seems to work best when the “touchup” option is used. Even so, AVI files with more than four frames were never successfully aligned. That means only four frames were coadded, and the SNR was only improved by a factor of two. Nevertheless, a significant improvement is apparent, as can be seen in ***Figure 12***. The wavelet algorithms included in Registax are largely responsible. They work quite well when applied to lunar and planetary images. Improvement was observed even when an AVI file with only one image frame was generated, imported into Registax and processed. Try the “dyadic-default” option and vary only the lowest spatial frequencies. This option ends at position B on the process flow diagram.

The second and third options may require that you write your own software to perform the coregistration and summation. If you decide to do this, the author is willing to advise with coding an algorithm development. The author can reached by contacting the editor of this Journal (shawn.dilles@alpo-astronomy.org). Coregistration is necessary because imperfect polar alignment causes the Moon to drift from image to image. Writing software to correct for this is somewhat more complicated, but is within the ability of an intermediate programmer. The row and column array indexing that must be handled is nothing more than simple arithmetic. Essentially, each of the input BMP images must be trimmed to a uniform size in such a manner that a single lunar surface feature that can be found in the first image will occur at the exact same row and column in all of the other images. The area of lunar surface covered in each of the trimmed images will be exactly the same and it will be the area that results from intersecting all of the images in the set.

In principle, the row-column location of a common feature in each of the input images could be determined interactively by examining each image, positioning the cursor over the feature, and recording the coordinates for input into the coregistration function. But that quickly becomes laborious. In the long run, much labor is saved by coding a function that takes as input the row-column coordinates of a rectangular area (patch) that contains the common feature and then automatically searches each of the other images in turn for the best match of the patch, recording the matching coordinates as it proceeds.

The key difficulty, of course, lies in defining a function that will automatically match a rectangular region taken from one image to the corresponding region in another image. Fortunately, a surprisingly simple and effective solution to this problem is available in photogrammetry literature referenced in the bibliography of this paper and should not be difficult for an intermediate level programmer to implement. The reference includes detailed diagrams that illustrate the row and column indexing details. Reduced to its essence, and described in two sentences, it calculates the sum of the squares of the differences between the pixel values of a selected patch from the reference image and the pixel values of all same-sized patches in the other image. The location of the patch in the other image that results in the minimum value for the sum of the squares is the location of the best match. (Imagine selecting a patch and applying the algorithm back to the same image. The minimal value of zero would be returned when it was applied to the row/column position from whence it came.) The author has coded it several times over the past 30 years, for various purposes, on a variety of operating systems. It has always worked well.

Of course, software libraries are available that may provide superior solutions without requiring any programming. For example, the author has heard of an add-on from Adobe that may automatically coregister a set of overlapping images, but he cannot verify that it is suitable to this task. The algorithmic description above at least provides guidance for the resourceful amateur to accomplish the necessary steps.

After coregistration, summation is trivial once the files have been converted to floating point format in order to avoid integer overflow during the summation process. The software only needs to sequentially read each of the raw images and add each new one to the running total that has accumulated. Dividing each of the pixel values in the final image by the number of images that were summed returns the range of data values back to 0 to 255.

Figure 13 corresponds to position C on the process flow diagram. It shows the result of averaging 26 raw Visimid images. The visible improvement in SNR over the raw image in ***Figure 10*** is worth the work required to coregister and sum the image set. The averaged image can also be histogram stretched to further expose low contrast detail that is not present in any individual raw image.

Now that we have described the second option in detail, let's move on to the third. It involves everything we did in option two, with the additional step of flat-fielding each of the raw images before coregistration.

Since the Visimid camera has an uncontrollable electronic auto-gain, standard flat-field generation procedures will not work. The author uses an unconventional method that has sufficed for all of the images that he has published since September 2019 with the exception of ***figures 8 through 13*** in this paper.

It is crude and simple. The set of overlapping images to be averaged are simply averaged together without first performing a coregistration. Due to image drift between exposures, this results in a smeared, blurry final image. It averages together all of the vignetting errors, fixed pattern noise, gain setting changes and image data that were recorded during the collection of a given set of raw images. This is the flat-field image that is divided into each of the raw images before repeating all of the steps of option two above. The result, corresponding to position D on the process flow diagram, is shown in ***Figure 14***. The improvement in tonal detail over ***Figure 13***, and all other images presented here, is clear to see. Of the three presented, this processing option reveals the most image detail.

In summary, you will want processing software that allows you to flat-field, stack (coregister), and average the raw frames.

Interpretation of Lunar Thermal Images

The interpretation and analysis of features that are visible in thermal images of the Moon taken with uncooled thermal imagers in 2020 is a complex subject. The next paper in this series (scheduled for publication in JALPO63-1 for release this winter) will provide a more detailed discussion of interpretation and analysis of lunar thermal images. In lieu of a complete discussion, four simple rules-of-thumb are presented here that can explain most of what you can expect to see.

Interpretation Rule Number 1

Lunar surface temperature variations are primarily due to variations in the solar elevation angle. Over long distances, this is proportional to the distance from the subsolar point. Over smaller distances, surface topography effects dominate.

Interpretation Rule Number 2

Albedo effects cause differences in rates of heating which result in noticeable temperature differences in some areas well into the lunar day.

Interpretation Rule Number 3

Given two objects at the same temperature, the one with the higher emissivity will appear brighter in a TIR image.

Interpretation Rule Number 4

If rules 1 through 3 don't explain what you see, it might be an outcrop of exposed silicates, free of insulating regolith, that has higher thermal inertia than the surroundings.

Summary

Good quality uncooled thermal imagers can now be purchased for about the cost of a high-end CCD imager. With a Newtonian reflector, they can be used to image the Moon in the TIR region of the spectrum. Although the raw images show temperature details on the lunar surface, various image processing options exist that can be used to greatly increase the amount of information that is visible. The processed images reveal information due to the thermophysical properties of the lunar surface that is invisible at visible light wavelengths.

About the Author

Darryl Wilson is a retired scientist and has been an amateur astronomer since age 12. This is the second in a series of JALPO articles he has published on thermal imaging of the Moon (to read the first one, see: Wilson, 2020). You can find other contributions on thermal imaging he has published in *The Lunar Observer* newsletter beginning with the September 2019 issue (available at: *http://moon.scopesandscapes.com/alpo_lunar/tlo_back/tlo201909.pdf*).

References

Wilson, Darryl, “Lunar Nighttime Thermal Analysis”, (2020). Journal of the Assn. of Lunar and Planetary Observers, Vol. 62 No. 3 (Summer 2020), pp. 47-51.

Wolf, Paul R., Elements of Photogrammetry, 1983, McGraw Hill, p. 383.

Papers & Presentations

Oh No! Mr. Bill and Billy

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Discussion

The southwest area of the Moon near sunrise provides many treats for the lunar observer. Along with the stunning Gassendi in Mare Humorum is the flooded crater Letronne, just to the north of Gassendi in Oceanus Procellarum. Looking similar to both Gassendi and Fracastorius in Mare Nectaris, Letronne, named after the French archeologist Jean Antoine Letronne who lived from 1787 to 1848, is a semicircular relief feature 116 km across. Like the aforementioned craters, Letronne is an example of subsidence with its northern, seaward limb completely covered by lava. On the floor of Letronne are three small mountain peaks, all that remains of the central mountain. Northwest of these peaks lies a craterlet surrounded by a bright halo. Letronne B, with a diameter of 5 km, also sports a bright halo near the inner eastern wall of Letronne. On the western wall of the flooded crater Letronne is an even more flooded crater, Winthrop, with a diameter of 17 km. This was named for John Winthrop, the American astronomer who lived from 1714 to 1779.

Perhaps most eye-catching feature in this area is the crater duo of Hansteen and Billy. Billy is the really easy one to see, at 45 km diameter and with a smooth, dark floor. Named for Jacques de Billy, the French Jesuit mathematician and astronomer who lived from 1602 to 1679, it has a small bright impact on its southwest floor that contrasts well with its dark floor.

Northwest of Billy lies Hansteen, a 44 km wide crater with a rough floor, concentric ridges and cracks that signify that this is a floor-fractured crater. Just west of Hansteen lies Rima Hansteen with a length of 25 km and width up to 3 km. Hansteen was named after Christopher Hansteen, a Norwegian geophysicist who lived from 1784 to 1873. Both Hansteen and Billy are around the same age, formed in the Upper Imbrian epoch, 3.75 to 3.2 billion years ago.

Both show features related to volcanic activity. Billy's lava deposits likely welled up from beneath its interior while the fractured appearance of Hansteen is due to the same structural occurrence that did not quite reach the surface. Hansteen may well have been another Billy, but its impact was on slightly higher ground, leaving a 200 meter difference in height between each of the floors. Besides the floor-fractured surface of Hansteen there is also a lava deposit on its northeast floor and an odd cleft on its north end. Maybe this was a gap that allowed some lava flows from Oceanus Procellarum to enter Hansteen.

Lying between Hansteen and Billy to the east is Mons Hansteen, an isolated mountain that is triangular in shape, roughly 30 by 30 km. This mountain is a bright volcanic mass that contains more silica than in surrounding mare lavas. As such, its origin is unknown.

Named after John Flamsteed, the first Astronomer Royal who lived from 1646 to 1719, the namesake crater is 20 km across. In Oceanus Procellarum to the northeast of Billy, Flamsteed is Eratosthenian in age, 3.15 to 1.1 billion years old. It lies in an area of high titanium basaltic lava flows that flooded the region, but did not spill into the crater's interior. Most notable, Flamsteed lies near the southern section of the much larger ghost crater Flamsteed P, a partially breached ring 110 km across. It is an old impact crater that was long ago submerged by lavas when Oceanus Procellarum was flooded. Back on 02 June 1966, Surveyor I landed near the inner northeast crater wall, ultimately sending back more than 11,000 images of the lunar surface. Nowhere do the walls of Flamsteed P rise more than 350 m above the Procellarum plains, and in some places, they rise only 50 m. It is easiest to see with full illumination.

Also, inside Flamsteed P are the craters Flamsteed D (6 km) and K (4 km). Altogether, it looks like a big shocked face looking back at us. I believe it was ALPO Solar Section Coordinator and very active lunar observer Rik Hill who said it reminded him of the Saturday

Online Readers

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

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

Observing Scales

Standard ALPO Scale of Intensity:

0.0 = Completely black
10.0 = Very brightest features

Intermediate values are assigned along the scale to account for observed intensity of features

ALPO Scale of Seeing Conditions:

0 = Worst
10 = Perfect

IAU directions are used in all instances.

Night Live character "Mr. Bill." Ever since I read that comment some time ago, that is what I see.

While you ponder whether or not Flamsteed P resembles a shocked face, it is worth considering the ages that are seen here. According to crater counts done by Schultz and Spudis, there are three areas of the southern Oceanus Procellarum that have mare patches of lava that are as young as the ray-covering lavas near Lichtenberg. These young patches are on the western floor of Letronne, inside the ring of Flamsteed P and just northeast of the Flamsteed ring. These lavas flowed about 1 billion years ago.

References

Chu, Alan, Wolfgang Paech, Mario Wigand & Storm Dunlop. 2012. The Cambridge Photographic Moon Atlas. Cambridge University Press, New York.

Kitt, Michael T. 1992. The Moon: An Observing Guide for Backyard Telescopes. Kalmbach Books, Waukesha.

Moore, John. 2014. Craters of the Near Side of the Moon.

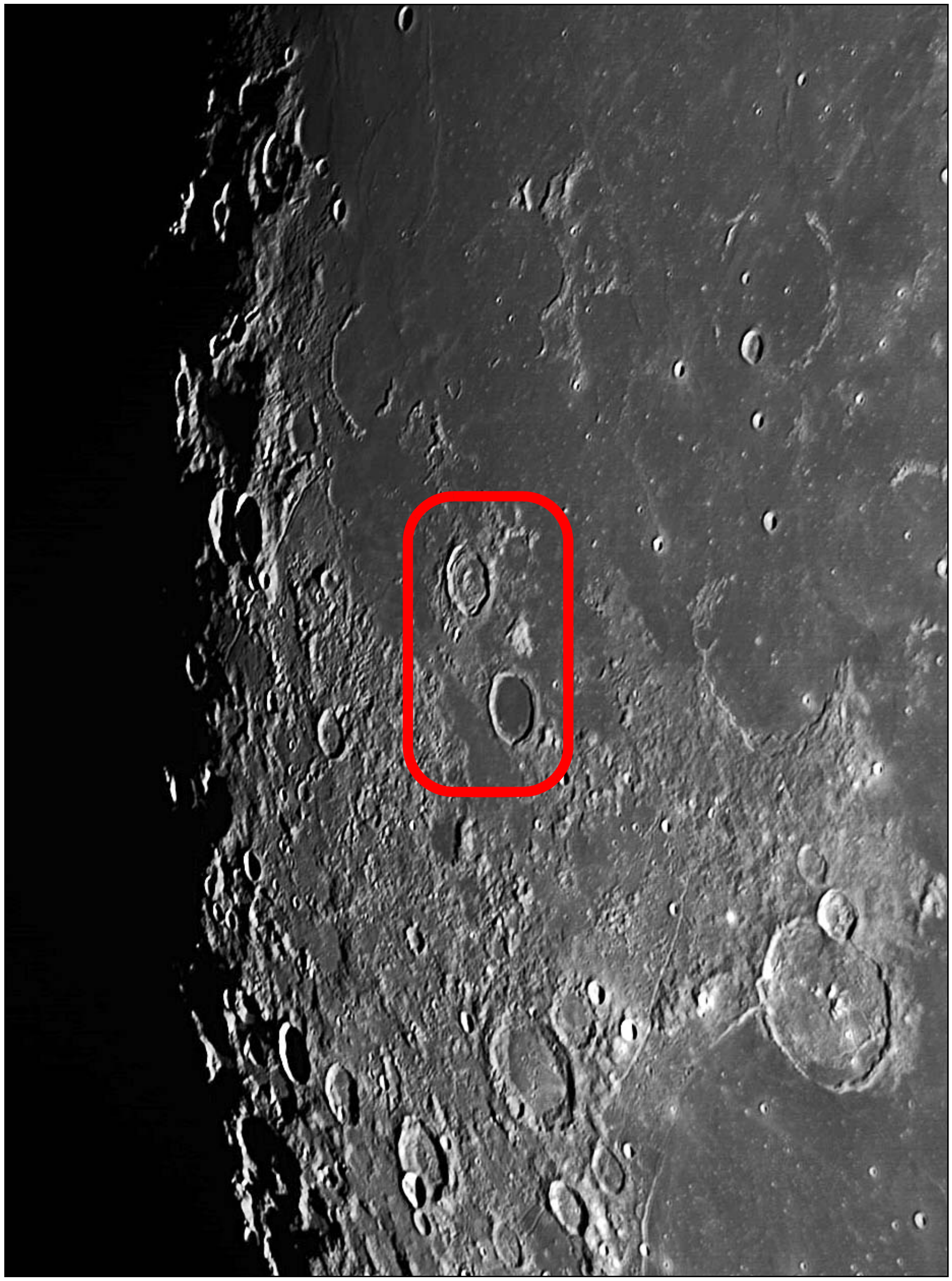
Planck, Andrew. 2015. What's Hot on the Moon Tonight? Moonscape Publishing LLC.

Rükl, Antonin: Atlas of the Moon, Kalmbach Books, 1990.

Wlasuk, Peter. 2000. Observing the Moon, Springer

Wood, Charles. 2003. The Moon: A Personal View. Sky Publishing Corp. Cambridge.

Wood, Charles & Maurice Collins. 2012. 21st Century Atlas of the Moon. Lunar Publishing, UIAI Inc., Wheeling, WV.



Hansteen and Billy, David Teske, Louisville, Mississippi, USA, 10 November 2019 at 0200 UT, colongitude 61.1°. Seeing 7/10, 180 mm Takahashi Mewlon, ZWOASI120mms, 500 frames, Firecapture, Registax, Photoshop. Seeing 7/10.

Papers & Presentations:

ALPO Observations of Saturn During the 2015 - 2016 Apparition

By Julius L. Benton, Jr.,
Coordinator, ALPO Saturn Section
jlbaina@msn.com

This paper includes a gallery of Saturn images submitted by a number of observers.

Please note that when a visual observer records or suspects a specific feature on Saturn, it is important to secure future observations quickly if we wish to obtain the period of rotation. For this purpose we encourage observers to use these facts: In System I (EZ plus NEB or SEB), 7 rotations are accomplished in close to 3 Earth-days, while in System II (rest of planet), 9 rotations require close to 4 such days.

A complete set of Saturn Observing Forms are available for downloading at http://www.alpo-astronomy.org/publications/ALPO Section Publications/SaturnReportForms - All.pdf

See the *ALPO Observing Section Publications* in the ALPO Resources section of this Journal for hardcopy availability.

Abstract

The ALPO Saturn Section received 256 visual observations and digital images for the 2015-16 apparition spanning the period from January 12, 2016 through October 23, 2016.

Observations were submitted by 24 observers in Australia, Brazil, Colombia, France, Greece, Philippines, South Africa, Slovenia, the United Kingdom, and the United States.

Instruments utilized for the observations ranged in aperture from 9.0 cm (3.5 in.) up to 106.0 cm (41.7 in.). Imaging during 2015-16 revealed a considerable amount of discrete activity within Saturn's northern hemisphere. Features included very sporadic small bright spots within the North Tropical Zone (NTrZ), the North Temperate Zone (NTeZ), and occasional white ovals and small dark spots the North

All Readers

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

Online Features

Left-click your mouse on:

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

Observing Scales

Standard ALPO Scale of Intensity:
0.0 = Completely black
10.0 = Very brightest features
Intermediate values are assigned along the scale to account for observed intensity of features
Ring B has been adopted (for most apparitions) as the standard on the numerical sequence. The outer third is the brightest part of Ring B, and it has been assigned a constant intensity of 8.0 in integrated light (no filter). All other features on the globe and in the rings are estimated using this standard of reference.

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

Scale of Transparency Conditions:
Magnitude of the faintest star visible near Saturn when allowing for daylight and twilight

IAU directions are used in all instances (so that Saturn rotates from west to east).

Table 1. Geocentric Phenomena in Universal Time (UT) for Saturn During the 2015-16 Apparition

Conjunction		2015	Nov	30^d
Opposition		2016	May	03^d
Conjunction			Nov	10^d
Opposition Data				
Visual Magnitude		0.0		
Constellation		Opiuchus		
Declination		-20.6º		
B		+25.9		
B'		+26.2º		
Globe	Equatorial Diameter	18.4″		
	Polar Diameter	16.4″		
Rings	Major Axis	41.6″		
	Minor Axis	18.2″		

Table 2. 2015-16 Apparition of Saturn: Contributing Observers

Tabl	Table Observer	Table Location	Table No. of Observations	Table Telescopes Used
1.	Abel, Paul G.Å	Leichester, UK	1 1 1	24.2 cm (9.5 in.) REF 31.5 cm (12.0 in.) REF 50.8 cm (20.0 in.) DAL
2.	Barry, Trevor	Broken Hill, Australia	35	40.8 cm (16.0 in.) NEW
3.	Benton, Julius L.	Wilmington Island, GA	2 3 12 3 2	12.7 cm (5.0 in.) MAK 14.0 cm (5.5 in.) REF 15.0 cm (5.9 in.) REF 18.0 cm (7.1 in.) MAK 18.0 cm (7.1 in.) MAK
4.	da Silva, Vlamir	San Paolo, Brazil	19	20.3 cm (8.0 in.) SCT
5.	Delcroix, Marc	Tournefeuille, France	8 3	32.0 cm (12.6 in.) NEW 106.0 cm (41.7 in.) CAS
6.	Foster, Clyde	Centurion, South Africa	6	35.6 cm (14.0 in.) SCT
7.	Go, Christopher	Cebu City, Philippines	10	35.6 cm (14.0 in.) SCT
8.	Hill, Rik	Tucson, AZ	1 23	9.0 cm (3.5 in.) MAK 20.3 cm (8.0 in.) MAK
9.	Hood, Mike	Kathleen, GA	2 2	20.3 cm (8.0 in.) REF 35.6 cm (14.0 in.) SCT
10.	Kardasis, Manos	Athens, Greece	5	35.6 cm (14.0 in.) SCT
11.	Maxson, Paul	Phoenix, AZ	52 9	25.0 cm (8.8 in.) DAL 31.5 cm (12.4 in.) DAL
12.	Melillo, Frank J.	Holtsville, NY	5	25.4 cm (10.0 in.) REF
13.	Melka, Jim	St. Louis, MO	1	45.0 cm (17.7 in.) NEW
14.	Peach, Damian	Norfolk, UK	16	35.6 cm (14.0 in.) SCT
15.	Phillips, Jim	Charleston, SC	1	25.4 cm (10.0 in.) REF
16.	Phillips, Michael	Swift Creek, NC	1	35.6 cm (14.0 in.) SCT
17.	Plante, Phil	Braceville, OH	2	15.2 cm (6.0 in.) NEW
18.	Rome, Joseph	Austin, TX	1	28.0 cm (11.0 in.) SCT
18.	Rosolina, Michael	Friars Hill, WV	3	35.6 cm (14.0 in.) SCT
20.	Smrekar, Matic	Luibliana, Slovenia	1	30.5 cm (12.0 in.) NEW
21.	Sweetman, Michael E.	Tucson, AZ	15	12.7cm (5.0 in.) REF
22.	Triana, Charles	Bogota, Colombia	4	25.4 cm (10.0 in.) SCT
23.	Walker, Gary	Macon, GA	4	25.4 cm (10.0 in.) REF
24.	Wesley, Anthony	Murrumbateman, Australia	13	36.8 cm (14.5 in.) NEW
	TOTAL OBSERVATIONS		**256**	
	TOTAL OBSERVERS		**24**	

Instrumentation Abbreviations:
NEW = Newtonian, SCT = Schmidt-Cassegrain, MAK= Maksutov-Cassegrain, REF = Refractor,
DALL = Dall-Kirkham, CAS = Cassegrain

Equatorial Belt, northern edge (NEBn).

Similar features were imaged in the North North Temperate Zone NNTeZ) and North North North Temperate Belt (NNTeB) during the observing season.

Recurring white spots were captured on digital images during 2015-16 in the (Equatorial Zone, northern half (EZn), as well as apparent short-lived white areas in the Equatorial Zone, southern half (EZs). A somewhat persistent dark condensation or spot, along with a closely associated white area at the same saturnigraphic latitude, was imaged at various wavelengths in the North North North Temperate Belt (NNNTeB).

The extraordinary hexagonal feature at Saturn's North Pole has been of continuing interest and amateurs routinely imaged it at different wavelengths.

Views of the major ring components, including Cassini's and Encke's divisions, were very favorable this apparition due to the increased inclination of Saturn's rings toward Earth since the immediately preceding 2014-15 apparition.

ALPO Saturn Section's dedicated team of visual observers and those who routinely imaged the planet at various wavelengths continued active participation in our Pro-Am efforts in support of the NASA Cassini mission.

The tilt of Saturn's ring system toward Earth, B, attained a

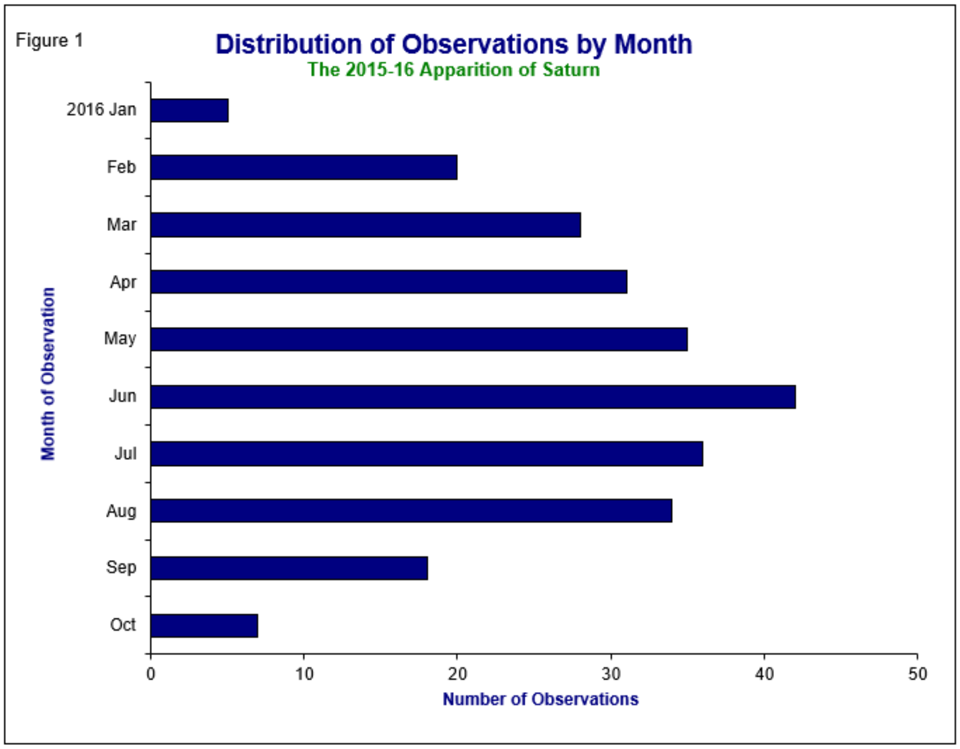


Figure 1. Number of observations by month during the 2015-16 Apparition of Saturn, opposition occurring on May 3, 2016 submitted to the ALPO Saturn Section.

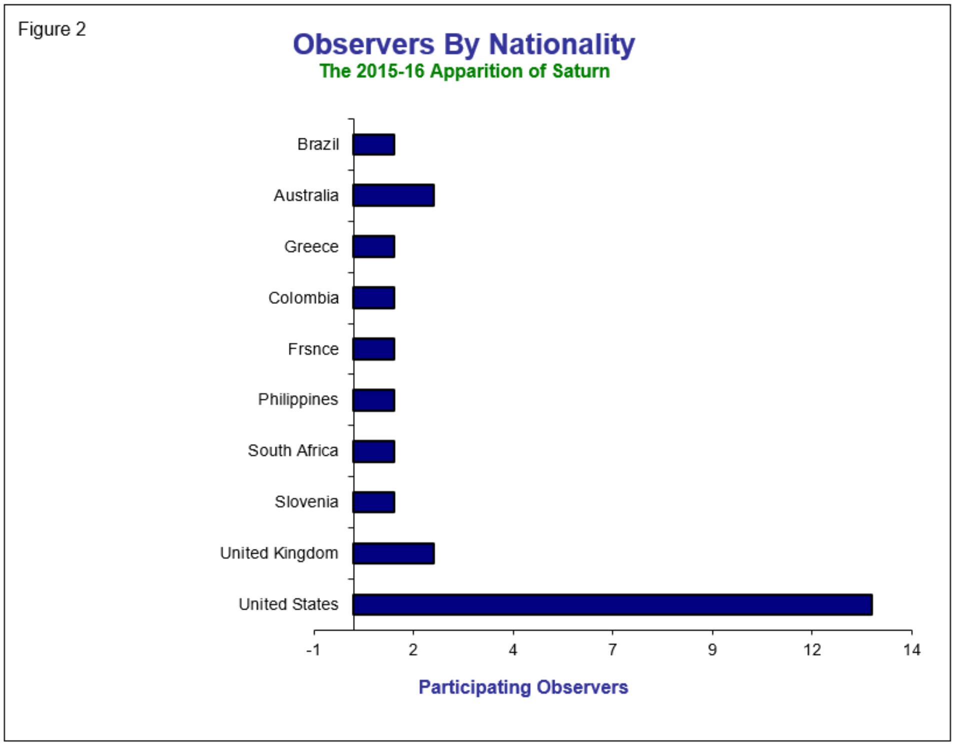


Figure 2. Number of observers by nationality during the 2015-16 Apparition of Saturn, submitted to the ALPO Saturn Section.

maximum value of +26.758° on December 6, 2016, affording observers advantageous views during the apparition of the northern Hemisphere of the globe and northern face of the rings.

A summary of visual observations and digital images of Saturn contributed during the 2015-16 apparition are discussed, including results of determined efforts to try to image the curious bi-colored aspect and azimuthal brightness asymmetries of the rings.

Accompanying the report are references, drawings, photographs, digital images, graphs, and tables.

Introduction

This report is derived from an examination of 256 visual observations, descriptive notes, visual numerical relative intensity estimates, and digital images contributed to the ALPO Saturn Section by 24 observers from January 12, 2016 through October 23, 2016, referred to hereinafter as the 2015-16 "observing season" or apparition of Saturn. Examples of submitted drawings and images are included with this report, integrated as much as feasible with topics discussed in the text, with times and dates all given in Universal Time (UT).

Table 1 provides geocentric data in Universal Time (UT) for the 2015-16 apparition. The numerical value of **B**, or the Saturnicentric latitude of the Earth referred to the ring plane (when north), ranged between the extremes of +25.962° (July 19, 2016) and +26.758° (December 6, 2016). The value of **B'**, the saturnicentric latitude of the Sun, varied from +25.765° (January 13, 2016) to +26.568° (October 23, 2016).

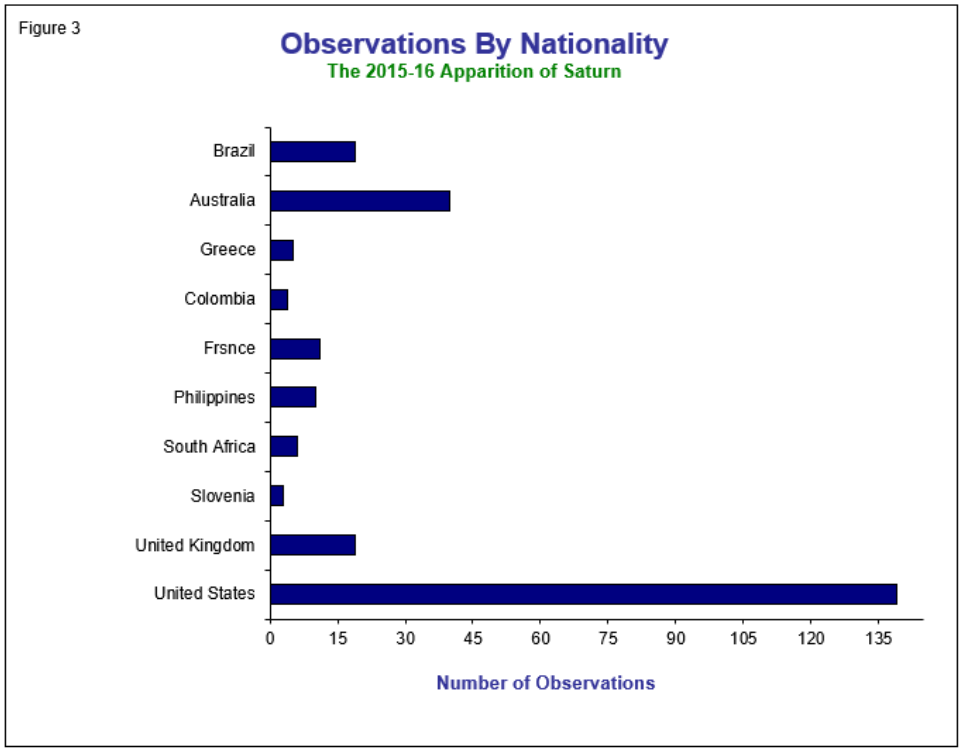


Figure 3. Number of observations by nationality during the 2015-16 Apparition of Saturn, submitted to the ALPO Saturn Section.

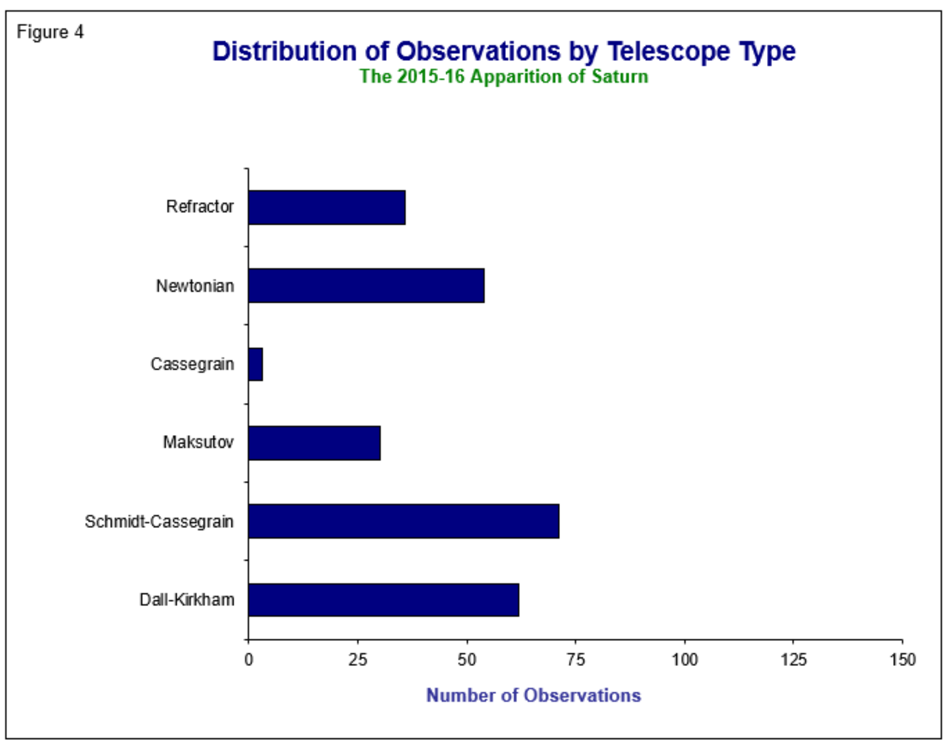


Figure 4. Number of observations grouped by optical type of telescope during the 2015-16 Apparition of Saturn, submitted to the ALPO Saturn Section.

Table 3. Visual Numerical Relative Intensity Estimates and Colors for the 2015-16 Apparition of Saturn

Table Globe/Ring Feature	Table # Estimates	Table 2015-16 Mean Intensity & Standard Error	Table Intensity Difference Table Since 2014-15	Table Average Table Estimated Color
Zones:				
EZn	13	7.38 ± 0.06	-0.02	Bright Yellowish-White
NPR	12	3.81 ± 0.09	-0.04	Very Dull Gray
NPC	7	2.00 ± 0.39	-2.00	Dark Gray
Globe N of Rings	35	5.11 ± 0.11	+0.50	Light Yellowish-Gray
NNTeZ	1	7.00 ± 0.00	------	Yellowish-White
NTeZ	3	6.33 ± 0.27	------	Yellowish-White
NTrZ	1	5.00 ± 0.00	------	Dull Yellowish-Gray
Belts:				
EB	1	5.00 ± 0.00	------	Very Light Brown
NEBw (whole)	32	3.55 ± 0.33	+0.06	Dull Yellowish-Brown
NEBn	9	3.49 ± 0.21	------	Dull Yellowish-Brown
NEBs	10	3.42 ± 0.13	------	Dull Yellowish-Brown
Rings:				
A (whole)	32	5.14 ± 0.14	-0.90	Dull Grayish-White
A (Outer Half)	3	5.37 ± 0.14	------	Dull Grayish-White
A (Inner Half)	3	5.57 ± 0.07	------	Dull Grayish-White
Encke's (A5)	3	0.67 ± 0.14	+0.70	Grayish-Black
Cassini's (A0 or B10)	21	0.14 ± 0.06	+0.10	Black
B (outer 1/3)	36	8.00 ± 0.00 **STD**	0.00	Brilliant White
B (inner 2/3)	30	7.05 ± 0.04	+1.00	Yellowish-White
Ring C (ansae)	30	1.51 ± 0.09	+0.20	Very Dark Gray
Crape Band	21	2.02 ± 0.08	0.00	Very Dull Gray
Sh G on R	20	0.00 ± 0.00	-0.10	Black shadow

Notes:
For nomenclature, see text and Figure 5. A letter with a digit (e.g. A0 or B10) refers to a location in the ring specified in terms of units of tenths of the distance from the inner edge to the outer edge. Visual numerical relative intensity estimates (visual surface photometry) are based upon the ALPO Intensity Scale, where 0.0 denotes complete black (shadow) and 10.0 refers to the most brilliant condition (very brightest Solar System objects). The adopted scale for Saturn uses a reference standard of 8.0 for the outer third of Ring B, which appears to remain stable in intensity for most ring inclinations. All other features on the Globe or in the rings are compared systematically using this scale, described in the Saturn Handbook, which is issued by the ALPO Saturn Section. The "Intensity Difference Since 2014-15" is in the same sense of the 2014-15 value subtracted from the 2015-16 value, "+" denoting an increase (brightening) and "-" indicating a decrease (darkening). When the apparent change is less than about 3 times the standard error, it is probably not statistically significant.

Table 2 lists the 24 individuals who sent 256 reports to the ALPO Saturn Section this apparition, including their observing sites, number of observations, telescope apertures, and type of instrument. Figure 1 is a histogram of the distribution of observations by month whereby 48.0% were made prior to opposition, 1.2% at opposition (June 3, 2016), and 50.8% thereafter.

Although many observers view Saturn most frequently at or near opposition, when the planet is well placed high in the evening sky, coverage favored a wider period of time on either side of opposition during the 2015-16 apparition (88.3% of all observations took place from early February through late August 2016). To achieve the best overall coverage, observers are urged to

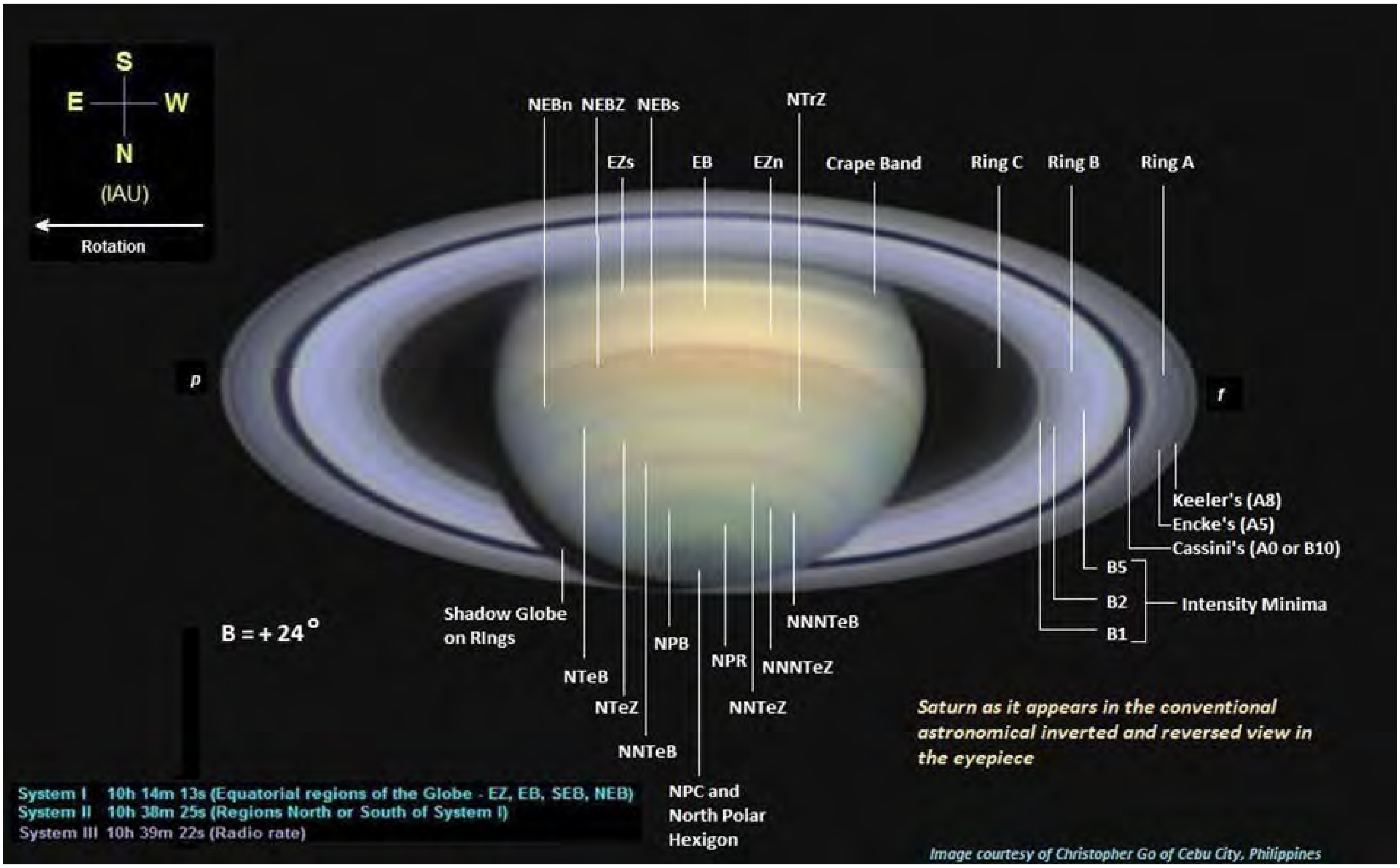


Figure 5. Saturn nomenclature, where A = Ring A, B = Band or Ring B or saturnicentric latitude of Earth, C = Ring C or Cap, E = Equatorial, f = following (celestial east), G = Globe, n = north component, N = North, p = preceding (celestial west), P = Polar, R = Ring(s) or Region, s = south component, S = South, Te = Temperate, Tr = Tropical, Z = Zone. The ring Ansae (not labeled) are the easternmost and westernmost protrusions of the Ring System. Note that "Gap" is also called "Division" or "Complex."z South is at the top in this inverted view, similar to the orientation seen through an inverting telescope in Earth's Northern Hemisphere.

begin viewing and imaging Saturn as soon as the planet becomes visible in the eastern sky before sunrise after conjunction with the Sun.

The objective is to keep up a well-balanced observational surveillance of the planet for as much of its mean synodic period of 378d as possible (this period refers to the elapsed time from one conjunction of Saturn with the Sun to the next, which is slightly longer than a terrestrial year).

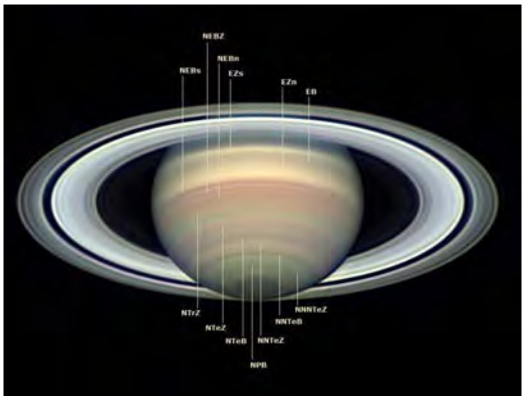
Figure 2 and *Figure 3* show the ALPO Saturn Section observer base and the international distribution of all observations submitted during the 2015-16 apparition. The United States accounted for 54.2% of the participating observers and 54.3% of the submitted observations. With 45.8% of all observers residing in Australia, Brazil, Colombia, France, Greece, Italy, New Zealand, Philippines, South Africa, Slovenia, and United Kingdom, whose total contributions represented 45.7% of the observations, international cooperation remained excellent this observing season.

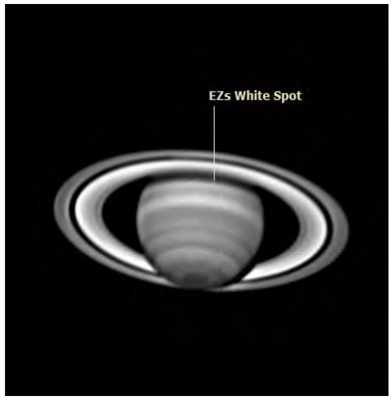
Figure 4 graphs the number of observations by instrument type in 2015-16. Slightly more than one-third (37.1%) of all observations were made with telescopes of classical design (refractors and Newtonians), while the remaining 62.9% were completed with catadioptrics (Schmidt-Cassegrains, Maksutov-Cassegrains, and Dall-Kirkhams).

Telescopes with apertures ranging from 9.0 cm (3.5 in.) through 106.0 cm (41.7 in.) were utilized for recording observations this apparition. Readers are reminded, however, that there are numerous past instances where smaller instruments of good quality have been successfully utilized for many of our Saturn observing programs.

The ALPO Saturn Section truly appreciates all of the digital images, visual drawings, descriptive reports, and supporting data submitted by observers listed in *Table 2* for the 2015-16

General Caption Note for Illustrations 1-37. *B = saturnicentric latitude of the Earth; B' = saturnicentric latitude of the Sun; CMI, CMII and CMIII = central meridians in longitude Systems I, II and III; IL = integrated light; S = Seeing on the Standard ALPO Scale (from 0 = worst to 10 = perfect); Tr = Transparency (the limiting naked-eye stellar magnitude). Telescope types as in Table 2; feature abbreviations are as in Figure 5. In all figures, south is at the top and IAU east is to the left.*





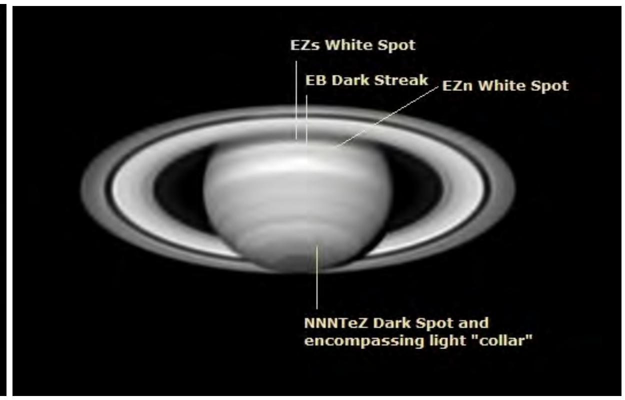


Illustration 001. 2016 April 20 03:00UT. Digital image by Clyde Foster. 35.6 cm (14.0 in.) SCT with RGB filters. S and Tr not specified. CMI = 202.4°, CMII = 19.6°, CMIII = 333.1°, B = +26.2°, B´ = +26.1° yellowish-white EZs visible northward of the where the rings traversed the globe of Saturn displaying a EZs white spot. Various belts, including the grayish-brown NTeB, as well as several brighter zones of Saturn's northern hemisphere are also visible in this excellent image.

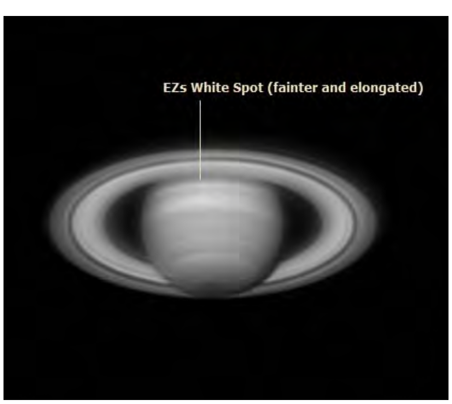
Illustration 002. 2016 February 18 18:38UT. Digital image by Trevor Barry. 40.8 cm (16.0 in.) NEW using a 685nm IR filter. S=6.0, Tr not specified. CMI = 241.7°, CMII = 240.7°, CMIII = 268.2°, B = +26.3°, B´ = +25.9°. Elongated EZs white spot is visible at -2.9 saturnigraphic latitude.

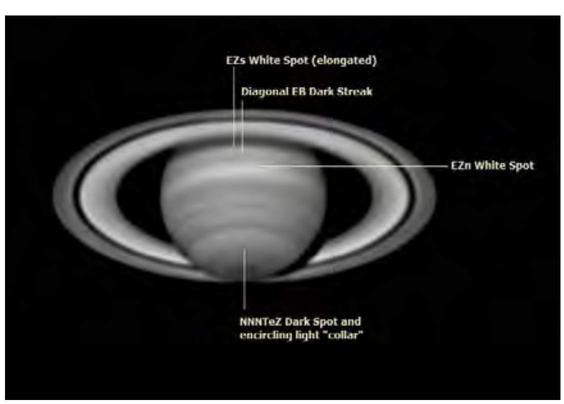
Illustration 003. 2016 February 29 18:56UT. Digital image by Trevor Barry. 40.8 cm (16.0 in.) NEW using a 685nm IR filter. S=6.0, Tr not specified. CMI = 140.9°, CMII = 74.8°, CMIII = 99.9°, B = +6.3°, B´ = +25.9°. Elongated EZs white spot at approximately -5.4 saturnigraphic latitude is shown approaching the CM.

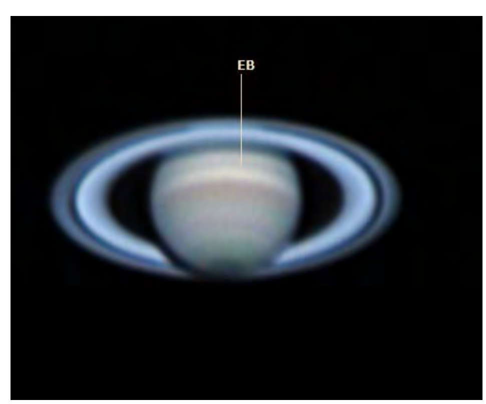
Illustration 004. 2016 March 18 09:08UT. Digital image by Damian Peach. 35.6 cm (14.0-in.) SCT with RGB filters. S and Tr not specified. CMI = 273.4°, CMII = 68.3°, CMIII = 61.4°, B = +26.3°, B´ = +26.0°. A somewhat more diffuse elongated EZs white spot is depicted close to the CM. Farther to the north in this image is an NTeZ white streak.

Illustration 005. 2016 March 27 07:56UT. Digital image by Damian Peach. 35.6 cm (14.0 in.) SCT with RGB filters. S and Tr not specified. CMI = 270.5°, CMII = 136.4°, CMIII =118.6°, B = +26.2°, B´ = +26.0°. The slightly diffuse and extended EZs white spot is obvious well to the west of the CM. Additionally, NTrZ and NTeZ white spots are visible in this excellent image.

Illustration 006. 2016 April 23 19:14UT. Digital image by Christopher Go. 35.6 cm (14.0 in.) SCT using RGB filters. S = 8.0, Tr = 4.0. CMI = 74.9°, CMII = 146.8°, CMIII = 96.4°, B = +26.2°, B´ = +26.1°. The diffuse EZs white spot is easily seen in this highly detailed image, showing numerous belts and zones in Saturn's northern hemisphere, including a few white spots within the NTrZ, an NTeB white spot. The NPB is discernable.

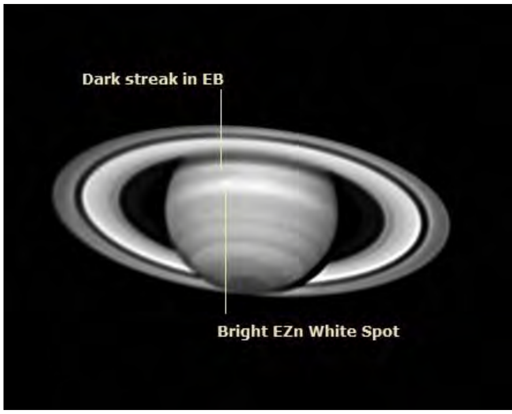


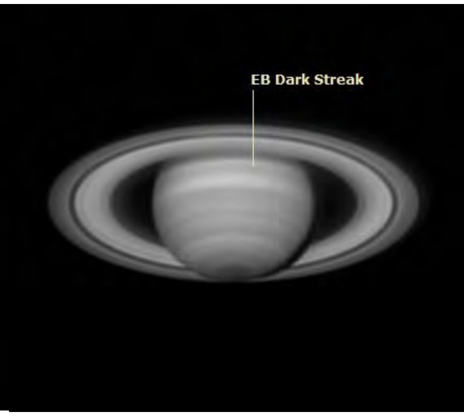




apparition. Without this dedicated teamwork, this report would not have been possible. Those wishing to join us in our various Saturn observing programs using visual methods in the form of drawings, estimates of visual numerical relative intensity, latitude estimates, and Central Meridian (CM) transit timings, as well as performing routine digital imaging, are encouraged to do so in upcoming observing seasons.

The domestic and international flavor of our observational work is most encouraging and valuable, and we strive to maintain participation by observers everywhere. All methods of recording observations are crucial to the success of our programs, whether one's preference is sketching Saturn at the eyepiece or simply writing descriptive reports, making visual numerical relative intensity and latitude estimates, or pursuing systematic digital imaging.





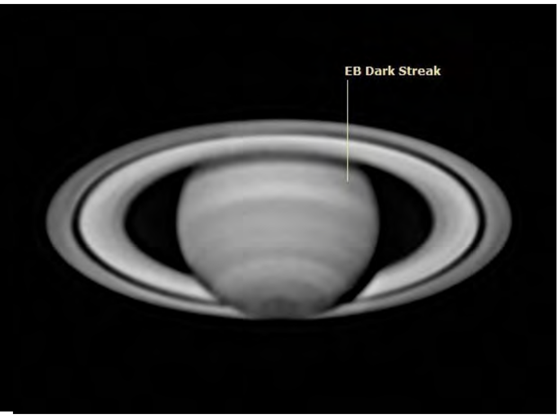


Illustration 007. 2015 July 02 11:54UT. Digital image by Anthony Wesley. 36.8 cm (14.5 in.) NEW at 685nm IR. S and Tr not specified. CMI = 114.6°, CMII = 23.7°, CMIII = 330.1°, B = +24.07°, B´ = +24.74°. A dark streak within the EB is depicted in this image along with a bright compact white spot in the EZn northward of the EB feature.

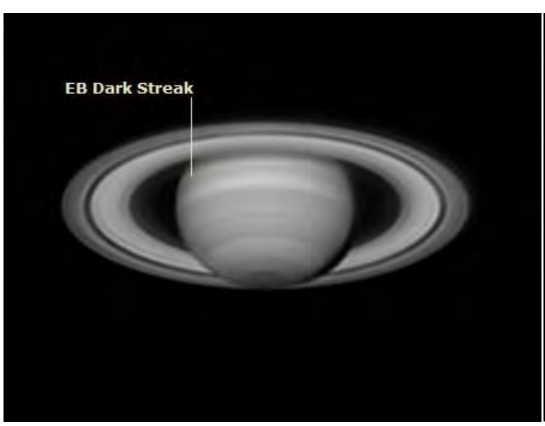
Illustration 008. 2015 July 27 12:09UT. Digital image by Trevor Barry. 40.6 cm (16.0 in.) NEW with 685nm IR filter. S = 5.5, Tr = not specified. CMI = 350.0°, CMII = 171.4°, CMIII = 87.6°, B = +24.03°, B´ = +24.87°. The fuzzy dark EB diagonal streak is approaching the CM.

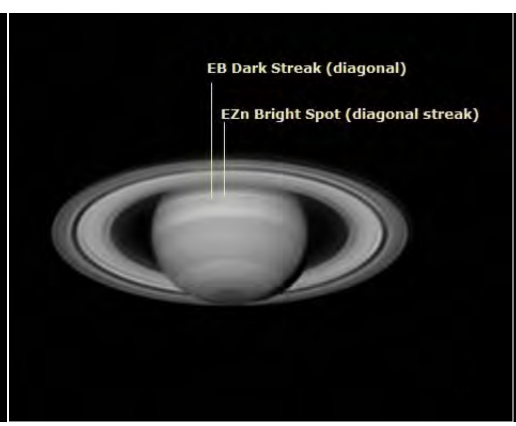
Illustration 009. 2015 August 14 17:29UT. Digital image by Clyde Foster. 35.6 cm (14.0 in.) SCT with 685nm IR filter. S = 7.0, Tr = 5.0. CMI = 253.5°, CMII = 206.3°, CMIII = 100.7°, B = +24.12°, B´ = +24.96°. The fuzzy dark EB diagonal streak is near the extreme West or following limb (f) of Saturn the CM.

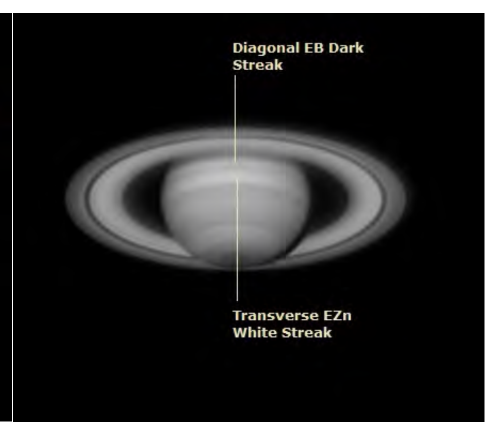
Illustration 010. 2015 August 17 09:51UT. Digital image by Trevor Barry. 40.6 cm (16.0 in.) NEW with 685nm IR filter. S = 5.5, Tr = not specified. CMI = 357.6°, CMII = 223.8°, CMIII = 114.9°, B = +24.14°, B´ = +24.98°. The EB dark elongation is about to rotate off the East or preceding (p) limb of the planet in this image.

Illustration 011. 2015 August 28 09:12UT. Digital image by Trevor Barry. 40.6 cm (16.0 in.) NEW with 685nm IR filter. S = 5.5, Tr = not specified. CMI = 260.8°, CMII = 132.6°, CMIII = 10.4°, B = +24.25°, B´ = +25.03°. This image depicts an interaction of the diagonal EB dark streak with a thin bright transverse elongated EZn white strip (apparently emanating from the EZn higher in Saturn's atmosphere) situated just to the West or following (f) side of the EB feature.

Illustration 012. 2015 September 25 09:30UT. Digital image by Trevor Barry. 40.6 cm (16.0 in.) NEW with 685nm IR filter. S = 5.5, Tr = not specified. CMI = 147.7°, CMII = 194.8°, CMIII = 38.9°, B = +24.66°, B´ = +25.16°. Both the diagonal EB dark streak and thin bright transverse EZn white strip are situated on the CM.







The ALPO Saturn Section especially emphasizes the ongoing need for more experienced observers to carry out regular visual numerical relative intensity estimates in integrated light and with standard color filters. Such estimates, which are simple to do, are greatly needed for maintaining our data to enable a recurring comparative analysis of belt, zone, and ring component brightness fluctuations over many apparitions. The ALPO Saturn Section is at all times happy to receive observations from novices, and the author is always delighted to offer assistance as one becomes acquainted with our programs.

All 256 observations submitted to the ALPO Saturn Section during 2015-16 were used to prepare this report. Drawings, digital images, tables, and graphs are included so readers can refer to them as they study the content of this report. As applicable, for drawings or images provided herein as examples of notable features or phenomena occurring within Saturn's belts and zones, contributors are identified in the text along with dates and times of those specific observations for easy reference back to the relevant tables that list instrumentation employed, seeing, transparency, CM data, and so forth. In addition, captions associated with illustrations provide useful information.

The numerical value of B (the Saturnicentric latitude of the Earth referred to the ring plane) attained a maximum value of +26.758° during the 2015-16 apparition. Opportunities for viewing the belts and zones and other phenomena of the planet's northern hemisphere have gradually improved each observing season with the Earth situated north of the rings as they continue to increase their tilt toward our line of sight with maximum orientation of $+27^{o}$ in 2017 (the time of summer solstice in Saturn's northern hemisphere). The rings primarily hid features of the southern hemisphere as they crossed in front of the globe.

Minor fluctuations in intensity of Saturn's atmospheric features (see *Table 3*) may be attributable to the varying inclination of the planet's rotational axis relative to the Earth and Sun, although photometric work in past years suggests that small oscillations of about ± 0.10 in the visual magnitude of Saturn likely happens over the span of a decade or so. Transient and longer-lasting atmospheric features seen or imaged in various belts and zones on the globe may also play a role in what appear to be subtle brightness variations.

Regular photoelectric photometry of Saturn, in conjunction with carefully executed visual numerical relative intensity estimates, is strongly encouraged. The intensity scale routinely employed by Saturn observers is the standard *ALPO Standard Numerical Relative Intensity Scale*, where 0.0 denotes a total black condition (e.g., complete black shadow) and 10.0 is the maximum brightness of a feature or phenomenon (e.g., an unusually bright EZ or dazzling white spot). This numerical scale is normalized by setting the outer third of Ring B at a “standard” intensity of 8.0. The arithmetic sign of an intensity change is determined by subtracting a feature's 2014-15 intensity from its 2015-16 value. Suspected variances of ± 0.10 mean intensity points are usually insignificant, while reported changes in intensity that do not equal or exceed roughly three times the standard error are probably not important.

It is important to evaluate contributed digital images of Saturn captured with different apertures using systematic filter techniques to understand the level of detail seen and how such phenomena compares with impressions by visual observers of the globe and rings. Moreover, it remains worthwhile to establish any correlation with spacecraft imaging and results from professional observatories.

In addition to routine visual studies, such as drawings and visual numerical relative intensity estimates, Saturn observers are asked to systematically image the planet every possible clear night, as applicable. This allows documentation of individual features on the globe and in the rings, their motion and morphology (including changes in intensity and hue), to facilitate comparisons with images taken by professional ground-based observatories and spacecraft monitoring Saturn at close range.

Furthermore, comparing images taken over several apparitions for a given hemisphere of the planet's globe provides information on long-term seasonal changes suspected by observers using visual numerical relative intensity estimates. Images and systematic visual observations by amateurs are being relied upon for providing initial alerts of interesting large-scale features on Saturn that professionals may not already know about but can subsequently examine with considerably larger and more specialized instrumentation.

Particles in Saturn's atmosphere reflect different wavelengths of light in very distinct ways, which causes some belts and zones to appear especially prominent, while others look very dark, so imaging the planet with a series of color filters may help shed light on the dynamics, structure, and composition of its atmosphere.

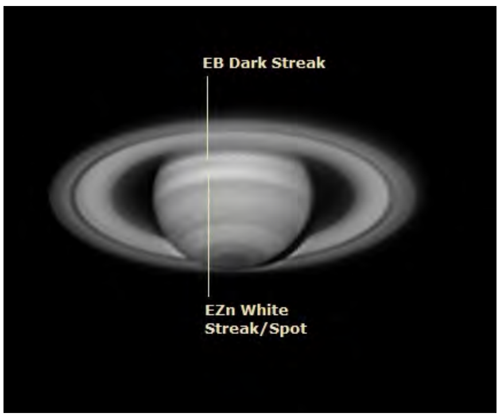
In the UV and IR regions of the electromagnetic spectrum, it is possible to determine additional properties as well as the sizes of aerosols present in different atmospheric layers not otherwise accessible at visual wavelengths, as well as useful data about the cloud-covered satellite Titan. UV wavelengths shorter than 320nm are effectively blocked by the Earth's stratospheric ozone (O_3), while CO_2 and H_2O-vapor molecules absorb in the IR region beyond 727nm. The human eye is insensitive to UV light short of 320nm and can detect only about 1.0% at 690nm and 0.01% at 750nm in the IR (beyond 750nm visual sensitivity is essentially zero).

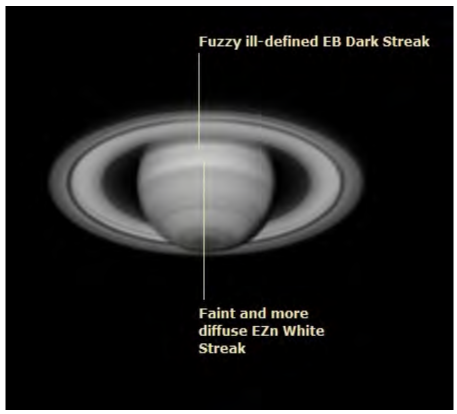
Although most of the reflected light from Saturn reaching terrestrial observers is in the form of visible light, some UV and IR wavelengths that lie on either side and in close proximity to the visual region penetrate to the Earth's surface, and imaging Saturn in these near-IR and near-UV bands has provided some remarkable results in the past. The effects of absorption and scattering of light by the planet's atmospheric gases and clouds at various heights and with different thicknesses are often evident. Indeed, such images sometimes show differential light absorption by particles with dissimilar hues intermixed with Saturn's white NH_3 clouds.

In the next few paragraphs, our discussion of features on Saturn's globe proceeds in the usual south-to-north order (traditional astronomical inverted and reversed view).

For clarity, the relative positions of major belts and zones can be identified by referring to the nomenclature diagram shown in *Figure 5*. If no reference is made to a global feature in this report, observers did not report the area during the 2015-16 apparition.

It has been customary in past Saturn apparition reports to compare the brightness and morphology of atmospheric features between observing seasons, and this practice continues with this report so readers are aware of very subtle, but nonetheless recognizable,





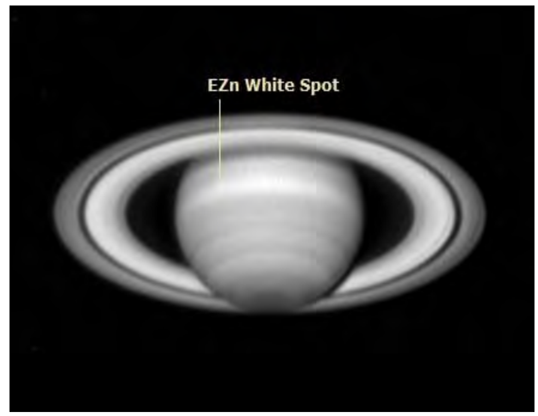


Illustration 013. 2016 October 23 09:27UT. Digital image by Trevor Barry. 40.6 cm (16.0 in.) NEW with Red filter. S = 5.0, Tr = not specified. CMI = 144.6°, CMII = 65.6°, CMIII = 154.5°, B = +26.5°, B´ = +26.6°. The EZn white spot is approaching the CM.

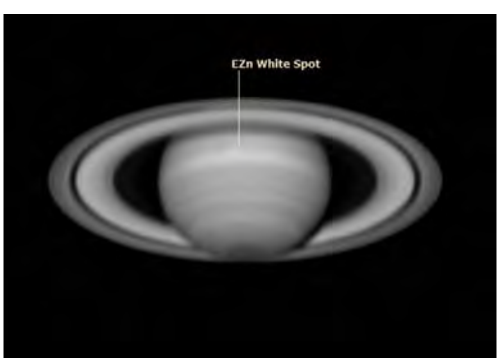
Illustration 014. 2016 April 12 04:17UT. Digital image by Vlamir da Silva. 20.3 cm (8.0 in.) SCT NEW with RGB filters. S (rated as average), Tr = not specified. CMI = 56.7°, CMII = 211.8°, CMIII = 70.4°, B = +26.0°, B´ = +26.3°. The yellowish-brown NEBw is quite apparent in this image.

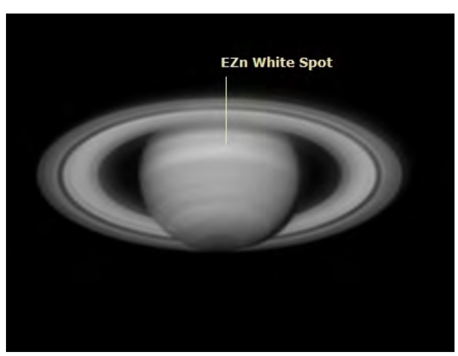
Illustration 015. 2016 June 28 12:56UT. Digital image by Trevor Barry. 40.6 cm (16.0 in.) NEW with RGB filters. S = 6.5, Tr = not specified. CMI = 134.5°, CMII = 229.6°, CMIII = 99.4°, B = +26.0°, B´ = +26.3°. The tiny, poorly defined NEBZ white spot is on the CM.

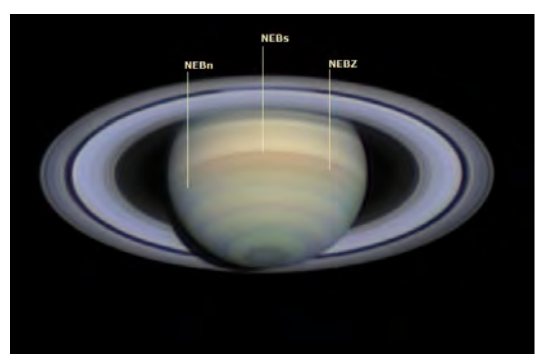
Illustration 016. 2016 August 08 03:05UT. Digital image by Paul Maxson. 25.4 cm (10.0 in.) REF with RGB filters. S=7.0 and Tr not specified. CMI = 203.7°, CMII = 67.8°, CMIII = 248.7°, B = +26.0°, B´ = +26.4°. The NEBZ white spot is located just to the E of the CM. The NNTeB is also labeled on the image.

Illustration 017. 2016 June 10 04 :22UT. Digital image by Damian Peach. 35.6 cm (14.0-in.) SCT with RGB filters. S and Tr not specified. CMI = 114.7°, CMII = 82.8°, CMIII = 334.7°, B = +26.00°, B´ = +26.3°. A small NEBn white spot is captured in this image.

Illustration 018. 2016 June 11 04:20UT. Digital image by Damian Peach. 35.6 cm (14.0-in.) SCT with a RGB filters. S and Tr not specified. CMI = 237.9°, CMII = 173.7°, CMIII = 64.4°, B = +26.00°, B´ = +26.3°. The NEBn white spot is depicted along with an NTeZ white spot. Father North is the nNNTeB dark spot with an encompassing white "collar" and displaying apparent interaction with the adjacent NNNTeZ.







variations that may be occurring seasonally on planet.

Saturn's Globe: The Southern Hemisphere

Saturn's southern hemisphere was obstructed from our view during 2015-16 where the rings crossed in front of those regions of the globe with the exception of the yellowish-white Equatorial Zone (EZs) appearing just south of the Equatorial Band (EB), but no visual numerical relative intensity estimates were submitted during the observing season.

Equatorial Zone—Southern Half (EZs). Higher resolution images revealed a portion of the yellowish-white Equatorial Zone (EZs) just northward of the where the rings traversed the globe of Saturn [refer to *Illustration No. 001*]. Visual observers provided descriptions of the EZs but regrettably provided no visual numerical relative intensity estimates during 2015-16.

The first report of discrete atmospheric phenomena associated with the EZs came from Trevor Barry who imaged an elongated white spot at saturnigraphic latitude -2.9° on February 18, 2016 from 18:39 UT to 19:11 UT using RGB, 685nm IR, and red filters; he, also imaged an EZs white spot between 18:27 UT an 19:27 UT at saturnigraphic latitude -5.4° on February 29, 2016 using a 685nmIR filter [refer to *Illustration Nos. 002 and 003*].

Damian Peach also imaged a small white spot at RGB wavelengths on March 18, 2016 at 09:08 UT, and he imaged it again on March 27, 2016 at 07:56 UT using the same RGB filters [refer to *Illustration Nos. 004 and 005*].

Nearly a month later, on April 23, 2016, Christopher Go reported what was presumably the same feature at 09:14 UTusing RGB filters [refer to *Illustration No. 006*], which was the last clear image of an EZs white spot received during 2015-16.

Saturn's Globe: The Northern Hemisphere

Equatorial Band (EB). Only one visual numerical relative intensity estimate of the very light brown Equatorial Band (EB) was submitted during 2015-16, and despite the single estimate, the belt was portrayed on several drawings in integrated light and noticeable on many of the digital images submitted during the observing season [refer to *Illustration Nos.008 and 009*]. Trevor Barry called attention to an EB dark spot on image captured on February 16, 2016 between 18:04 UT and 19:08 UT employing RGB, 685nm IR, and red filters [refer to *Illustration No. 010*]. Other than his image, there was no other activity reported in the EB during the 2-15-16 apparition.

Equatorial Zone—Northern Half (EZn). With the numerical value of **B** ranging between the extremes of +25.962° (July 19, 2016) and +26.758° (December 6, 2016), the northern half of the Equatorial Zone (EZn) was seen and imaged to best advantage in 2015-16. Based on limited visual numerical relative intensity estimates and numerous digital images, the bright yellowish-white Equatorial Zone (EZn) displayed no significant change in brightness since

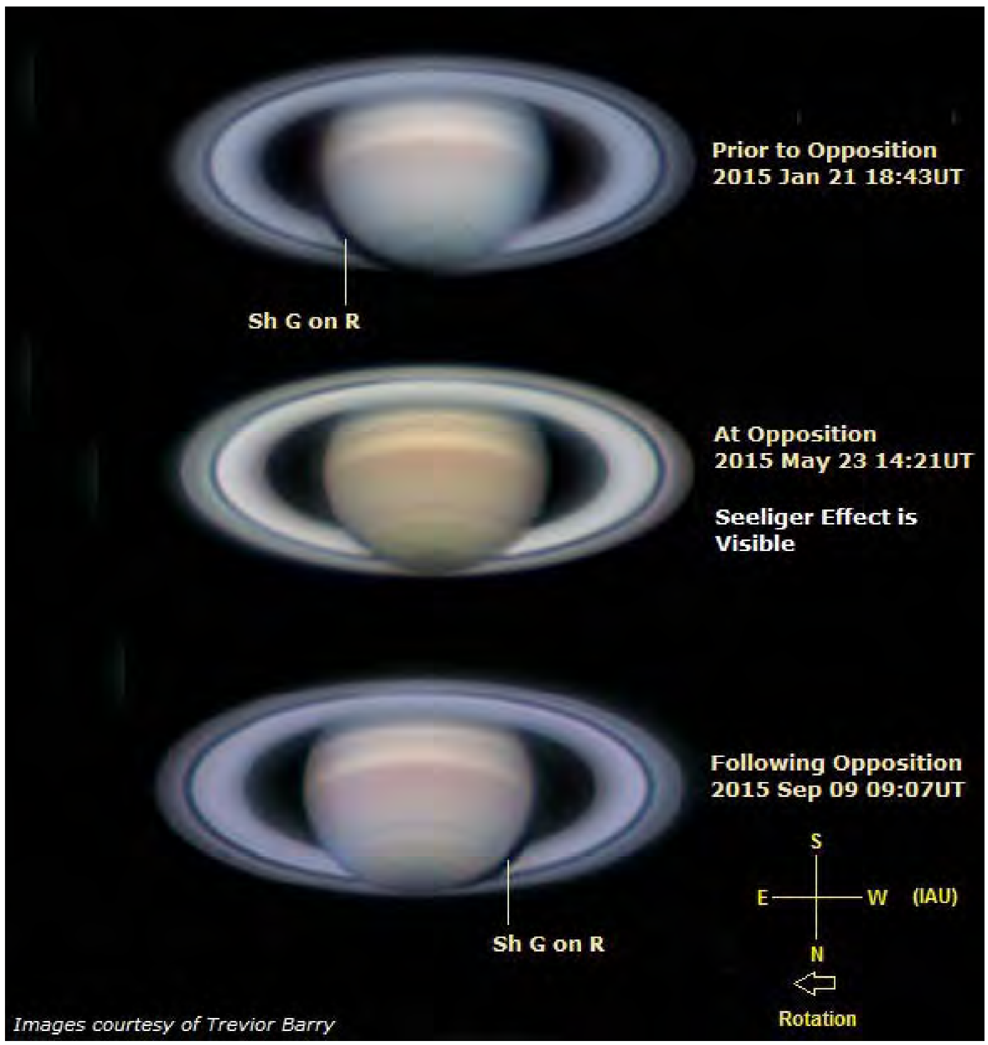


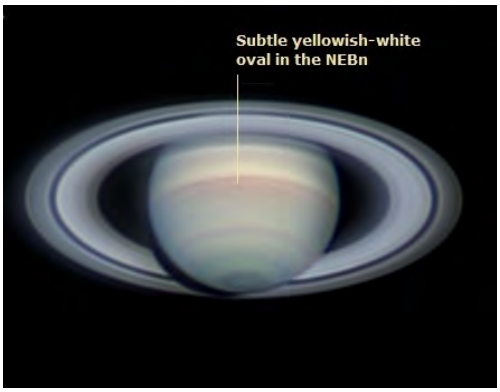
Figure 6. Three digital images furnished by three separate ALPO Saturn Section observers, namely Mike Hood on April 4, 2016 at 09:51UT(before opposition), Christopher Go on June 3, 2016 at 04:06UT (at opposition), and Marc Delcroix on August 8, 2016 at 21:01UT (after opposition).

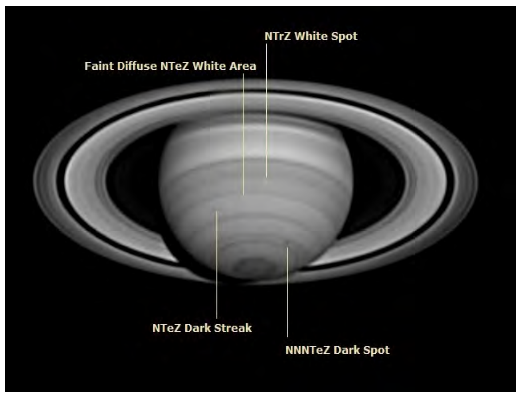
2014-15 (a mean intensity difference of only -0.20 is considered negligible), yet it was always the brightest zone on Saturn's globe in 2015-16.

The first report to the ALPO Saturn Section of a white spot in the EZn came from Trevor Barry on February 16,2016 from 18:04 UT to 19:08 UT at saturnigraphic latitude +8.7° using RGB, 685nm IR, and red filters [refer to *Illustration No. 010*]. Damian Peach also imaged a somewhat elongated white spot in the EZn on June 14, 2016 between 02:53 UT and 03:58 UT using RGB filters [refer to *Illustration No. 011*].

Trevor Barry submitted a digital image of a bright EZn feature situated at approximately +7.6° saturnigraphic latitude taken using RGB, 685nm IR, and The NEBw showed no significant change in appearance or intensity since 2014-15, and usually displayed a lighter-to-darker southward progression in intensity across its broad width, consistent also with its form on most digital images [refer to *Illustration No. 014*]. Most digital images in 2015-16 revealed a grayish-brown NEBs appearing generally narrower and darker than the slightly wider grayish-brown NEBn, sometimes with a barely perceptible narrow yellowish-gray NEBZ lying in between.

In terms of atmospheric activity associated with the NEB, Trevor Barry using 685nm IR bandpass, red and RGB





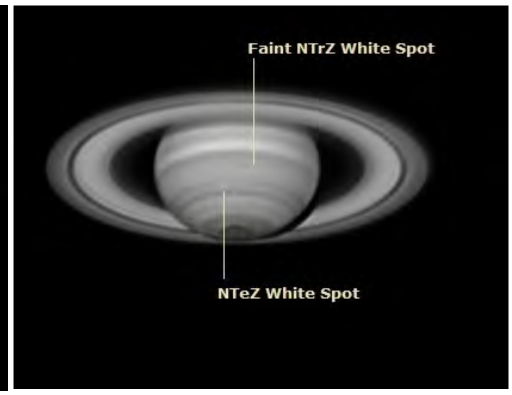


Illustration 019. 2016 June 15 04:03UT. Damian Peach. 35.6 cm (14.0 in.) SCT with RGB filters. S and Tr not specified. CMI = 5.4°, CMII = 172.4°, CMIII = 58.3°, B = +26.00°, B´ = +26.3°. A small NEBn white spot is captured in this image as well as the NTeZ White Spot, along with the EZn white streak and NNNTeB dark spot and adjacent white feature.

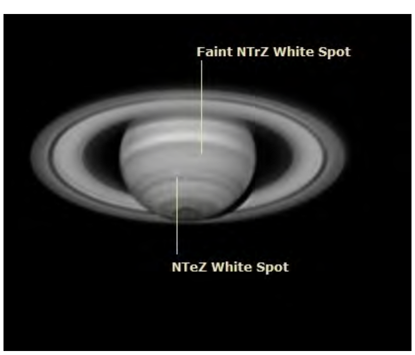
Illustration 020. 2016 June 15 1356UT. Digital image by Christopher Go. 35.6 cm (14.0 in.) SCT with RGB filters. S = 8.0, Tr = 4.5. CMI = 353.1°, CMII = 146.8°, CMIII = 32.2°, B = +24.26.0°, B´ = +26.3°. The yNEBn white spot and NTeZ can be seen in this high resolution image. Note that this image is a near-simultaneous observation to that of Damian Peach on the same date (see Illustration No. 019).

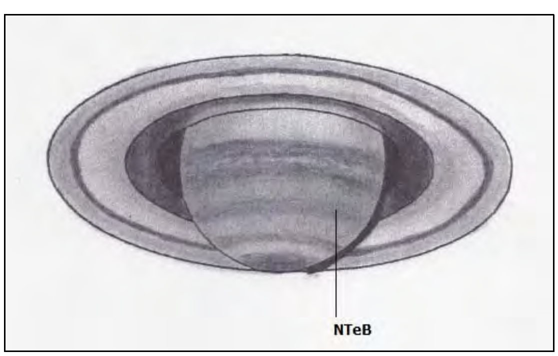
Illustration 021. 2016 June 17 03:42UT. Damian Peach. 35.6 cm (14.0 in.) SCT with RGB filters. S and Tr not specified. CMI = 5.4°, CMII = 172.4°, CMIII = 58.3°, B = +26.00°, B´ = +26.3°. The NEBZ white spot is depicted along with the NEBn and NNNTeB dark spot and nearby white area.

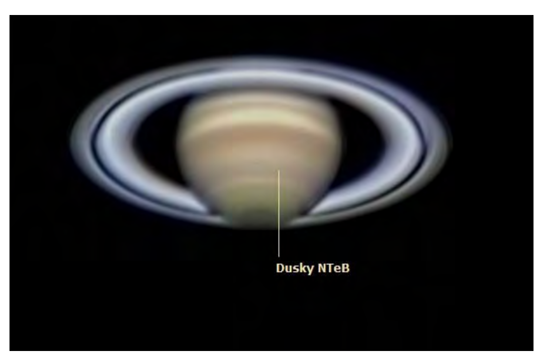
Illustration 022. 2016 July 15 11:45UT. Christopher Go. 35.6 cm (14.0 in.) SCT with RGB filters. S = 8.0, Tr = 4.5. CMI = 46.2°, CMII = 313.8 CMIII = 163.2°, B = +26.00°, B´ = +26.3°. The NEBn white spot looks a bit more diffuse in this image.

Illustration 023. 2016 July 14 11:52UT Digital image by Christopher Go. 35.6 cm (14.0 in.) SCT with RGB filters. S = 8.0, Tr = 4.5. CMI = 86.0°, CMII = 225.8 CMIII = 76.3°, B = +26.00°, B´ = +26.3°. The NEBn white spot appears quite compact. The NNNTeB dark spot is also visible with a less well-defined white area nearby.

Illustration 024. 2016 July 15 11:45UT. Digital image by Christopher Go. 35.6 cm (14.0 in.) SCT with RGB filters. S = 8.0, Tr = 4.0. CMI = 46.2°, CMII = 313.8 CMIII = 163.2°, B = +26.0°, B´ = +26.3°. The NEBn white spot looks a little less compact.





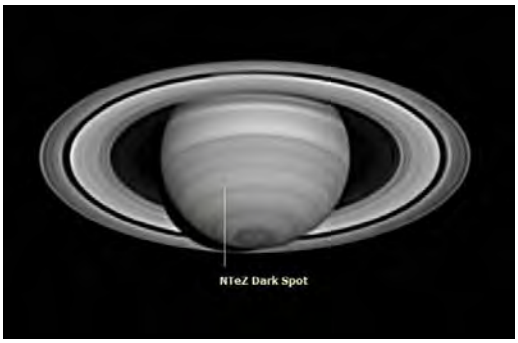


filters, furnished an image of a small an ill-defined yellowish-white oval immersed within the NEBZ on March 5, 2016 between 18:16 UT and 19:50 UT that he estimated at approximate saturnigraphic latitude +24.0°, and again on June 14, 2016 between 02:53 UT and 03:58 UT. He also imaged it later on in the apparition on June 28, 2016 from 12:38 UT to 13:39 UT at approximately saturnigraphic latitude +24.9° [refer to *Illustration Nos. 007, 011 and 015*].

Paul Maxson also imaged a very small white area using RGB filters within the NEBZ on August 8, 2016 at 03:05 UT [refer to *Illustration No. 016*].

Damian Peach submitted an RGB image of a white spot in the NEBn on June 10, 2016 at 04:22 UT near the CM as well as another RGB image of a white spot between 03:28 UT and 04:20 UT on June 11, 2016 [refer to *Illustration Nos. 017 and 018*]. Over the span of several days, Damian Peach captured RGB images of rather compact white spots at the northern edge of the NEBn beginning on June 14, 2016 (02:53 UT to 03:58 UT), again on June 15, 2016 between 03:11 UT and 04:03 UT, and on June 17, 2016 at 03:42 UT [refer to *Illustration Nos. 011, 019 and 021* respectively].

In a near-simultaneous observation, Christopher Go imaged similar white spots at the northern edge of the NEBn on June 15, 2016 between 13:56 UT and 04:10 UT with RGB and IR filters [refer to *Illustration No. 022]*. In



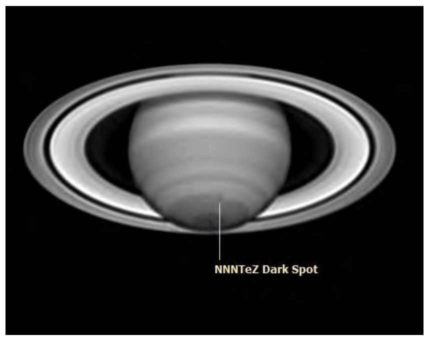


Illustration 025. 2016 August 14 10:04UT. Digital image by Trevor Barry. 40.6 cm (16.0 in.) NEW with a Red filter. S = 5.5, Tr = not specified. CMI = 114.7°, CMII = 135.6°, CMIII = 308.9°, B = +26.0°, B´ = +26.4°. The NNNTeB dark spot with the surrounding white "collar" can be seen W of the CM in this image.

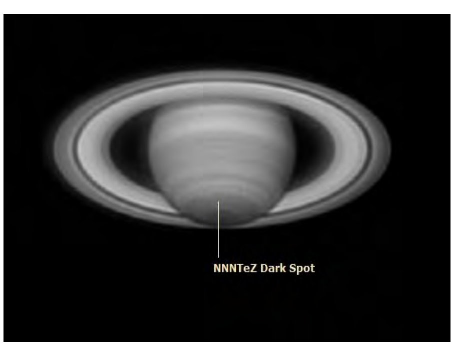
Illustration 026. 2016 July 31 10:39UT. Digital image by Anthony Wesley. 36.8 cm (14.5 in.) NEW at 675nm IR. S and Tr not specified. CMI = 181.2°, CMII = 307.9°, CMIII = 138.6°, B = +26.0°, B´ = +26.4°. Faint NTrZ white spots and the dark spot in the NNNTeB is surrounded by the curious "collar" of much lighter intensity.

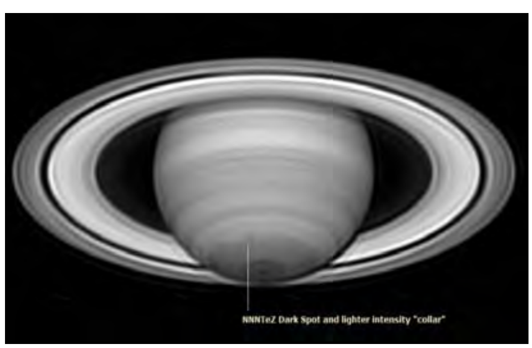
Illustration 027. 2016 July 30 10:11UT. Digital image by Anthony Wesley. 36.8 cm (14.5 in.) NEW at 685nm IR filter. S and Tr not specified. CMI = 55.2°, CMII = 200.5°, CMIII = 31.8°, B = +26.0°, B´ = +26.4°. Faint NTrZ white spots appear scattered across the globe.

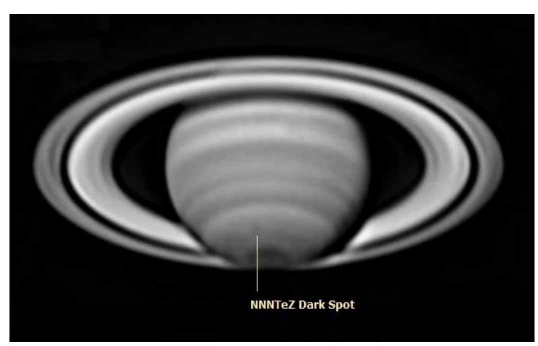
Illustration 028. 2016 July 28 11:32UT. Digital Image by Trevor Barry. 40.6 cm (16.0 in.) NEW with Red filter. S = 5.5, Tr = not specified. CMI = 114.7°, CMII = 62.2°, CMIII = 255.9°, B = +26.0°, B´ = +26.4°. The NNNTeB dark spot with the surrounding white "collar" is about to rotate off the E limb of Saturn in this image.

Illustration 029. 2016 March 25 09:71.6UT. Digital image by Charles Triana. 25.4 cm (10.0 in.) SCT at 09:21UT with RGB filters. S= 4.0, Tr= 4.5. CMI = 71.6°, CMII = 0.2°, CMIII = 344.7°, B = +26.3°, B´ = +26.0°. The NTeZ dark spot is well E of the CM.

Illustration 030. 2016 August 13 01:17UT. Digital image by Jim Phillips. 25.4 cm (110.0 in.) REF. S and Tr not specified. CMI = 9.5°, CMII = 245.1°, CMIII = 163.5°, B = +24.03°, B´ = +24.86°. The rather inconspicuous yellowish-white NNTeZ is shown in this image.







addition to the aforementioned observations, Christopher Go imaged white spots using RGB at the northern edge of the NEBn on July 14, 2016 (11:52 UT to 12:15 UT) and on July 15, 21016 from 11:45 UT to 12:11 UT [refer to *Illustration Nos. 023 and 024*].

Paul G. Abel submitted a detailed colorful visual drawing made at 03:09 UT on August 30, 2016 depicting what he described as vague darker markings or festoons situated within the NEBs that perhaps extended into the NEBZ [refer to *Illustration No. 008*].

North Tropical Zone (NTrZ). A single visual numerical relative intensity estimate in 2015-16 rated this zone forth in order of brightness compared with the EZn, NNTeZ, and NTeZ.

The yellowish-white NTrZ was apparent on most images in good seeing conditions throughout the observing season. In terms of specific NTrZ atmospheric phenomena, Anthony Wesley captured images of NTrZ white spots on July 30, 2016 at 10:11 UT and again on July 31, 2016 at 10:39 UT using RGB and 685nmIR filters [refer to *Illustration Nos. 026 and 027*]. It should be pointed out that the white spot features addressed in our foregoing discussion of white spots imaged or observed at the north edge of the NEBn,

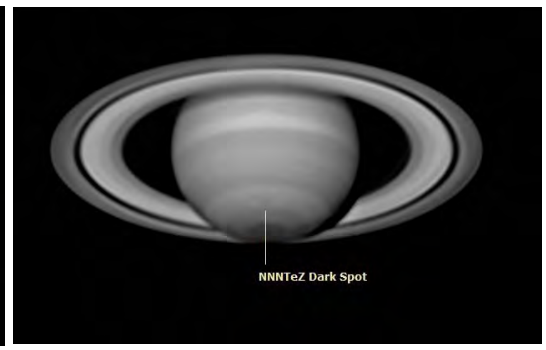


Illustration 031. 2016 July 03 10:39UT. Digital image by Trevor Barry. 40.6 cm (16.0 in.) NEW with Red filter. S = 5.5, Tr = not specified. CMI = 315.8°, CMII = 252.5°, CMIII = 116.4°, B = +26.0°, B´ = +26.4°. The NNNTeB dark spot with the leading and following white area approaching the CM.

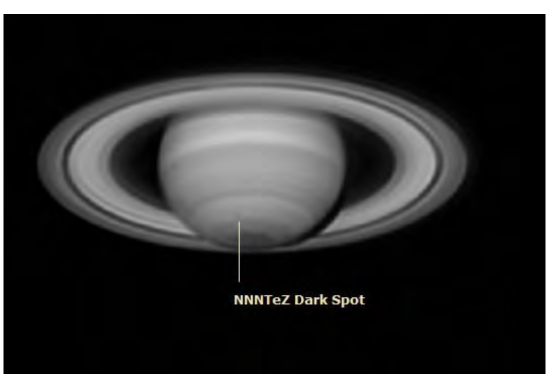
Illustration 032. 2016 July 21 11:36UT. Digital image by Trevor Barry. 40.6 cm (16.0 in.) NEW with Red filter. S = 5.5, Tr = not specified. CMI = 66.6°, CMII = 140.7°, CMIII = 342.8°, B = +26.0°, B´ = +26.4°. The NNNTeB dark spot is very close to rotating beyond the E limb of Saturn.

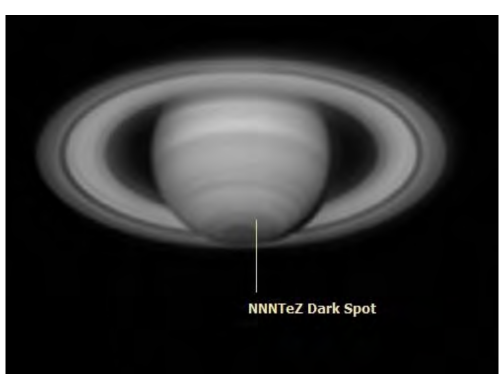
Illustration 033. 2016 July 21 12:23UT. Digital image by Anthony Wesley. 36.8 cm (14.5 in.) NEW at 685nm IR filter. S and Tr not specified. CMI = 94.2°, CMII = 167.2°, CMIII = 9.3°, B = +26.0°, B´ = +26.4°. The NNNTeB dark spot is very close to rotating beyond the E limb of Saturn (this is a near-simultaneous observation with the image provided by Trevor Barry on the same date (see illustration 032).

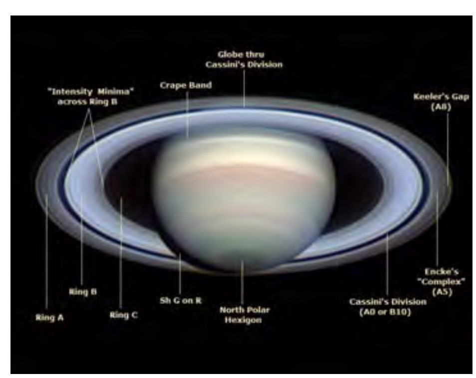
Illustration 034. 2016 August 04 1035UT. Trevor Barry. 40.6 cm (16.0 in.) NEW with Red filter. S = 6.5, Tr = not specified. CMI = 330.5°, CMII = 313.8°, CMIII = 139.1°, B = +26.0°, B´ = +26.4°. The NNNTeB dark spot has just moved past the CM.

Illustration 035. 2016 August 07 11:08UT. Trevor Barry. 40.6 cm (16.0 in.) NEW with Red filter. S = 4.5, Tr = not specified. CMI = 2.6°, CMII = 248.2°, CMIII = 69.9°, B = +26.0°, B´ = +26.4°. The NNNTeZ dark spot with its just barely perceptible white "collar" is approaching the CM.

Illustration 036. 2016 April 02 19:36UT. Digital Image by Christopher Go. 35.6 cm (14.0 in.) SCT with RGB filters. S = 7.0, Tr = 3.5. CMI = 347.3°, CMII = 3.6°, CMIII = 338.0°, B = +26.2°, B´ = +26.1°. This superb image depicts the major ring components A, B, and C, the Crape Band, Sh G on R, and the major divisions within the rings typically observable with amateur telescopes, plus several minor "intensity minima" within Ring B. The southern hemisphere of the globe is just barely perceptible through Cassini's division where the rings cross the globe toward the south.







the features were all situated in their latitudinal proximity close to the domain of the adjacent NTrZ during 2015-16, leading to some confusion among observers when attempting to describe their observational results.

North Temperate Belt (NTeB). The grayish-brown NTeB was occasionally seen by visual observers during the observing season, and although no visual numerical relative intensity estimates were provided, when seen the belt was described as somewhat duskier in appearance and perhaps slightly wider since 2014-15.

Digital images of Saturn during the apparition also recorded a slightly wider NTeB in general agreement with visual impressions; for instance, consider the RGB image taken by Clyde Foster on April 20, 2016 at 03:00 UT [refer to *Illustration No. 001*]. The NTeB white spot was also quite apparent on an RGB image by Christopher Go on April 23, 2016 at 09:14 UT[refer to *Illustration No. 006*]. Visual observers did not report specific atmospheric features within in the NTeB during 2015-16.

North Temperate Zone (NTeZ). Although there were several visual numerical relative intensity estimates of the dull yellowish-gray NTeZ received this apparition, it was not possible to evaluate any change in prominence of the zone since the previous observing season (there were no estimates during 2014-15). Nevertheless, the NTeZ was frequently apparent on drawings submitted during the apparition as well as captured on the majority of digital images received.

The NTeZ was a bit more conspicuous than the NTrZ on most images, and in order of brightness, it ranked third when compared with the EZn and the NNTeZ. Observers who routinely imaged Saturn detected recurring atmospheric spot activity in the NTeZ during 2015-16.

For instance, the initial image of discrete phenomena in the NTeZ occurred in the form of a small dark spot reported by Charles Triana using RGB filters at 09:21 UT on March, 25, 2016 [refer to *Illustration No. 029*]. Later in the apparition, Damian Peach imaged a rather diffuse white area with RGB filters that was situated close to the latitude of the NTeZ not far from the CM between 03:28 UT and 04:20 UT on June 11, 2016 [refer to *Illustration No. 0018*].

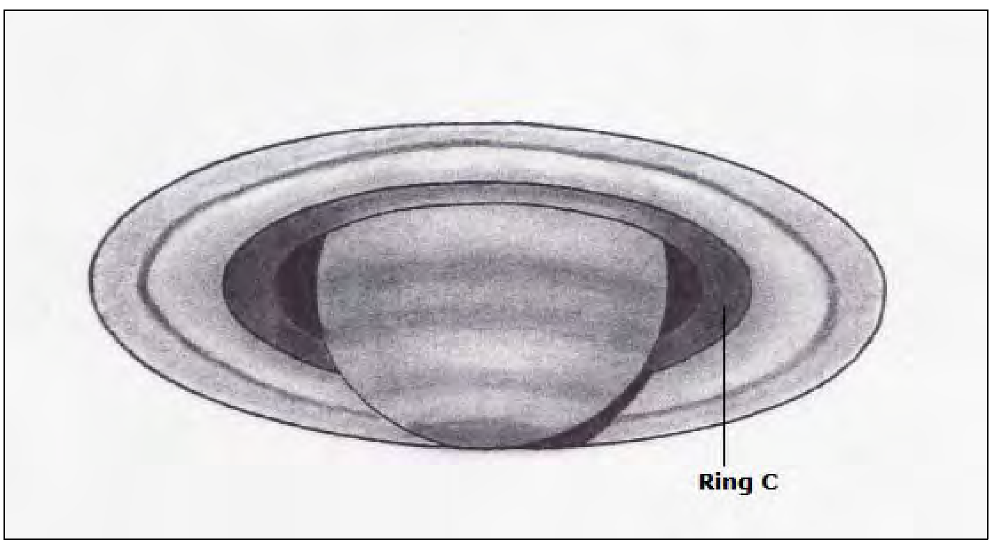


Illustration 037. 2016 February 17 13:43UT. Digital image by Paul Maxson. 25.4 cm (10.0 in.) REF with 685nm IR filter. S and Tr not specified. CMI = 203.7°, CMII = 67.8°, CMIII = 248.7°, B = +26.0°, B´ = +26.4°. This image shows the Crape Band running across the globe and the Sh R on G seen S of the Crape Band across the globe.

Damian Peach also imaged the same white spot with RGB filters on June 15, 2016 from 03:11 UT to 04:03 UT [refer to *Illustration No.019*]. Christopher Go also imaged the same NTeZ white spot with RGB and IR filters on June 15, 2016 between 13:56 UT and 14:40 UT in what constituted a near-simultaneous observation [refer to *Illustration No.020*].

North North Temperate Belt (NNTeB). The very dull gray NNTeB was difficult to detect even on the best images taken in good seeing conditions in 2015-16, for example consider the RGB image by Paul Maxson on August, 8, 2016 at 03:05 UT to 03:11 UT [refer to Illustration Nos. 016]. Visual observers did not report the NNTeB during the apparition, and suspicion by those attempting to capture images of any features in the NNTeB remained unconfirmed.

North North Temperate Zone (NNTeZ). During 2015-16, the often yellowish-white NNTeZ, second only to the EZn in overall brightness, was not reported visually but was barely obvious on many of the best images taken with moderate-to-larger apertures during the observing season [refer to *Illustration No. 030*]. Although several observers suspected small white and dark features during the observing season, definitive corroboration of discernible atmospheric detail within the NNTeZ was not forthcoming from observers when imaging Saturn.

North North North Temperate Belt (NNNTeB). A few careful observers imaged the very narrow dull gray NNNTeB displaying recurring activity in the form of dark and white spots in good seeing during the 2015-16 apparition. Damian Peach imaged a NNNTeB dark spot with an encompassing lighter “collar” near +61.1° saturnigraphic latitude apparently interacting with the adjacent NNNTeZ in his RGB image on June 11 from 03:28 UT to 04:20 UT [refer to Illustration No. 018]. He also recorded a NNNTeB dark spot with a close NNNTeB white spot on June 14, 2016 from 02:53 UT to 03:58 UT[refer to *Illustration No. 011*].

Damian Peach imaged the NNNNTeB dark spot with the nearby white area on June 17, 2016 at 03:42 UT [refer to *Illustration No. 021*]. Trevor Barry imaged a NNNTeB dark spot on July 3, 2016 between 10:25 UT and 11:07 UT that he measured at +63.6° saturnigraphic latitude along with an associated leading and following NNNTeB white spot [refer to *Illustration No. 031*].

Christopher Go recorded a dark spot in the NNNTeB with a less well-defined associated white area at RGB wavelengths July 14, 2016 (11:52 UT to 12:18 UT) [refer to *Illustration No. 023*]. Using RGB and 685nmIR filters,

Trevor Barry imaged the NNNTeB dark spot at +63.0° saturnigraphic latitude on July 21, 2016 between 10:40 UT and 11:23 UT, which showed an associated leading and following NNNTeB white area [refer to *Illustration No. 032*]. On the same date a near-simultaneous 685nmIR image was provided by Anthony Wesley of a NNNTeB dark spot at +63.0° saturnigraphic latitude between 10:21 UT and 12:23 UT [refer to *Illustration No. 033*]. Trevor Barry once again imaged the same NNNTeB dark spot at +63.0° saturnigraphic latitude on July 28, 2016 (10:43 UT to 11:47 UT) which displayed the same overall morphological appearance as a week earlier on July 21, 2016 [refer to *Illustration No. 031*].

Using RGB filters, Anthony Wesley imaged a NNNTeB dark spot with an encompassing white "collar" on July 31, 2016 at 10:11 UT with RGB filters [refer to *Illustration No. 026*]. Trevor Barry also imaged the NNNTeB dark spot on July, 28 2016 at 11:32 UT with RGB, 685nm, and red filters [refer to *Illustration No. 028*]. He also provided images of the NNNTeB dark spot +63.0° saturnigraphic latitude subsequently on August 4, 2016 (10:26 UT to 117 UT) with a red filter, August 7, 2016 (10:06 UT to 11:08 UT) using red filter, and a final time this observing season he provided an excellent image captured on August 14, 2016 (from 10:26 UT to 11:17 UT employing his a red filter [refer to *Illustration Nos. 034, 035, and 025* respectively].

North North North Temperate Zone (NNNTeZ). Visual observers did not call attention to the yellowish-gray NNNTeZ during the 2015-16 apparition, but it was frequently seen in higher resolution images at various wavelengths. Based on the volume of excellent digital images received during 2015-16, from our immediately preceding discussion of the NNNTeB, it is clear that the NNNTeZ exhibited some interaction with the nearby NNNTeB this observing season with respect to bright and dark spot activity.

Readers should refer to the foregoing discussion of recurring atmospheric phenomena associated with the NNNTeB, as well as consider the examples of contributed images of these regions in the far northern latitudes of Saturn's northern hemisphere; which illustrates how the complex behavior of nearby atmospheric features can influence one another with respect to longevity, overall behavior, and morphology.

North Polar Region (NPR). Visual observers frequently reported the very dull gray NPR, and it was quite evident on digital images contributed during the 2015-16. Visual numerical relative intensity estimates suggested only an insignificant dimming of the NPR by -0.04 in mean intensity since 2014-15. The NPR was devoid of any recognizable activity by visual observers and those imaging Saturn during the observing season. Based on visual observations, the dark North Polar Cap was considerably darker by -2.0 mean intensity points since 204-15 (perhaps visual observers were estimating the NPC because the north polar hexagon was not resolvable visually.

Although visual observers did not report the North Polar Belt (NPB) in 2014-16, this narrow feature was sometimes recognizable on detailed images encircling the NPR [refer to *Illustration No. 006*]. The always intriguing dark North Polar hexagon within the NPR was easily recognizable on many of the best images this apparition, such the one by Christopher Go taken on April 23, 2016 at 19:14 UT [refer to *Illustration No. 006*].

Shadow of the Globe on the Rings (Sh G on R). The Sh on G was visible to observers as a geometrically regular black shadow on either side of opposition during 2015-16. Any presumed variation of this shadow from a totally black intensity (0.0) during an apparition is merely a consequence of poor seeing conditions or the presence of extraneous light. Digital images of the Sh G on R showed the feature as completely black.

It should be noted that the globe of Saturn casts a shadow on the rings toward the left or IAU East prior to opposition, and on neither side at opposition (no observable shadow), and toward he right or IAU West after opposition. *Figure 6* includes selected digital images by several ALPO Saturn observers to help illustrate this phenomenon.

Latitude Estimates of Features on the Globe. Observers did not submit latitude estimates of features on Saturn's globe during 2015-16, however, several of the sharpest images in good seeing were measured to ascertain as accurately as possible the saturnigraphic latitude of specific discrete phenomena discussed in this report.

Readers are encouraged to try the historically effective visual technique developed by Walter Haas over 70 years ago to estimate latitudes. It merely involves determining as accurately as possible the fraction of the polar semidiameter of Saturn's globe subtended on the central meridian (CM) between the limb and the feature whose latitude is desired. As a control on the accuracy of this method, observers should include in their estimates the position on the CM of the projected ring edges and the shadow of the rings. The actual latitudes can then be calculated from the known values of **B** and **B'** and the dimensions of the rings, but this test cannot be effectively applied when **B** and **B'** are near their maximum attained numerical values.

Experienced observers have used this visual convenient procedure for many years with very reliable results, especially since filar micrometers are virtually non-existent, and even if available, they tend to be very expensive, not to mention sometimes tedious to use. A detailed description of the technique can be found in the author's book entitled *Saturn and How to Observe It*, published by Springer and available from booksellers worldwide.

Saturn's Ring System

This section addresses visual studies of Saturn's ring system with the accustomed comparison of mean intensity data between apparitions, as well as interpretations of digital images of the rings contributed during 2015-16. With the ring tilt toward Earth in 2015-16 increasing to as much as +26.758° (December 6, 2016), the major ring components were much easier to see and image as the rings progress toward their theoretical maximum inclination of +27° during the future 2016-17 apparition.

Ring A. Visual numerical relative intensity estimates suggested that the dull greyish-white Ring A (taken as a whole) appeared slightly dimmer in 2015-16 than in the immediately preceding apparition by a difference of -0.9 mean intensity points. Visual observers described Ring A as being largely homogeneous as opposed to being subdivided into inner and outer halves, but digital images of Saturn in 2015-16 often showed inner and outer halves of Ring A, with the inner half somewhat lighter than the outer half.

Visual observers reported the very dark gray Encke's division (A5) at the ansae (the portion of Saturn's rings visible on either side of the planet's disk) during the observing season in good seeing and with larger apertures, but there was a minimal number of visual numerical relative intensity estimate (see *Table 3*).

Many of the higher resolution images revealed Encke's division (A5) and Keeler's gap (A8), but the latter was seldom described except by visual observers with the largest instruments used [refer to *Illustration No. 036*].

Ring B. The outer third of Ring B is the traditional standard of reference for the ALPO Saturn Visual Numerical Relative Intensity Scale, with an assigned value of 8.0.

Under circumstances of greater ring tilt during the 2015-16 apparition, visual observers reported that the outer third of Ring B appeared brilliant white with no variation in intensity, and compared with other ring components and atmospheric phenomena of Saturn's globe, it was always the brightest intrinsic feature.

The inner two-thirds of Ring B during this apparition, described as yellowish-white and uniform in intensity, displayed a lighter intensity by a mean factor of +1.00 compared with 2014-15. Digital images confirmed most visual impressions during this observing season, and those of the highest resolution in favorable seeing exhibited several "intensity minima" across the breadth of Ring B [refer to *Illustration No. 036*].

Cassini's Division (A0 or B10). Visual observers regularly saw Cassini's division (A0 or B10) in 2015-16, and visual numerical relative intensity estimates averaged out at a difference of +0.10 since the previous apparition, but any suspected deviation of Cassini's Division from a totally black intensity (i.e., intensity of 0.0) was almost certainly a result of poor seeing, scattered light, or insufficient aperture.

Indeed, most visual observers viewing Saturn in good seeing conditions, and those submitting digital images, described or depicted it as a totally black gap at both ansae and usually traceable all the way around Saturn's ring system (except, of course, where the globe blocked views of the rings). This was also true for most of the high-resolution images submitted [refer to *Illustration No. 036*].

The globe could be seen through Cassini's division (A0 or B10) in a quite a number of the best images submitted this observing season [refer to *Illustration No. 036*].

Ring C. The very dark gray Ring C was observed at the ansae on most digital images during 2015-16 and splayed on drawings made by visual observers [refer to *Illustrations Nos. 008 and 036*]. Intensity estimates this apparition suggested that Ring C (at the ansae) was slightly lighter by +0.20 mean intensity points since 2014-15.

The Crape Band (Ring C across the globe of Saturn) was reported by visual observers as appearing very dull gray with uniform intensity. It displayed no change in mean intensity since 2014-15, and it was routinely evident on drawings and digital images [refer to *Illustrations Nos. 008 and 036*].

Opposition Effect. The Seeliger "opposition effect" was reported by a handful of observers on opposition date (June 3, 2016), which is a readily noticeable brightening of Saturn's ring system during a very brief interval on either side of opposition when the phase angle between Sun, Saturn, and the Earth is $\leq 0.3°$.

This ring brightening is due to coherent back scattering of sunlight by µ-sized icy particles that make up the rings, scattering light far more efficiently than the particles of Saturn's atmosphere. The Seeliger effect is exhibited on the opposition date image shown in *Figure 6*.

Shadow of the Rings on the Globe (Sh R on G). The Sh R on G, when normally seen or imaged under the correct geometric circumstances in 2015-16, was designated by observers in good seeing as a fully black shadow situated where the rings crossed Saturn's globe. Those very few instances when the shadow appeared as grayish-black, a departure from an overall black (0.0) intensity, occurred for the same reason as previously noted in our discussion regarding the Sh G on R.

When **B** and **B'** are both positive, and the value of **B** is greater than that of **B'**, the ring shadow (Sh R on G) is to the north of the projected rings, which happened prior to May 4, 2016 [refer to Illustration No. 037].

When **B** and **B'** are both positive, and the value of **B** is less than of **B'** the shadow of the rings on the globe (Sh R on G) is cast to their south, circumstances that occurred starting May 5, 2016 through October 23, 2016 (the final observation received for the apparition).

It should be pointed out that, since the rings blocked views of the southern hemisphere of the globe, it was not favorable to see the Sh R on G from May 5, 2016 onward through the end of the apparition.

Terby White Spot (TWS). The TWS is an apparent brightening of the rings immediately adjacent to the Sh G on R. There were only a handful of instances when visual observers suspected this spurious feature during 2014-15. The TWS is an artificial contrast effect and not an intrinsic feature of Saturn's rings, but it is helpful to try to find any correlation that might exist between the visual numerical relative intensity of the TWS and the varying tilt of the rings, including its brightness and visibility using variable-density polarizers, color filters, and digital images.

Bicolored Aspect of the Rings and Azimuthal Brightness Asymmetries. The bicolored aspect of the rings is an observed difference in coloration between the East and West ansae (IAU system) when systematically compared with alternating W47 (where W denotes the Wratten filter series), W38, or W80A (all blue filters) and W25 or W23A (red filters).

Michael E. Sweetman reported a bicolored aspect where the West ansa was brighter than the East ansa as well as with a blue filter, but comparing the ansae with a red filter both appeared of equal brightness on Jun14, 2016 from 08:33 UT to 08:56 UT. He noticed an identical bicolored aspect effect on July 11,2016 from 07:35 UT to 07:57 UT).

There were no other reports of this phenomenon during the rest of the observing season, although in recent years observers have been systematically attempting to document the presence of the bicolored aspect of the rings using digital imagers.

In the past, there have been rare instances when the phenomenon was allegedly photographed, and of particular importance would be images of the bicolored aspect at the same time it is sighted visually, especially when it occurs independent of similar effects on the globe of Saturn (which would be expected if atmospheric dispersion were a contributing factor). Such simultaneous visual observations cannot be stressed enough so that more objective confirmation of the bicolored aspect of the rings can occur.

Professional astronomers are well-acquainted with Earth-based sightings of azimuthal variations in the rings (initially confirmed by Voyager spacecraft), which probably is a consequence of light-scattering by denser-than-average clumps of particles orbiting in Ring A.

ALPO Saturn observers are encouraged to try to image any azimuthal brightness asymmetries in Ring A, preferably at the same date that visual observers report it. There were no reports of this phenomenon during 2015-16.

Saturn's Satellites

Many of the planet's satellites show tiny fluctuations in visual magnitude as a result of their varying orbital positions relative to the planet and due to asymmetries in distribution of surface markings on a few. Despite close proximity sensing by spacecraft, the true nature and extent of all of the observed satellite brightness variations is not completely understood and merits further investigation.

Visual Magnitude Estimates and Photometry. ALPO Saturn Section observers in 2015-16 conducted no systematic visual magnitude estimates of Saturn's satellites using suggested ALPO Saturn Section methodology.

Although photometry has largely replaced visual magnitude estimates of Saturn's moons, visual observers should still try to establish the comparative brightness of a satellite relative to reference stars of calibrated brightness when the planet passes through a field of stars that have precisely known magnitudes. To do this, observers need to employ a good star atlas that goes faint enough and an accompanying star catalogue that lists reliable magnitude values. A number of excellent computer star atlases exist that facilitate precise plots of Saturn's path against background stars for comparative magnitude estimates.

The methodology of visually estimating satellite magnitudes is simple. It starts with selection of at least two stars with well-established magnitudes and those that have about the same color and brightness as the satellite. One of the stars chosen should be slightly fainter and the other a little brighter than the satellite so that the difference in brightness between the stars is roughly 1.0 magnitude. This makes it easy to divide the brightness difference between the two comparison stars into equal magnitude steps of 0.1.

To estimate the visual magnitude of the satellite, simply place it along the scale between the fainter and brighter comparison stars. In the absence of suitable reference stars, however, a last resort alternative is to use Saturn's brightest satellite, Titan, at visual magnitude 8.4. It is known to exhibit only subtle brightness fluctuations over time compared with the other bright satellites of Saturn that have measured amplitudes.

Some observers have begun using digital imagers with adequate sensitivity to capture the satellites of Saturn together with nearby comparison stars, thereby providing a permanent record to accompany visual magnitude estimates as described above.

Images of the positions of satellites relative to Saturn on a given date and time are worthwhile for crosschecking against ephemeris predictions of their locations and identities. It is important to realize, however, that the brightness of satellites and comparison stars on digital images will not necessarily be the same as visual impressions because the peak wavelength response of the CCD chip is typically different from that of the eye.

Observers who have photoelectric photometers may also contribute measurements of Saturn's satellites, but they are notoriously difficult to measure owing to their faintness compared with the planet itself. Rather sophisticated techniques are required to correct for scattered light surrounding Saturn and its rings.

Spectroscopy of Titan. Since 1999 observers have been urged to attempt spectroscopy of Titan whenever possible as part of a cooperative professional-amateur project. Although Titan has been studied by the Hubble Space Telescope (HST), very large Earth-based instruments, and at close range the ongoing *Cassini-Huygens* mission, opportunities continue for amateurs to contribute systematic observations using appropriate instrumentation.

Thanks to the *Cassini-Huygens* mission starting in 2004 and ending in 2017), we now know that Titan is a very dynamic world with transient and long-term variations. From wavelengths of 300nm to 600nm, Titan's hue is dominated by a reddish methane (CH_4) atmospheric haze, and beyond 600nm, deeper CH_4 absorption bands appear in its spectrum. Between these CH_4 wavelengths are "portals" to Titan's lower atmosphere and surface, so regular monitoring in these regions with photometers or spectrophotometers is a useful complement to professional work.

Long-term studies of Titan's brightness from one apparition to the next is meaningful in helping shed light on Titan's known seasonal variations. Observers with suitable equipment are being asked to participate in these professional-amateur projects, and further details can be found on the Saturn page of the ALPO website at http://www.alpo-astronomy.org/ as well as directly from the ALPO Saturn Section.

Simultaneous Observations

Simultaneous observations, or studies of Saturn by individuals working independently of one another at the same time and on the same date, offer unparalleled chances for verification of ill-defined or traditionally controversial phenomena.

There were a few occasions during 2015-16 when near-simultaneous observations were accomplished fortuitously as discussed earlier in this report. Such corroborating observation helped strengthen the objectivity of the data received. To encourage and increase the likelihood of such conformational work, the ALPO Saturn Section has organized a simultaneous observing team so that several individuals in reasonable proximity to one another can maximize opportunities for viewing and imaging Saturn on any given night using similar equipment and methodology.

Joint efforts like this significantly reinforce the level of confidence in the data submitted for each apparition.

Pro-Am Opportunities

Our involvement in professional-amateur (Pro-Am) projects continued in 2015-16 in support of the ongoing *Cassini* mission with ALPO observers submitting images of discrete phenomena sighted or imaged on the globe of Saturn. Readers of this Journal should remember the combined efforts of amateurs and professionals in keeping track of the dynamic, brilliant NTrZ white storm raging on Saturn during the past 2010-11 apparition.

Ever since *Cassini* started observing Saturn at close range in April 2004 until the mission ended in 2017, digital images at wavelengths ranging from 400nm to 1 were actively sought by the professional community from amateurs.

This continues as a project of high significance, even though the mission has concluded. Nevertheless, advanced observers continue to be encouraged to submit images using classical broadband filters (e.g. Johnson system: B, V, R and I) with apertures upwards of 30.5 cm (12.0 in.) or larger, in addition to imaging through an 890-nm narrow band CH4 (methane) filter.

Therefore, to sustain our Pro-Am work following closure of the *Cassini* mission ALPO Saturn observers are asked to pursue diligent systematic patrol of the planet every clear night for individual features, keeping track of their motions, locations, and morphology.

Such reports provide input concerning interesting large-scale targets to alert the professional community as our Pro-Am endeavors continue for years to come. In addition, visual observers with apertures ranging upwards from about 15.2 cm (6.0 in.) can play a very meaningful role by making routine visual numerical relative intensity estimates and recording suspected variations in belt and zone reflectivity (i.e., intensity) and color.

Up until the time that the mission concluded, the *Cassini* team combined ALPO Saturn Section images with data from the Hubble Space Telescope and from other professional ground-based observatories for in depth study.

As a means of facilitating and stimulating active Pro-Am observational cooperation, readers are asked to contact the ALPO Saturn Section with any questions as to how they can share their observational reports, drawings, and images of Saturn and its satellites with the professional community.

The author is always pleased to offer guidance to novices, as well as observers that are more experienced. A meaningful resource for novices to learn how to observe and develop skill in recording data on Saturn is the ALPO Training Program, and it is recommended that beginners take advantage of this valuable educational resource.

Conclusions

Although the quantity of visual numerical relative intensity estimates was fewer than usual during 2015-16, features of Saturn's globe seemed marginally lighter in appearance compared with the immediately preceding apparition. Saturn's southern hemisphere during 2015-16 was blocked from our view by the rings with the exception of the yellowish-white Equatorial Zone (EZs) just to the south of where the Equatorial Band (EB) crossed the globe.

Activity within Saturn's northern hemisphere throughout the 2015-16 apparition, as described in detail in the foregoing discussion of this report, included for example, features such as recurring dark and bright spots (some quite sporadic) in the North North North Temperate Zone (NNNTrZ), North North North Temperate Belt (NNNTeB), the North Temperate Zone (NTeZ), North Tropical Zone (NTrZ), North Equatorial Belt, northern edge (NEBn) and North Equatorial Belt zone (NTeZ).

Nearly all of these atmospheric features were successfully imaged by several observers at various wavelengths as exemplified in the images provided in this report.

Observations of the major ring components, including Cassini's and Encke's divisions, plus occasional views of Keeler's division (A8) and “intensity minima” in Ring B, were even more favorable this apparition because of the improved inclination of Saturn's rings toward Earth since 2014-15.

One observer used standard visual procedures for trying to confirm any bi-colored aspect of the rings during the 2015-16 observing season, but there were no other reports of the phenomenon by visual observers, and its presence on digital images was not noticeable.

ALPO Saturn Section observers studying the planet by visual methods or through routine digital imaging of the planet at various wavelengths, kept active participation alive in our Pro-Am efforts supporting the ongoing *Cassini* mission during the 2015-16 observing season. Digital imaging, which now occurs as routinely as visual studies of Saturn, frequently divulges minute detail on the globe and in the rings below the normal visual threshold.

With a combination of both observational methods, opportunities markedly increase for detecting changes on Saturn during any given apparition. Because of their sensitivity, digital imagers help detect outbursts of activity that visual observers might ultimately try to study with their telescopes. This helps establish limits of visibility of discrete features in integrated light (no filter) and at various wavelengths.

With regard to Saturn's satellites, during the 2015-16 apparition observers did not submit magnitude estimates.

The author truly appreciates all of the efforts by dedicated observers mentioned in this report in submitting their excellent drawings, digital images, descriptive reports, simultaneous observations, and visual numerical relative intensity estimates during 2015-16.

Regular systematic observational work highly enriches our pursuits and reinforces Pro-Am collaboration we try to better understand Saturn as a planet. Observers everywhere are encouraged to join us in our activities in upcoming apparitions.

References

Alexander, A.F. O'D. (1962). *The Planet Saturn*. London: Faber and Faber. http://www.amazon.com/planet-Saturn-history-observation-discovery/dp/B0006AYB=82U

Benton, J.L. Jr, (2005). *Saturn and How to Observe It*. London: Springer-Verlag. http://www.amazon.com/Saturn-Observe-Astronomers-Observing-Guides/dp/1852338873/ref=sr_1_1/105-9507435-7968466?ie=UTF8&s=books&qid=1183915123&sr=1-1

__________ (1996). *Visual Observations of The Planet Saturn: Theory and Methods (The Saturn Handbook)*. Savannah, GA: Review Publishing Company, 1996 (Eighth Revised Edition—now available also in *.pdf format) from the author.

__________ (2014). “ALPO Observations of Saturn During the 2010-2011 Apparition,” *JALPO*, 56, 2: 31-66. http://alpo-astronomy.org/gallery3/index.php/Publications-Section/ALPO-Journals

__________ (2015). “ALPO Observations of Saturn During the 2011-2012 Apparition,” *JALPO*, 57, 2: 48-74. http://alpo-astronomy.org/gallery3/index.php/Publications-Section/ALPO-Journals

__________ (2016). “ALPO Observations of Saturn During the 2012-13 Apparition,” *JALPO*, 58, 4: 53-80. http://alpo-astronomy.org/gallery3/index.php/Publications-Section/ALPO-Journals

__________ (2018). “ALPO Observations of Saturn During the 2013-14 Apparition,” *JALPO*, 60, 4:74-92. http://alpo-astronomy.org/gallery3/index.php/Publications-Section/ALPO-Journals

__________ (2019). “ALPO Observations of Saturn During the 2014-15 Apparition,” *JALPO*, 61, 4: 64-84. http://alpo-astronomy.org/gallery3/index.php/Publications-Section/ALPO-Journals

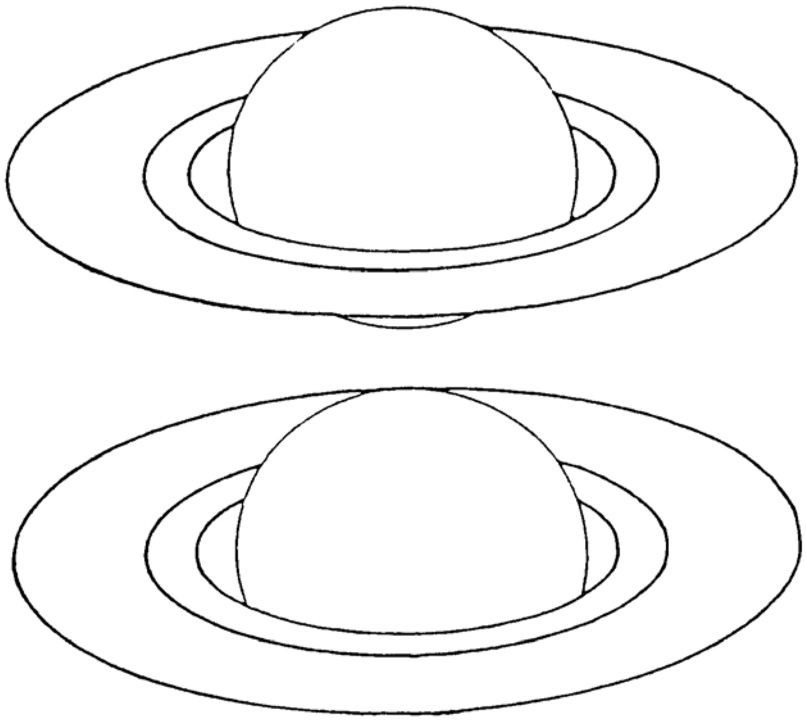
Lissauer, Jack J, and de Pater, Imke (2013). *Fundamental Planetary Science*. New York: Cambridge University Press. http://www.amazon.com/dp/052161855X/?tag=mh0b-2-&hvadid=4162391626&ref=pr_sl_7lqawqcmqg_e

United States Naval Observatory (2015, 2016). The Astronomical Almanac. Washington: U.S. Government Printing Office. (Both annual editions were used in this report.)

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

A.L.P.O. Visual Observation of Saturn for B = –22° to–24°

S



N

Coordinates (check one): [ ] IAU [ ] Sky

Observer__________________________________Location____

UT Date (start) _______________ UT Start ______________ CM I (start) _____________° CM II (start) _____________° CM III (start) _____________°

UT Date (end) _______________ UT End ______________ CM I (end) _____________° CM II (end) ____________° CM III (end) ___________°

B = __________° B′ = __________° Instrument ____ Magnification(s) __________ x_{min} _________ x_{max}

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

Saturn Global and Ring Features	Visual Photometry and Colorimetry IL	f_1	f_2	f_3	Absolute Color Estimates	Latitude Estimates ratio y/r

<u>Bicolored Aspect of the Rings</u>: (*always use IAU directions*)

No Filter (IL) (*check one*): [ ] E ansa = W ansa [ ] E ansa > W ansa [ ] W ansa > E ansa

Blue Filter (_________) (*check one*): [ ] E ansa = W ansa [ ] E ansa > W ansa [ ] W ansa > E ansa

Red Filter (_________) (*check one*): [ ] E ansa = W ansa [ ] E ansa > W ansa [ ] W ansa > E ansa

IMPORTANT: Attach to this form all descriptions of morphology of atmospheric detail, as well as other supporting information. Please <u>do</u> <u>not</u> write on the back of this sheet. The intensity scale employed is the *Standard A.L.P.O. Intensity Scale*, where 0.0 = completely black ⇔ 10.0 = very brightest features, and intermediate values are assigned along the scale to account for observed intensity of features.

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http://moon.scopesandscapes.com/ALPO_Lunar_Program.htm

Lunar Selected Areas Program

http://moon.scopesandscapes.com/alpo-sap.html

Lunar Banded Craters Program

http://moon.scopesandscapes.com/alpo-bcp.htm

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Lunar Meteoritic Impacts Search Program

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

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Lunar Transient Phenomena Program

http://www.alpo-astronomy.org/lunar/LTP.html; also *http://www.LTPresearch.org*

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- Assistant Coordinator, John McAnally, 2124 Wooded Acres, Waco, TX 76710; *CPAJohnM@aol.com*
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Remote Planets Section

http://www.alpo-astronomy.org/remote

- Coordinator; Richard W. Schmude, Jr., 109 Tyus St., Barnesville, GA 30204; *schmude@gordonstate.edu*

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The Monograph Series

http://www.alpo-astronomy.org/publications/Monographs page.html

Publications too lengthy for publication in *The Strolling Astronome*r. All are available ONLY online as a pdf files. NONE are available any longer in hard copy format. There is NO CHARGE for any of the ALPO monographs.

- **Monograph No. 1.** *Proceedings of the 43rd Convention of the Association of Lunar and Planetary Observers. Las Cruces, New Mexico, August 4-7, 1993. 77* pages. File size approx. 5.2 mb.
- **Monograph No. 2**. *Proceedings of the 44th Convention of the Association of Lunar and Planetary Observers. Greenville, South Carolina, June 15-18, 1994. 52* pages. File size approx. 6.0 mb.
- **Monograph No. 3**. *H.P. Wilkins 300-inch Moon Map.* 3rd Edition (1951). Available as one comprehensive file (approx. 48 megabytes) or five section files (Part 1, 11.6 megabytes; Part 2, 11.7 megabytes; Part 3, 10.2 megabytes; Part 4, 7.8 megabytes; Part 5, 6.5 mb)
- **Monograph No. 4.** *Proceedings of the 45th Convention of the Association of Lunar and Planetary Observers. Wichita, Kansas, August 1-5, 1995.127* pages. Hard copy $17 for the United States, Canada, and Mexico. File size approx. 2.6 mb.
- **Monograph No. *5.*** *Astronomical and Physical Observations of the Axis of Rotation and the Topography of the Planet Mars. First Memoir; 1877-1878.* By Giovanni Virginio Schiaparelli, translated by William Sheehan. 59 pages. File size approx. 2.6 mb.
- **Monograph No. *6.*** *Proceedings of the 47th Convention of the Association of Lunar and Planetary Observers, Tucson, Arizona, October 19-21,*

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1996.20 pages. File size approx. 2.6 mb.

- **Monograph No. 7.** *Proceedings of the 48th Convention of the Association of Lunar and Planetary Observers. Las Cruces, New Mexico, June 25-29, 1997.76* pages. File size approx. 2.6 mb.
- **Monograph No. 8**. *Proceedings of the 49th Convention of the Association of Lunar and Planetary Observers. Atlanta, Georgia, July 9-11,1998.122* pages. File size approx. 2.6 mb.
- **Monograph Number 9**. *Does Anything Ever Happen on the Moon?* By Walter H. Haas. Reprint of 1942 article. 54 pages. File size approx. 2.6 mb.
- **Monograph No. 10.** *Observing and Understanding Uranus, Neptune and Pluto*. By Richard W. Schmude, Jr. 31 pages. File size approx. 2.6 mb.
- **Monograph No. 11**. *The Charte des Gebirge des Mondes* (Chart of the Mountains of the Moon) by J. F. Julius Schmidt, this monograph edited by John Westfall. Nine files including an accompanying guidebook in German. Note files sizes:
  Schmidt0001.pdf, approx. 20.1 mb;
  Schmidt0204.pdf, approx. 32.6 mb;
  Schmidt0507.pdf, approx. 32.1 mb;
  Schmidt0810.pdf, approx. 31.1 mb;
  Schmidt1113.pdf, approx. 22.7 mb;
  Schmidt1416.pdf, approx. 28.2 mb;
  Schmidt1719.pdf, approx. 22.2 mb;
  Schmidt2022.pdf, approx. 21.1 mb;
  Schmidt2325.pdf, approx. 22.9 mb;
  SchmidtGuide.pdf,approx. 10.2 mb
- **Monograph No. 12.** *Solar Activity from 2014 through 2016* (subtitled *An unorthodox analysis of solar activity during three years, on the way to solar minimum*) by Theo Ramakers. Documents the research done to evaluate the relationship between the Wolf number indicator used to identify solar activity in many amateur solar reports and the size of the areas which Active Regions occupy during times of high solar energy."
- **Monograph No. 13.** *A Manual for Observing the Moon: The ALPO Lunar Selected Areas Program* by Dr. Julius Benton. Second update to original 1994 edition. Intended for serious enthusiasts who want to seriously contribute to lunar science through participation in the specialized efforts of the ALPO Lunar Selected Areas Program (which now includes the Dark Haloed Craters Program (DHCP) and the Bright and Banded Craters Program (BBCP). The handbook includes fundamental methods and techniques for conducting systematic observations of specific types of lunar features, including remarks on the lasting value of current lunar visual observations by amateur astronomers with Earth-based telescopes.
- **Monograph No. 14.** *Theory and Methods for Visual Observations of Saturn* by Dr. Julius Benton. Intended for the individual who seeks to gain an understanding of the observational theory and methodology involved in pursuing a worthwhile program of observing Saturn, its ring system, and accompanying satellites. The methods and techniques presented will hopefully be instructive and helpful to the observer who wishes to produce the most useful and reliable data possible for analysis, whether one is conducting a purely visual program or utilizing digital imagers to capture images of Saturn at various wavelengths.
- **Monograph No. 15.** *A Guide for Visual Observations of the Planet Venus* by Dr. Julius Benton. Update to the original 2016 edition. Intended for the individual who seeks to gain an understanding of the observational theory and methodology involved in pursuing a worthwhile program of observing the planet Venus. This small (65-page) handbook has been written for the amateur astronomer who wants to pursue an organized program of systematic visual observations of this planet, a beautiful but exceedingly difficult object to observe.

ALPO Observing Section Publications

Order the following directly from the appropriate ALPO section recorders; use the address in the listings pages which appeared earlier in this booklet unless another address is given.

- **Solar:** *Guidelines for the Observation of White Light Solar Phenomena*, *Guidelines for the Observing Monochromatic Solar Phenomena* plus various drawing and report forms available for free as pdf file downloads at *http://www.alpo-astronomy.org solarblog*.
- **Lunar & Planetary Training Section:** *The Novice Observers Handbook* $15. An introductory text to the training program. Includes directions for recording lunar and planetary observations, useful exercises for determining observational parameters, and observing forms. Available as pdf file via e-mail or send check or money order payable to Timothy J. Robertson, 195 Tierra Rejada Rd., #148, Simi Valley, CA 93065; e-mail *cometman@cometman.net*.
- **Lunar:** (1) *The ALPO Lunar Selected Areas Program Handbook* (hardcopy, $17.50). Includes full set of observing forms. (2) *Observing forms*: Send a SASE for a hardcopy of forms. Both the Handbook and individual observing forms are available for download (as pdf files) at *moon.scopesandscapes.com/alpo-sap.html*. Use of observing forms will ensure that all requested information is included with observations, but are not required. Various lists and forms related to other Lunar section programs are also available at *moon.scopesandscapes.com*. NOTE: Observers who wish to make copies of the observing forms may instead send a SASE for a copy of forms available for each program. Authorization to duplicate forms is given only for the purpose of recording and submitting observations to the ALPO lunar SAP section. Observers should make copies using high-quality paper.
- **Lunar**: *The Lunar Observer*, official newsletter of the ALPO Lunar Section, published monthly. Free at *http://moon.scopesandscapes.com/tlo.pdf* or send SASE to: Wayne Bailey, 17 Autumn Lane, Sewell, NJ 08080.
- **Venus (Benton):** Introductory information for observing Venus, the comprehensive *ALPO Venus Handbook*, as well as all observing forms and ephemerides, can be

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- **Mars:** Free resources are on the ALPO website at www.alpo-astronomy.org . Click on "Mars Section" in the left column; then on the resulting webpage, look for links to resources in the right column including "Mars Observing Form", and "Mars Links". Under "Mars Links", click on "Mars Observers Cafe", and follow those links to The New "Internet Mars Observer's Handbook."

- **Minor Planets (Derald D. Nye):** *The Minor Planet Bulletin*. Published quarterly; free at http://www.minorplanetobserver.com/mpb/default.htm. Paper copies available only to libraries and special institutions at $24 per year via regular mail in the U.S., Mexico and Canada, and $34 per year elsewhere (airmail only). Send check or money order payable to "Minor Planet Bulletin", c/o Derald D. Nye, 10385 East Observatory Dr., Corona de Tucson, AZ 8564l-2309.

- **Jupiter:** *(1) Jupiter Observer's Handbook*, from the Astronomical League Sales, temporarily out of stock. (*2*) *ALPO_Jupiter*, the ALPO Jupiter Section e-mail network; to join, send a blank e-mail to *ALPO_Jupiter-subscribe@yahoogroups.com* (3) *Jupiter Observer's Startup Kit*, $3 from Richard Schmude, Jupiter Section Coordinator.

- **Saturn (Benton):** Introductory information for observing Saturn, including all observing forms and ephemerides, can be conveniently downloaded as pdf files at no cost to ALPO members and individuals interested in observing Saturn as part of our regular programs at http://www.alpo-astronomy.org/saturn. The former *ALPO Saturn Handbook* was replaced in 2006 by *Saturn and How to Observe It* (authored by Julius L. Benton) and it can be obtained from book sellers such as Amazon.com.

- **Meteors:** (1) *The ALPO Guide to Watching Meteors* (pamphlet). $3 per copy (postage & handling); check/money order to Astronomical League Sales, 9201 Ward Parkway, Suite 100, Kansas City, MO 64114; phone 816-DEEP-SKY (816-333-7759); e-mail leaguesales@astroleague.org. (2) *The ALPO Meteors Section Newsletter*, free (except postage), published quarterly (March, June, September and December). Send stamps, check or money order for first class postage to cover desired number of issues to Robert D. Lunsford, 14884 Quail Valley Way, El Cajon, CA 92021-2227.

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Vol. 35 (1991) Nos. 1, 2, and 4
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THE ASSOCIATION OF LUNAR & PLANETARY OBSERVERS (ALPO)

The Association of Lunar & Planetary Observers (ALPO) was founded by Walter H. Haas in 1947 and incorporated in 1990 as a medium for advancing and conducting astronomical work by both professional and amateur astronomers who share an interest in Solar System observations. We welcome and provide services for all individuals interested in lunar and planetary astronomy. For the novice observer, the ALPO is a place to learn and to enhance observational techniques. For the advanced amateur astronomer, it is a place where one's work will count and be used for future research purposes. For the professional astronomer, it is a resource where group studies or systematic observing patrols add to the advancement of astronomy.

Our Association is an international group of students that study the Sun, Moon, planets, asteroids, meteors, meteorites and comets. Our goals are to stimulate, coordinate, and generally promote the study of these bodies using methods and instruments that are available within the communities of both amateur and professional astronomers. We hold a conference each summer, usually in conjunction with other astronomical groups.

We have "sections" for the observation of all the types of bodies found in our Solar System. Section coordinators collect and study submitted observations, correspond with observers, encourage beginners, and contribute reports to our quarterly Journal at appropriate intervals. Each section coordinator can supply observing forms and other instructional material to assist in your telescopic work. You are encouraged to correspond with the coordinators in whose projects you are interested. Coordinators can be contacted either via e-mail (available on our website) or at their postal mail addresses listed in our Journal. Members and all interested persons are encouraged to visit our website at http://www.alpo-astronomy.org. Our activities are on a volunteer basis, and each member can do as much or as little as he or she wishes. Of course, the ALPO gains in stature and in importance in proportion to how much and also how well each member contributes through his or her participation.

Our work is coordinated by means of our quarterly periodical, the *Journal of the Assn. of Lunar & Planetary Observers* (known also as *The Strolling Astronomer*). Membership dues include a subscription to our Journal. Two versions of our Journal are distributed — a hardcopy (paper) version and an online (digital) version in portable document format (pdf) at considerably reduced cost.

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