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Reflector

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Jeffrey O. Johnson (Astronomical Society of Las Cruces) captured this image of the M45 from his backyard in Las Cruces, New Mexico, with a Takahashi FS-60C refractor with a QSI 690wsg CCD camera. More details can be found here: jeffjastro.com/dso/M45_25Sep20.htm. *Image © Jeff Johnson.*

Reflector

The Astronomical League Magazine

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A FEDERATION OF ASTRONOMICAL SOCIETIES
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

QUARTERLY PUBLICATION OF THE ASTRONOMICAL LEAGUE

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***REFLECTOR* AND CLUB ROSTER DEADLINES**

March issue	January 1
June issue	April 1
September issue	July 1
December issue	October 1

LETTERS TO THE EDITOR
Send to *editor@astroleague.org* with subject line "letter to editor"

To the Editor

I want to congratulate Jai and Neal Shet (*Reflector,* March 2021) for their inspired and beautifully executed digital panorama of the Moon with all parts imaged at the same solar hour, for a consistent degree of shadowing and depiction of relief everywhere. I've seen other examples of this type of panorama, but to my recollection done only on film and never so well. The resolution and visual impact of the Shets' seamless digital pano are breathtaking! Hats off to them for their nocturnal perseverance – not to mention the Sitzfleisch that enabled them to endure all those hours at their computer!

This striking image is also a tribute to the venerable 1980s-vintage Celestron 8-inch SCT they used; I still have, and use, my orange-tube C8 that I bought new in 1973. I appreciate the sacrifice of the donor who provided them with this scope – after almost five decades of ownership, I can't conceive of parting with mine!

—Howard L. Ritter, Jr., M.D.
Cincinnati Astronomical Society

Editor's Corner

As we put another *Reflector* to bed, I recently had the time to take a breath and consider all of the hard work that goes into each issue. The blood, sweat, and sometimes tears of a group of talented people is behind every single page. First, a heartfelt thanks from yours truly to my eagle-eyed assistant editor Kevin Jones, awesomely creative layout/design guru Michael Patterson, and always on-top-of-their-game photo editor Dan Crowson, advertising representative Carla Johns, and national Observing Program directors Cliff Mygatt, Al Lamperti, Aaron Clevenson, and Maynard Pittendreigh for being such a pleasure to work with. You truly are an amazing team! A special shout-out belongs to the font-of-all-knowledge Mitch Glaze, AL office manager, for his continued help with all questions great and small. I am also grateful to president Carroll Iorg and the rest of the League officers and executive council for their continued support, and managing editor Ron Kramer for the trust he puts in us to bring you a magazine you can be proud of.

A special round of applause goes out to all of our authors, both the "regulars" and everyone who has ever written a single piece, no matter the length, for continuing to deliver interesting, informative, and inspiring content. Finally, thanks to YOU, our readers, for your kind words of support. They mean more than you know. The *Reflector* team and AL leadership is hard at work behind the scenes planning further improvements to YOUR magazine. Always feel free to contact me with ideas or concerns at *larsen@ccsu.edu.*

As we slowly and cautiously begin to emerge from the pandemic, I look forward to getting back to in-person public outreach and completely face-to-face teaching, but I hope to benefit from the lessons I've learned regarding the possibilities offered by virtual communications. Let's all work together to make amateur astronomy even better than it was before the-year-that-shall-not-be-named.

—Kristine Larsen
Reflector *Editor*

Star Beams

ALCON 2021 – VIRTUAL

League leadership has made the painful, yet necessary, decision to postpone the next in-person ALCon convention to July 28–30, 2022. It is again scheduled for Albuquerque, New Mexico.

In the meantime, we have also made the decision to plan a vibrant and diversified virtual event this year. The dates for the virtual event are Thursday, August 19, through Saturday, August 21, 2021. Much more information will follow, but tentatively there will be a special Astronomical League ALCon pin, which also helps celebrate the 75th anniversary of the Astronomical League. Our co-chairs, Terry Mann and Chuck Allen, are hard at work bringing an outstanding group of speakers together for the event. We greatly appreciate Explore Scientific and Scott Roberts' generous offer to handle this multi-faceted online event.

We will be scheduling our normal youth and adult award presentations in the virtual format.

More specific information will be published soon.

THE ASTRONOMICAL LEAGUE AS PART OF YOUR ESTATE PLANNING

The Astronomical League recently was notified of a generous gift from the estate of one of our long-time members. This reminded us that we should give all our members the opportunity to do this as well.

If you have enjoyed your League affiliation, whether through our Observing Programs that motivated you to hunt objects during your nights out with your telescope, or whether you like the camaraderie and fellowship of attending ALCons and other events and hearing world-class speakers, or any other way you have received immense benefit from your involvement with the League, then we would appreciate being named as the recipient of a gift from your estate.

For more information, please contact the League president at *president@astroleague.org.*

YOUTUBE LEAGUE PRESENCE

The Astronomical League now has a YouTube channel, an addition to our online options. We are compiling a variety of videos of speakers from our Global Star Party collaboration with Explore Scientific as well as other activities. I would encourage you to tune in, subscribe, and like our posts, at *youtube.com/channel/UCtvCHdJ1vOx0T-t4vR0g2taA*.

ON TO THE NEW "NORMAL"

As the country begins the process of reopening, the League recently reaffirmed the policy initiated last spring of restricting regional activities, including regional conventions, for the time being.

We are also hearing of innovations that are transforming the way our groups interact with their members and outreach audiences. Larger audiences for online events are now becoming possible with no traveling needed to attend, so this opens unlimited opportunities to greatly expand the reach of our future events.

Even with these wonderful innovations, nothing can replace looking through the eyepiece of your own telescope. So, let's get out and get reacquainted with the night skies.

—Carroll Iorg
President

International Dark-Sky Association

DARK SKY ADVOCACY DURING A PANDEMIC

The year 2020 was the year of the pandemic, and the pandemic is still with us in early 2021. There is hope, as the number of cases is falling at the time of writing, and vaccinations are taking place in increasing numbers. Amateur astronomy has been adversely affected by the pandemic. We cannot meet in person for club meetings, and star parties are hard, if not impossible, to organize for the public. On the other hand, virtual meetings with Zoom or a similar product have proven to be quite popular, as have "virtual star parties." Whenever this pandemic is behind us, I believe virtual meetings will remain a part of amateur astronomy complementing our usual in-person gatherings.

No matter what, the sky is always there for us. Astronomy manufacturers cannot keep up with the public's demand for their equipment. The wonderful astronomy shops in Tucson are packed every day even with the challenges of appropriate masking and social distancing. It is almost impossible to reach someone on the phone. If we are forced to forgo most of our routine activities, we can still observe and enjoy the beauty of the sky. Unfortunately, light pollution is still with us. How does one conduct dark-sky advocacy during a pandemic?

IDA discusses this issue on its website *(www.darksky.org/dark-sky-advocacy-pandemic).* I recommend you read this short piece. I especially liked hearing about Megan Eaves, an IDA delegate based in London, leading virtual stargazing sessions over Twitter. Technology has given us many tools to connect with people all over the world. IDA advocates are taking advantage of this technology to overcome the COVID-19 pandemic challenges to keep up our advocacy for dark skies.

—Tim Hunter
Co-founder, IDA

Full STEAM Ahead

STANDING ON THE SHOULDERS OF GIANTS

Thank God I got over my fear of heights, as I have encountered a few remarkable "giants" in my astronomy life. I count it an honor to be numbered among the trendsetters, the avant-garde, movers and shakers, and fellow out-of-the-box innovators who swim upstream and go against the flow every once in a while.

John L. Dobson – need I say more? His vision for everyone to have an experience viewing through an eyepiece, no matter how young or old, speaks for itself. I identify with his spontaneity, finding a way to get scopes into as many hands as possible. Doing outreach with John, Donna Smith, and Jane Houston Jones of JPL in Pasadena, California, was a profound experience and life-changing, to say the least. As a former board member for the Sidewalk Astronomers, John will always be an inspiration and will never be forgotten. I laughed when I asked myself once, "What would John Dobson do?" (WWJDD). John would build telescopes with kids, and then "give the scopes to the kids, they'll know what to do."

Another pioneer is Noreen Grice, of You Can Do Astronomy, LLC. Noreen has revolutionized astronomy outreach by broadening it into the visually impaired and other disabled members of the community. Starting in the 1980s, Noreen took special classes and got certifications to add to her degrees. She is an author of countless books, most of which are tactile, or swell printed, for blind readers. When I encountered her through a working group with Astronomers Without Borders in 2010, I started collecting her books, if I could find them! I highly recommend the book *Everyone's Universe* that spotlights the various challenges and considerations to working with people with disabilities. In this book, she spotlights ideas, technology, and equipment that amateur astronomy clubs should consider for meaningful engagements. I started to make my own tactile resources that are not 3-D printed, but still present great astronomy concepts. I have successfully tested them with my local Council for the Blind organization.

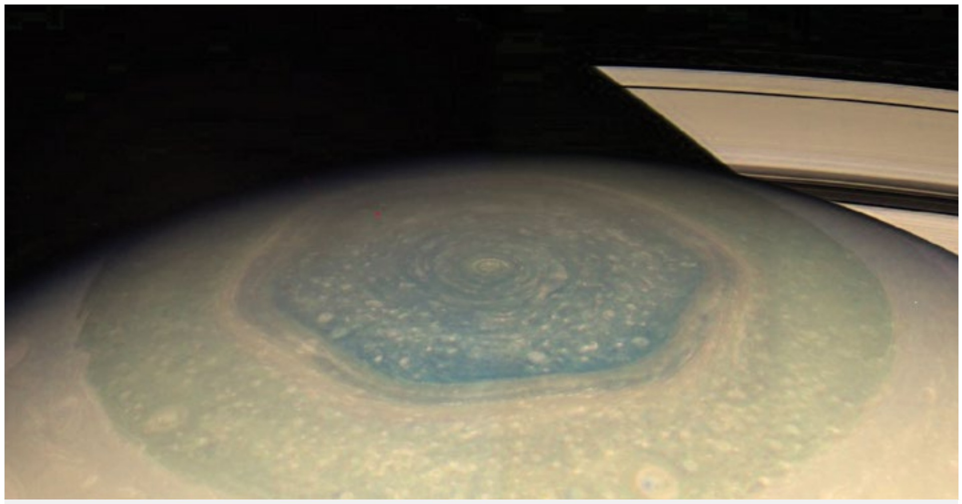
And then there is Bill Bogardus from the Astronomical League. I met Bill at the Astronomical League council meeting in Casper, Wyoming, as I filled in for the MSRAL regional chair since Missouri was in the path of totality. During the council meeting, I was the only female in the room, and was highly intimidated, as I was clueless as to the real workings of being a proxy. But there came a point where I asked about engagement with youth and students. Putting my size 8½ shoe further into my mouth I blurted out that the AL really needed to have a conference for kids alongside the adult conference. Bill's eyes got big, and after talking to the president, as he was vice president at the time, Bill asked if I would like to fill the youth coordinator position. I said yes and immediately my innovative brain let loose.

The newest "giants" for me are Merry and Wayne Wooten. After my introduction article in the *Reflector* in 2017, Merry and Wayne contacted me to see if there was a way we could collaborate and get the STEM Spyglass telescopes into the ALCon Jr. program. The more we talked, I realized that Merry had actually started to do family activities at the ALCons in the mid- to late 1990s and early 2000s. I was blown away by the fabulous connection that I did not know would catalyze my Alcon Jr. planning. I was truly honored that they reached out to me. The Wootens have sent me many parts and pieces to hopefully get this program in full swing through the Astronomical League. No luck as of yet, but anyone who would like to team up and see how we can make this a reality, please contact me for brainstorming at *astroleague_steam@cox.net.*

It is because of John, Noreen, Bill, Merry, and Wayne that I am the STEAM and accessible outreach astronomer that I am today. Because of their influence I have developed what I hope will be a great ALCon Jr. conference for families with accessibility as a core plan. So, I remain hopeful for 2022 and the opportunities that are around the corner. Full STEAM ahead!

—Peggy Walker

Note: Merry Wooten recently left us. Her legacy endures.



The hexagon at Saturn's north pole is visible from Earth as long as the planet is tilted downward (spring and summer in Saturn's northern hemisphere), but the best images of it have been taken by NASA's Cassini spacecraft. This view taken November 28, 2012, shows the north polar hexagon and the north polar vortex. The white spots inside the hexagon are convective storms. The center of the vortex at the pole has a clear area with winds moving rapidly around it. Image Credit: NASA/JPL-Caltech/SSI; Color composite by Jason Major

Wanderers in the Neighborhood

A HEX ON SATURN

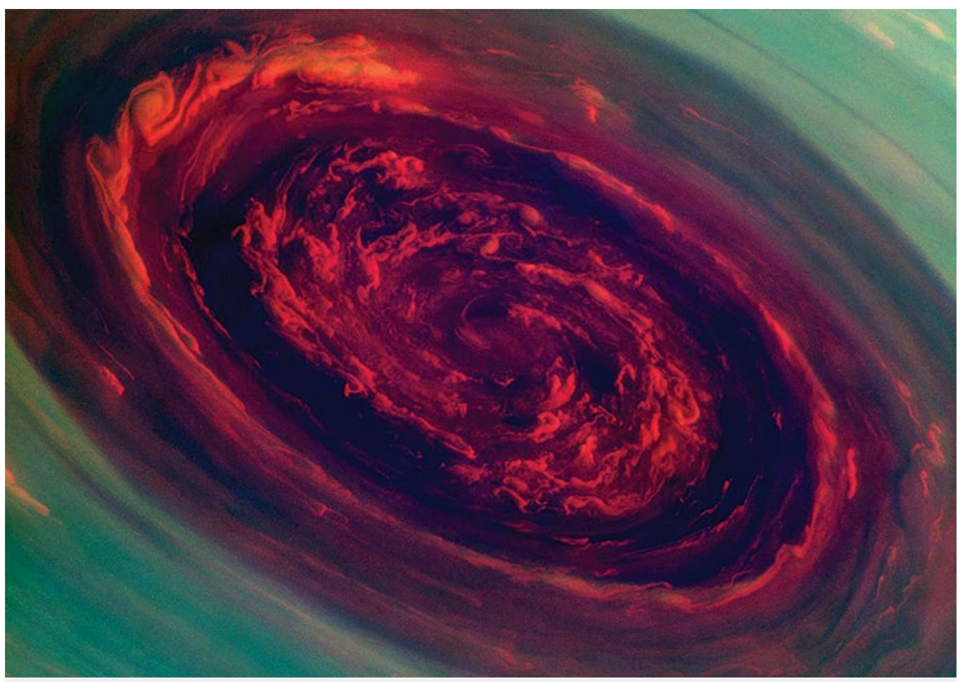
The gas-giant planet Saturn is 95 times the mass of our Earth and it is composed mostly of gas. Unlike Earth, Saturn has no solid surface, so the "surface" we see is just the top of the atmosphere. Images of Saturn are replete with bands stretching horizontally across its disk. The bands appear parallel from the far north of the disk to the far south.

But Saturn has a unique north polar region. Rather than the northernmost band being circular around the pole near 77° north latitude, it makes a hexagon centered on the pole. The six sides of the hexagon appear to be six straight bands that suddenly turn corners as the next side of the hexagon begins. The sides of the hexagon are each 9,000 miles long, forming a hexagon 18,000 miles across. As an upper atmospheric phenomenon, it is just 60 miles deep and takes 10 hours, 39 minutes, and 23 seconds to rotate around the pole.

The hexagon was discovered in the early 1980s as the two Voyager spacecraft flew past the planet. It was still visible when NASA's Cassini mission arrived in late 2004, but since the north pole was in darkness, the hexagon could only be imaged in infrared light. Saturn's rotation in its orbit brought the north pole into sunlight in January 2009. Cassini was then able to observe the hexagon in visible light, showing that it was a jet stream of dark clouds moving at about 220 miles per hour. Saturn's north pole soon became visible from Earth and was observed by the Hubble Space Telescope. In 2013, the hexagon was imaged by amateur astronomers as the planet approached its 2017 maximum downward tip, which allowed the northern pole to be more easily seen from Earth.

This unusual shape is believed to be caused by a rapid change in wind speed between the bright belt just south of the hexagonal band and the band itself. To simulate the hexagon, water in a tank was rotated at a higher speed in the center than around the outside. This caused the formation of not just a hexagon, but also shapes with three to eight sides. The different wind speeds cause vortices to form on the slower side, away from the pole. They become evenly spaced around the pole and push the band poleward to form the straight segments. As the band moves away from each vortex, it drifts away from the pole, keeping the straight shape. As it starts to come under the influence of the next vortex, it again gets pushed toward the pole, marking a corner of the hexagon.

Other theoretical models have the hexagon being created by instabilities in the band that propagate around the pole until they have made a complete trip. This forms a standing wave



Cassini's narrow-angle camera took this image of the north polar vortex on November 27, 2012, after it was illuminated by the Sun. The image was taken in infrared light color-coded with 890 nanometers wavelength as blue, 728 nanometers as green, and 752 nanometers as red. This palette highlights low clouds in red and high clouds in green. The eye of this storm is about 1,250 miles across with the clouds moving 330 miles per hour around it. This image was taken at a distance of 261,000 miles. Image Credit: NASA/JPL-Caltech/SSI pattern that keeps repeating itself. In either case, these polygonal shapes can only form at a narrow range of wind-speed differences, temperatures, and pressures. Because these requirements are not usually met, none of the other gas giants in our Solar System have a polygon at either of their poles.

Inside the hexagon, the rapidly rotating atmosphere forms a hurricane-like vortex centered on the north pole. The pole itself is in the eye of the storm, an area around 400 miles in diameter that is clear of high clouds. Surrounding it is an eyewall of higher clouds that casts a shadow into the pole-eye, making it appear dark. Surrounding the eyewall, the winds travel the fastest near the eyewall, becoming slower farther from the pole. Although the polar region moves like a hurricane, it is caused by different mechanisms.

The overall rotation of the system triggers hundreds of small convective storms that surround Saturn's pole. Upwelling air currents in the hearts of these storms bring up large particulates from lower in Saturn's atmosphere, large enough to block the far-infrared thermal radiation coming from deep inside Saturn. This silhouettes the storms against the far-infrared heat radiation from Saturn's interior.

The hexagon has been there over 40 years |and there is no reason to believe that it will become unstable and dissipate any time soon. Along with the rings, the hexagon marks Saturn as one of the most visually stunning objects in our Solar System.

—Berton Stevens

Deep-Sky Objects

THE NEEDLE IN BERENICE'S HAIR

Coma Berenices is one of the faintest constellations in the sky: it contains no stars brighter than fourth magnitude. From dark sites, a large open star cluster several degrees in diameter known as Melotte 111 can be seen. Melotte 111 may be the source of the comparison to wispy hair, giving rise to the constellation's name. The brightest stars in the cluster are 5th and 6th magnitude, while the integrated magnitude is 1.79.

Without the interference from bright stars, nebulae, and the Milky Way, Coma Berenices is a haven for exploring galaxies. The constellation contains many bright galaxies, including the Messier objects M85, M88, M91, M98, M99, and M100. Coma Berenices is also home to the galaxy NGC 4565, known by many astronomers as the best galaxy that Messier missed.

William Herschel discovered NGC 4565 in 1785. The galaxy is 16 by 3 arcminutes in size with magnitude estimates ranging from 9 to 10.5. Distance estimates to NGC 4565 range from 39 to 56 million light-years. The galaxy can be seen in 3-inch telescopes, but is best viewed in 8-inch or larger scopes.

NGC 4565 is one of the finest edge-on galaxies in the sky. It has a bright disk with a classic bright oval central bulge. Its razor-thin appearance gives rise to its common name, the Needle Galaxy. NGC 4565 has a very prominent dust lane running the length of the disk. The lane runs in front of the core, too, blocking views of the center of the galaxy.

The measured rotation of the galaxy is similar to that of our Milky Way galaxy. Therefore, the Needle Galaxy is thought to be comparable in mass (light and dark matter) to the Milky Way. Because we cannot see anything but the edge of NGC 4565, we don't know if it is a normal or barred spiral galaxy. Our home galaxy is a barred spiral.

The three brightest stars in Coma Berenices are Alpha (magnitude 4.31), Beta (4.25) and Gamma (4.34), which form a right triangle with Beta at the right angle. Along the hypotenuse of the triangle, the Needle Galaxy lies about 20 percent of the way from Gamma to Alpha. NGC 4565 also can be found 2.5 degrees east of the center of Melotte 111.

The image here of NGC 4565 was taken with an 8-inch f/8 Ritchey–Chrétien telescope with a 0.8× focal reducer/field flattener and an SBIG ST-2000XCM CCD camera. The exposure was 220 minutes. In the image north is up and east to the left. The bright star near the bottom of the image is magnitude 9.1, about the same brightness as the brightest estimates for the galaxy's integrated magnitude (defocus your eyepiece and compare the two!). The star above the core is magnitude 13.5 and may not be visible in smaller telescopes. The fainter spiral galaxy below and to the right of the Needle is NGC 4562. NGC 4562's brightness is somewhere between magnitudes 13.5 and 14.4. It is 1.9 by 0.6 arcminutes in size and is a barred spiral galaxy. NGC 4562 may be the same distance as NGC 4565, making it a companion galaxy.

Capturing brighter galaxies at the eyepiece is always exciting. While exploring the plethora of magnificent galaxies along the Virgo–Coma Berenices border, take a gander a little farther north at the Needle Galaxy. You will find it just as mesmerizing as those magnificent Messier marvels.

—Dr. James R. Dire

All Things Astronomical

FREE NASA/JPL WEBINARS

The era of COVID-19 has taught us the potential of technology to bring people together. As part of its educational mission, NASA/JPL offers free public webinars on a variety of topics (and for diverse audiences), including insights on careers in science, best practices in astronomy education and outreach, and new discoveries. Don't miss this opportunity to interact live with NASA/JPL experts. A calendar of events is available at *jpl.nasa.gov/edu/events/*.

JAMES WEBB SPACE TELESCOPE PROGRAM AIMS TO MAP THE EARLIEST STRUCTURES OF THE UNIVERSE

When the James Webb Space Telescope (JWST) – the long-awaited successor to the Hubble Space Telescope – becomes operational in 2022, one of its first orders of business will be mapping the earliest structures of the universe.

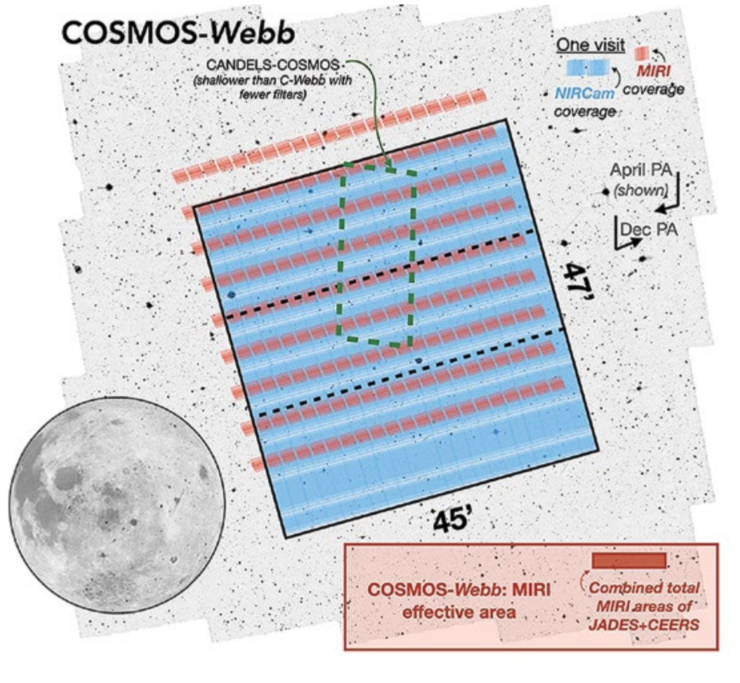
A team of nearly 50 researchers led by scientists at Rochester Institute of Technology and University of Texas at Austin will attempt to do so through the COSMOS-Webb program, the largest General Observer program selected for JWST's first year.

Over the course of 208.6 observing hours, the COSMOS-Webb program will conduct an ambitious survey of half a million galaxies with multi-band, high-resolution near-infrared imaging and an unprecedented 32,000 galaxies in mid-infrared. The scientists involved said that because COSMOS-Webb is a treasury program, they will rapidly release data to the public so it can lead to countless other studies by other researchers.

The survey will map 0.6 square degrees of the sky – about the area of three full moons – using JWST's Near-Infrared Camera (NIRCam) instrument while simultaneously mapping a smaller area of 0.2 square degrees with the Mid-Infrared Instrument (MIRI). Through this approach, the scientists hope to achieve three main goals.

The first goal focuses on the epoch of reionization, which took place from 400,000 to 1 billion years after the Big Bang. When the first stars and galaxies formed, they provided energy to re-ionize the early universe and it likely happened in little pockets, not all at once. COSMOS-Webb aims to map out the scale of these reionization bubbles.

A second goal is to use the MIRI instrument to look for fully evolved galaxies at high redshifts that seemingly matured soon after the universe formed. Hubble Space Telescope (HST) has found examples of these galaxies, which challenge existing models about how the universe formed, so the hope is to find more examples of these high-redshift galaxies and study them in more detail to understand how they could have evolved so rapidly.



The COSMOS-Webb survey will map 0.6 square degrees of the sky – about the area of three full moons – using JWST's Near-Infrared Camera (NIRCam) instrument while simultaneously mapping a smaller 0.2 square degrees with the Mid-Infrared Instrument (MIRI). Credit: J. Kartaltepe/RIT; C. Casey/UT Austin; A. Koekemoer/STScI

The third primary objective makes use of a technique called weak lensing. Because gravity is sensitive to all kinds of matter including that we cannot see, scientists can use the distortions of light around galaxies to estimate of the amount of dark matter. Jason Rhodes, a senior research scientist at NASA's Jet Propulsion Laboratory, said COSMOS-Webb will provide important insight about how dark matter in galaxies has evolved with the stellar content of galaxies over the age of the universe.

"A key result from the original HST-COSMOS effort over a decade ago was showing that dark matter is the cosmic scaffolding upon which the structures in the universe we see today are formed," said Rhodes. "COSMOS-Webb will make use of the JWST's larger mirror to push that dark matter mapping farther in time and to higher resolution maps, allowing us to study how dark matter has influenced the evolution of individual galaxies from the early universe to now."

COSMOS-Webb is one of just 286 General Scientific Observer programs selected out of more than 1,000 proposals for the telescope's first year of science, known as Cycle 1. These specific programs will provide the worldwide astronomical community with one of the first extensive opportunities to investigate scientific targets with Webb. NASA is currently targeting Oct. 31, 2021, for JWST's launch.

—from press release

From Around The League

RALEIGH ASTRONOMY CLUB FLOURISHES AMID PANDEMIC

On January 25, 2020, I presented a lecture at the North Carolina Museum of Natural Science in Raleigh concerning the Fermi Paradox and the possibilities of life in the universe. This lecture centers on a simple question once asked by nuclear physicist Enrico Fermi (paraphrased): "If there's so much potential for life to form in the universe, and life has had billions of years to form and evolve, then where are they (extraterrestrials)?"

My lecture attempted to explain the paradox by suggesting that there may be "great filters," barriers that are extremely difficult for life to overcome, which result in low occurrences of life within the universe. Some of the filters I discussed in the lecture are nuclear war, the challenges of global warming, incoming asteroids, and the effects of a global pandemic.

I had recently updated my slides to include the SARS-CoV-2 virus that causes COVID-19. Based on our previous successes with pandemics of SARS, MERS, and Ebola, I thought our nation, along with the World Health Organization, had a pretty high success rate on managing global pandemics. Little did I know that our state would implement social distancing restrictions within a month and a half due to the pandemic's arrival in North Carolina. Nor did I foresee the unimaginable toll the SARS-CoV-2 Virus would take on our nation and the world.

On March 4, 2020, North Carolina reported its first case of COVID-19. At that time, we thought the virus mainly affected people above the ages of 55. Unfortunately, as with many "graying" hobbies, the majority of Raleigh Astronomy Club members were in that age group. For us the risk was obvious: one infection spread during a club meeting could decimate our club.

In a sense the SARS-CoV-2 virus became a great filter for astronomy clubs for the following reasons:

- Astronomy is considered a graying hobby.
- Few young people have an interest in it.
- It carries a stigma of not being "cool": too nerdy, and sort of a "people who can't get dates club."

Developing strategies to survive a great filter takes planning, leadership, and tenacity in plan execution. In a matter of weeks, as our state was implementing social distancing restrictions, Raleigh Astronomy Club officers made the following decisions to protect our club members and the public and to position our club for growth:

- Converted all meetings to virtual sessions over Zoom supported by live Facebook feeds.
- Developed a COVID-19 observing policy for members-only observing sessions and trained the membership on how to follow it.
- Bolstered media presence by nominating and empowering a social media director to handle all social media traffic, a web content manager to update our web presence and keep it updated, and a webmaster to maintain and improve our web infrastructure.
- Boosted advertising for our imaging group meetings, offered training through social media, and published all recorded sessions on our YouTube page.
- Conducted new member training sessions over Zoom and placed recorded sessions on YouTube.
- Created a mentor program to keep new members engaged.
- Announced new members to the club via email and congratulated them on joining. This is something we used to do during indoor meetings; now email serves this purpose.
- Focused public enthusiasm into new memberships through virtual meetings and public engagement during popular astronomical events, such as the SpaceX successful Crewed Dragon Demo and crewed return to space, brightening of Comet NEOWISE, conjunction of Moon and Mars, opposition of Mars, and conjunction of Jupiter and Saturn.

How a life form or entity thrives or declines while attempting to pass through a great filter is the measure of how well it will thrive once the threat has passed. If a life form survives its test only to emerge mortally weakened and perishing soon thereafter, it means that the great filter was effective. Within the crucible of the filter an entity must not only survive but thrive, otherwise it will surely face a rapid demise not long after it emerges.

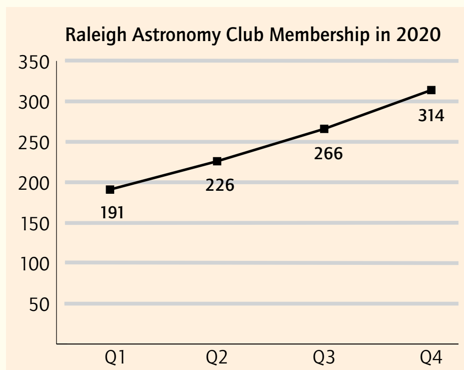
As with all great filters, the SARS-CoV-2 virus has created not only a dire challenge for humanity but also an open door for innovation and development by suppressing old norms that slowed progress. Nothing is more telling of this than the development of messenger RNA (mRNA) vaccine technology. Before SARS-CoV-2, mRNA had been limited to vaccine research and not rolled out to the public. The SARS-CoV-2 virus made developing this technology an absolute necessity, and the benefits of the vaccines' rapid development, safety, and efficacy are undeniable.

In a similar manner, our club had to overcome its own self-limiting technology. For our astronomy club, having only one place for astronomy meetings had to change due our meeting venues closing. Now our meetings and observation sessions occur from our driveways and homes over Zoom via electronically assisted astronomy (EAA) and virtual meeting rooms.

During this time, we found that the public's interests were also changing. Activities and settings that had previously siphoned people away from pursuits like astronomy were suddenly gone or operating in limited capacity. Some of the reasons for changing public interests include TV programs becoming boring, movie theaters shutting down, afterschool sports becoming restricted, sports and entertainment venues closing, and people exploring new avenues for personal learning.

This created an entertainment vacuum and a zest for knowledge. If we were to survive, we needed to engage people who were looking for a science-based social outlet while this public interest existed.

To fill this entertainment vacuum, we implemented the changes mentioned above. Moreover, our web team developed an astronomy skills matrix that allows us to drive our mentoring program for new members. These activities have resulted in phenomenal growth for our club. In just 9 months, we've increased membership by 64 percent, from 191 to 314 members.



These new memberships have come with their own sets of challenges. These include keeping members involved, ensuring early success for new members, proactively addressing new member equipment and observing issues, and proactively disseminating club knowledge.

The pandemic has made us realize that we can no longer exist in the boxes that we once hemmed ourselves into. Technological breakthroughs allow us to reach greater audiences than ever before. They've also enabled us to try more innovative ways to reach an eager populace. This pandemic has also raised our awareness of potential disease transmission at the eyepiece. For this, we're now experimenting with direct projection from our scopes to the ground or a nearby screen, as well as displaying images via electronically assisted astronomy on walk-by monitors or cellphone holders and cellphones attached to our scopes.

With the emergence of new vaccines, mankind will soon have passed through one of the great filters, and our astronomy club, by leveraging new technologies, has not only survived but flourished during its passage. It is my sincere hope that our stately scientific pursuit of the stars will continue to grow and thrive as we all face future tests of endurance in the years to come.

—Doug Lively
Raleigh Astronomy Club
and NASA/JPL Solar System Ambassador

THE NEW YOUTH ASTRONOMER OBSERVING PROGRAM

The Astronomical League has introduced a new Observing Program designed for our youth. It began with a conversation I had with John Goss, one of the Astronomical League's past presidents, who is always thinking of the League's growth and expansion. He asked me if we should have an observing program for teenagers.

It was one of those casual comments that would gnaw at me. We had Sky Puppies for astronomers age 10 and younger. We had Beyond Polaris for astronomers of any age. These were great starter programs, but we did not have something specifically for teenagers.

The one hesitation I had about adding another Observing Program was that I could not imagine what astronomical objects would appeal specifically to teenagers. There is, after all, nothing to stop young astronomers from engaging in the many observing programs we already offer. And that is when it hit me – we needed an observing program that would encourage young astronomers to enjoy all sorts of astronomical challenges. With the wealth of Observing Programs in the Astronomical League, a sampling of several of them would provide youth with an opportunity to experience the broad range of astronomy. Working with other National Observing Program Directors – Aaron Clevenson, Al Lamperti, and Cliff Mygatt – the Youth Astronomer Observing Program was created.

The program is specifically for astronomers age 17 and younger. It provides a young astronomer with the opportunity to sample twenty of the existing observing programs. Only five observations need to be made of each of these programs. This provides the young person with the opportunity to dabble with the Lunar Binocular Observing Program, without having to complete the program, and then moving onto observing the Messier objects without needing to observe all of them.

Not all Observing Programs can be used in this program. We left the Sunspotter out because we were concerned about safety. The Radio Telescope program is not included because the requirements for that program involve constructing equipment with a minimal number of observations, and as such it did not fit the nature of the Youth Astronomer Observing Program.

There are five observing programs that *must* be included in this program: Constellation Hunter, Lunar, Solar System, Messier, and Binocular Messier. These five give the observer an introduction to some of the basic elements of astronomy. With each of these, an individual simply needs to select five observations.

The observer must also select fifteen more programs and make five observations from each. There must be some variety, and no more than two galaxy-based Observing Programs can be included among these programs.

There are many facets to astronomy, and the Youth Astronomer Observing Program enables a young person to sample the large cosmic buffet, taking a few observations here and a few there. Hopefully the observers will find some areas of passion and continue to work on many Observing Programs. The five observations made for the Youth Astronomer Observing Program can be applied toward a submission in later programs. For example, if the submission includes five observations from the Carbon Stars Observing Program, then those five can be used among the 100 observations required of the Carbon Stars program.

Many of our clubs have young astronomers in their membership. Others want to build a youth membership. What a great tool this program can be to your clubs. Imagine a club that introduces this program and uses it each month to have young people work together with a mentor to introduce and guide the young members in their observations. This could be something many mentors could work on – one on spectroscopy, another with binocular observing, etc. This could build excitement, interest, and enthusiasm among the younger members. Many clubs say they want to welcome younger members, and this Observing Program is a tool to promote the recruitment of young members in local clubs.

Those completing the program will receive a certificate and a pin. The pin matches the style of the other starter programs, Sky Puppies and Beyond Polaris. Submissions may be sent to me at *maynard@pittendreigh.net.*

—W. Maynard Pittendreigh

2021 Officer Candidate Bios

TERRY MANN

Candidate for Astronomical League Secretary

I am currently secretary of the Astronomical League and have past service as League president (2006–2010), vice president (2002–2006), and secretary (1997–2001). I also serve as chair of the Great Lakes Region (2018–present) and as a League trustee. I co-chaired ALCon 2011 at Bryce Canyon National Park and received the G.R. Wright Service Award in 2004. I also received the Great Lakes Region's Hans Baldauf Award for contributions to astronomy in 2007. Serving as secretary during the past year, I again have had the pleasure of working with friends I have known for years and of making new friends.

I have worked very hard to help the League develop its strong virtual presence, working closely with Scott Roberts of Explore Scientific.

Starting in December 2020, Scott and I have co-hosted monthly League live events that feature speakers, night-sky imaging, and talks on League events, awards, and Observing Programs. For over six months, I have also coordinated the League's regular weekly participation in Explore Scientific's widely viewed global star parties. This August, I will also be co-chairing ALCon 2021 Virtual along with Chuck Allen.

As we emerge from this pandemic, I believe it is vital for us to continue using the virtual tools and skills we have developed in the past year to have an increased presence with our members and to continue to bring online experiences to the public. As we look ahead, I want to see the League continue its efforts to be more accessible to people with disabilities, to become more gender and ethnically diverse, and to attract youth and international members.

WILLIAM C. DILLON

Candidate for Astronomical League Treasurer

My first experience with amateur astronomy came under the tutelage of a very patient uncle at the tender age of eight while living in the suburbs of Philadelphia. His homemade 6-inch refractor opened the night sky for me, and I was hooked. Many years and three telescopes later, after spending the better part of my life living under the heavily light-polluted skies of Philadelphia, New York City, Chicago, Atlanta, and Northern Virginia, the night sky was opened again for me when my wife and I retired and moved to southwest Virginia near Roanoke. My favorite observing location is my backyard and the sky, compared to anywhere else I have lived, is actually dark.

My credentials for the position of treasurer include a bachelor's degree in accounting from Villanova University, a master's degree in finance from DePaul University, and 42 years of practical accounting and financial management experience with, among others, Macy's, Target, and the U.S. Marine Corps.

Since retirement, I continue to stay involved in my community by serving in several volunteer positions including chairman of my church pastoral council and as treasurer of the board of directors of a nursing home in Roanoke.

It has been my honor and privilege to have served the Astronomical League as treasurer since September 2018, and I ask for your support to continue serving in the position of treasurer for another three-year term.

MILKY WAY HYDROGEN LINE RADIO OBSERVING IS NOW EASIER

By Stephen Tzikas

The Astronomical League's Radio Astronomy Observing Program notes that one can observe hydrogen in the galactic plane using software-defined radio (SDR) with a dish less than 1 meter in diameter. Plans for building such telescopes are available on the Internet and they are affordable to construct, but many might be reluctant to do so unless they possess electronics skills. However, a new ready-made, affordable kit that is easy to assembly is now available. This new radio telescope is called scope-in-a-box and is available through the Society of Amateur Radio Astronomers (SARA) at *radio-astronomy.org*. The scope-in-a-box system is based on an article at *rtl-sdr.com/cheap-and-easy-hydrogen-line-radio-astronomy-with-a-rtl-sdr-wifi-parabolic-grid-dish-lna-and-sdrsharp*.

This scope-in-a-box kit has all the hardware, electronics, and software one needs for an easy assembly and software installation. Pablo Lewin, a member of SARA, helped lead the effort at SARA to standardize the purchase process and software installation and create a more thorough instruction. As a result, the scope-in-a-box will help bring radio astronomy to many people who otherwise might not have had the confidence to construct a radio telescope on their own. Pablo's personal version includes a bigger antenna and another low-noise amplifier in line with the original one. A video of his setup, which is based on the system at *tinyurl.com/3r8fbupm*, can be found at *youtube.com/watch?v=jgTAw_SvH48*.

The scope-in-a-box is an excellent way to learn and observe in radio astronomy.

The part I enjoyed the most was the hands-on experience I obtained through the scope's easy assembly and software use. In 1951, Harvard scientists Ewen and Purcell were the first to detect the hydrogen line. The original horn antenna they used can be found on campus of the Green Bank Observatory in West Virginia in front of the Jansky Laboratory. The Green Bank Observatory is the location for SARA's annual summer conference. These annual conferences are a great place to be introduced to radio astronomy, with presentations at levels from novice to advanced. Participants also have the opportunity to use a 40-foot radio telescope during their time on campus, among many other activities. Those in the western portion of the nation might be interested in the SARA spring conference, which meets in that area but is not fixed to one location as it is in the east.

Those who order the scope-in-a-box will receive a reflector grid antenna. The antenna measures 23.6 by 41.7 inches. This parabolic grid antenna is different from those in other radio telescope kits, that is, it is different from the parabolic dish of the Itty-Bitty Telescope (IBT), the loop antenna of a SuperSID, and the dipole antenna of a Radio Jove kit. The tripod and base mount is 3 feet tall and is constructed of metal.

The electronics in the scope-in-a-box consists of an SAWbird low-noise amplifier (LNA) and RTL-SDR dongle. The Nooelec SAWbird LNA and filter is specifically designed for amateur radio astronomers to be used with the RTL-SDR dongle for receiving the hydrogen line. The RTL-SDR dongle takes radio frequency signals and converts them to audio frequency; hence, the scope-in-a-box picks up many FM radio stations. The SDR receiver/dongle performs all of the digital signal processing, i.e., the software takes the analog signals received from the sky and convert them to digital. Radio telescopes can observe during the day or at night, as well as in cloudy weather. However, not all parts of the radio telescope are waterproof, so care needs to be exercised during inclement weather.

The new scope-in-a-box kit represents the latest effort to bring a part of radio astronomy to a wider audience. It is affordable, easy to assemble, and offers hours of enjoyment and a launch pad for other radio astronomy activities. ✶

AlCon Virtual 2021

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QUESTIONS?

Contact Chuck Allen, *vicepresident@astroleague.org*
or Terry Mann, *secretary@astroleague.org*

Finding Possibly Habitable Exoplanets With Machine Learning Algorithms

Abhi Milind Gudipati

Whether there is life beyond our own solar system is a question that has been asked for many generations, inspiring scientists, artists, storytellers, and even conspiracy theorists. But as scientific achievements have progressed and the issues on planet Earth have grown to attract most of humanity's attention, this question has slowly dissipated in value because no single person has been able to give a concrete answer of "yes" or "no." In other words, people say it's possible, but how many are out there? With the progressing technological advancements of the twenty-first century, it is possible to quantify the chance that there might be life outside of Earth, maybe even some concrete "yes" or "no" answers.

There are many factors that came into play to have Earth be able to support life for such a long time. Since there are so many of these factors, conditions must be nearly perfect for a planet to be habitable. But, to put this into perspective, we have one universe; in this universe, we have approximately two trillion unique galaxies; on average, there are about 100 billion stars per galaxy. So, in total, there might be, very roughly, around 200,000,000,000,000,000,000,000 stars in our universe. Currently there are around 4,364 known exoplanets, according to the NASA Exoplanet Archive *(exoplanetarchive.ipac.caltech.edu),* and that number could most definitely increase, perhaps exponentially. So there most definitely is a chance, and there is most definitely a quantity that defines this.

But how would we know that probability? We would have to know the factors that determine whether a planet is able to support life. Then we would have to calculate them for every single planet just to know whether it is a possibly habitable exoplanet. But if we had the tools to find the determining factors, why can't we use this technology to calculate the habitability of a planet? It would still be inconvenient because it would take time to instruct a computer to do those calculations or write code for it. There is a way, however, to perform this task. By training a machine on exoplanet data, you teach a machine about exoplanets rather than instruct it. So, when the machine is given a set of data from habitable exoplanets and non-habitable exoplanets and taught about what makes them different, it can draw conclusions supplementary to the numbers. This is how we know the chance of habitable exoplanets in the universe. This is the concept of machine learning algorithms.

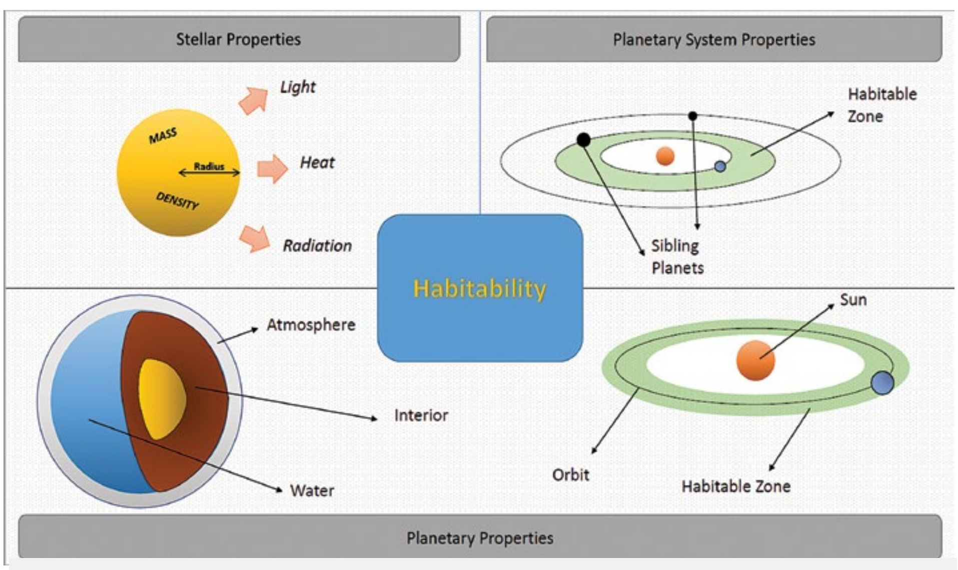


Figure 1. The three categories of habitability and their main properties. Diagrams by the author.

For my project, I used a machine learning algorithm to simply distinguish between possibly habitable and non-habitable exoplanets using the factors that determine habitability, as shown in Fig. 1. These factors may be categorized into three groups: planetary system, stellar, and planetary factors. Planetary system factors include orbital data, habitable zone information, and how many other planets are in the exoplanet's solar system, because these things affect the orbital dynamics of the exoplanet and whether it is in, and will stay in, the habitable zone of its planetary system. Stellar properties include factors such as the star's size, brightness, radius, mass, luminosity, and temperature. Stars affect the location of the habitable zone of the planetary system. Planetary properties include four main subcategories: the interior (affecting the magnetic field, mass, density, etc.), the surface (whether it has liquid water and the right temperature), the atmosphere (whether it can sustain the liquid water, temperature, and the biochemical properties we think are necessary for life), and orbital dynamics (whether it is currently in the habitable zone and stays in it).

Of course you need data to conduct any data science project. This is simple enough because the NASA Exoplanet Archive hosts all kinds of data for all the known exoplanets. However, this step led to multiple other challenges as well. There were only around 132 exoplanets that were known to be in the habitable zone of their planetary systems out of the over 4,000 known exoplanets. To conclude whether they are completely habitable or not, we would have to consider all the other factors previously stated, and that would take an inconvenient amount of time, as we have noted. One hundred thirty-two is an incredibly small number for a machine learning algorithm to work with. Computers are awfully fast; they can go through numbers and analyze them within a fraction of a second, so 132 rows with more than 12 features or so would not take long. Using a classroom analogy, a student must do practice problems to solidify the learning process, which is exactly what needs to be done for the computer as well.

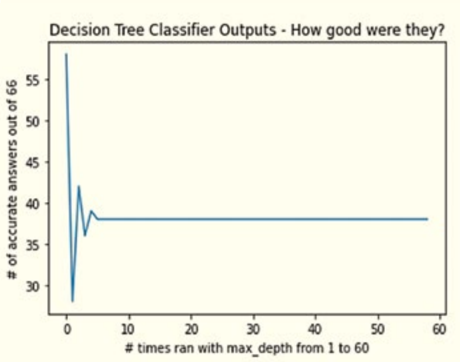
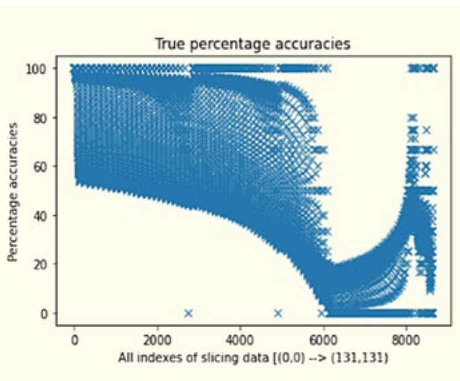
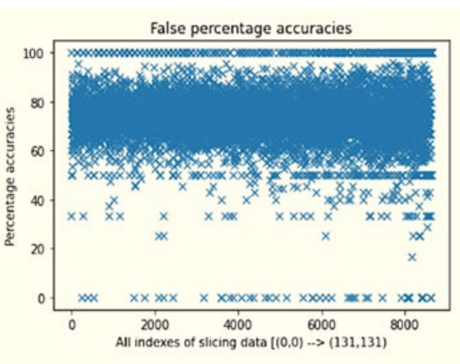


Figure 2: The accuracy of the decision tree classifier out of 60 tries, where the higher the points are the more accurate answers are in the output.

But even though there were some drawbacks for the algorithm, it ended up doing better than I expected. By slicing through all the datasets that I had gathered (more than 8,000 slices to test the model) I had a 50 percent accuracy predicting (possible) habitability and a 74 percent accuracy predicting non-habitability in planets (Figs. 2, 3, and 4). Overall, this project shows that machine learning combined with the newest technological advancements could be used to find habitable exoplanets, and maybe even find some extraterrestrials, but they most likely aren't the big-eyed, big-headed, skinny-bodied grays of Hollywood. ✶

Abhi Milind Gudipati (Abhi) is completing his junior year at Strake Jesuit College Preparatory in Houston. A member of the Fort Bend Astronomy Club, he has won AL awards for his achievements in photographing and hand-sketching the Moon and other objects in the solar system.





Figures 3 and 4. The percent accuracies of the model when put through the Gaussian classifier.

Black Widow Pulsars

By Dave Tosteson

When two heats differ much in degree, one destroys the other

–Francis Bacon

Leonardo da Vinci looked carefully at the world and saw connections between disparate matters. The way water swirled about a curved object in a river made him think about pressures surrounding smoke flowing over a wing. The changing shape of the Moon's crescent presaged its orbital path. The showing of his Codex Leicester at our Minneapolis Institute of Art was a rare opportunity to glimpse the creative process in the mind of an associative genius. It seems natural, then, when considering a certain type of unusual celestial object, to inquire about its terrestrial counterpart. How does a mateless arachnid relate to a solitary, spinning ball of neutrons in deep space?

Spiders of the genus known as *Latrodectus* are commonly called "widow" spiders for their sexual cannibalism, and species include the redback from Down Under and the black widow in the U.S. From one-third to two-thirds of males are eaten during mating, and since their physiology allows them only one opportunity to reproduce, males appear hardwired to martyr themselves for their future. A third of a century ago, a celestial correlate to this bizarre behavior was discovered: the binary millisecond pulsar.

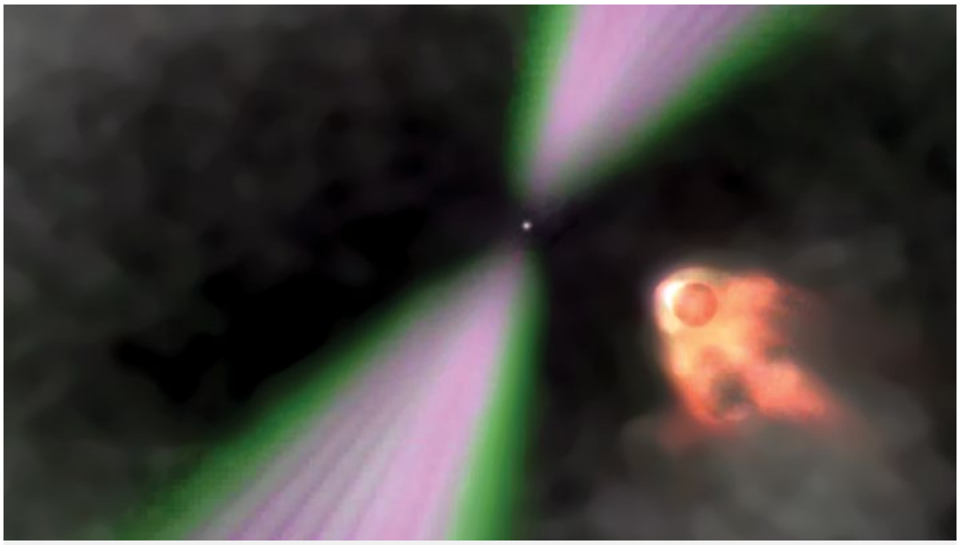
The Arecibo radio telescope before its collapse last December. Photo Credit: Mario Roberto Durán Ortiz via Wikimedia.

In a May 1988 issue of the journal *Nature*, using data from the now-collapsed Arecibo radio telescope that was at the forefront of radio astronomy for six decades, Andy Fruchter and his colleagues published the discovery of the first binary companion to what is called a millisecond pulsar. Pulsars had been identified in the early 1960s by their rapid and regular radio signals. In 1982, pulsars with extremely short rotational periods had been found, termed millisecond pulsars for their periods shorter than ten milliseconds, and astronomers wondered how they attained such rapid rotation, as recently formed pulsars had relatively modest periods, such as thirty rotations per second for the one energizing the Crab Nebula. The discovery of the first binary companion in the system called B1957+20 provided the clue to solving the mystery. A close companion that survived the supernova in which its partner became a pulsar could contribute mass to that pulsar and increase its rotation rate through the addition of angular momentum.

Over the following years, the pair was studied with radio, optical, and X-ray telescopes. The picture that emerged was of a nearby star being eaten away, or ablated, by the energy of the pulsar, and this sickle of life was named the Black Widow. Five thousand light-years from Earth, B1957+20 had a pulsar rotation time of 1.6 milliseconds. Its neutron star was pegged at ten miles wide and 2.4 solar masses (sm), nearing the theoretical limit of 3.0 sm proposed by physicists. Over that mass, nuclear forces may be unable to support the neutrons against gravity, causing the star to implode. Takata studied the pulsar's companion, placing its mass at 0.022 sm. This in the range of brown dwarf stars, but ablation had removed a portion of its mass, so the companion is likely a "whittled" white dwarf on its way to oblivion. Researchers were baffled by isolated millisecond pulsars, unable to explain their rapid rotation. As with the reproductive success of the female spiders, the complete destruction of a partner that had spun them up could explain their existence.

A study by the Chandra X-ray Telescope in 2003 helped develop a model of the system. In 2012, Huang found most of the system's X-rays were produced where the pulsar wind interacted with the ablated material surrounding the pair. An eclipse of the pulsar's radio signals for twenty minutes during each orbit was interpreted as being caused by ablated material surrounding the companion. The whole system was moving through the interstellar medium at a speed of one million kilometers per hour, creating a bow shock like that of a boat's wake. This was visible in hydrogen-alpha light, and the image on Chandra's website overlayed these different-wavelength findings onto the visual pattern of nearby stars. The temperature difference between the two sides of the companion star was studied by Takata in 2013, who found the temperature of the illuminated side facing the pulsar to be 8,300 K, and the opposite, "dark" side to be 2,900 K. He measured a visual maximum magnitude of 19.7 and a minimum of 24.5.

B1957+20 was thought to be the missing link between low-mass X-ray binaries and isolated millisecond pulsars. There were two hypotheses concerning the formation of the latter: complete ablation of a close binary companion and ejection of the millisecond pulsar from a triple system. Astronomers needed a larger sample to determine their formation and evolution, and several years ago found an ingenious method of recovery. Dr. Roger Romani of Stanford was sifting through Fermi Gamma-ray Space Telescope data for what he termed "anomalous" sources. Most of Fermi's sources could be associated with known



Black Widow pulsar ablating its mate – a still from an animated NASA visualization of J1311. Gamma-ray emission is shown in magenta; radio emission is shown in green. The full animation can be viewed at svs.gsfc.nasa.gov/11215. *Credit: NASA's Goddard Space Flight Center/Cruz deWilde*

pulsars or active galactic nuclei, but several defied classification. They featured rapid periods, like black widows, but were not visible in the radio spectrum. Romani searched for these outliers in visible light and found what appeared to be orbital periods and spectral variation suggesting close binary companions. He reasoned the more energetic gamma rays were getting through the surrounding haze of ablated material, but the radio waves were being blocked. Paul Ray of the U.S. Naval Research Lab then considered that higher-frequency radio waves could better penetrate the obscuring torus. His subsequent search found them, but they were visible only 10 percent of the time. This led to an archival study of four years of Fermi gamma-ray data for similarly veiled signals by Holger Pletsch of the Einstein Institute in Hanover, Germany. Once the pieces of this search technique were proven, astronomers had a powerful new tool to identify binary millisecond pulsars. They could take previously unassociated, rapidly pulsing gamma-ray sources, and follow up with targeted radio evaluations to find the new patterns.

Romani's work identified the pulsar J1311–3429 in northern Centaurus. It was one of the first millisecond pulsars found using gamma-ray pulsations, and its orbit of 94 minutes became the shortest known. It also had the most massive pulsar yet identified, at up to 2.70 sm. Its usual visual maximum of 20 is augmented by occasional flares to magnitude 18. Fermi found 43 millisecond pulsars and nineteen new black widow systems (only three were known before). The larger data set allowed differentiation of the binary millisecond pulsars into two categories based on the mass of the companion. A mass of 0.08 sm is the dividing line between black widows on the lower end and what are termed redback systems at higher masses. Explanatory factors for the larger masses may include younger systems, those farther from the pulsar, slower ablation, and greater initial masses. The relative efficiency of radiative beaming of the pulsar's energy is a deciding factor in some models, and there is conjecture that the two populations are truly separate, wherein one does not evolve into the other. What can we, as amateurs, expect to see in the eyepiece observing these arcane objects?

There is only one actual pulsar visible to amateurs: the 16.5-magnitude core object of the Crab Nebula. This can be seen in moderate-size instruments, but there is interference from the nebula itself, and it needs to be split from a similar-magnitude star a few arcseconds away. What are visible in black widows and redbacks are not the actual pulsars, but their radiated companions. As described above, the side facing the pulsar is brighter because energy striking its surface ablates the star. Since the light curves vary, it is important to either have an ephemeris with times of minimum and maximum brightness, or to observe a system at different times in its orbit. From a visual observer's standpoint, they are best viewed at their brightest, since all known objects are very faint even at maximum, and all but a few would be invisible to present equipment at minimum.

In April 2007 I used my 32-inch f/4 reflector from my home in east-central Minnesota to view B1957+20, the original Black Widow Pulsar system. On a night of exceptional clarity and stillness, I pushed the magnification to the highest I have used, 1,626 power. I was able to put a 2.5× Barlow on a 5 mm Nagler Type 6 eyepiece. There is a large trapezoid of stars to the west of the system, about 30 arcseconds in north-south length, with its reference 16.3 magnitude northeastern star just 10 arcseconds to the northwest of the pulsar. The coordinates of that star are 19h 59m 36.30s, +20d 48m 20.9s. The Black Widow is located at 19h 59m 36.77s, +20d 48m 15.12s. On the POSS 2 red plate, two pairs of faint stars can be noted just to the south and southeast of the reference star, forming a small trapezoid. In the pair to the southeast, the pulsar companion is the one closest to the reference star. Through the eyepiece that night, even with the extreme magnification, the southeastern pair of 20th-magnitude objects 2 arcseconds apart could not be separated. Dr. Romani of Stanford, one of the field's lead researchers, pointed out (in private communication) that since the black widows are at or below the lower mass limit for stellar fusion (0.07 sm), and their luminance is derived entirely from the absorbed invisible energy of the pulsar, visually viewing one below this threshold may be the equivalent of observing an extrasolar planet, though their formation histories are different.

Because the companion stars of redbacks are more massive, they are usually larger and brighter, making visual observation in amateur equipment easier than for traditional black widow systems. In February 2013, Breton published data on the optical counterparts of four energetic Fermi millisecond pulsars. One of his objects, J2215+5135, was one of the brightest visual binary millisecond pulsars so far identified. At a distance of 3.1 kiloparsecs, and with a companion of 0.213 sm, its magnitude (g) varied from 18.6 to 19.5 with a period of 4.14 hours. In August 2015 I used the 32-inch from my home to attempt the redback J2215+5135. Its coordinates are 22h 15m 32.68s, +51d 35m 36s. There is a bright, magnitude 9.5 reference star 56 arcseconds north-northeast of it at 22h 15m 34.22s, +51d 36m 31.1s. Six arcseconds to the west of J2215 is a magnitude 19.2 star that was visible 10 to 15 percent of the time using a 2.5

mm Nagler Type 6 eyepiece, giving 1300× and a 3.8-arcminute field of view. On the opposite side of the pulsar, 8.5 arcseconds to the east-northeast, is another star of the same magnitude. In the middle, between these two, was the companion to the pulsar. My impression was that J2215 was fainter than both stars to its east and west, suggesting the observation was at minimum according to Breton's data. Over more than an hour of observing, the pulsar companion was visible a few percent of the time as a faint smudge of light estimated at magnitude 19.3–19.5.

In fall 2015, Dr. Romani brought another relatively bright pulsar companion to my attention. The brightest of this class, the redback companion PSR J2129–0459, is located 1.2 degrees north-northwest of Beta (22) Aquarii. Its magnitude ranges from 17.3 to 17.7 in the green, with an orbital period of 15.2 hours. I used my 32-inch reflector with a 6 mm Clavé eyepiece to tease out the object in murky conditions, and it should be visible in an 18- to 20-inch telescope. Another system found by Albert Kong and his colleagues in Taiwan, the millisecond pulsar 2FGL J2339.6–0532, was about one degree north-northeast of NGC 7721 in northeastern Aquarius. Its companion attained a maximum of slightly brighter than magnitude 18, within visual range of 20-inch scopes. On the warm night of November 15, 2015, I used my 32-inch reflector with a 6 mm Zeiss Abbe Ortho giving 542× from my home to follow this object that was 0.5 arcminutes south-southwest of a magnitude 17.8 (V) reference star, halfway through its 4-hour cycle. It appeared slightly fainter than that star. The brightest true black widow peaks about 20th magnitude, and will be a challenge to see, even with very large amateur telescopes.

The "sacrifices" of their companion stars have taught us a great deal about these pulsar systems. They have shown how mass transfer spins up rotational periods, and that ablating surfaces create variable light curves to help study their orbital mechanics. With novel future techniques we may learn to measure their rates of mass loss, and the compositions of ablated material. We might find a pulsar accreting matter at the theoretical Tolman-Landau limit, and see a moment of black hole formation. Like a patient spider on its web, amateurs through careful observation can capture a small part of this unfolding drama. ✶

The great globe itself…
shall dissolve

–William Shakespeare

Design of a Novel Binocular Chair

By Dave Wickholm

Relaxing with binoculars is a great way to end a night spent teasing faint fuzzies out of the sky background with a big telescope. At the 2017 Texas Star Party I saw several people using an improved outdoor reclining lounge chair called a "gravity chair" to enjoy the sky either with small binoculars or with the unaided eye. I had recently built a parallelogram type mount for a set of 7×44 binocs and wondered if there might be a way to combine the two. My first attempts were disasters. Elevation sweeps were possible only if you did not recline the chair. Azimuth sweeps, well, let's just say it wasn't pretty. I had to move the binocular mount or the chair and often both. Clearly not an optimum solution.

I am a retired optical designer and engineer and as a result have some knowledge of helmet-mounted displays. Now mounting a 4- or 5-pound pair of binoculars firmly to my head is a non-starter, but it gave me some ideas. My desire was to minimize head movement as well as vibration. After playing around with several concepts on paper, I settled on one in which the elevation was achieved by reclining the chair and azimuth was achieved by suspending the binocular in front of the user by means of an arm that pivoted about a point in line with the rotation of the user's neck.

As a practical matter I also needed to provide vertical and in-out adjustments to place the binocular eyepieces in the correct location with respect to the user's eyes. The parallelogram came in handy here.

A simple clamping mechanism attaches the binocular mount to the gravity chair. Finally I attached the binoculars to the mount by means of a captive ¼-inch×20 screw that fastens to the central pivot that provides the interpupillary adjustment for the binoculars. The tilt of this screw is adjustable by loosening the screw that clamps the two outer angles against the captive screw housing. This allows me to set the binocular elevation range for either near-zenith or near-horizon use.

I mounted the 7×44 binoculars on the chair for the first time at the 2018 TSP and thoroughly enjoyed the relaxed view of the Milky Way. On a whim, I entered the binocular chair in the ATM contest and won second prize. One of the questions I was asked was if I had considered using larger binoculars. This led to selecting and mounting a larger pair.

I wanted to see at least a four-degree diameter field of view to enjoy sweeping the summer and winter Milky Way. This is big enough to see the entire Veil Nebula complex or the North America Nebula. The weight of the binoculars had to be kept in mind as well, so the chair would not tip over when reclining to look near zenith. Cost was also an issue: I wanted to spend less than $500 and preferably less than $400.

There are many options at this point, as an internet search will reveal. I settled on the Oberwerk 15×70 Deluxe. They weigh in at 4.3 pounds and have a 4.2-degree field. The eye relief is a generous 18 mm so I can wear my glasses.

After assembly was complete, I realized

Close-up view of mechanism. Photos by the author.

additional weight was needed near the foot of the gravity chair. I easily took care of this by attaching 5 pounds of diving weights to a piece of oak trim and clamping that to the foot of the chair. I added a pair of arm pulls to aid in reclining the chair as well.

The finished chair has a full 90-degree azimuth range and a 60-degree range in elevation. That is quite a patch of sky to explore without having to move. It made working the AL Binocular Double Star and Binocular Messier Observing Programs a lot easier as well.

You may wonder if there is any chance of the binocular crashing down on your eyes when looking near the zenith. I thought of that, and designed a counterweight that increased the restraining force on the lateral adjust arms as the line of sight was increased toward vertical, but I found if I kept the clamps tight the binoculars were stable. The weights also increased the required ballast near the foot of the chair so eliminating the counterweight kept the required foot weight manageable.

At the 2019 TSP, around 2 a.m., after a night of chasing faint galaxies with my big Dob, I decided to chill out with my new binocular chair and view the summer Milky Way now well above the horizon. Starting in Cygnus I panned slowly southward. The star density increased and the background grew brighter. M27 was a luminous glow. My skin began to tingle as I reached the Scutum Star Cloud. I realized I was holding my breath. M11 was a fan-shaped haze flaring out to the west. Curtains of stars passed as I continued south through the Sagittarius Star Cloud. The Trifid was a radiant ball almost a quarter-degree across with a central star. Just below it was the magnificent Lagoon Nebula, the darker gap within the nebula easily seen with averted vision. I panned down to M6 and M7, noting just how amazingly bright this part of the Milky Way is. I ended at the "false comet," a stunning fan of stars rising from Zeta Scorpii. How do you describe this glorious vista? Someone would have to be a poet to come close to doing it justice!

Those of you who would like to indulge your inner muse can find the plans I created to build this binocular chair at *astroleague.org/files/Wickholm_binocular_chair_plans.jpg*

You may need to adjust some of the dimensions depending upon the chair you choose, but these will get you started. All the parts may be purchased at any of the large "box" stores and at most lumber yards. ✶

OBSERVING CHALLENGE

One of the most beautiful sights in the twilight sky is a super-slender crescent Moon, within one day on either side of new. The unaided eye record for youngest waxing crescent Moon is widely accepted to be Stephen James O'Meara's 15.5 hours. But you can also try to spy with your little eye a really old waning crescent Moon just before sunrise. Due to the angle of the ecliptic, summer is a great time for northern hemisphere observers to try their hand at viewing an "old moon in the new moon's arms." Your ability to see a very slender crescent depends on many factors, including your visual acuity, local horizon, and sky conditions. If you would like to practice using the waxing crescent at sunset, the British Her Majesty's Nautical Almanac Office has an excellent resource, their Moonwatch website: *astro.ukho.gov.uk/moonwatch/index.html.* Predictions on the probability of viewing the newborn crescent from different geographical regions are published monthly, based on their computer algorithm. Share your successes, frustrations, and helpful hints with us here at the *Reflector* (care of editor Kris Larsen, *larsen@ccsu.edu*), and we will aggregate them into an article for a future issue.

Thin crescent Moon setting over ESO's Paranal Observatory in Chile. Image Credit: ESO/B. Tafreshi/TWAN *(twanight.org)*

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INTERNATIONAL DARK-SKY ASSOCIATION

A Game of Comets

By Kristine Larsen

Fantasy writer George R. R. Martin features a potentially prophetic comet in his famed *A Song of Ice and Fire* novel series, first mentioned in *A Game of Thrones* (1996) and continuing in much more detail in *A Clash of Kings* (1998). In an email response to a fan, Martin explained that his inclusion of the comet was not motivated by Halley's Comet's connection to the Battle of Hastings as the fan assumed, but instead was a reference to Shakespeare's *Julius Caesar* and to the comets in the sky during the time of his writing.

While Martin doesn't name the specific comets he was referring to, the timing of the novels' publication suggests that it was some combination of three famous comets: Comet Shoemaker-Levy 9, Comet Hale-Bopp, and Comet Hyakutake. Comet Shoemaker-Levy 9, discovered on March 23, 1993, by Carolyn and Eugene Shoemaker and David Levy, was peculiar from the start, as photographs quickly showed that it was actually an aggregate of separate pieces flying in formation that dove into Jupiter in July 1994. The "collisions" of the nearly two dozen dirty-snowball fragments (the largest about a mile wide and liberating an energy equivalent to over 200,000 Hiroshima bombs) with Jupiter's dense gaseous atmosphere actually occurred on the backside of the planet. The resulting "black eyes" of the debris fields – some the size of earth – astounded astronomers when the planet's rotation carried them into view several hours later. Many of us remember observing them through our own telescopes.

On July 23, 1995, amateur astronomers Alan Hale and Thomas Bopp independently discovered a comet that, like Kohoutek before it, promised to deliver a spectacular show at closest approach in 1997, based on its unusually large size. But backyard observers did not have to wait that long for a naked-eye comet; on January 30, 1996, Japanese amateur astronomer Yuji Hyakutake discovered his second comet in five weeks. While more conservative in girth than Hale-Bopp, Comet Hyakutake's orbit was forecast to bring it unusually close to our planet a scant two months later. Not only was it easily visible to the unaided eye from even light-polluted skies, but from dark skies, its tail stretched an impressive 100 degrees.

The sensational success of Hyakutake set the bar even higher for Hale-Bopp's 1997 flyby, but it was medieval superstitions and pseudosciences with a modern twist that captured the public imagination. Instead of witches and demons, the comet was claimed to be cavorting with extraterrestrials; in particular, a November 14, 1996, photograph became a media sensation due to false claims that the comet was being followed by a "Saturn-like object" (in actuality merely the distorted image of a star) that was alleged to be a UFO. As the comet neared its "closest" approach to Earth (at a distance farther than the sun) in March 1997, doomsday predictions increased. In actuality, the world only ended for 39 members of the Heaven's Gate cult, who committed suicide in the false hope that the alleged UFO was their magic chariot ride back to their true interstellar home. It is no wonder that these comets provided such potent fodder for George R. R. Martin's imagination. ✶

Kristine Larsen is a Professor of Astronomy at Central Connecticut State University, the editor of this magazine, and a member and board member of the Springfield Telescope Makers.

For more information on comets and popular culture, see *talesaftertolkien.blogspot.com/2020/10/guest-post-kristine-larsen-tale-of.html.*

The portion of the Bayeux Tapestry depicting what is thought to be Halley's Comet. Image by Myrabella from Wikimedia Commons.

WE'RE RETURNING FOR 2021... STILL SOME OF THE DARKEST SKIES IN AMERICA

Camp Billy Joe in the Oklahoma Panhandle has long been home to one of the nation's top amateur astronomy events: the Okie-Tex Star Party.

We are returning for 2021!

The Okie-Tex Star Party is a week of some of the darkest skies in North America. The days are filled with first-class speaker presentations, a multi-day astrophotography workshop, swap meets, and plenty of attractions within driving distance.

New for this year: updated health and safety protocols and a new 40' x 60' facility for our speakers and vendors.

Okie-Tex runs from Friday, October 1 through Saturday, October 9 this year.

Hope to see you in the Mesa!

REGISTER NOW AT WWW.OKIE-TEX.COM

Photo by Andy Fryhover

GALLERY

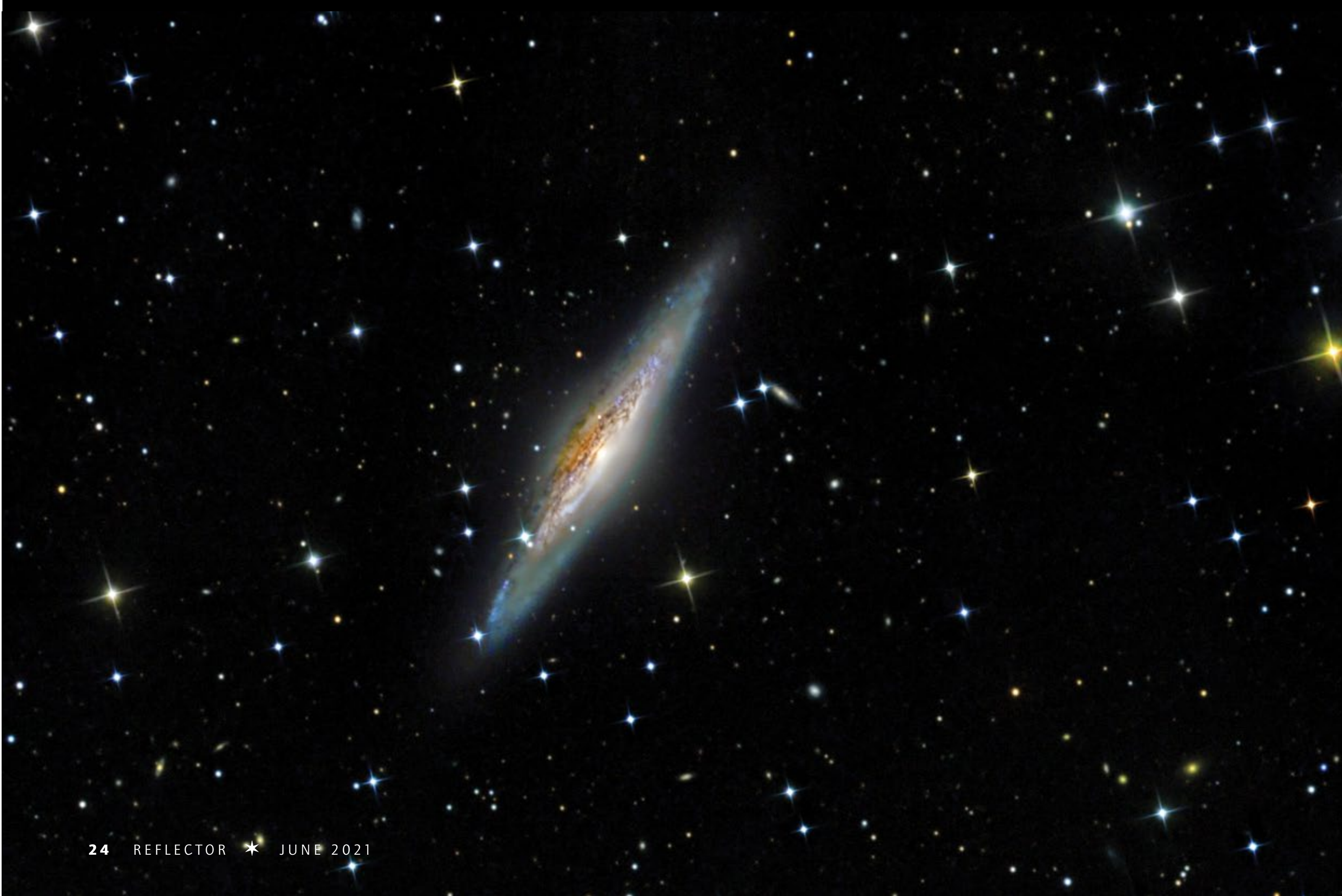
MEMBER ASTROPHOTOGRAPHS

This page top: James Dire (Peoria Astronomical Society) captured this view of the Orion Nebula with a William Optics 132 mm f/7 refractor with 0.8× focal reducer/flattener and an SBIG ST-4000XCM CCD camera. The ninety minutes of exposures were collected from Jubilee College State Park near Peoria, Illinois.

This page bottom: Frank Colosimo (Delaware Valley Amateur Astronomers) captured this image of NGC 2683 from his Blue Mountain Vista Observatory using a Hyperion 12.5-inch (f/9 – 2532 mm) and Celestron EdgeHD-11 (2760 mm) telescopes with Apogee U8300 and SBIG STL-11000 cameras. Approximately 32 hours of exposures were taken through LRGB filters over five months.

Next page top: M.J. Post (Longmont Astronomical Society) used four hours of RGB exposures to capture this view of the Cone Nebula using a PlaneWave CDK14 telescope and a ZWO ASI 6200MM camera from his DSNM observatory in Animas, New Mexico.

Next page bottom: Steven Bellavia (Amateur Observers' Society of New York) captured this image of Bernard 18 or Kutner's Cloud using a TS-Optics Photoline 72 mm f/6 FPL-53/Lanthanum doublet APO refractor with a ZWO ASI183MM Pro camera. More details can be found here: astrobin.com/full/gffcir/0/.



REACHING OUT

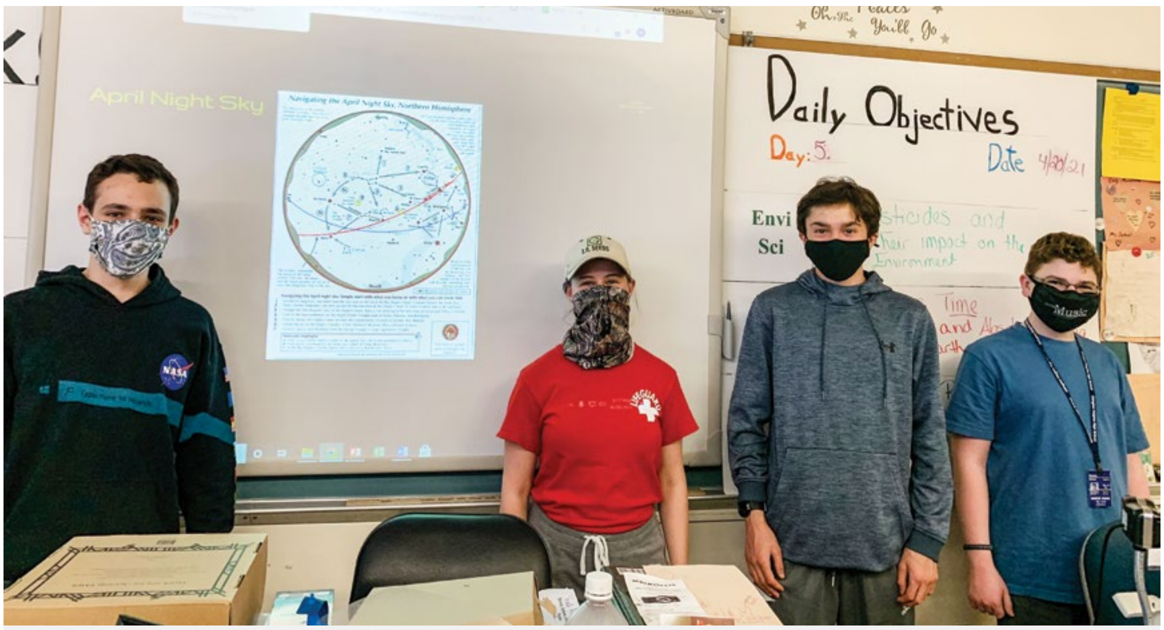
By Conal Richards

For most of my life, stargazing and reading about the universe have captivated me. Throughout my childhood, I was overcome with curiosity and wonder whenever I looked at the stars and planets. I wanted to explore the distant worlds I read about in science books and investigate how the universe worked. Fortunately, backyard astronomy has made these dreams of exploration a reality. When I turned thirteen, I received a 6-inch Newtonian telescope for my birthday, which opened up the infinite night sky for me. My fascination with the stars led me to the rich hobby of amateur astronomy, and I vividly remember the first night I opened my telescope to the skies. I selected the Moon as my first target to explore, and I quickly became eager to share my discoveries with family and friends. I'm seventeen years old at the time of this writing, and through exploring the hobby and sharing my experiences with others, I became aware that teenagers are relatively rare in amateur astronomy.

My experience grew from using my trusty reflector. Though I could only find the Moon at first, I eventually learned the ropes of the hobby and started exploring the night sky in full. On August 21, 2017, I recorded my view of the Great American Eclipse in my notes: "Bailey's beads are visible around the circumference of the Sun. The Moon is a deep black color, and it is surrounded by a purple ring of light." In 2019, I had my first exposure to the Virgo Galaxy Cluster, and in 2020, I challenged myself to map the surface of Mars by sketching every longitude over an opposition. These experiences were unique in their own way, and they opened the door for a lifetime of enjoyment in such a rich hobby. I knew I had to share the joy and knowledge that come from exploring the universe.

Over the past four years, I've become much more experienced in the hobby, and I've created my own outreach programs to share the joys of stargazing with my peers. At the beginning of my junior year, I founded the Abington Heights High School Astronomy Club, my school's first club related to astronomy. To found the club, I was asked to provide a list of at least ten interested students to demonstrate the longevity and potential for the organization. I'll never forget walking into the principal's office with my club proposal and watching the look of surprise on his face as he read thirty-seven names.

I've heard many hobbyists lament that young people have no interest or time for astronomy in their lives. Fortunately, I've found this not to be the case. Rather, teens and young people are more interested in astronomy than ever, making outreach a matter of accessibility rather than interest. Though interest and fascination in astronomy is abundant, the central obstacle I had to tackle was a lack of experience with equipment and stargazing. Few of our club members had ever used a telescope, binoculars, or even a chart of constellations to observe the night sky. Hence, my first meetings focused on identifying planets in the sky, noticing seasonal changes in the stars, and observing other naked-eye phenomena like meteor showers and planetary conjunctions.



Some members of the Abington Heights High School Astronomy Club. Photo provided by the author.

My meetings were successful and I was satisfied with the turnout of students, but I still wanted to expand the club's reach and open up new outreach platforms. To do this, I developed a website where I shared astronomical observing guides based on my personal notes and experience. Eager to keep my audience engaged, I linked my favorite books, magazines, and online learning resources to encourage club members to get involved in amateur astronomy and stargazing. Additionally, I created social media accounts to share current events, such as the historic SpaceX Crew Dragon launch, the dimming of Betelgeuse, and Perseverance's bold landing on Mars.

TO THE FUTURE

Throughout the ongoing COVID-19 crisis, hosting meetings remained challenging. My club members were already sitting at the computer six hours a day for school, so another online meeting may have been unappealing for most. To navigate this challenge, I discovered the impact of bite-sized media and its potential for high school outreach. My Instagram posts about phosphine being found on Venus or the impact of Lord Rosse's telescopes on studying "spiral nebulae" were met with great success in provoking members' curiosity. By using social media, I managed to fit astronomy outreach into a fast-paced digital environment.

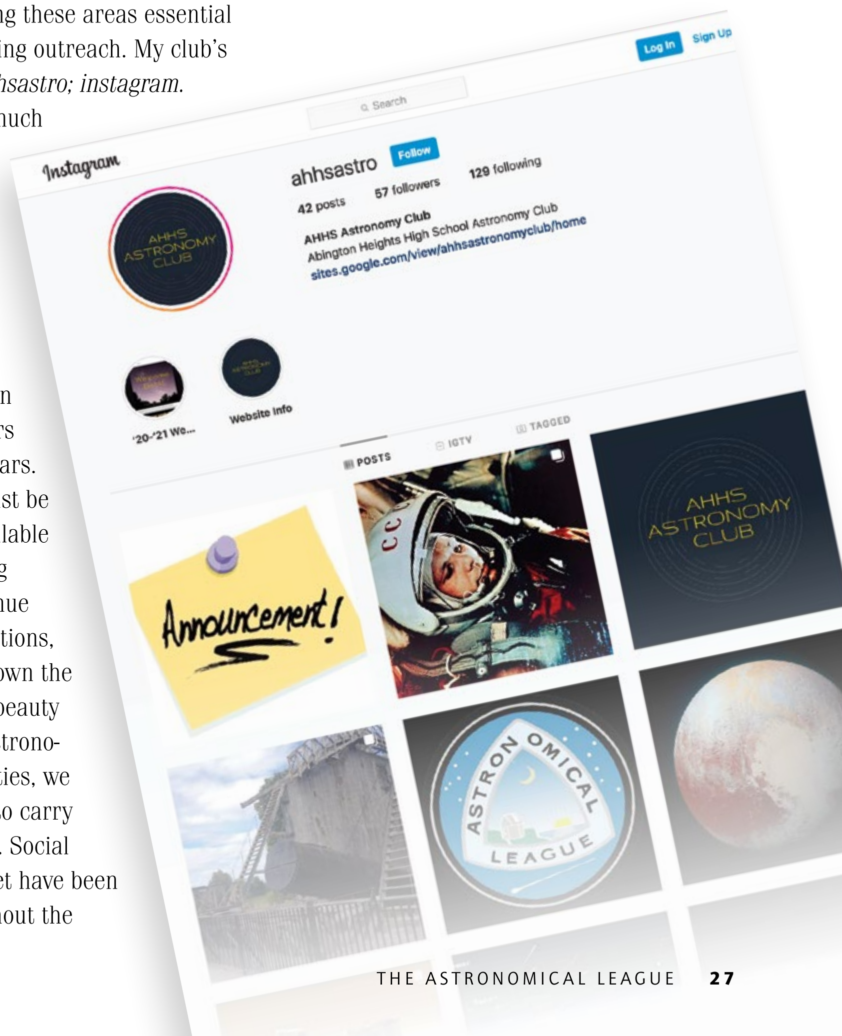
Bolstered by online engagement, I conducted a week-long virtual event surrounding the 2020 Mars opposition. Titled "Mars Week," my event included a self-produced series of two-minute videos discussing Martian climate, geology, and exploration. Additionally, I curated a list of online resources for ongoing self-learning, including live streams from Lowell Observatory and some of the best images from the Mars Reconnaissance Orbiter. To illustrate the concepts I shared with members, I used a DSLR camera to take nightscapes of the constellations, comet NEOWISE, and the Perseid meteor shower. This allowed me to provide visual aids along with my presentations and lessons. Having taken the pictures myself and with modest equipment, I demonstrated to my club members that the night sky can be appreciated by anyone. It only requires one to look up and have an open mind.

As 2021 dawned, I was determined to take my astronomy club farther than ever before through new programs and ideas. Using my local library as a resource, I sought and secured grant funding to support library telescope observing and the distribution of material kits with planispheres and observing guides. Just after that, I discovered the Astronomical League and what it could offer my members in terms of observing programs, youth awards, and guest speakers at our meetings. In January, I completed the Lunar Observing Program and had the good fortune of meeting the League vice president, Chuck Allen. He and I discussed how light pollution, the end of the Space Race, and the "graying" of amateur astronomy have impacted younger hobbyists and outreach efforts across the country. He suggested my club join the League and provide some basic observing programs to members as an introduction to astronomy. As a starting point for new astronomy hobbyists, I've found the Lunar, Messier, and binocular Observing Programs best suited for teenagers.

Many amateur astronomers are familiar with the challenge of hunting down dim galaxies and nebulae. These targets elude our equipment and observing skills until we learn where and how to look at them. Outreach to teenagers behaves in much the same way; you just need to know where to look for the interest and how to expose it. Teens experience much of the world through social media and technology, making these areas essential platforms for conducting outreach. My club's Instagram page *(@ahhsastro; instagram.com/ahhsastro)* saw much success in sharing astronomical news and events with high schoolers.

Going back to my first experiences in astronomy, I've been dazzled by the wonders of the night sky for years. These experiences must be shared and made available to all, especially young people who will continue our hobby. For generations, people have passed down the knowledge, lore, and beauty of the night sky. As astronomers in our communities, we have a responsibility to carry this tradition forward. Social media and the Internet have been indispensable throughout the past year of COVID-19 restrictions, and they represent valuable tools for reaching out to high school–age astronomy enthusiasts. Welcoming students through easier observing programs gets them looking at the Moon, planets, and constellations, developing interests of a lifetime in the process. These students are the future of our hobby, and their talent and interest will carry the fire of scientific curiosity forward. As these outreach methods encourage younger audiences to join the hobby, the popularity and news will spread, bringing even more fresh faces into the community. Looking forward, interest is more widespread than ever, and representation of young audiences holds great potential for us as hobbyists. Go find these rising stars and see how they shine! ✶

Conal Richards is a high school student from Scranton, Pennsylvania. He can be reached at *conal.richards@gmail.com*



CITY OF STARS

By Linda Prince

Have you ever seen astronomy-related items in your town or city, for example a sundial or art piece on display in a public place? In a January 2002 special issue of *Natural History* magazine titled "City of Stars" *(haydenplanetarium.org/tyson/photos/2002-10-city-of-stars/index.php)*, Hayden Planetarium director Neil deGrasse Tyson listed and described over 20 astronomy-related landmarks in New York City. I was inspired to lead tours for members of the Amateur Observers' Society of New York (AOS) and their guests to visit some of these sites. Over the years, more sites have been discovered, expanding this list to 46 items. Some are iconic landmarks, such as the ceiling of stars at Grand Central Terminal, but many are hidden treasures not widely known to the public. Each item comes with its own unique characteristics and interesting and sometimes surprising history.

Tour participants visit the News Building globe. Photo by the author.

These items are all listed and described on our City of Stars page *(aosny.org/city-of-stars.html)*. Two examples of items on the City of Stars list are the Earth Globe at the News Building and the Atlas Sculpture at Rockefeller Center.

EARTH GLOBE

What is now called the News Building located on 42nd Street between 2nd and 3rd Avenues was home to the *New York Daily News* newspaper until 1994. Designed by architect Raymond Hood, this 37-story building was constructed in 1929–30 and features strong vertical lines. The *News* allotted $150,000 to be spent on the lobby, which resulted in a beautiful space designed in the art deco style with a 12-foot-diameter, 4,000-pound, tilted, rotating globe of the Earth. The globe is dramatically lit from below and sits in a depression with tiered sides. On these tiers the sizes and distances of various celestial objects are compared with the size of the globe to scale. On opening day, when the motor was turned on, the globe rotated in the wrong direction. This was quickly fixed, and it has been spinning ever since, completing one rotation every ten minutes, 144 times faster than the real Earth.

A large compass on the terrazzo floor radiates out from this sphere with lines indicating directions and distances to various cities around the world. On the book-matched marble walls are instrument panels displaying data such as temperature and wind speed, clocks showing local times at locations around the world, and a pictorial history of the building. The News Building was designated a National Historic Landmark in 1978 and its lobby a New York City Landmark in 1981. This lobby served as a model for the lobby at the *Daily Planet*, a fictional newspaper in the *Adventures of Superman* television series (1952–1958) and was the set for scenes in the movie *Superman* (1978).

Entering the lobby of the News Building is like going back in time: some of the astronomical size and distance comparisons are based on outdated knowledge, the geo-political features on the globe have not been updated for decades, the brass instrument panels on the walls appear to be from a bygone era, and the art deco style is evident everywhere.

ATLAS SCULPTURE

This icon of Rockefeller Center, located on 5th Avenue between 50th and 51st Streets, was designed by Lee Lawrie and sculpted by Rene Chambellan in the art deco style and installed in 1937. Atlas was the Titan who taught humans astronomy, a tool used by sailors to navigate the sea and by farmers to measure the seasons. He led the Titans in a war against the Olympic gods. After the Titans' defeat, Atlas was punished by Zeus and forced to carry the world and the heavens on his shoulders for eternity. It is Atlas who turns the heavens and causes the stars to revolve.

This 45-foot-tall bronze sculpture features a muscular Atlas holding on his shoulders an armillary sphere with rings positioned to represent the celestial equator, the ecliptic with symbols of the 12 zodiacal constellations that pass through it, and a celestial longitude ring with a fleur-de-lis indicating the direction of north. The north-south axis of the armillary sphere points to the North Star. The curved board laid across his shoulders bears the symbols of the planets, with Neptune, Uranus, Saturn, Mars, Earth (with a crescent Moon nearby), Venus, and Mercury. Even though Pluto was discovered in 1930, it is not included. Jupiter is not visible; perhaps it is hidden behind Atlas's neck. Why? It has been suggested that Jupiter is omitted from view and may be weighing down the most heavily of all the planets because Jupiter or Zeus was the one who punished Atlas!

It has been great fun to research the many astronomy-related landmarks of New York City and learn their stories, and even greater fun to actually wander the city and visit them. Perhaps someday you will visit New York and check out some of these sites using our web page as your guide. I hope that you will be inspired to look in your community and create your own City of Stars! ✶

The Atlas sculpture at Rockefeller Center. Photo from Wikimedia Commons by Another Believer.

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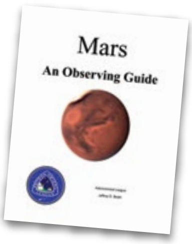

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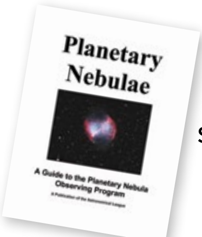

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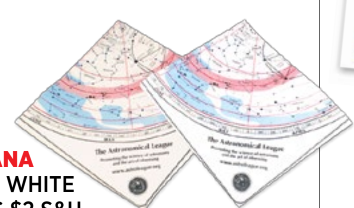

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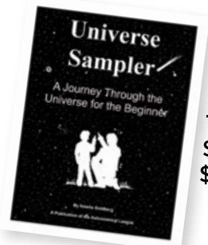

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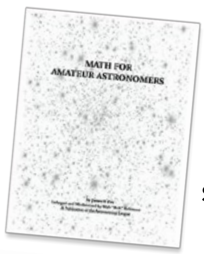

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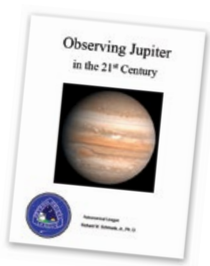

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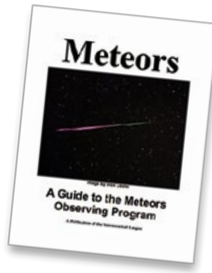

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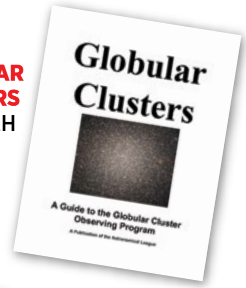

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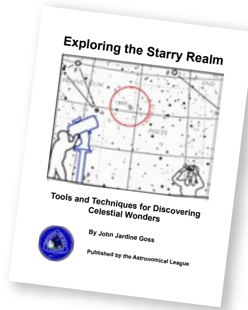

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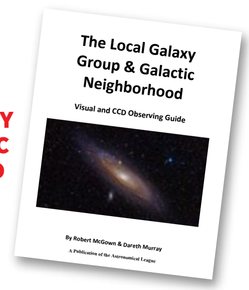

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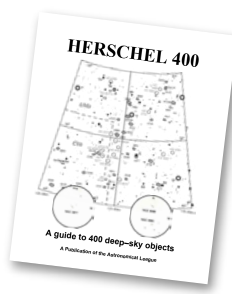

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Observing Awards

Active Galactic Nuclei Observing Program

No. 22-V, **Paul Harrington,** Member-at-Large

Advanced Binocular Double Star Program

No. 39, **Andrew Corkill,** Member-at-Large; No. 40, **Bernie Venasse,** Lifetime Member

Alternate Constellation Observing Program

No. 7, **Al Lamperti,** Delaware Valley Amateur Astronomers

Analemma Observing Program

No. 18, **Marc Machin,** Member-at-Large

Asterism Observing Program

No. 66, **Jonathan Cross,** Seattle Astronomical Society

Asteroid Observing Program

No. 60, **Jenny Stein,** Regular, Houston Astronomical Society; No. 61, **Robert Stein,** Regular, Houston Astronomical Society; No. 62, **Gerard Jones,** Regular, Minnesota Astronomical Society

Beyond Polaris Observing Program

No. 44, **Paul Harrington,** Member-at-Large

Binocular Double Star Observing Program

No. 177, **Gary Davis,** Member-at-Large; No. 178, **Hans de Moor,** Member-at-Large

Binocular Messier Observing Program

No. 1212, **Stephen Pavela,** La Crosse Area Astronomical Society; No. 1213, **Kristin Hendershot,** Member-at-Large; No. 1214, **Laura Ryan,** Member-at-Large; No. 1215, **Sean Smith,** Denver Astronomical Society; No. 1216, **Philip Babcock,** New Hampshire Astronomical Society; No. 1217, **Conal Richards,** Youth Member-at-Large; No. 1218, **Daniel Beggs,** Albuquerque Astronomical Society

Binocular Variable Star Observing Program

No. 49, **Mark Davis,** Lowcountry Stargazers

Bright Nebula Observing Program

No. 23, **John L. Goar,** Advanced, Olympic Astronomical Society; No. 24, **Peter Detterline,** Advanced, Member-at-Large; No. 25, **Michael Overacker,** Advanced, Star City Astronomy Network; No. 26, **Mark Simonson,** Advanced, Everett Astronomical Society; No. 27, **Cindy L. Krach,** Advanced, Haleakala Amateur Astronomers

Caldwell Observing Program

Silver Award, No. 273, **Richard Wheeler,** Northeast Florida Astronomical Society

Carbon Star Observing Program

No. 123, **Jonathan Cross,** Seattle Astronomical Society; No. 124, **Steve Berte,** Howard Astronomical League; No. 125, **George Zanetakos,** STAR Astronomy Society

Citizen Science Special Program

Rich Krahling, Richland Astronomical Society, Active Silver, SuperWASP Variable Stars; **Rich Krahling,** Richland Astronomical Society, Active Gold, Class 1, SuperWASP Variable Stars; **Rich Krahling,** Richland Astronomical Society, Active Gold, Class 2, SuperWASP Variable Stars; **Al Lamperti,** Delaware Valley Amateur Astronomers, Active Gold, Class 7, Galaxy Zoo Clump Scout; **Al Lamperti,** Delaware Valley Amateur Astronomers, Active Gold, Class 18, Galaxy Zoo, Star Notes; **W. Maynard Pittendreigh,** Lifetime Member, Active Bronze, ASAS-SN; **W. Maynard Pittendreigh,** Lifetime Member, Active Bronze, Mapping Historic Skies; **W. Maynard Pittendreigh,** Lifetime Member, Active Bronze, Galaxy Zoo; **W. Maynard Pittendreigh,** Lifetime Member, Active Bronze, Supernova Hunters; **W. Maynard Pittendreigh,** Lifetime Member, Active Bronze, Galaxy Clump; **W. Maynard Pittendreigh,** Lifetime Member, Active Bronze, SuperWASP Variable Stars; **W. Maynard Pittendreigh,** Lifetime Member, Active Bronze, Backyard Worlds, Planets; **W. Maynard Pittendreigh,** Lifetime Member, Active Bronze, Gravity Spy; **W. Maynard Pittendreigh,** Lifetime Member, Active Bronze, Radio Meteor Zoo; **W. Maynard Pittendreigh,** Lifetime Member, Active Bronze, Planet Hunters TESS; **W. Maynard Pittendreigh,** Lifetime Member, Active Silver, Planet Hunters TESS; **W. Maynard Pittendreigh,** Lifetime Member, Active Gold Class 1, Planet Hunters TESS; **W. Maynard Pittendreigh,** Lifetime Member, Active Gold Class 2, Planet Hunters TESS; W. **Maynard Pittendreigh,** Lifetime Member, Active Bronze, Spiral Graph; **W. Maynard Pittendreigh,** Lifetime Member, Active Bronze, Disk Detective; **W. Maynard Pittendreigh,** Lifetime Member, Active Bronze, Zwicky Chemical Factory; **W. Maynard Pittendreigh,** Lifetime Member, Active Bronze, Bursts from Space; **W. Maynard Pittendreigh,** Lifetime Member, Active Bronze, Planet Four Terrain

Comet Observing Program

No. 119, **Timothy Printy,** Silver, New Hampshire Astronomical Society

Constellation Hunter Northern Skies Observing Program

No. 258, **Bruce Bookout,** Colorado Springs Astronomical Society; No. 259, **Matt Orsie,** Tri-State Astronomers; No. 260, **Marc Machin,** Member-at-Large; No. 261, **Michael Overacker,** Star City Astronomy Network; No. 262, **Michael R. Martin,** Roanoke Valley Astronomical Society; No. 263, **Michael Grabner,** Rose City Astronomers; No. 264, **John Lilly,** Boise Astronomical Society

Dark Nebulae Observing Program

No. 33-I, **Tim Hunter,** Lifetime Member-at-Large

Deep Sky Binocular Observing Program

No. 421, **Andrew Corkill,** Member-at-Large; No. 422, **Fred Schumacher,** Member-at-Large; No. 423, **Andrew Jaffe,** New Hampshire Astronomical Society; No. 424, **Jim Hontas,** Cincinnati Astronomical Society; No. 425, **John Galla,** Astronomical Society of Eastern Missouri

Double Star Observing Program

No. 666, **Eric Edwards,** Albuquerque Astronomical Society; No. 667, **David Wickholm,** San Antonio Astronomical Association; No. 668, **Francis Hahn,** El Valle Astronomers; No. 669, **Colin Nicholls,** El Valle Astronomers; No. 670, **Tom VanBuskirk,** Member-at-Large; No. 671, **Steve Berte,** Howard Astronomical League; No. 672, **Stephen Pavela,** La Crosse Area Astronomical Society

Galileo Observing Program

No. 67, **Paul Harrington,** Member-at-Large; No. 68, **Dan Posey,** Hill Country Astronomers

Globular Cluster Observing Program

No. 358-V, **Tim Moyer,** South Jersey Astronomy Club; No. 359-V, **Jonathan Cross,** Seattle Astronomical Society; No. 360-V, **Janean L. Shane,** Omaha Astronomical Society; No. 361-I, **W. Maynard Pittendreigh,** Lifetime Member

Hydrogen Alpha Solar Observing Program

No. 52, **Douglas L. Smith,** Tucson Amateur Astronomy Association

Library Telescope Award

No. 10, **Jerelyn Ramirez,** Gold, Kansas Astronomical Observers; No. 11, **Allan Staib,** Silver, North Central Arkansas Astronomical Society; No. 12, **Gerard Jones,** Silver, Minnesota Astronomical Society; No. 13, **Tom Lynch,** Silver and Gold, Amateur Observers' Society of New York

Lunar Observing Program

Nos. 1129 and 1129-B, **Joe Novosel,** Fort Wayne Astronomical Society; Nos. 1130 and 1130-B, **Karl Schultz,** Central Arkansas Astronomical Society; Nos. 1131 and 1131-B, **Louie Robida,** Rose City Astronomers; Nos. 1132 and 1132-B, **Laura Ryan,** Member-at-Large; No. 1133, **Forrest Smith,** Baton Rouge Astronomical Society, Nos. 1134 and 1134-B, **Jim Hontas,** Cincinnati Astronomical Society; No. 1135, **Viola Sanchez,** Albuquerque Astronomical Society; Nos. 1136 and 1136-B, **Sean Smith,** Denver Astronomical Society; Nos. 1137 and 1137-B, **McKenzie Roman,** Kalamazoo Astronomical Society; Nos. 1138 and 1138-B, **Aaron Roman,** Kalamazoo Astronomical Society.; Nos. 1139 and 1139-B, **Michael Harang,** Texas Astronomical Society of Dallas.

Lunar II Observing Program

No. 114, **Brad Payne,** Northern Virginia Astronomy Club; No. 115, **Eric Edwards,** Albuquerque Astronomical Society

Lunar Evolution Program

No. 10, **Rob Ratkowski,** Haleakala Amateur Astronomers; No. 11, **Rodney Rynearson,** St. Louis Astronomical Society; No. 12-I, **Peter K. Detterline,** Member-at-Large; No. 13, **Juan Velasquez,** Denver Astronomical Society

Mars Observing Program

No. 9, **Dick Francini,** Neville Public Museum Astronomical Society; No. 10 Imaging, **Gregory T. Shanos,** Museum Astronomical Resource Society Astronomy Club; No. 11 Imaging, **Robert Stein,** Houston Astronomical Society; No. 12 Imaging, **Jenny Stein,** Houston Astronomical Society

Messier Observing Program

No. 2835, **Richard De Midio,** Honorary, New Hampshire Astronomical Society; No. 2848, **Mike Titus,** Regular, Cincinnati Astronomical Society; No. 2849, **Timothy Palmer,** Honorary, Utah Valley Astronomy Club; No. 2850, **Keith Lawrence,** Honorary, Vermont Astronomical Society; No. 2851, **Ralph McConnell,** Honorary, Barnard Astronomical Society; No. 2852, **Sean Smith,** Honorary, Denver Astronomical Society

Meteor Observing Program

No. 190, **Fred Schumacher,** 30 hours, Member-at-Large

Open Cluster Observing Program

No. 91, **Lisa Wentzel,** Basic, Twin Cities Amateur Astronomers; No. 92, **Brian McGuinness,** Basic, Northern Colorado Astronomical Society; No. 93, **Jim Chenard,** Basic, Member-at-Large; No. 94, **W. Maynard Pittendreigh,** Basic Imaging, Lifetime Member; No. 95, **Frank Dempsey,** Advanced, Member-at-Large

Outreach Observing Program

No. 856-S, **Rodney R. Rynearson,** St. Louis Astronomical Society; No. 1220-O, **Kevin Kimball,** Member-at-Large; No. 1220-S, **Kevin Kimball,** Member-at-Large; No. 1221-O, **John Zimitsch,** Minnesota Astronomical Society; No. 1221-S, **John Zimitsch,** Minnesota Astronomical Society; No. 1222-O, **Mark Davis,** Lowcountry Stargazers; No. 1223-O, **Scott Hull,** Goddard Astronomy Club; No. 1223-S, **Scott Hull,** Goddard Astronomy Club; No. 1224-O, **Allen Barrett,** Member-at-Large; No. 1224-S, **Allen Barrett,** Member-at-Large; No. 1224-M, **Allen Barrett,** Member-at-Large

Planetary Nebula Observing Program

No. 41, **Larry Bloom,** Basic, Longmont Astronomical Society; No. 87, **Michael Overacker,** Advanced, Manual, Star City Astronomy Network; No. 88, **Matt Orsie,** Advanced, Tri-State Astronomers

Radio Astronomy Observing Program

No. 23-S, **Brad Payne,** Silver, Northern Virginia Astronomy Club

Sketching Observing Award

No. 42, **Edgar Fischer,** Albuquerque Astronomical Society; No. 43, **Stephen L. Snider,** Albuquerque Astronomical Society

Sky Puppy Observing Program

No. 72, **Lindsey Benson,** Independent; No. 73, **Aditya Mandke,** Houston Astronomical Society

Solar System Observing Program

No. 173, **Michael Grabner,** Rose City Astronomers; No. 174, **Michael R. Martin,** Roanoke Valley Astronomical Society; No. 175, **Jason Wolfe,** Member-at-Large; Nos. 176 and 176-B, **Richard Wheeler,** Northeast Florida Astronomical Society

Stellar Evolution Observing Program

No. 84, **Douglas Liebert,** Olympic Astronomical Society

Sunspotters Observing Program

No. 199, **Stephen L. Snider,** Albuquerque Astronomical Society

Two in the View Observing Program

No. 42, **Kevin McKeown,** Member-at-Large; No. 43, **Paul Harrington,** Member-at-Large; No. 44, **Dee Friesen,** Albuquerque Astronomical Society; No. 45, **Steve Jaworiwsky,** Howard Astronomical League

Universal Sampler Observing Program

No. 153-N, **Laurie Ansorge,** Naked Eye, Member-at-Large

Urban Observing Program

No. 217, **Mark Davis,** Lifetime Member; No. 218, **Andrew Jaffe,** New Hampshire Astronomical Society; No. 219, **Jim Rasmussen,** Denver Astronomical Society

Variable Star Observing Program

No. 46-I, **David M. Douglas,** East Valley Astronomy Club; No. 47, **Lewis Cason,** Lowcountry Stargazers

Master Observer Progression

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Eric Edwards, Albuquerque Astronomical Society; **Michael J. Grabner,** Rose City Astronomers; **Matt Orsie,** Tri-State Astronomers

ADVANCED OBSERVER AWARD

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MASTER OBSERVER AWARD - SILVER LEVEL

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Great Conjunction AL Observing Challenge

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