*Published by the Astronomical League*
**Vol. 76, No. 1 DECEMBER 2023**

# Reflector

**A TOUR OF THE ORION NEBULA**

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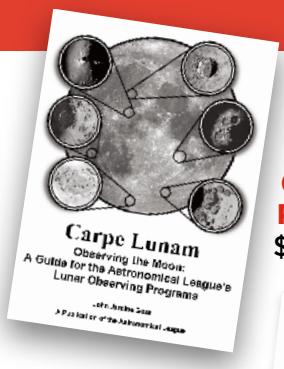


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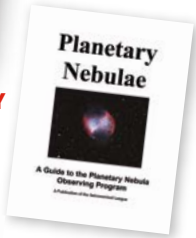


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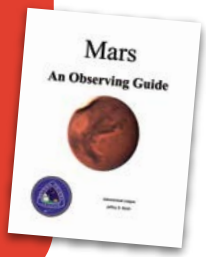


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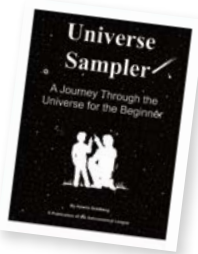


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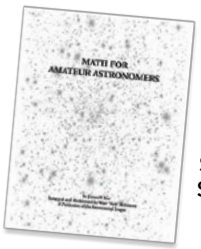


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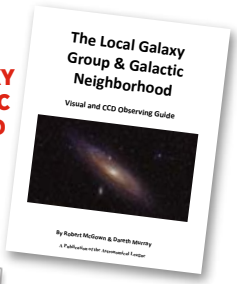


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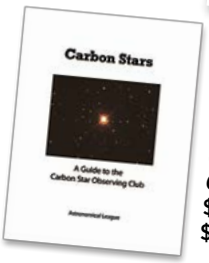


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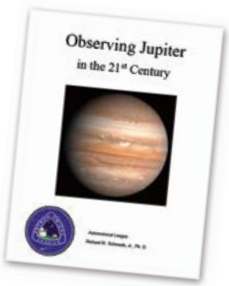



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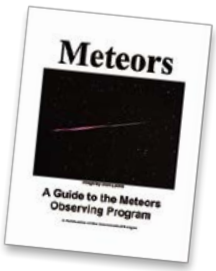


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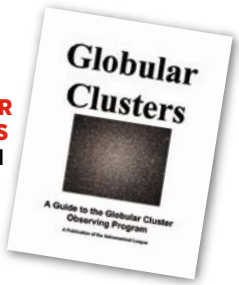


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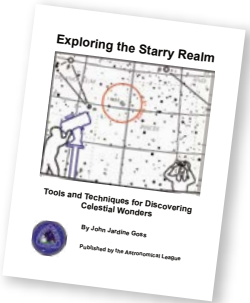


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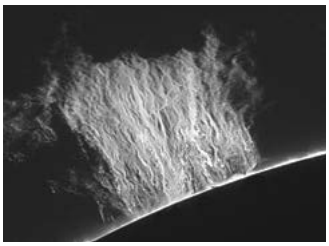

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***M. J. Post*** *(Longmont Astronomical Society) captured this image of supernova remnant CTA1 using a Celestron 11-inch RASA telescope and a ZWO ASI 6200MM camera from his DSNM observatory in Animas, New Mexico.*


# Reflector

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A NON-PROFIT ORGANIZATION
To promote the science of astronomy

- by fostering astronomical education,
- by providing incentives for astronomical observation and research, and
- by assisting communication among amateur astronomical societies.

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# Reflector

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| | |
|---|---|
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| **June issue** | **April 1** |
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Send to *larsen@ccsu.edu* with subject line "letter to editor"


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## Erratum

We would like to correct an error that crept into our June issue: The recipient of third place honors for the Mabel Sterns Newsletter Award is Lisa Wieland, editor of the Wabash Valley Astronomical Society's newsletter, *The Nebula.* We regret misspelling her name and congratulate her on this achievement.

## Editor's Corner

It's hard to believe that 2024 is right around the corner. But this means we are closer to the April 8, 2024, total solar eclipse. If you have not made your reservations to be in the path of totality, time is running out! Excitement for the eclipse is certainly reflected in this issue, as most of the articles we received focused on solar observing in some way. We hope that you benefit greatly from the authors' enthusiasm and knowledge.

You may also notice that there have been some changes in this issue, and there are more changes to come, some involving format and layout, and others content. After many years of enhancing our familiarity with our Solar System family, Berton Stephens has retired his "Wanderers in the Neighborhood" column. We thank him for sharing his passion for our planetary (and other) siblings with readers for so long. As Tim Hunter shared with you in the last issue (and continues to explain in this one), there have been changes in the International Dark-Sky Association – now DarkSky International – that will focus and strengthen its mission and public relations. Changes in our light pollution coverage are coming as well. Beginning with the March 2024 issue, look for the new "DarkSky Corner," in which Tim will direct us to timely information on the DSI website (*darksky.org*) for our further reading. Similarly, we will be encouraging all authors to include links to information available online, for those readers who wish to explore a particular topic in more detail.

As we strive to bring our readers the most engaging and informative magazine possible, we will be working closely with our authors, including creating a style sheet and submission checklist. We encourage first-time authors to contact us before submitting an article, especially students, to discuss how we can best aid you in possibly bringing your idea to publication. The *Reflector* staff is excited that we have articles authored by high school and college students not only in this issue, but already cued up for the March 2024 issue. As we all know, young people are the future of amateur astronomy, and we particularly encourage their participation in popularizing our science. Having said that, we are increasingly receiving more articles than we can accommodate in a single issue, so we ask authors to be patient if there is some delay in bringing their work to print. We are also closely examining all submissions to make sure that they give proper credit to the work of others, are scientifically correct (to the best of our staff's knowledge), and are aligned with the mission of the Astronomical League (as published on the table of contents page of each issue of the *Reflector*).

Please let us know how we are doing – our main aim is to serve you, our readers, and your opinion means a great deal to us!

Wishing you all clear skies, and successful eclipse plans!

**—Kris Larsen**

## About Our Look

Financial reality has required us to reduce our page count. To continue to bring you, as closely as possible, the same amount of content as always, we have developed a more compact design. Text type remains the same size, but is set with a little less space between lines. Headings are smaller to save more space. You'll see some other changes too. We welcome your thoughts and suggestions about these changes as we move forward.

**—Michael Patterson**

## Star Beams

### WEBSITE UPDATE

Thanks to the many website viewers who have posted questions for the support team on the new website! We have attempted to route these questions to the correct people. We appreciate the strong response to this new service. One of the decisions we made shortly after the new website became live was to leave the society rosters section empty. The reasoning was that since the data is grossly out of date, the national office will request current rosters from our member societies. This task should be completed soon.

### HYBRID ALCON 2024 PLANNED

ALCon 2024 is scheduled for July 17-20, 2024, in Kansas City, marking the beginning of a hybrid option for ALCon. It is anticipated that most of the convention's offerings will be simulcast online for a nominal fee. This will offer an option for people who are unable to attend ALCon in person to participate online. More information will follow.

### AWARDS

Do you, your family, or your business have an interest in sponsoring an Astronomical League Award program such as the Mabel Sterns Newsletter Award, the League's Webmaster Award, or perhaps one of the Horkheimer Suite of Awards (Service Award, Journalism Award, or Imaging Award)? If so, I would like to discuss possible

sponsorship with you. Please email me at *president@astroleague.org.*

### A REMINDER

Anyone who was unable to attend ALCon 2023 to receive their award plaque in person and had it shipped to you instead, please have pictures taken of you and your plaque, with a presenter if possible, and send them to *president@astroleague.org* so we can share your great accomplishments.

### ANOTHER REMINDER

Once again, I would like to remind you that it is possible to add the Astronomical League to your estate planning program. Please contact us for more information.

Happy observing!

**—Carroll Iorg**
*President*

## DarkSky

Recently, the name for the International Dark-Sky Association (IDA) was changed to DarkSky International (DSI). The new name DarkSky is felt to retain the existing brand equity with it just being shortened a bit from before. In the process there is a new logo for the organization, which I really like. After quite a bit of work, the organization's website, *darksky.org*, has been updated, and you should give it a look.

I think the new website design is quite easy to navigate and gives a great introduction to the issue of light pollution and what needs to be done about it. It succinctly notes "Light pollution disrupts wildlife, impacts human health, wastes money and energy, and blocks our view of the universe." The issue of blocking my view of the universe is what got me started in the battle against light pollution. I wanted to preserve the sky for my observatory and for astronomers worldwide. I also hope someday some formerly dark areas can be restored to their original darkness.

IDA was very astronomy-centric in its earliest days in the late 1980s and early 1990s. Fortunately, it soon broadened its horizons and DSI now represents an entire spectrum of people who want to preserve our nighttime heritage. Without this broad point of view – embracing environmentalists, poets, outdoor enthusiasts, ecologists, and cultural anthropologists, alongside astronomers – we couldn't hope to interest the public in the issue and make any progress. Even so, the battle is long and hard, requiring continued vigilance to maintain dark skies where they now exist (let alone reduce the ever-present sky glow in suburban and urban regions across the globe).

Take time to stroll through the new revised DSI website. If you are not already engaged in the effort, use the website to find a chapter near you. Find approved lighting products or learn about dark sky places around the world to visit. Also look at DSI partners who support the organization with time and money, and thank them by considering their products. We are making progress. Think how much worse things would be without the efforts of DSI and its supporters.

**—Tim Hunter**
*DarkSky International*

## Night Sky Network

### GETTING YOUR NEW BOARD ON-BOARD

With the start of a new year, many clubs are conducting elections or seating newly elected board members. Research done with hundreds of clubs across the country has shown that it's healthy to rotate club board positions and that the most successful clubs have practices in place to support new board members. Luckily, it's easy to on-board your new board members with these few tips.

### TERM LIMITS

While not always a popular option, research shows that term limits on board positions make for a stronger club culture, allow innovative ideas, and assure volunteers that they won't be "stuck" in a position forever. If it seems like a daunting task to find new members, read on for recruiting ideas that work.

### EFFECTIVE RECRUITING STRATEGIES

Start by inviting members to observe and learn before asking them to commit to a position. Don't make an announcement asking for board members. Talk with people directly about why you think they'd be good at the position.

### TRAINING AND SUPPORT

Have a job description prepared with tasks and hours required. Make sure the new volunteer gets coaching from the current person in that position. Let them know where they can go with questions. This could be a volunteer coordinator position! Have incumbents recruit the next person for their position. Be ready with the job description and approach people one-on-one, not as a callout at a club meeting.

### PUBLIC RECOGNITION

Make the club aware of the many tasks that go on behind the scenes and acknowledge your volunteers – it's really easy. Highlight a few people's contributions at monthly meetings or through the newsletter. Get badges made that designate the person's service position. Highlight contributions to the club at an annual awards ceremony. The Night Sky Network offers annual pins designed to do just that. Each active club receives three free pins and can order additional pins at cost.

Find more detailed information, checklists, and videos to share with your astronomy club board members at *www.astrosociety.org/SharingTheUniverse.*

If you would like to set up a time to talk strategies or organization ideas with the Night Sky Network team, schedule an office hour at *bit.ly/talknsn.*

This research was part of the Sharing the Universe Grant led by the Astronomical Society of the Pacific and the researchers at the Institute for Learning Innovation, funded by the National Science Foundation.

**—Vivian White**
*Astronomical Society of the Pacific*

## STEAM

### ASTRONOMICAL CAUSE AND EFFECT

In August 2023, just days before the new school year was about to start, Broken Arrow Sidewalk Astronomers was extended an invitation to help an individual host an Astronomy Night. This new contact was a young businessman/entrepreneur who was restoring a historic mansion built during the Reconstruction era, well before Oklahoma was a state. After a return email and a phone call, we planned a mobile observatory (MOB) visit for his event, to be held at the original home of Dr. Francis B. Fite, a New York–trained surgical technique medical doctor who settled in the then-named Muskogee Indian Territory in 1889.

Mr. Charles Crawford wanted to give students a last fun day before school started so he reached out to the school system, but they were busy prepping for opening day. I helped him by contributing STEM tables with the MOBs, to complement lawn games, a water booth, cotton candy/popcorn booth, and food trucks. One of these featured a "pay what you can afford" option, so no one was going to leave hungry! Restoration work was still proceeding on the Fite Mansion, and the local crews of workers involved in the project and their families were invited to attend.

The event started before sunset, and while temperatures were still in the 90s, the children boisterously enjoyed all the activities. But at dark, the games shut down and the children and parents made their way to the MOBs in the driveway. These families had generally not previously had the opportunity to look through a telescope, so they eagerly swarmed to the lawn where some attendees had already spread picnic blankets and set up lawn chairs to look for meteors. A green laser constellation talk was given and sprinkled among the group were the Muskogee Chamber of Commerce members, prominent business owners, and magazine reporters. Even a renowned young blogger and live streamer was in attendance!

The interaction was dynamic as people came through the MOBs; since the tree line was high, the added height of the trailers really saved the night. The atmosphere was overall very inviting and resulted in great conversations, with people

extending me their business cards for future events. Mr. Crawford's event coordinator came by and booked the MOBs for the spring.

This Oklahoma town of almost 37,000 people has a diverse population and a checkered past in terms of how different groups have interacted with each other. With these past difficulties still in the forefront of many adult minds, events of this type serve another purpose besides science, technology, engineering, art, and math: they bring together individuals from all walks of life for a common cause – to appreciate the night sky that belongs equally to all of us.

We met up with Charles a week later and he shared something most unexpected. After the videos from the event were posted by the blogger, Charles received a call from one of the Chamber of Commerce members who claimed that he could not believe his eyes... (stay tuned for the rest of the story in the March issue)

Full STEAM ahead (with a cliffhanger),

**—Peggy Walker**

*Astronomical League STEAM and Jr. Activities Coordinator*

# Deep-Sky Objects

### A WHALE OF A GALAXY

M77, a spiral galaxy, is one of the most fascinating galaxies cataloged by the 18th century French astronomer Charles Messier. Aside from the unique physical structure of the galaxy, many of its distinctions are purely a factor of the geometry of our vantage point and constellation boundaries.

M77 resides in the constellation Cetus 6.3 degrees southwest of the star Menkar (Alpha Ceti) and 3.3 degrees south of Gamma Ceti. The galaxy shines at magnitude 9 and is 7.1 by 6.2 arcminutes in size.

M77 is the only Messier object in Cetus, one of the largest constellations, and is the only Messier object on the celestial equator. The next closest is M2, 0.8 degrees south of the celestial equator. M77 is also the first target on the list for my March Messier Marathon – the one night around the late March new moon when it is possible to spy the entire Messier catalog. My best was 102 Messier objects the night on March 17–18, 2007.

M77 was discovered in 1780 by Pierre Mechain, a colleague of Messier. Messier originally thought it was a star cluster, as did William Herschel. The Irish astronomer William Parsons (Lord Rosse) discovered its spiral nature and in 1850 listed it among 13 others as spiral nebulae that were thought to reside within the Milky Way Galaxy. A century ago, Edwin Hubble discovered that these spiral nebulae were really distant galaxies. M77 lies nearly 70 million light-years away.

M77 is a moderately wound spiral galaxy with massive dust lanes and a bright, starlike core. The galaxy has an active galactic nucleus and is thus classified as a Seyfert galaxy. The galaxy emits massive amount of radio waves and is also known as the radio source Cetus A. X-rays and neutrinos have also been detected coming from M77. All of this energy, across the spectrum, is powered by a supermassive black hole at the center, obscured in visible wavelengths by a massive cloud of cosmic dust. The black hole may have the equivalent mass of ten million suns!

My image of M77 was taken with an 8-inch Ritchey–Chrétien telescope with a SBIG ST-2000XCM CCD camera. The exposure was 160 minutes. As seen in the image, the galaxy is nearly face-on. Barely visible in the image is a large ring structure circling the galaxy. Better images taken with extremely large telescopes show this ring may be composed of two enormous extended spiral arms. The ring also contains a large amount of dust and is undergoing as much new star formation as the inner spiral arms. The outer ring may have formed when a smaller galaxy passed though M77 causing an outward push of star-forming material around the larger galaxy.

Whether it's from the central black hole, from a galactic merger, or both, M77 has the brightest star-forming regions in any galaxy within 100 million light-years of Earth. All of this provides good food for thought when spying this little faint fuzzy object in an 8-inch telescope.

**—Dr. James R. Dire**

# Around the League

### CALL FOR AWARD SUBMISSIONS

Applications or nominations for all 2023 League youth and general awards must be received no later than March 31, 2024, at 11:59 p.m. CDT. Award information, including applications, eligibility criteria, and available cash prizes, if any, appears on the "Awards" page at *www.astroleague.org.* Award submissions are not deemed complete until you receive a confirming email acknowledging receipt. If no confirmation is received within 48 hours of submission, contact the League vice president.

### LEAGUE YOUTH AWARDS

**National Young Astronomer Award** – Qualified U.S. citizens (or U.S. school enrollees) under the age of 19 who are engaged in astronomy-related research, academic scholarship, or equipment design are encouraged to apply for the National Young Astronomer Award, now in its 32nd year. League membership is not required. The top two winners win expense-paid trips to the League's national convention (U.S. travel only) and receive Explore Scientific telescope prizes. The application, research paper, and a photo of the nominee must be emailed to *NYAA@astroleague.org*.

**Youth Service Awards** – Qualified League members under the age of 19 who are engaged in service to the League, their clubs, their schools, and/or the amateur astronomy community are encouraged to apply for the Horkheimer/Smith Youth Service Award. Club or regional officers may nominate candidates. The Horkheimer/Smith winner receives a plaque, a cash prize, and an expenses-paid trip to the League's national convention (U.S. travel only). The application or nomination and a photo of the nominee must be emailed to *HorkheimerService@astroleague.org.*

**Youth Imaging Award** – Qualified League members under the age of 19 who are engaged in astronomical imaging are encouraged to apply for the Horkheimer/Parker Youth Imaging Award. Club or regional officers may nominate candidates. The winner receives a plaque, and the top three

finishers receive cash prizes. The application, astrophoto, and a photo of the astrophotographer must be emailed to *HorkheimerParker@astroleague.org.*

**Youth Journalism Award** – Qualified League members ages 8–14 are encouraged to enter a science essay in competition for the Horkheimer/O'Meara Youth Journalism Award. Club or regional officers may nominate candidates. The winner receives a plaque, and the top three finishers receive cash prizes. The application, essay, and photo of the young journalist must be emailed to *HorkheimerJournalism@astroleague.org.*

## LEAGUE AWARDS

The following general League awards are open to all League members regardless of age. Winners receive award plaques.

**Mabel Sterns Award** – The Mabel Sterns Award acknowledges the important role of club newsletter editors. Club officers may nominate a newsletter editor by emailing either a copy of the club's print newsletter as a PDF file or a link to an online newsletter to *sternsnewsletter@astroleague.org,* along with a nomination cover letter (PDF) that includes the name and address of the nominee and a photo of the newsletter editor. Nominees and nominating officers must be League members.

**Webmaster Award** – The League's Webmaster Award recognizes excellence in creating and maintaining society web pages. Club officers may nominate a webmaster by emailing a website link to *WebmasterAward@astroleague.org* along with a nomination cover letter (PDF) that includes the name and address of the nominee and a photo of the webmaster. Nominees and nominating officers must be League members.

**Williamina Fleming Imaging Awards** – These awards, now generously sponsored by Explore Scientific, are open to female League members who are 19 years of age or older. Awards are given in four categories of astrophotography: deep sky (>500 mm excluding Solar System), Solar System (>500 mm), rich field (201–500 mm), and wide field (200 mm or less). Images submitted by professional astrophotographers as defined in the rules will not be accepted. Submissions are made by emailing the entry form, a photo of the entrant, and up to three JPEG attachments not exceeding a total of 25 megabytes to *flemingaward@astroleague.org.* All submissions must consist of images taken and processed solely by the individual.

**TelescopeTrader Sketching Award** – The Sketching Award recognizes the fundamental role that sketching plays in observing. The award is open to League members of all ages. In addition to the winner's plaque, cash prizes are awarded to the top three finishers. Sketches should be submitted as high-resolution JPEG files (10 megabytes maximum) along with a JPEG photo of the applicant to *Sketch@astroleague.org.*

**—Chuck Allen**

## CALL FOR OFFICER NOMINATIONS

Nominations for the offices of League **president, vice president,** and **treasurer** for terms beginning on September 1, 2024, must be received by nominating committee co-chair John Goss at *gossjohn@gmail.com* no later than March 31, 2024, at 11:59 p.m. CDT. The duties of each office appear in the League bylaws. Nominations should be accompanied by (1) a background statement of 250 words indicating qualifications and/or reasons for seeking the position and (2) a photo of the nominee, both for inclusion in the *Reflector* and on the ballots.

**—Chuck Allen**

## ALCON 2023 REPORT

The 2023 Astronomical League Convention (ALCon 2023) was held July 26–29 in Baton Rouge, Louisiana, at the historic Capitol House Hotel (the Hilton Baton Rouge Capitol Center). Our theme was **"Astronomical Gumbo,"** which represents the blend of diverse subfields and people within the vast field of astronomy. Gumbo is a dish that combines the culinary practices of Africans, Native Americans, French, and Spanish, and is often used as a metaphor for the mix of cultures that exist in southern Louisiana.

*The planetarium at the Louisiana Art & Science Museum. The evening featured a presentation by Fred Espenak with questions and answers on solar eclipses.*

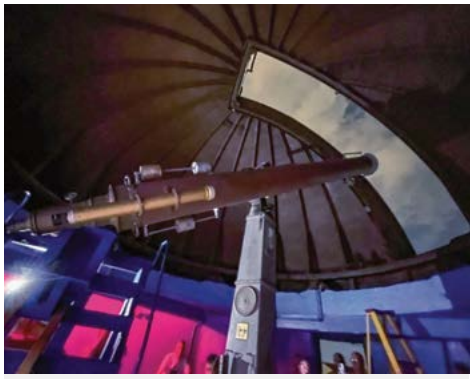
ALCon 2023 kicked off with an opening reception at the historic Landolt Astronomical Observatory atop the physics and astronomy building (Nicholson Hall) on the main campus of Louisiana State University. The attendees enjoyed "100 Years of LSU Astronomy: From a Lone Astronomer to Exoplanets, Black Holes, and Cosmic Explosions!" by LSU Professor Dr. Rob Hynes before heading upstairs for viewings through an 11.5-inch Alvan Clark telescope.

Attendees were treated to a wide selection of excellent presentations. For example, Chuck Allen gave a talk on "Astronomical Yardsticks," the different yardsticks needed for different subfields of Astronomy, Debbie Moran talked on "Light Pollution and Its Mitigation," Dr. James Dire spoke on the "History of the Telescope," and Greg Andrews, the planetarium manager at Sci-Port Discovery Center in Shreveport, Louisiana, gave a talk on astronomical outreach. "Mr. Eclipse," Fred Espenak, spoke at the Louisiana Art & Science Museum, where we saw a show in the state-of-the-art Irene Pennington Planetarium, and the AAVSO conducted a workshop on "Showing Real-Time Stellar Variability to the Public."

*Ron Kramer, David Levy, Carroll Iorg*

The two National Young Astronomer Award (NYAA) winners gave their presentations. The two speakers were Kaitlyn Wang and León Garcia, who tied for first place in the NYAA competition.

"Youth in Astronomy" was also the topic of one of the panel discussions. Moderator Pranvera Hyseni and panelists Ashini Modi, Kaitlyn Wang, León Garcia, Dhruva Kalyani, and Anyalina Vertigan led this timely discussion. The AL president's panel discussion, "The Astronomical



*The 11.5-inch Alvan Clark telescope in the Landolt Astronomical Observatory at Louisiana State University.*

League: Boldly Welcoming the Future," was led by President Carroll Iorg. There was also a panel discussion on "Being a Science Communicator," with panelists Vivian White, Brother Guy Consolmagno, David Eicher, and Pranvera Hyseni. In a separate talk, Brother Consolmagno and co-author Dan Davis discussed their classic book, *Turn Left at Orion.* Another highlight was a talk by David Levy on his famed comet hunting activities; afterwards he was presented with the 2023 Astronomical League Award for outstanding contributions to the field of astronomy.

The attendees' gastronomical interests were also attended to. The astronomical gumbo/jambalaya/BBQ was held at the Highland Road Park Observatory (Minor Planet Center code 747) where at least 55 asteroids have been discovered by members of the Baton Rouge Astronomical Society. The annual Astronomical League awards banquet was held to honor the recipients of AL awards. The keynote speaker for the evening was David Eicher, who spoke on "Galaxies."

One group of lucky attendees went on a tour of LIGO (Laser Interferometer Gravitational-Wave Observatory) outside the town of Livingston, Louisiana, one of a pair of an increasing number of such facilities around the globe that were created to detect gravitational waves.

**—Steven M. Tilley**

## YOUR ASTRONOMICAL LEAGUE JUST GAVE AWAY EIGHT LIBRARY TELESCOPES

In 2023 the Astronomical League again offered a free Library Telescope to a lucky Astronomical League club in each region, plus one to a member-at-large.

The Library Telescope consists of a 4.5-inch Dobsonian reflector fitted with an 8–24 mm zoom eyepiece. The value of this opportunity is approximately $325; the potential is enormous.

The Library Telescope Program was initiated fifteen years ago by the New Hampshire Astronomical Society and has grown into a nationwide presence. Clubs donate an easy-to-use portable telescope with both quality optics and a sturdy mount to their local library. Patrons can then check it out as they do books.

Thank you to Orion Telescopes and Woodland Hills Camera and Telescope for making this wonderful program possible!

Congratulations to these 2023 winners!

**GLRAL – Evansville Astronomical Society**
**MERAL – Back Bay Amateur Astronomers**
**MSRAL – Kansas Astronomical Observers**
**NCRAL– Popular Astronomy Club**
**NERAL – Amateur Observers' Society of New York**
**NWRAL – Island County Astronomical Society**
**WRAL – Astronomers of Humboldt**
**MAL – Steve Boerner**

# NASA Press Release

## JET STREAM NEAR JUPITER'S EQUATOR HAS 320 MILE PER HOUR WINDS

NASA's James Webb Space Telescope has discovered a new, never-before-seen feature in Jupiter's atmosphere. The high-speed jet stream, which is more than 3,000 miles (4,800 kilometers) wide, sits over Jupiter's equator above the main cloud decks. The discovery of this jet is giving insights into how the layers of Jupiter's famously turbulent atmosphere interact with each other, and how Webb is uniquely capable of tracking those features.

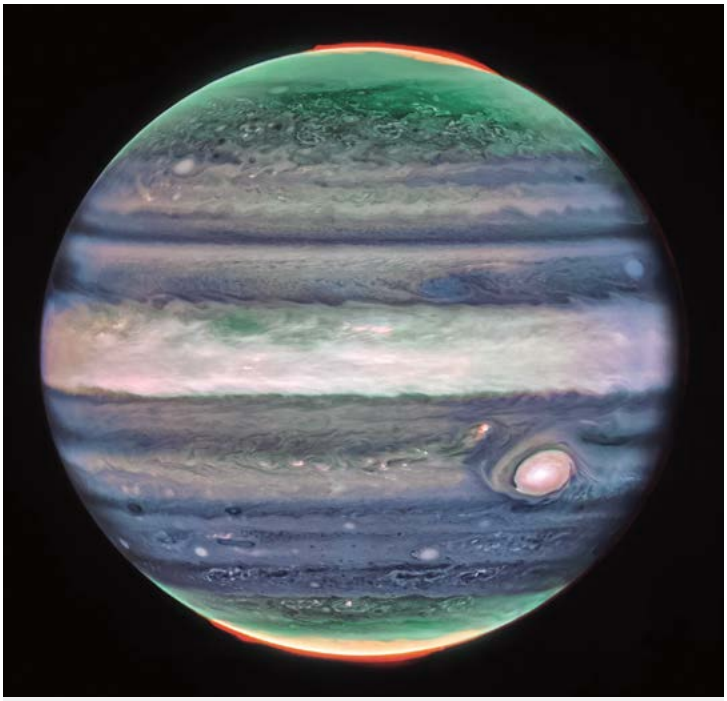


*Image credits: NASA, ESA, CSA, STScI, R. Hueso (University of the Basque Country), I. de Pater (University of California, Berkeley), T. Fouchet (Observatory of Paris), L. Fletcher (University of Leicester), M. Wong (University of California, Berkeley), J. DePasquale (STScI)*

This image of Jupiter from NASA's James Webb Space Telescope's NIRCam (Near-Infrared Camera) shows stunning details of the majestic planet in infrared light. In this image, brightness indicates high altitude. The numerous bright white spots and streaks are likely very-high-altitude cloud tops of condensed convective storms. In contrast, dark ribbons north of the equatorial region have little cloud cover. Auroras, red in this image, extend to higher altitudes above both the north and south poles of the planet.

"This is something that totally surprised us," said Ricardo Hueso of the University of the Basque Country in Bilbao, Spain, lead author on the paper describing the findings. "What we have always seen as blurred hazes in Jupiter's atmosphere now appear as crisp features that we can track along with the planet's fast rotation."

The research team analyzed data from Webb's NIRCam (Near-Infrared Camera) captured in July 2022. The Early Release Science program – jointly led by Imke de Pater from the University of California, Berkeley, and Thierry Fouchet from the Observatory of Paris – was designed to take images of Jupiter 10 hours (one Jupiter day) apart, in four different filters, each uniquely able to detect changes in small features at different altitudes in Jupiter's atmosphere.

While Jupiter is different from Earth in many ways – Jupiter is a gas giant; Earth is a rocky, temperate world – both planets have layered atmospheres. Infrared, visible, radio, and ultraviolet wavelengths observed by other missions detect lower, deeper layers of the planet's atmosphere – where gigantic storms and ammonia ice clouds reside.

Webb's ability to look farther into the near-infrared makes it especially sensitive to the higher-altitude layers of the atmosphere, around 15–30 miles (25–50 kilometers) above Jupiter's cloud tops. In near-infrared imaging, high-altitude hazes typically appear blurry, with enhanced brightness over the equatorial region. With Webb, finer details are resolved within the bright hazy band.

The newly discovered jet stream travels at about 320 miles per hour (515 kilometers per hour), twice the speed of sustained winds of a category-5 hurricane here on Earth. It is located around 25 miles (40 kilometers) above the clouds, in Jupiter's lower stratosphere.

By comparing the high-altitude winds observed by Webb to the winds observed at deeper layers by Hubble, the team could measure how the winds change with altitude and generate wind shear. The researchers are looking forward to additional observations of Jupiter with Webb to determine if the jet's speed and altitude change over time.

The peer-reviewed paper recently appeared in *Nature Astronomy (www.nature.com/articles/s41550-023-02099-2).*

**—Adapted from a NASA press release authored by Laura Betz, Hannah Braun, and Christine Pulliam**

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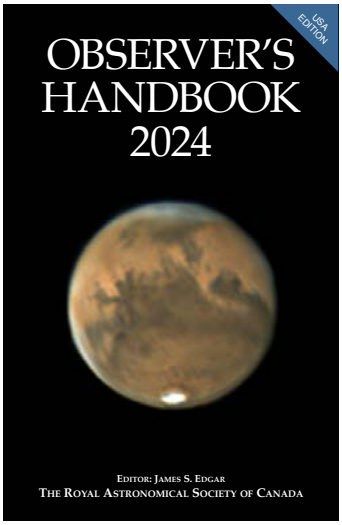


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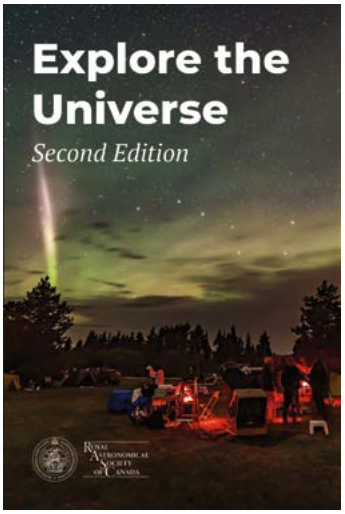


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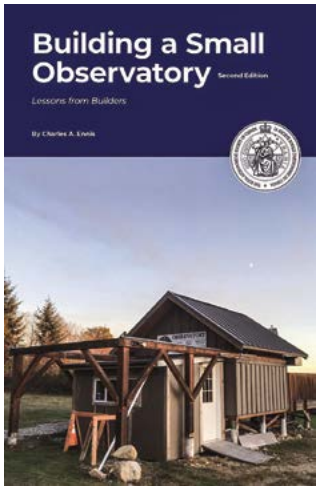


## BUILDING A SMALL OBSERVATORY

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# THE SUN CROWS

*Image from a Han Dynasty mural, public domain. Color added.*

By Christina Ding

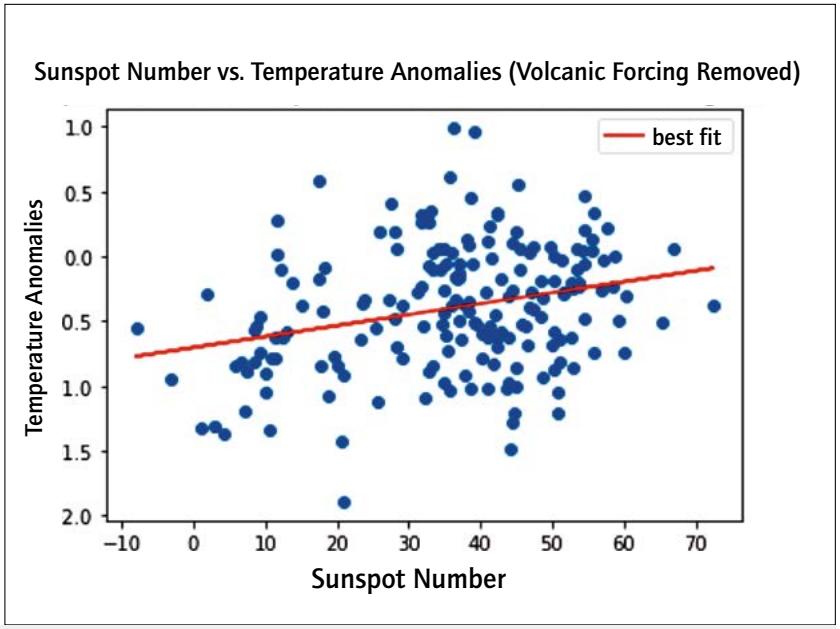



*Figure 2. A comparison between sunspot number and global temperature anomalies from 1850 to 1950. Graph by author using Python.*

In ancient Chinese tales, people often associated the Sun with a mystical creature known as "San Zu Niao," a crow with three feet. According to the tales, long ago, the mischievous three-footed-crows soared into the heavens and transformed into ten suns. As a result, scorching heat and devastating droughts plagued the land of China. To restore balance, a heroic archer named Hou Yi used his exceptional archery skill to shoot down nine of the ten suns, leaving only one sun in the sky. He brought relief to the climate, allowing life to flourish once more. In ancient China, the presence of three-footed-crows – sunspots – was associated with hot temperatures; interestingly, we now know that when sunspots increase, so do other forms of solar activity, resulting in a slightly larger solar irradiance that can potentially help make our planet hotter.

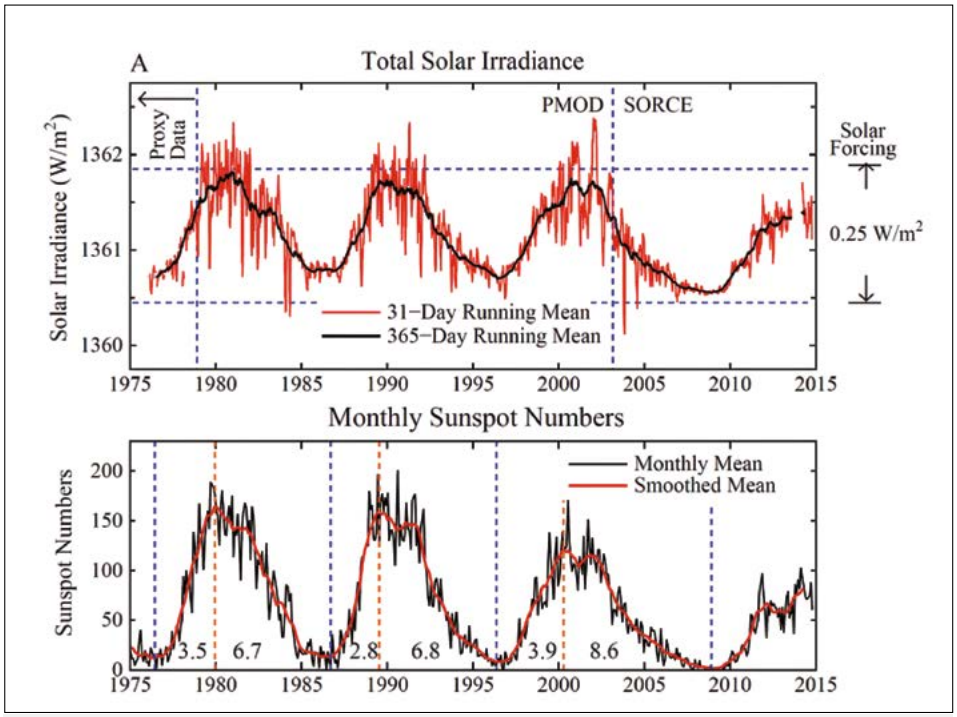



*Figure 1. Correlation of solar irradiance with sunspot numbers. From J. Hansen et al. (2013) PLoS ONE 8(12): e81648. https://doi.org/10.1371/journal.pone.0081648. Public domain image.*

## WHAT ARE SUNSPOTS?

Sunspots are intriguing phenomena on the surface of the Sun. They are darker and cooler than the surrounding areas and are often associated with intense magnetic activity. The number of sunspots follows a cyclic pattern known as the solar cycle, driven by the Sun's internal magnetic field. This also leads to variations in other solar activity, such as flares and coronal mass ejections.

## PROXY DATA

In fact, neither sunspot data nor temperature data were directly measured or observed in the past – there weren't people counting the number of sunspots every day! So how do astronomers determine their numbers a long time ago? Thanks to proxy data, which refers to indirect records that can provide information about the past behavior of a phenomenon when direct observations are unavailable, scientists can estimate the number of sunspots in the past.

One common proxy method for studying sunspot data involves analyzing cosmogenic

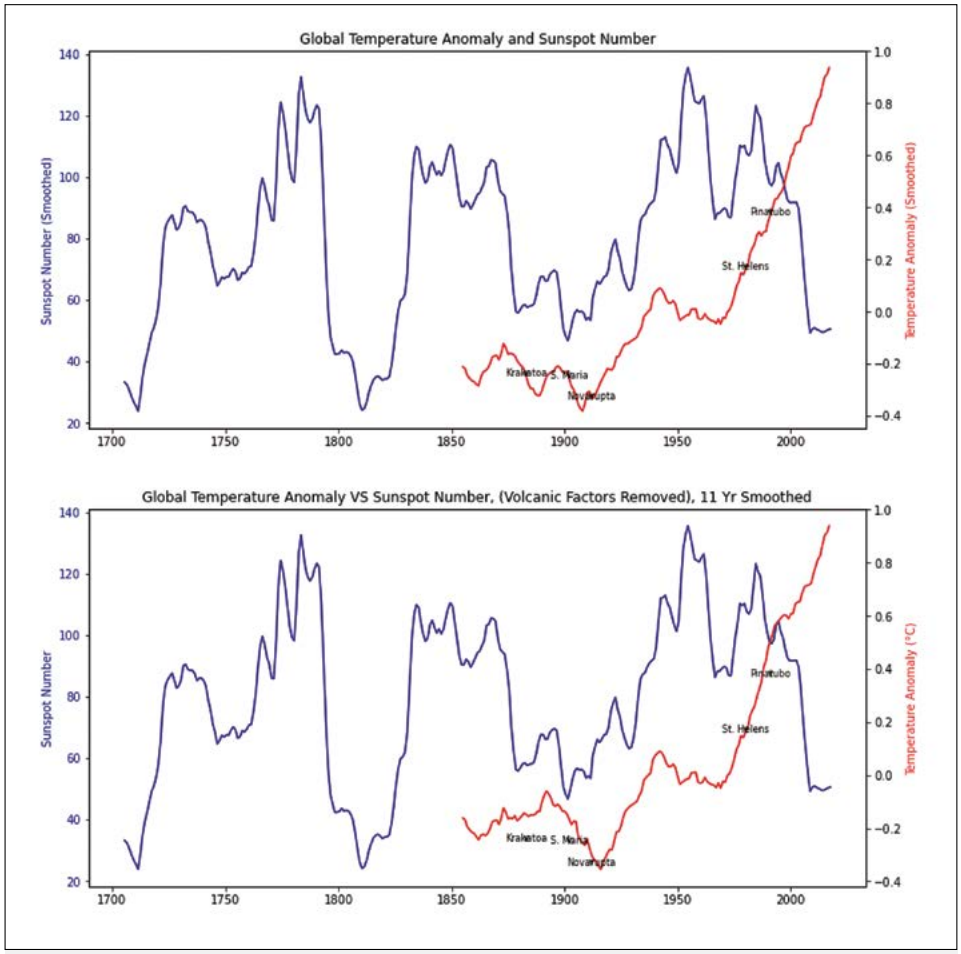



*Figure 3. Above: Global temperature anomaly and sunspot number (smoothed) versus time. Below: The data with volcanic factors removed. Graphs by author using Python.*

isotopes, such as carbon-14 and beryllium-10, preserved in natural archives like tree rings and ice cores. These isotopes are produced in the Earth's atmosphere when high-energy cosmic rays, predominantly originating from the Sun, interact with atmospheric particles. The concentration of these isotopes can be measured and used as an indicator of solar activity, including sunspot variations, over long periods of time.

## SUNSPOTS' POSSIBLE INFLUENCE ON EARTH'S CLIMATE

Sunspots can affect the Earth's climate through variations in solar radiation. During periods of maximum sunspot activity, the Sun's luminosity experiences a slight rise. This increase is particularly noticeable in the form of heightened ultraviolet radiation, which significantly impacts the Earth's atmosphere. Conversely, during times of minimum sunspot activity, the energy we receive from the Sun diminishes. As you can see from figure 1, the change is very small, only one or two tenths of a percent. Sunspot numbers have been correlated with some climate shifts, although their impact is relatively limited compared to other significant factors.

## THE MAUNDER MINIMUM

One intriguing period that highlights this connection is known as the Maunder Minimum, one of the most notable grand minima of the Sun. Lasting from about 1645 to 1715, the Maunder Minimum was an extended time of remarkably low sunspot activity. Coinciding with this period, parts of Europe experienced a prolonged cold spell known as the "Little Ice Age." Scientists have investigated the extent to which the scarcity of sunspots during the Maunder Minimum could have contributed to this unusual cooling on our planet.

However, it's essential to note that the Little Ice Age extended beyond the Maunder Minimum, indicating that low solar activity may have only intensified the colder temperatures rather than causing them. Furthermore, it's crucial to acknowledge that the influence of sunspots is limited and overshadowed by more significant drivers of climate change, such as human-generated greenhouse gas emissions and volcanic activity. These factors have a more substantial and long-lasting impact on our climate system.

## BY THE NUMBERS

Limitations aside, I decided to investigate the data myself. By collecting sunspot data and comparing them with temperature records from NOAA, I created a scatterplot (figure 2) that correlates sunspot number and global temperature anomalies by year, which reveals a discernible, positive correlation but not a particularly strong one.

Even though my data did not cover the Maunder or Dalton (1790–1830) solar minima, I selected the period 1850–1950 for analyzing sunspot number and global temperature for several reasons. Greenhouse gas emissions were lower than they are now, allowing focus on natural factors. Data accuracy for sunspot numbers and temperature was high. Precise data on temperature changes caused by volcanic activity before the 19th century were limited, making it difficult to estimate their impact. In figure 3, the top panel compares the sunspot number and global mean temperature with 11-year smoothing; on the other hand, the temperature data in the bottom panel had rough temperature decreases caused by volcanoes removed, allowing a slightly more accurate relationship between sunspot number and global mean temperature. In the bottom panel, better correspondence is shown, particularly right before 1900, as well as their simultaneous growth in the first half of the 20th century. After about 1950, human-caused greenhouse gases were being released significantly more than before, therefore the recent steady rise of temperatures should be ignored.

## FINAL THOUGHTS

I came to the realization that it is important to consider the correspondence between sunspots and global temperatures on a large scale – that is, not to focus on every year, or even every solar cycle, as the solar activity varies from year to year and decade to decade, and the solar influence is ultimately still easily overshadowed by other climate forcings. Thus, my study led me independently to the same conclusion as climate scientists; we need to look further back over larger periods of history if we want to see what impact solar activity might have on our climate, and try to account for other influences (such as volcanoes). My project was a valuable learning experience, and I recommend that others look at the available data for themselves. ✷

*Christina Ding is a member of Teen Texas Astronomical Society and a winner of the League's Horhheimer/Smith Youth Service Award.*

# MY LAST CORONAGRAPH

by James Daley

The current coronagraph, in Jim Daley's Ludwig Schuppman Observatory, in New Ipswich, New Hampshire.

Like so many amateur telescope makers, I got my start by making a Newtonian while in high school. With a mirror grinding kit from E&W Optics, I ground and polished a 6-inch plate glass primary mirror, built a tube, and began viewing the Moon and stars. I was smitten. My life's work in optics, both professionally and as an amateur, was cast.

I became interested in the solar coronagraph in 1963 after reading an article in the February 1963 issue of *Applied Optics,* titled "Reduction of Scattered Light in the Coronagraph," by Gordon Newkirk Jr. and David Bohlin. I knew then that I must build one. I ground and polished a 3.4-inch fused silica objective lens and soldered up some brass tubing with O-ring flanges to make what may have been the world's first evacuated coronagraph. Since then I've made three more coronagraphs, each one an improvement on the last. This story describes the culmination of my coronagraph efforts, along with some observing techniques.

The author's first coronagraph

## HISTORY

In the late 1870s, solar astronomers pondered the possibility of observing the corona without an eclipse. Early attempts, starting in 1878, continued for 52 years without success. Despite the efforts of many notable astronomers, none succeeded in observing the corona in full daylight. Astronomers knew from eclipse observations that coronal light was polarized. Using a Savart polariscope, R. W. Wood made a failed attempt to detect this intrinsically strong polarization. Professor H. O. Barnard urged Bernard Lyot to continue Wood's quest based on Lyot's success measuring planetary polarization with a very sensitive polarimeter of his own design. Lyot realized that scattered light from the telescope optics would overwhelm the light of the corona even in the clearest skies of high-altitude mountain sites. He set out first to measure the sources of scattered light from a single-element crown glass objective lens of 80 mm aperture and then, based on his findings, designed an entirely new and elegant optical system that produces an artificial eclipse.

In the spring of 1930, Lyot, using lumber lying about the Pic du Midi Observatory, built the world's first coronagraph. He reduced the above-mentioned objective's aperture to 30 mm and, on July 25th of that year, observed prominences without a filter! He did find that a red glass filter substantially improved the contrast. Using his polarimeter he detected the inner corona. On July 30, Lyot used a simple spectroscope and observed the 5,303-angstrom iron line in the inner corona.

On June 12, 1931, a new and improved coronagraph of 130 mm aperture was installed and further spectroscopic work was done. Lyot's final coronagraph, built in 1935, was a 200 mm beauty. His images of the inner corona at many wavelengths remain among the best photos extant. I was born a year later.

The Lyot coronagraph makes it possible to view and image the Sun's most beautiful features: the prominences. Standing on or sometimes well proud of the Sun's limb, these magnificent objects often reach heights of hundreds of thousands of kilometers. They occur in every imaginable structural form, some stable, some erupting, some collapsing, giving astronomers, particularly astrophysicists, a classification dilemma. Thankfully there exist varied but useful morphological classification schemes tailored to both the amateur and professional astronomer.

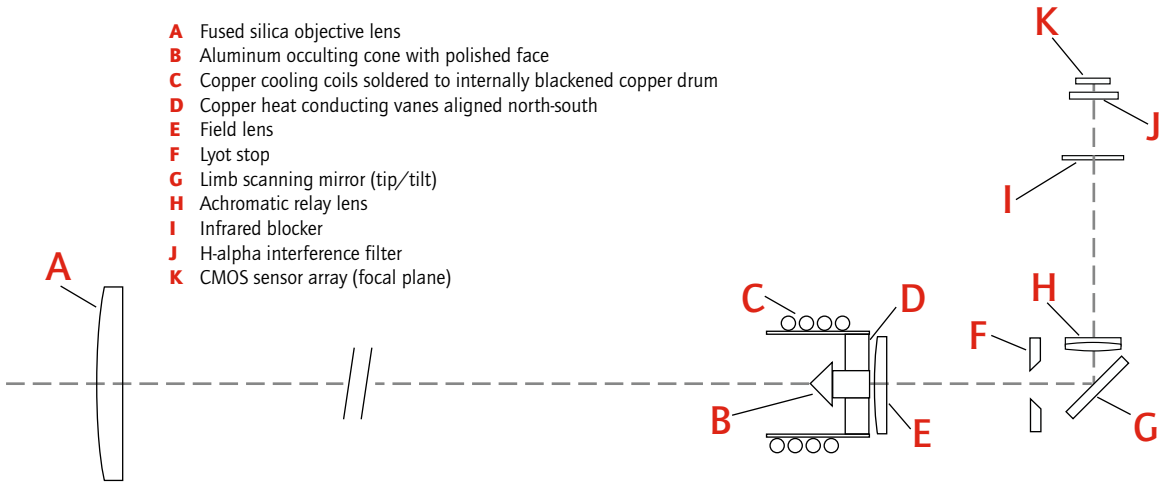
Prominences are observable almost every clear day and their antics delight the keen observer. During my amateur telescope making years I've had long experience building and using coronagraphs, yet every observation brings a feeling of wonder. These ethereal objects, to me, are simply amazing.

## ATMOSPHERIC CONDITIONS

Observing prominences makes one very aware of the daytime sky quality. A sky suitable for imaging the corona itself is blue right up to the Sun's limb. These are the rare days, usually after a storm clears the atmosphere of particles, when it is possible to view or image the inner corona in the iron green line (Fe XIV) at 5,303 angstroms. The prominences are much brighter and perfect skies are not need-

ed to easily view them in the red emission line of hydrogen at 6,563 angstroms. This line, named H-alpha, is the first of the hydrogen Balmer series of lines which extend into the deep violet.

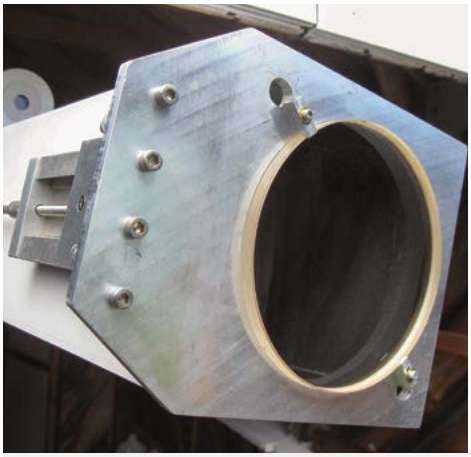
The Earth's atmospheric light scatter is caused by airborne particles with strong forward scattering properties, such as dust, smoke, pollen, and high-altitude ice crystals. The larger the particle, the more forward (propagated roughly in the direction it comes from the source) the scattering is directed, and the narrower the scattering angle. This is extremely harmful to solar observations of such a delicate nature.




*Schematic diagram of the coronagraph, not to scale*

## SEEING CONDITIONS

To record prominence fine structure the seeing must good indeed. At my site the best seeing occurs in the morning hours when the Sun is between 12 and 36 degrees elevation angle with a weak southwest air flow. Although atmospheric turbulence is minimized at these low angles, the path length is long, and I need to be sure that the jet stream is north of the line of sight. High altitude northerly winds destroy seeing at my location. This does not preclude noontime observations, as on rare occasions I observe very fine seeing with a stronger southerly or southwesterly breeze. Additionally, precise instrument focus can only be achieved in near perfect seeing. I often use the prominences' smallest bright "knots," as they are called, as point sources for focusing the instrument.



*The objective lens cell and focus mechanism*

## SPECIAL FEATURES OF MY FINAL CORONAGRAPH

I made the 5-inch diameter 89-inch focal length (f/18) objective lens from a Corning #7980 fused silica blank. This material is by far the best for ground-based instruments, with extremely low internal scatter, and, when carefully polished, shows an incredibly smooth and scatter-free surface quality. The lens is ground to a coma-free shape. Light aspheric figuring corrected the lens for spherical aberration. The remaining lens aberration is astigmatism, but it is harmless out to the tops of even tall prominences.

The lens is mounted in a cantilevered cell attached to a focus slide. A long extension rod attached to the focuser's lead screw reaches a handy position.

After over 60 years building coronagraphs, I find this focusing arrangement offers the only practical method of keeping the Sun precisely focused on the occulting cone rim for any chosen spectral line. It also allows the occulter to be mounted solidly in a fixed location, minimizing optical problems in the relay section.

The next special feature is the water-cooled occulter and heatsink drum. The solar heat load for this instrument is about 12 watts. This level of heat, if left to accumulate, will corrupt the wavefront due to induced tube currents. Various schemes abound in the literature to remove this heat. My design addresses both the energy reflected off the occulting cone and the non-trivial heat absorbed by the cone itself. The photo, taken during construction, shows the polished aluminum occulting cone, heavy copper central support rod with its short heat conducting vanes, and gravity-fed water-cooling coils and drum. The internal surface of the drum was later painted flat black. The drum assembly is supported by the straps shown, which are screwed to wood rails glued to the inner tube walls.

The effectiveness of this heat removal method is easy to demonstrate, especially under superb seeing when cooling counts the most, by shutting off the water flow and watching the image slowly degrade.

*The polished aluminum occulter in its water-cooled copper housing*

The third special feature is the limb-scanning mirror and unique position of the relay lens. My elbow arrangement allows the Lyot stop, scanning mirror, and relay lens to be tightly packed. With this optical geometry (see diagram), the optical axis of the relay lens always coincides with the center of the CMOS chip. After placing the prominence image on the chip center by tilting the gimbal-mounted diagonal scanning mirror, the image is then on the axis of the relay. This feature is vitally important because relay lenses are the source of the greatest off-axis aberrations in most coronagraphs. One must strive to keep its working field small. My ray trace results, using OSLO, confirm this.

A fourth simple feature is a blue filter window mounted on the tube top surface just before the Lyot stop. It forms a viewing port

to check the centering of the entrance pupil image on the Lyot stop. Because most of the imaging is in the light of H-alpha, the blue filter effectively blocks the red in skylight as a source of diffuse scatter, and thus needs no cover.

The Lyot stop is vital to the success of a coronagraph. Its purpose is to block the bright diffracted light of the objective's edge. It must be sized (on theoretical grounds) such that only 85 percent of the objective's aperture is allowed through the stop. In my instrument, the field lens, which images the aperture on the stop, provides a 0.724-inch intermediate pupil diameter. I punched a 0.625-inch hole in thin aluminum for the stop aperture. The stop is painted with the best flat black obtainable.

## THE H-ALPHA INTERFERENCE FILTER

I chose an inexpensive commercial grade 10-angstrom (full width at half maximum) interference filter of about 21 mm clear aperture made by Andover Corporation. The filter is located within 1 mm of the detector window where the beam cones are very tiny at f/21 (the final f number set by the Lyot stop), thus small errors in filter surface flatness are optically harmless. The coronagraph is so scatter-free that I can take advantage of the filter's thermal and tilt insensitivity and the full Doppler coverage it affords.

## THE TUBE

The tube is made from 3/16-inch pine planks that I re-sawed from 1-inch-thick rough lumber, ensuring that the tube is both lightweight and very stiff. The cross section is 6 by 6 inches, reinforced with 1/2-inch square longerons and crosspieces glued in place. The rear section of the tube, from the occulter onward, is flanged to the main tube so that this section can be easily removed for bench work. Various removable panels are provided for easy hand access to specific components. The tube is left rough sawn inside to reduce light scatter when sprayed flat black, and the outside is sanded smooth and painted white.

My mount is a solid German equatorial with 3.5-inch diameter polar and declination shafts. It can be seen in the photo of the telescope. A 9-inch diameter bronze worm wheel provides the smoothness and stiffness required the keep the Sun's image hidden behind the occulting cone, even in a fair breeze. The mount is equipped with fine motion controls in right ascension and declination, either manual or motor driven. The mount is bolted to a heavy concrete pier within a small roll-off roof observatory All this permanence of setup is an absolute requirement because a beautiful clear sky can appear and disappear in just an hour, so I must be ready to jump into action. I can begin imaging just 8 minutes after entering the observatory.

## IMAGING

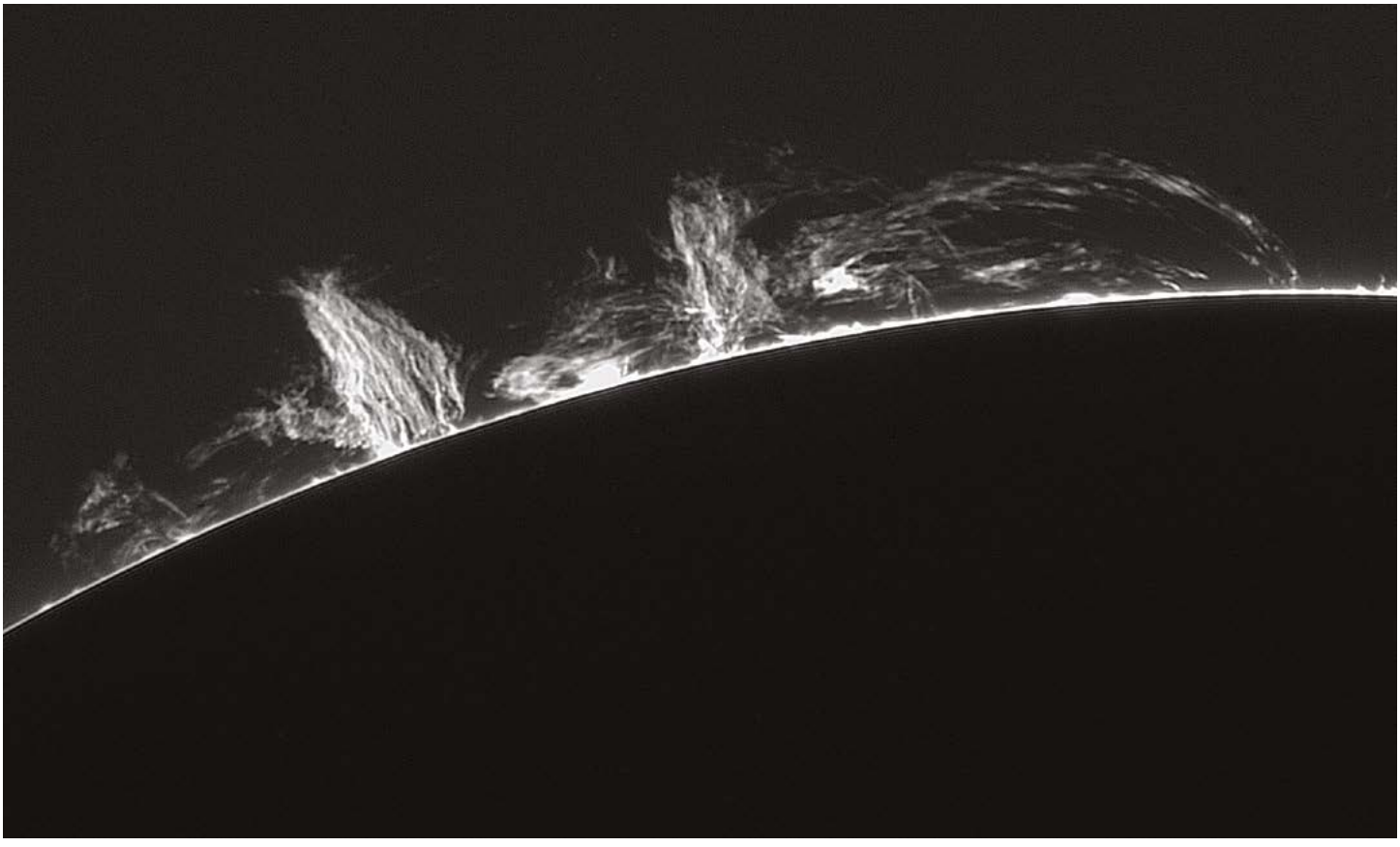
Images are collected by taking 6-second-duration videos using SharpCap 3. The videos are processed with AutoStakkert! and gently sharpened in RegiStax using wavelets. I find time-lapse movies to be exciting and informative; this is done by making a video* with each exposure typically 4-seconds apart. Playing the video at normal rates shows the dynamic behavior of almost all prominences. I usually make the movie cover 1 to 2 hours, which plays back in less than a minute. Measuring knot velocities is very interesting with apparent speeds of 35–110 kilometers per second rather common as they plunge into the photosphere.

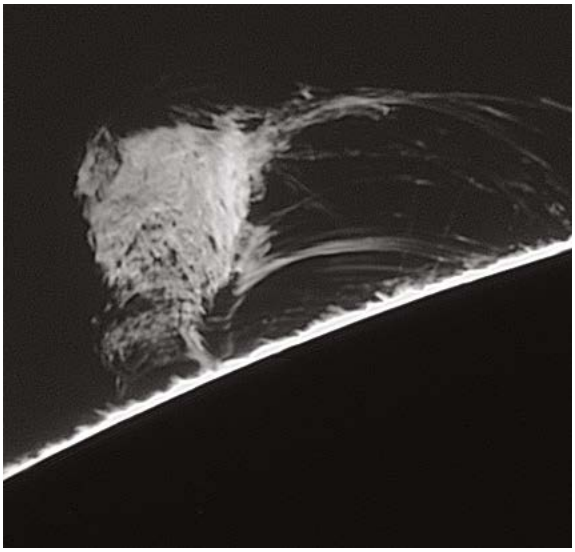
I hope this article will create some interest in observing the Sun with a Lyot coronagraph. For the advanced telescope maker and optical designer, the coronagraph represents an optical system of unsurpassed economy, intrinsic delight, beauty, and, of course, a joyous celebration of M. Bernard Lyot's genius. ✶

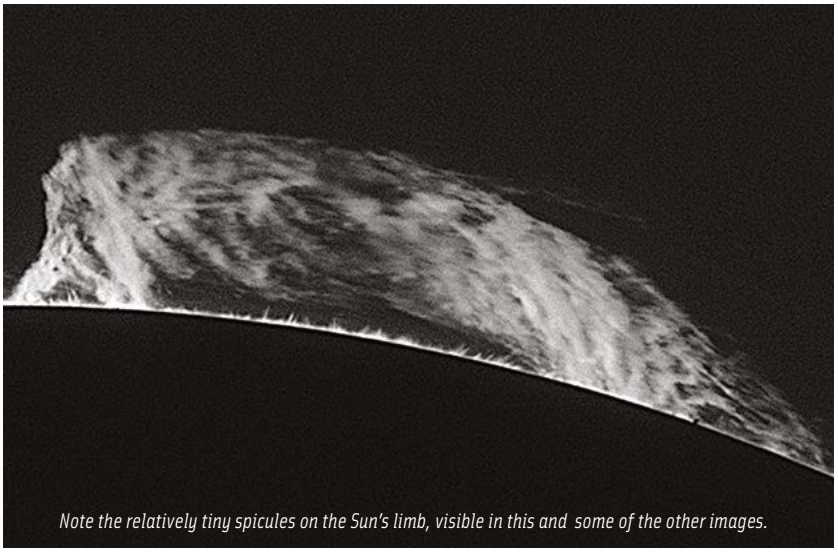
*James Daley is a member of the Springfield Telescope Makers. He is the author of* The Schupmann Telescope *(Willman-Bell, 2007).*



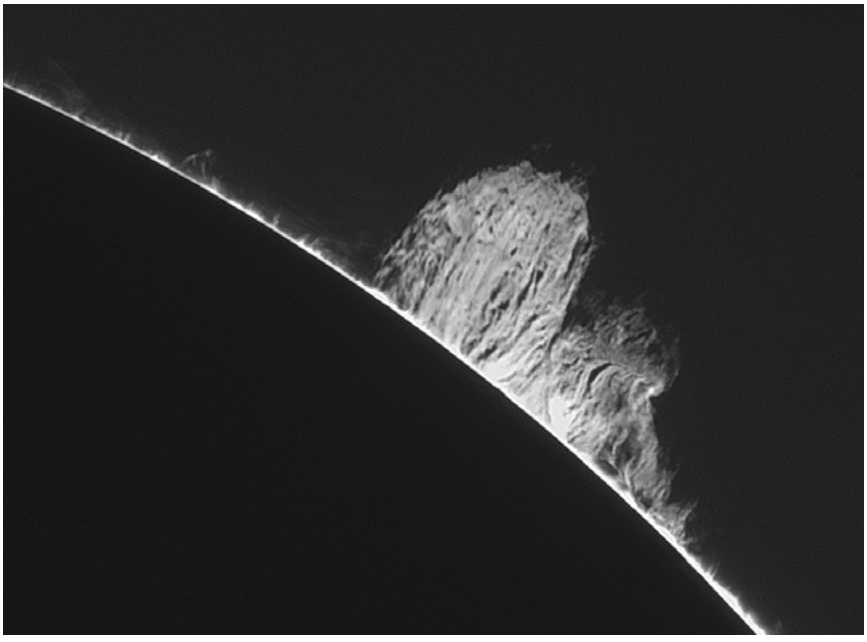
**An example of these videos can be seen at* youtu.be/fzOyMfQchgM

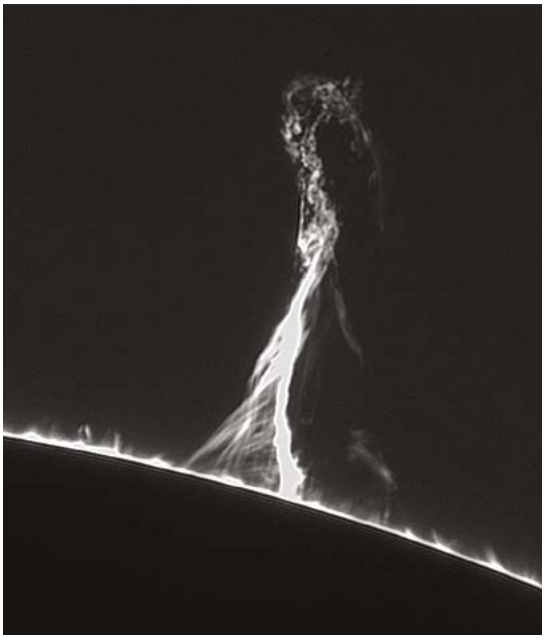


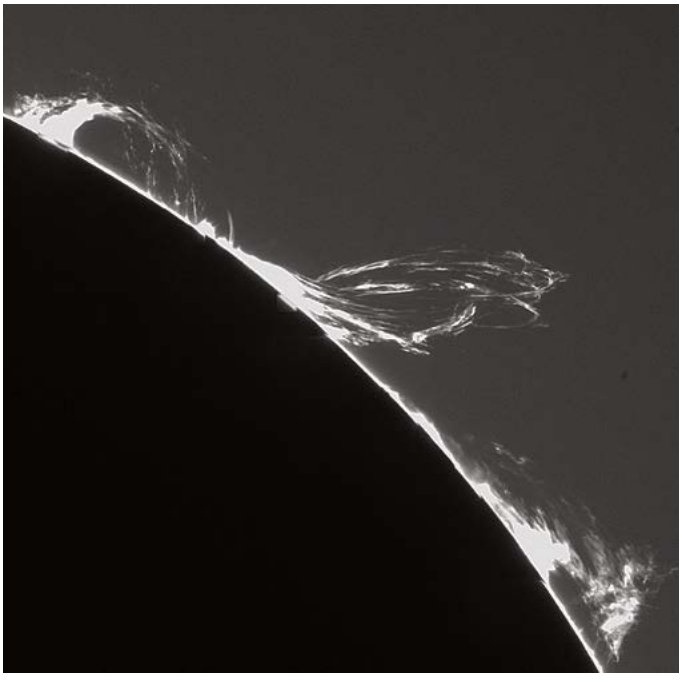


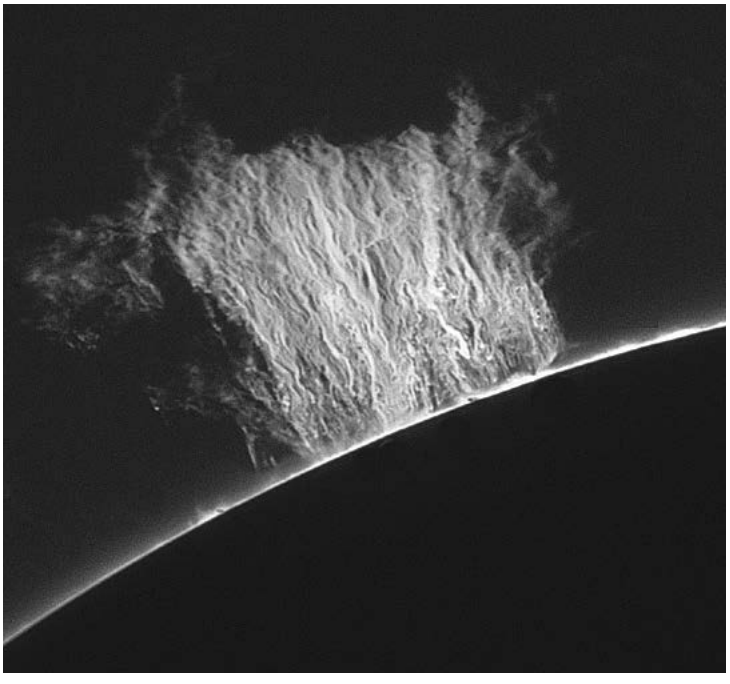


*Note the relatively tiny spicules on the Sun's limb, visible in this and some of the other images.*



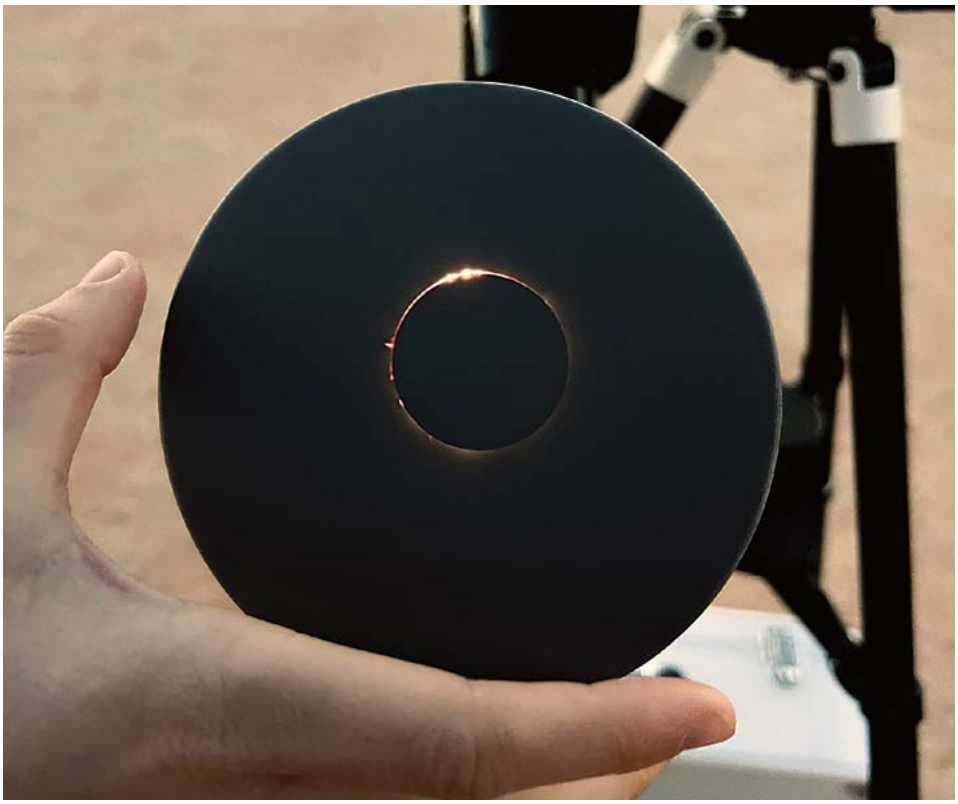






# THE SUN FUNNEL

## UNIQUE CONDITIONS AND A FEW MISTAKES RESULT IN A ONE-OF-A-KIND IMAGE OF TOTALITY.

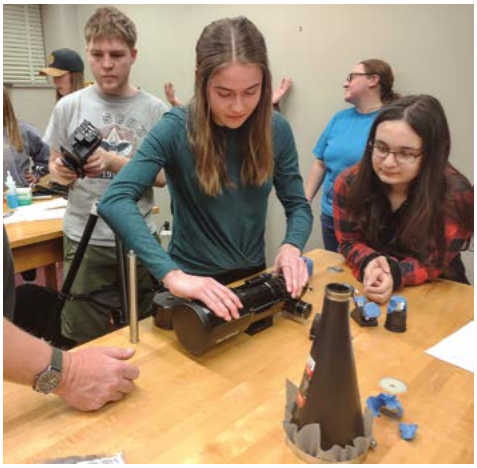


By R. Baer, C. Brevik, H. Henson, and L. Mayo

In April 2023, students, faculty, and staff from Southern Illinois University Carbondale (SIU) traveled to Exmouth, Western Australia, for a combined study abroad and research trip to observe a total solar eclipse. Students participated in dark sky observations and outreach throughout Australia in cooperation with Western Australia Astrotourism and Perth Observatory. Prior to leaving the United States, they underwent telescope training and practiced observations that included how to use a Sun funnel, a projection device used to view a partial solar eclipse.

The Sun funnel is a simple, inexpensive, and safe method of viewing the Sun when attached to the eyepiece of a small refractor. The instructions on how to build one were first published in 2012 by Feinberg, Bueter, and Mayo[1]. A Sun funnel is made up of very few parts that include a common automotive oil funnel, rear projection material, and hose clamps. The assembly is attached to the eyepiece of a telescope. When focused properly, an image of the Sun appears on the projection material stretched over the top of the funnel. The Sun funnel can produce high-resolution images that show details such as sunspots or the progression of a partial solar eclipse. It provides a safe alternative solar viewing method especially useful for a group of people.

After making the trip by air from Illinois to Perth and finally driving to Exmouth, the SIU group set up for their solar eclipse observation using equipment from the Dynamic Eclipse Broadcast (DEB) Initiative[2] and the Citizen Continental-America Telescopic Eclipse (CATE) Experiment [3,4], the precursor project to the DEB Initiative. Sixty-eight 80 mm refractor telescopes were donated by Daystar Filters in 2015 as part of the original CATE Experiment. A unique feature of both these projects developed by SIU adjunct faculty member Matt Penn is that the equipment stays with observation teams to allow them to continue to contribute to citizen science and outreach endeavors. The Daystar telescopes have been used by several groups for subsequent day- and nighttime observations and outreach, as was done in Australia.



Once the telescopes were set up, we noticed the solar image on the Sun funnel was too bright and realized the correct size eyepiece had not been packed for the trip. The students were using lower magnification 26 mm eyepieces instead of the 13 mm eyepieces we had intended to bring. This made the image smaller than intended and brighter. With the eclipse approaching, we decided to leave the setup as it was.

The original plan was to remove the Sun funnels during totality (when the entire disk of the Sun is covered by the Moon) and observe the corona through the eyepiece. There is some danger in doing this for inexperienced observers who try to observe too early or too late. In Exmouth, the chance for error was increased because this was a short, hybrid eclipse with the Moon just barely covering the

solar disk. Given the potential for eye damage, study abroad lead Corinne Brevik advised the students to leave the Sun funnel in place. It turned out to be not just the safe thing to do, but it allowed these students to see totality in a new way.

All total solar eclipses are unique, and this one was phenomenally so. The Moon being so closely matched in apparent size to the Sun made for a spectacular sight with prominences and the chromosphere visible. The corona was large due to increased solar activity as we approach solar maximum. The sky was also exceptionally clear and dry, adding to the apparent brightness of the corona.

It was not until long after the group returned to Carbondale that an image taken by SIU student, Paige Chamberlin, was identified for what it was, a unique image of totality on a Sun funnel. In fact, the image shown on page 16 is the only photo known to exist of totality on a Sun funnel. Ms. Chamberlin and fellow student Kallie Heavrin had both taken mobile phone pics of totality on the Sun funnel, and were unaware that they had just witnessed and documented something unique.

We have now demonstrated that it is possible to view *all* phases of a solar eclipse, including totality, with a Sun funnel. This is exciting for those of us doing solar outreach and group observations, especially outreach involving youth for the upcoming annular and total eclipses in the United States. The Sun funnel allows everyone in a group to view the same image and have features pointed at and explained. Observers do not all need to have their own eclipse glasses, which may be in short supply during the event. First time viewers are often overwhelmed when seeing totality and can miss important features like the diamond ring. The Sun funnel allows you to see sunspots, the diamond ring, prominences, the chromosphere, and the inner corona – all enlarged to a format that is easy to see. Observers should keep in mind that viewing totality by looking directly at the corona is still an experience they should not miss. You can also observe the few minutes of totality (when the entire disk of the Sun is covered by the Moon) with binoculars or a small telescope; however, knowing when to look and when not to look is often confusing for people who have not seen an eclipse before. The Sun funnel is a tool that helps us to safely and effectively conduct small-group outreach with a big impact. ✷

*R. Baer, C. Brevik, H. Henson, are with Southern Illinois University Carbondale; L. Mayo is with ARIES Scientific.*

*Images courtesy of the authors and their students*

**References**

[1] The Sun Funnel: A Do-It-Yourself Projection Device for Safe Solar Viewing by Groups, Fienberg, R. T., Bueter, C., & Mayo, L. A. *Connecting People to Science: A National Conference on Science Education and Public Outreach.* Proceedings of a conference held at Baltimore, Maryland, USA, 30 July - 3 August 2011. ASP Conference Series, Vol. 457. Edited by J.B. Jensen, J.G. Manning, M.G. Gibbs, and D. Daou. San Francisco: Astronomical Society of the Pacific, 2012., p.29. *eclipse.aas.org/resources/downloads#sun_funnel*

[2]*debinitiative.org*

[3]Matthew J. Penn *et al.* 2020, Acceleration of Coronal Mass Ejection Plasma in the Low Corona as Measured by the Citizen CATE Experiment, *PASP* 132 014201

[4]M. J. Penn *et al.* 2017, Instrumentation for the Citizen CATE Experiment: Faroe Islands and Indonesia, *PASP* 129 015005

# A HIGH SCHOOL STUDENT CHASING THE STARS

By Yuliang Feng

My first serious thought about getting into astrophotography was on a trip to the Kumtag Desert in 2022 when late one night I looked up and saw a sky full of stars. Having grown up in light-polluted Shanghai for the past sixteen years, seeing this amount of detail in the night sky was a shock to my eyes. Months later I became a student at Vermont Academy in the relatively remote location of Saxtons River, Vermont. The dark skies of Vermont and the lack of light pollution on campus has provided me with an incredible opportunity for viewing and photographing the night sky

I got the idea to photograph the Milky Way when I visited the school's observatory for the first time last winter with our astronomy teacher, Ms. Armiger, and some fellow students. We had hoped to catch a glimpse of the green comet (C/2022 E3 ZTF) in one of the telescopes, but the Moon was too bright. Still, we saw many stars that night and I began to imagine a photograph with the observatory (which kind of looks like a log cabin) in the foreground under the arch of the Milky Way.

Months passed until it was mid-May, with only a week left before the end of the school year. I determined that the Milky Way arch would be fully visible from about 11:30 p.m. to 3 a.m. I checked the weather forecast every day that week and finally decided to shoot in the early morning of May 14. I checked in with Ms. Armiger, who also runs the campus

outing club, to see if I could borrow a tent and a sleeping bag. She left the equipment on her porch for me to pick up later that day.

I arrived at the observatory field with my camera and camping equipment at around 11:15 p.m. on May 13. The sky was cloudless. I tried to set up the tent but I was unsuccessful in the darkness due to the unique construction of that tent and my inexperience with camping. I shifted my focus to the camera and tripod, aiming in the direction of the Milky Way, guided by the Star Walk 2 app. The cold early morning air made it difficult for me to position the tripod and mount the camera, but I finally got everything in place.

I shot six angles with a 14 mm lens, using a 30-degree interval between shooting angles, and created panoramas in post-processing, stacking multiple shots for each image. The cine lenses I used allowed me to achieve precise focus. The Milky Way shooting process lasted until about 2 a.m., and afterward I took a set of star trail photos.

Having given up on the tent, I then slipped into my sleeping bag in my thickest clothes. I slept fitfully and awoke in the morning feeling groggy, but when I shared my pictures with the astronomy teacher, she was so excited! She shared my pictures with a couple of other teachers and our head of school, Dr. Zaccara, who loved them! I was invited to share my pictures with the whole community the following Monday at our all-school meeting.

Though my photoshoot last May might have been one of the coldest nights of my life, sleeping under the Milky Way was a wonderful experience. My pictures have inspired a lot of people at Vermont Academy and now some students are even talking about starting an astrophotography club.. ✷

*I would like to thank Mr. Bob Kesler (Ms. Armiger's stepfather and a contributor to* Reflector*'s March 2023 issue) for giving me advice about how to set up my photos and for encouraging me to write this article and share my pictures. —Yuliang Feng*

# ALL ABOUT THE GREAT NEBULA IN ORION

By Scott Harrington

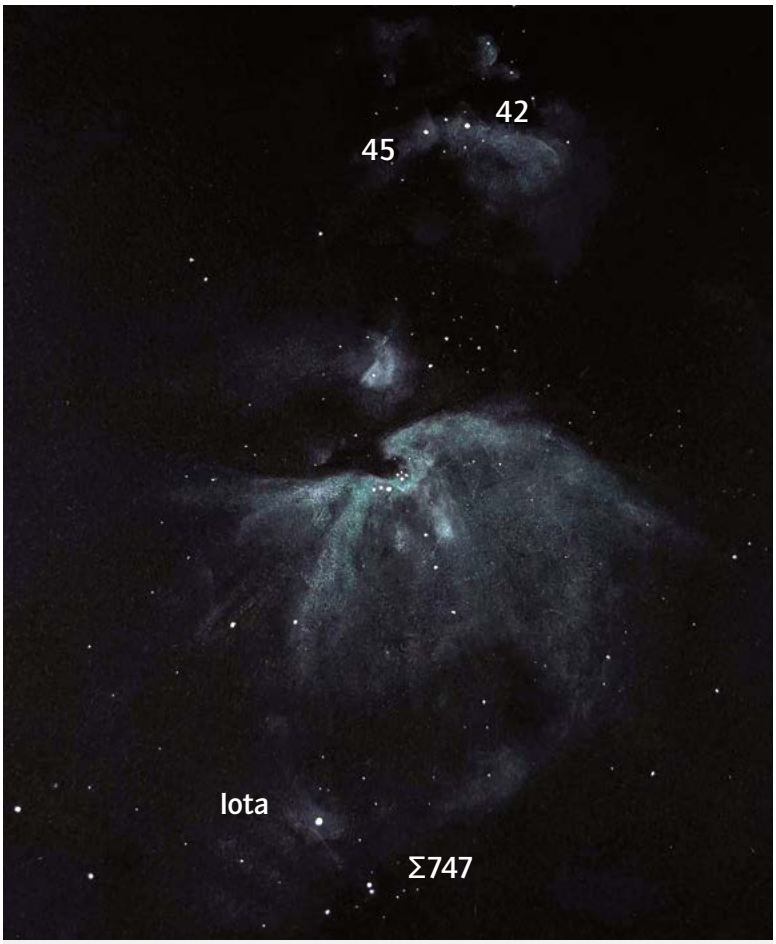
*Join the author on a grand tour of the first deep-sky object he ever sought out 15 years ago...*

Even though we believe it's been bright enough to see for the last 50,000 years or so [1], it seems history didn't pass down to us any record of a particular star in Orion's Sword looking noteworthy before the 17th century. In Johann Bayer's famous 1603 unaided-eye star atlas, *Uranometria*, it merely received the stellar designation Theta (θ) Orionis. Records show it wasn't until the first decade or so *after* the advent of the telescope that it was seen as a nebula – with not one but *three* stars embedded! [2]

However, I find it quite easy to see the Great Orion Nebula as a bright, diffuse glow with the unaided eye. The real trouble is remembering which one it is since with concentration, none of the four "stars" in the Sword appear stellar to me. That's right – not only can I split the 8.2-arcminute-wide optical pairing of Iota (ι) Ori and Struve (Σ) 747 just south of it and the optical pairing of 42 and 45 Ori just north, but I can also see the open cluster NGC 1981 farther north as a diffuse glow.

Situated some 1,350 light-years away, the Orion Nebula lies a bit farther along than us in the Cygnus Spur of our Galaxy's Sagittarius Arm, near where the Orion Spur begins. From our perspective, the entire nebula spans an impressive 35 light-years tall and 24 light-years wide when we include NGC 1973/75/77 (which is only separated visually by an unlit portion). However, it's only a luminous "blister" on this side of the Orion Molecular Cloud, which is one of the nearest sites of ongoing massive star formation.

The emission nebula itself is visible thanks to the two brightest stars in the region: 5th-magnitude Theta[1] Orionis C (41 Ori) at its center and Theta[2] Orionis A (43 Ori) just 134.4 arcseconds southeast. These hot, young stars lie less than a light-year apart in space and are the principal sources of ionizing radiation. Even keen-eyed observers such as myself have found splitting them with the eye alone to be a tough challenge [3]. To accomplish it, you need excellent "seeing" and... wait for it... a *bright* sky so that the nebula itself is barely visible! I accomplished it only last year by waiting until it was high in the sky with a waxing gibbous Moon nearby.




*Pastel and gel pen drawing by (©)Andrew Clark, used by permission*

Theta[1] Orionis is the brightest member of a very young star cluster that's emerging into view as it evacuates the nebula it formed from. The famous Italian astronomer Galileo Galilei was the first to see this when in February 1617, he split it into three stars using his telescope and a magnification of roughly 27 times. Known now as members A, C, and D, Astronomical Society of Kansas City member and self-styled "binocular astronomy evangelist" Fiske Miles has found that they can be seen in as little as 10x50 binoculars if one has a quality pair and tripod-mounts them [4].

It took until March 1673 for the French astronomer Jean Picard to discover the fourth member star, now known as B. Interestingly, while the Dutch astronomer Christiaan Huygens had made a sketch of the Orion Nebula in 1656 with a 23-foot air refractor, he only saw the same three stars that Galileo discovered. It wasn't until 1684 that Huygens made another sketch (this time with a 44.5-foot air refractor) and included the fourth member.

In the next century, French comet hunter Charles Messier made the nebula around Theta[1] Orionis the 42nd entry in his famous catalog in 1769. But it seems it was the consummate observer William Herschel, in his initial catalog of double stars thirteen years later, who was the first to use the name "Trapezium" when he wrote *"θ Orionis. Quadruple. It is the small telescopic Trapezium in the Nebula. Considerably unequal [5]."*

The count stood at four members of the Trapezium until 1826, when Wilhelm Struve spotted the E star (+11.1). Then, just four years later, John Herschel made out the even more difficult F star (+10.1). While I once saw E and F in my 10-inch at 140x, I've read of others having done so with 80 mm telescopes in exceptional seeing! One reason they are so much harder to spot is because each of them lies just 4.5 arcseconds from much brighter A and C, respectively.

The last stars to be discovered visually were done with the 36-inch Lick refractor atop Mount Hamilton in central California. The optics for the telescope had been ground by Alvan Clark & Sons and on January 7, 1888 – the first full night of operation – Alvan G. Clark (the youngest son of Alvan Clark, who had passed away five months prior) spotted

*ESO Very Large Telescope MUSE image of proplyd 244-440 in the Orion Nebula. The young object is ejecting a jet (red) and is surrounded by a blue halo of unknown origin. Credit: ESO/Kirwan et al.*

star G (+13.7) while using M42 to test the image quality of the instrument. Finally, after years of other stars having been claimed to be seen *inside* the Trapezium, this was the first one whose existence was firmly established.

Later that year, keen-eyed Edward E. Barnard used the telescope to discover star H (+15.8; which we now know is a double) along with I (+16.3). But once again, intrepid amateurs under extremely favorable conditions have seen these last three stars with smaller instruments. The smallest-aperture sighting I've heard of was by veteran southern California amateur astronomer Donald Pensack. As he explained to me, on one occasion he managed to see all three at 304x while not even specifically looking for them in his finely crafted 12.5-inch Dobsonian at an altitude of over 8,000 feet in superb transparency and seeing.

In the following decades, photography revealed more and more stars scattered around the Trapezium. And they were believed to be nothing more than such because of their stellar appearance on even the best images. It wasn't until 1979 when French astronomers Pierre Laques and Jean-Louis Vidal, using interference filtered photographs taken at Pic du Midi Observatory in southern France, discovered that several of the stars near Theta[1] Orionis C (which included G, H, and I) displayed nebula-like emission-lines. Their interpretation was that instead of being stars, they were actually very compact, partially ionized globules with the ionization coming from the ultraviolet radiation emanating from Theta[1] Orionis C. But there were more surprises to come.

In 1993, the Hubble Space Telescope released images taken of the area south of Theta[1] Orionis C using filters that enhance the light from the ionized shock front. Entire protoplanetary disks could be seen in silhouette against the backdrop of the nebula while being illuminated on the end facing towards Theta[1] Orionis C. These objects quickly became known as *proplyds* (an acronym for ***pro**to**pl**anetar**y** **d**isks).*

Subsequent images were detailed enough to show that the proplyds appeared different depending on their viewing angle with respect to Theta[1] Orionis C. Those directly behind the star appeared nearly stellar with little more than their ionized side being visible, while those at the same distance but off to the side displayed dark, ragged disks with the end nearest the star being illuminated. Thus, we learned that Trapezium member stars G, H, and I are not only young enough but far enough from Theta[1] Orionis C to still have their proplyds intact.

We've known about proplyds in the Orion Nebula since before I was born, yet the problem for a visual observer like myself is that the vast majority are simply outshone by the newborn star (also known as a "young stellar object" or YSO) inside. Such is the case I believe with stars G, H, and I. But through a careful study, I've come up with a short list of proplyds to attempt that I believe truly outshine the YSO inside them.

The brightest of them, proplyd 244-440, lies 142.3 arcseconds from Theta[1] Orionis C, 29.2 arcseconds from Theta[2] Orionis A, and is one of the few being ionized by *both* stars. It's also one of the largest known in the Orion Nebula with a diameter well over 1,000 astronomical units. Such factors are seemingly what made it visible as a faint yet nonstellar glow at 440x in my 16-inch Dobsonian last winter! The ones I will be trying for this winter are proplyds 142-301 and 177-341 and are labeled on the image below. ✷


Further Reading:

Bally et al. (1998) Externally Illuminated Young Stellar Environments in the Orion Nebula: Hubble Space Telescope Planetary Camera and Ultraviolet Observations (*ui.adsabs.harvard.edu/abs/1998AJ....116..293B/abstract*)

Kirwan et al. (2023) A Spectacular Jet from the Bright 244-440 Orion Proplyd: The MUSE NFM View (*ui.adsabs.harvard.edu/abs/2023A%26A...673A.166K/abstract*)

[1] Visibility hypothesis (*ui.adsabs.harvard.edu/abs/2008hsf1.book..483M/abstract*)

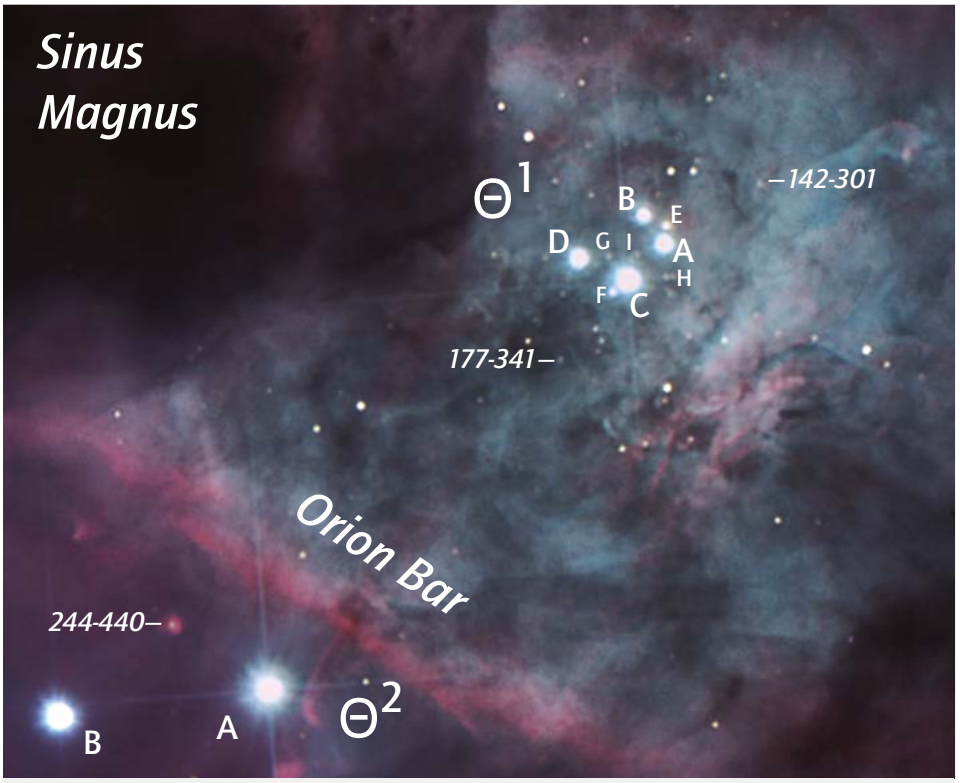
[2] Nicolas-Claude Fabri de Peiresc probably saw the nebula in a telescope in 1610 followed by Johann Baptist Cysat of Luzern in 1611. In 1617, Galileo Galilei observed the nebula but only commented on the fact that Theta Orionis was composed of three stars.

[3] The Theta Orionis challenge (*www.astronomy.com/observing/test-your-visual-acuity-with-the-theta-orionis-challenge*)

[4] Amateur Fisk Miles split Trapezium into three with 10x, four with 15x (*www.cloudynights.com/topic/852195-10x-trapezium/?p=12316434*)

[5] William Herschel (1782) *Catalogue of Double Stars*, p. 129. (*royalsocietypublishing.org/doi/pdf/10.1098/rstl.1782.0014*)

[6] P. Laques & J.L. Vidal (1979) *Astronomy and Astrophysics* 73: 97-106. (*ui.adsabs.harvard.edu/abs/1979A&A....73...97L*)


*A close-up image of Orion's Nebula with the Trapezium stars and brightest proplyds labeled. The original image has been rotated 75° counterclockwise to place north at top and east to the left, and cropped. Background image by Franz Hofmann and Wolfgang Paech,* chamaeleon-observatory-onjala.de, *used with permission.*

# It's a Family Affair: Women in Observational Astronomy Before the 20th Century

By Kristine Larsen

Before the late 19th century, women interested in observing the heavens, whether for pleasure or to add to our astronomical understanding, found "space" in family observatories. Working alongside their husband, brother, or father in such a private area afforded them both physical safety and adherence to societal norms that dictated what they could and could not do freely.

For example, Johannes Hevelius, a wealthy German engraver, built a private observatory for cataloging stars with the unaided eye across the roofs of three adjoining houses

images are in the public domain

*Elisabeth Hevelius observing the sky with a brass octant. Detail from an engraving from Johannes Hevelius's "Machinae Coelestis: Pars Prior", (1673).*

owned by his family. His second wife, Elisabeth (1647–1693), became his assistant; much of their library was lost in a fire, but after her husband's death, Elisabeth was still able to publish their research, the largest star catalog compiled using just the human eye. Caroline Herschel (1750–1848) served as an assistant to both her brother, William, famous for discovering the planet Uranus, and later his son, John, both of whom were well-known amateur astronomers. Caroline also made her own telescopic observations of the heavens, and

*1847 Portrait of Caroline Herschel around 97 years of age*

is credited with eight independent discoveries of comets; for five of these she was the first person to see the comet. Although as a woman Caroline was ineligible for admission to the Royal Astronomical Society, she was awarded its Gold Medal in 1828, and in 1835 she and famed science writer Mary Somerville (1780–1872) became the first female honorary members of the RAS.

Elizabeth Brown (1830–1899) made astronomical and meteorological observations using her father's observatory, and became a founding member, and the director of the Solar Section, of the British Astronomical Association.

Astronomical education was also largely open to women through self-study using the family library or private tutoring, often by or alongside a family member. For exam-

*British astronomer Elizabeth Brown (1830–1899) with her 3½-inch Wray refractor.*

ple, Maria Mitchell (1818–1889) learned how to observe the heavens at her father's side, frequently from the roof of the bank where he worked, and increased her own astronomical and mathematical knowledge through reading the books at the Nantucket Athenaeum, where she was a librarian. Maria became internationally famous after discovering a comet in 1847, receiving a medal from the King of Denmark. Vassar College founder Matthew Vassar offered Maria the position of astronomy professor at his new institution of higher learning

*Maria Mitchell born in 1818, died 1889. She discovered a comet in 1847, and was the first professor of astronomy at Vassar College beginning in 1865.*

for women, building her an observatory with the then third-largest refracting telescope in the United States. At Vassar, Maria offered her female students a high-quality education, and several went on to become astronomers in their own right.

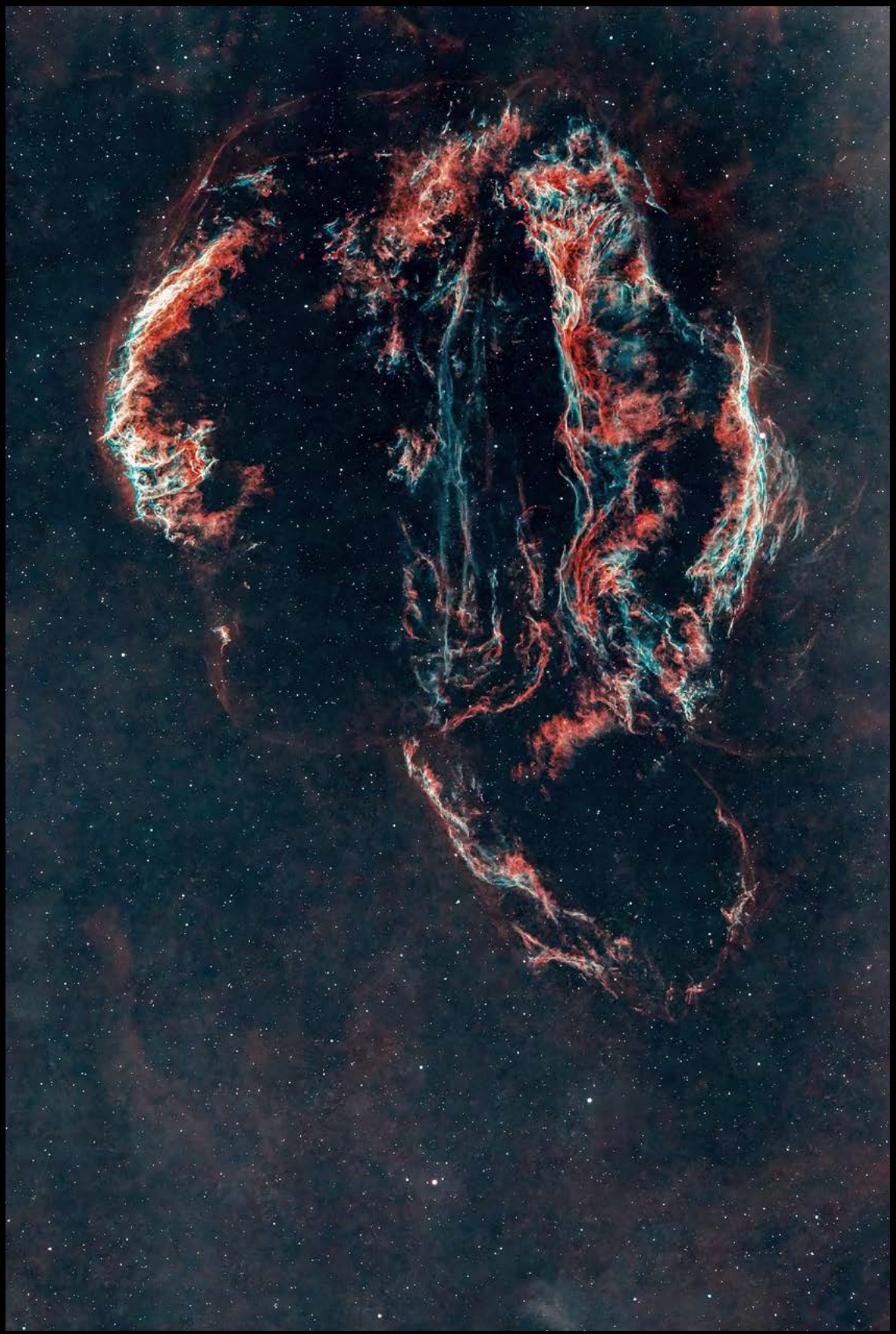
Another example of a family observatory was that of New York physician Dr. Henry Draper, in the village of Hastings-on-Hudson in New York. His father had been the first person to produce a telescopic photograph of the moon (in 1840), and Henry pushed the technology of astrophotography to include the analysis of starlight, called spectroscopy. He was joined in his love of astronomy by his wife, Mary Anna Palmer Draper (1839–1914), born in Stonington, Connecticut, who had inherited a significant fortune from her father. After Henry's untimely death from pleurisy, Anna Draper became a major benefactor of American astronomy, including the work of some of the famous woman "computers" at Harvard: Henrietta Leavitt, Williamina Fleming, and Annie Cannon. But that is a story for another day. ✶

Kristine Larsen is a member of the Springfield Telescope Makers and a professor at Central Connecticut State University.

To read more about family observatories, see "A Woman's Place is in the Dome." (*academinist.org/wp-content/uploads/2009/10/Woman_Place_Larsen.pdf*)

# Gallery


Images are processed by *Reflector* staff for better contrast and tonal range on the printed page.



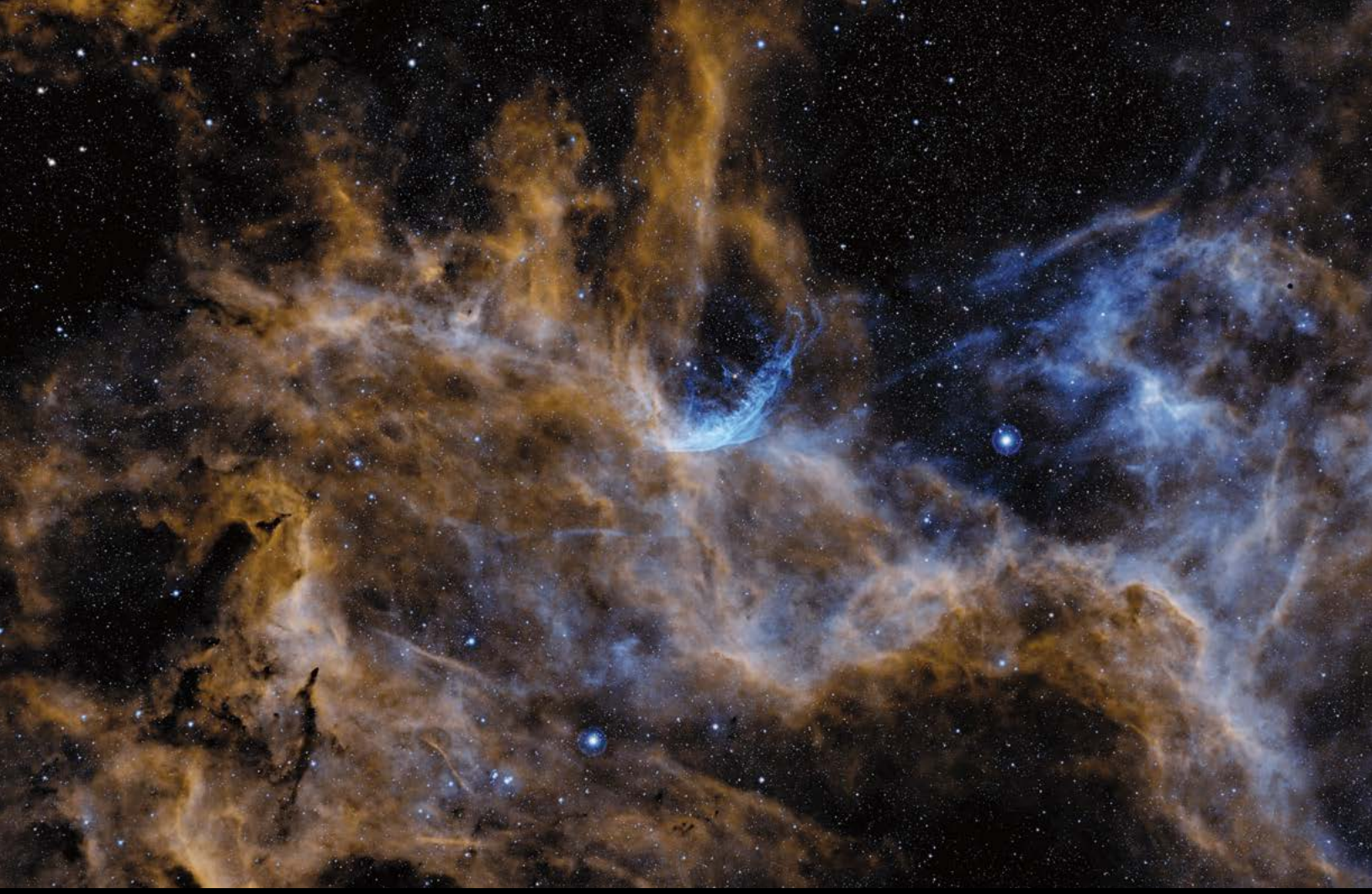
Míguel Acosta (Astronomical Society of Eastern Missouri) captured this image of the Cygnus Loop Nebula with a William Optics RedCat 51 II telescope and a ZWO ASI2600MC Pro camera from Whetstone Creek Conservation Area, Williamsburg, Missouri.

*RIGHT:*
*Clement Elechi (Roanoke Valley Astronomical Society) captured this image of M92 with an Astro-Tech AT6RC and a ZWO ASI1600MM camera.*

.

*BELOW:*
*Bernard Miller (East Valley Astronomy Club) captured this image of M77 with a PlaneWave CDK-24 and a QHY600M camera from* Telescope.Live *in Rio Hurtado, Chile.*

*Note: you can now earn the AL Messier Award with imaging.*



*ABOVE:*
*Steven Bellavia (Amateur Observers' Society of New York) captured this image of Wolf-Rayet WR-134 using a William Optics FLT91 and a ZWO ASI 294MM Pro camera.*

*RIGHT:*
*Jeffrey O. Johnson (Astronomical Society of Las Cruces) captured this image of M20 from his backyard in Las Cruces, New Mexico, with a Takahashi TOA-130F refractor and a QSI 690wsg CCD camera.*

# Observing Awards

## ADVANCED BINOCULAR DOUBLE STAR OBSERVING PROGRAM

No. 59, **István Mátis**, Member-at-Large

## ALTERNATE CONSTELLATION OBSERVING PROGRAM

No. 14, **Jeffrey Corder**, Gold, Ancient City Astronomy Club; No. 17, **Jeffrey Corder**, Silver, Ancient City Astronomy Club

## ARP PECULIAR GALAXIES NORTHERN OBSERVING PROGRAM

No. 118, **Mark Bailey**, Member-at-Large; No. 119, **Viola Sanchez**, Albuquerque Astronomical Society

## ASTEROID OBSERVING PROGRAM

No. 75-I, **Russell F. Pinizzotto**, Gold, Southern Maine Astronomers

## BENNETT OBSERVING PROGRAM

No. 2, **Eric Edwards**, Albuquerque Astronomical Society; No. 2, **Eric Edwards**, Full List, Albuquerque Astronomical Society

## BEYOND POLARIS OBSERVING PROGRAM

No. 66, **Richard Bryant**, Bartlesville Astronomical Society; No. 67, **Joe Setaro**, Member-at-Large; No. 68, **Debra Wagner**, Member-at-Large

## BINOCULAR DOUBLE STAR OBSERVING PROGRAM

No. 208, **Paul Runkle**, Chapel Hill Astronomical and Observational Society

## BINOCULAR MESSIER OBSERVING PROGRAM

No. 1255, **Michael K. Roberts**, Midlands Astronomy Club;
No. 1256, **Eric Hanson**, Member-at-Large;
No. 1257, **Brian Hayward**, Rose City Astronomers

## BINOCULAR VARIABLE STAR OBSERVING PROGRAM

No. 64, **Viola Sanchez**, Albuquerque Astronomical Society;
No. 65, **Rich Krahling**, Richland Astronomical Society

## BRIGHT NEBULA OBSERVING PROGRAM

No. 38, **Scott Cadwallader**, Advanced, Baton Rouge Astronomical Society; No. 39, **Terry N. Trees**, Advanced, Amateur Astronomers Association of Pittsburgh

## CARBON STAR OBSERVING PROGRAM

No. 153, **Bill Bond**, Omaha Astronomical Society;
No. 154, **George Plumfield**, S.T.A.R. Astronomy Society;
No. 155, **John Hodge**, Midlands Astronomy Club

## CITIZEN SCIENCE AWARD

**Dan Crowson**, Astronomical Society of Eastern Missouri, Active Asteroids, Active, Gold Class 45; **Rich Krahling**, Richland Astronomical Society, Kilonova Seekers, Active, Bronze; **Rich Krahling**, Richland Astronomical Society, Kilonova Seekers, Active, Gold Class 1; **Rich Krahling**, Richland Astronomical Society, Star Notes, Active, Gold Class 2; **Rich Krahling**, Richland Astronomical Society, Backyard World: Cool Neighbors, Active, Silver; **Rich Krahling**, Richland Astronomical Society, Citizen ASAS-SN, Active, Silver; **Al Lamperti**, Delaware Valley Amateur Astronomers, Active Asteroids, Active, Gold Class 162; **Al Lamperti**, Delaware Valley Amateur Astronomers, Star Notes, Active, Gold Class 285; **Al Lamperti**, Delaware Valley Amateur Astronomers, Kilonova Seekers, Active, Gold Class 1; **Al Lamperti**, Delaware Valley Amateur Astronomers, Space Warps-DES Vision Transformer, Active, Bronze; **Brad Young**, Astronomy Club of Tulsa, Variable Stars, Observational, Gold Class 9

## COMET OBSERVING PROGRAM

No. 64, **Tom Gazzillo**, Gold, Chesmont Astronomical Society;
No. 137, **Mike Phelps**, Silver, Atlanta Astronomy Club

## CONSTELLATION HUNTER NORTHERN SKIES OBSERVING PROGRAM

No. 303, **Alice Krinsky Formiga**, Member-at-Large;
No. 304, **Ryan Behrends**, Hill County Astronomers;
No. 305, **Craig Laminson**, Houston Astronomical Society

## CONSTELLATION HUNTER SOUTHERN SKIES OBSERVING PROGRAM

No. 15, **Peter K. Deterline**, Member-at-Large

## DEEP SKY BINOCULAR OBSERVING PROGRAM

No. 448, **Jenny Stein**, Houston Astronomical Society; No. 449, **Michael McCabe**, South Shore Astronomical Society

## DOUBLE STAR OBSERVING PROGRAM

No. 708, **George Plumfield**, STAR Astronomy Society; No. 709, **Peter Berbee**, Patron Member; No. 710, **Michael R. Martin**, Roanoke Valley Astronomical Society

## GALAXY GROUPS AND CLUSTERS OBSERVING PROGRAM

No. 57-M, **Jim Kaminski**, Lifetime Member

## GALILEO OBSERVING PROGRAM

No. 83, **Michael R. Martin**, Roanoke Valley Astronomical Association; No. 84-B, **John Zimitsch**, Minnesota Astronomical Society; No. 85-B, **Dick Francini**, Neville Public Museum Astronomical Society; Nos. 86 and 86-B, **Karl A. Schultz**, Central Arkansas Astronomical Society; No. 87-B, **Stephen R. Hildenbrandt**, Miami Valley Astronomical Society; No. 88-B, **Michael Blase**, Olympic Astronomical Society; No. 89, **Stephen J. Nugent**, Member-at-Large; No. 90, **Russell F. Pinizzotto**, Southern Maine Astronomers; No. 91-B, **William Clarke**, Tucson Amateur Astronomy Association; No. 92-B, **Viola Sanchez**, Albuquerque Astronomical Society

## GLOBULAR CLUSTER OBSERVING PROGRAM

No. 396, **Hans de Moor**, Member-at-Large; No. 397-I, **Jason J. Wolfe**, Member-at-Large; No. 398-I, **Robert Wood**, Member-at-Large; No. 399, **Mary Barteau**, St. Louis Astronomical Society

## HERSCHEL 400 OBSERVING PROGRAM

No. 656, **Jason J. Wolfe**, Member-at-Large;
No. 657, **John Strebeck**, St. Louis Astronomical Society

## HERSCHEL SOCIETY AWARD

**John Goar**, Silver, Olympic Astronomical Society

## HERSCHEL II OBSERVING PROGRAM

No. 125, **Christen K. Slotten**, Olympic Astronomical Society;
No. 126-M, **Viola Sanchez**, Albuquerque Astronomical Society

## HYDROGEN ALPHA SOLAR OBSERVING PROGRAM

No. 74, **Steve Riegel**, Colorado Springs Astronomical Society;
No. 75-I, **David Wickholm**, San Antonio Astronomical Association;
No. 76, **Darcy Howard**, Central Arkansas Astronomical Society

## LIBRARY TELESCOPE AWARD

No. 35, **Joan Carman**, Silver and Gold, Salt Lake Astronomical Society; No. 36, **David Lloyd**, Silver, Astronomical Society of Eastern Missouri; No. 37, **Larry Campbell**, Silver, Astronomical Society of Eastern Missouri; No. 38, **Sonali Deshmukh**, Silver, Omaha Astronomical Society; No. 39, **Jon Larsen**, Silver, Omaha Astronomical Society

## LOCAL GALAXY GROUP AND NEIGHBORHOOD OBSERVING PROGRAM

No. 60, **Bruce Scodova**, Richland Astronomical Society; No. 61, **Viola Sanchez**, Albuquerque Astronomical Society; No. 62-I, **Marie Lott**, Atlanta Astronomy Club; No. 63-I, **Scott Sudhoff**, Wabash Valley Astronomical Society

## LUNAR EVOLUTION OBSERVING PROGRAM

No. 33, **Page Jennings**, Tri-Valley Stargazers

## LUNAR OBSERVING PROGRAM

Nos. 1211 and 1211-B, **Matt Shulse**, Astronomical Society of Kansas City; No. 1212-B, **Scott Kranz**, Astronomical Society of Kansas City; No. 1213, **Tom Nelson**, Tucson Amateur Astronomy Association; Nos. 1214 and 1214-B, **Patrick Peak**, Louisville Astronomical Society; Nos. 1215 and 1215-B, **Mike Modrcin**, Omaha Astronomical Society; Nos. 1216 and 1216-B, **Jeff Bender**, Cumberland Astronomy Club; No. 1217, **James Goodwin**, Member-at-Large; Nos. 1218 and 1218-B, **Clariza E. Kern**, Pontchartrain Astronomy Society; Nos. 1219 and 1219-B, **Claire Weaverling**, Minnesota Astronomical Society

## MESSIER OBSERVING PROGRAM

No. 2796, **Brian McGuinness**, Honorary, Northern Colorado Astronomical Society; No. 2909, **Brian Hayward**, Honorary, Rose City Astronomers; No. 2911, **Alec Sheedlo**, Regular, Northwest Suburban Astronomers; No. 2912, **John Winston Garth**, Honorary, Von Braun Astronomical Society; No. 2913, **Tyler Malone**, Regular, Barnard Astronomical Society; No. 2914, **William Clarke**, Regular, Tucson Amateur Astronomy Association; No. 2915, **Richard Benson**, Honorary, Rio Rancho Astronomical Society; No. 2916, **Eric Hanson**, Honorary, Member-at-Large

## MULTIPLE STAR OBSERVING PROGRAM

No. 23, **Dick Francini**, Neville Public Museum Astronomical Society

## OUTREACH AWARD

No. 100, **Carl Freyaldenhoven**, Stellar, Master, Central Arkansas Astronomical Society; No. 128, **Robert Togni**, Stellar, Master, Central Arkansas Astronomical Society; No. 476, **Amy White**, Stellar, Master, Astronomical Society of Eastern Missouri; No. 842, **Anna Leslie**, Master, Fort Bend Astronomy Club; No. 860, **Christophe Caille**, Master, Fort Bend Astronomy Club; No. 907, **Ed White**, Master, Astronomical Society of Eastern Missouri; No. 1067, **Anil Ketkar**, Master, Fort Bend Astronomy Club; No. 1172, **Russell F. Pinizzotto**, Stellar, Southern Maine Astronomers; No. 1240, **Andy Walker**, Stellar, Astronomical Society of Eastern Missouri; No. 1267, **Don Ladwig**, Stellar, Astronomical Society of Eastern Missouri; No. 1268, **Jim Stenzel**, Master, Astronomical Society of Eastern Missouri; No. 1281, **Justin Thompson**, Stellar, Astronomical Society of Eastern Missouri; No. 1288, **Carl Turek**, Stellar, Astronomical Society of Eastern Missouri; No. 1321, **Elizabeth Prochnow**, Stellar, Fort Bend Astronomy Club; No. 1344, **Spencer Chapman**, Stellar, River Bend Astronomy Club; No. 1383, **Dan Graham**, Outreach, Astronomical Society of Eastern Missouri; No. 1384, **Roger Harty**, Outreach, Astronomical Society of Eastern Missouri; No. 1385, **Mike Krawczynski**, Outreach, Astronomical Society of Eastern Missouri; No. 1386, **Janet Kunze**, Outreach, Astronomical Society of Eastern Missouri; No. 1387, **John Kunze**, Outreach, Astronomical Society of Eastern Missouri; No. 1388, **Dave Lloyd**, Outreach, Astronomical Society of Eastern Missouri; No. 1389, **Tom Richards**, Outreach, Astronomical Society of Eastern Missouri; No. 1390, **Jim Roe**, Outreach, Stellar, Master, Astronomical Society of Eastern Missouri; No. 1391, **Yvonne Roe**, Outreach, Stellar, Master, Astronomical Society of Eastern Missouri; No. 1392, **Bill Sheehy**, Outreach, Astronomical Society of Eastern Missouri; No. 1393, **Flory Sheehy**, Outreach, Astronomical Society of Eastern Missouri; No. 1394, **Rick Steiling**, Outreach, Astronomical Society of Eastern Missouri; No. 1395, **Stacey Thater**, Outreach, Stellar, Master, Astronomical Society of Eastern Missouri; No. 1396, **Don Martin**, Outreach, Von Braun Astronomical Society; No. 1397, **Eric Hanson**, Outreach, Stellar, Member-at-Large; No. 1398, **Harry Kessler**, Outreach, Roanoke Valley Astronomical Society; No. 1399, **Darcy Howard**, Outreach, Stellar, Master, Central Arkansas Astronomical Society; No. 1400, **Larry Cain**, Outreach, Minnesota Astronomical Society; No. 1401, **Sharon McLean**, Outreach, Omaha Astronomical Society; No. 1402, **Dean Herring**, Outreach, Raleigh Astronomy Club; No. 1403, **Susan Herring**, Outreach, Raleigh Astronomy Club; No. 1404, **Paul Runkle**, Outreach, Chapel Hill Astronomical and Observational Society; No. 1405, **Azam Syed**, Outreach, Fort Bend Astronomy Club; No. 1406, **David Roberts**, Outreach, Fort Bend Astronomy Club; No. 1407, **George Tallichet**, Outreach, Fort Bend Astronomy Club; No. 1408, **Narahari Rao**, Outreach, Fort Bend Astronomy Club; No. 1409, **Thrayee Rao**, Outreach, Fort Bend Astronomy Club; No. 1410, **Wendy Walfoort**, Outreach, Fort Bend Astronomy Club

## PLANETARY NEBULA OBSERVING PROGRAM

No. 24-I, **Keith Kleinstick**, Advanced, Lifetime Member; No. 47, **Patrick Peak**, Basic, Louisville Astronomical Society; No. 107-M, **Paul Runkle**, Advanced, Chapel Hill Astronomical and Observational Society

## RADIO ASTRONOMY OBSERVING PROGRAM

No. 17, **Marie Lott**, Gold, Atlanta Astronomy Club

## SKETCHING OBSERVING PROGRAM

No. 63, **David Wickholm**, San Antonio Astronomical Association

## SOLAR NEIGHBORHOOD OBSERVING PROGRAM

No. 3-I, **Steve Boerner**, Telescopic, Member-at-Large; No. 4, **Al Lamperti**, Telescopic, Delaware Valley Amateur Astronomers; No. 5, **Michael A. Hotka**, Telescopic, Longmont Astronomical Society; No. 6-I, **Marie Lott**, Telescopic, Atlanta Astronomy Club; No. 7, **Brad Young**, Telescopic, Astronomy Club of Tulsa; No. 8, **Paul Harrington**, Telescopic, Member-at-Large; No. 14, **Eric Edwards**, Eyes Only, Albuquerque Astronomical Society; No. 15, **Stephen R. Hildenbrandt**, Binocular, Miami Valley Astronomical Society; No. 16, **István Mátis**, Binocular, Member-at-Large

**SOLAR SYSTEM OBSERVING PROGRAM**
Nos. 217 and 217-B, **Richard Benson**, Rio Rancho Astronomical Society; Nos. 218 and 218-B, **Debra Wagner**, Member-at-Large; No. 219-B, **István Mátis**, Member-at-Large

**SOUTHERN SKIES BINOCULAR OBSERVING PROGRAM**
No. 110, **Jonathan Poppele**, Minnesota Astronomical Society

**SUNSPOTTER OBSERVING PROGRAM**
No. 165-I, **Marie Lott**, Atlanta Astronomy Club

**TARGET NEO! OBSERVING PROGRAM**
No. 29, **Eric Edwards**, Intermediate, Albuquerque Astronomical Society

**TWO IN THE VIEW OBSERVING PROGRAM**
No. 60, **Mike Blase**, Olympic Astronomical Society; No. 61, **István Mátis**, Member-at-Large

**UNIVERSE SAMPLER OBSERVING PROGRAM**
No. 166-T, **Bruce Bookout**, Colorado Springs Astronomical Society

**URBAN OBSERVING PROGRAM**
No. 240, **Rick Ray**, North Houston Astronomy Club; No. 241, **Laurie Ansorge**, Lifetime Member

## MASTER OBSERVER PROGRESSION

**OBSERVER AWARD**
**Richard Benson**, Rio Rancho Astronomical Society; **Debra Wagner**, Member-at-Large

**MASTER OBSERVER AWARD**
No. 261, **Jason J. Wolfe**, Member-at-Large; No. 262, **John Strebeck**, St. Louis Astronomical Society

**ADVANCED OBSERVER**
**Scott Cadwallader**, Baton Rouge Astronomical Society; **Russell F. Pinizzotto**, Southern Maine Astronomers; **Paul Runkle**, Chapel Hill Astronomical and Observational Society

**BINOCULAR MASTER AWARD**
**Viola Sanchez**, Albuquerque Astronomical Society

**MASTER OBSERVER AWARD – SILVER**
**David Wickholm**, San Antonio Astronomical Society

**MASTER OBSERVER AWARD – GOLD**
**Eric Edwards**, Albuquerque Astronomical Society; **Marie Lott**, Atlanta Astronomy Club; **Viola Sanchez**, Albuquerque Astronomical Society

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