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Reflector

2018 ASTRONOMICAL LEAGUE/ OPT IMAGING AWARDS

VOIDS: SOME PARTS OF THE UNIVERSE ARE EMPTIER THAN OTHERS

ORBITAL TILTS AND HIGH-FLYING MOONS

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Cover Image: *Andrew Klinger (Texas Astronomical Society) took this fantastic image of M16 through narrowband filters using a William Optics GT81 with 0.8x reducer (382 mm at f/4.7) with a ZWO ASI1600MM CMOS camera on an Orion Sirius mount.*

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

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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"

Reflector Mail

To the Editor:

I am honored to be the recipient of the 2018 Horkheimer/Smith Youth Service Award and as such have received a fair degree of media attention, both at home and in regional/national publications. As is to be expected, there have been a few omissions as well as conflations of some of the facts from my experiences and history. Though I would generally be dismissive of such, I feel that given my position as a fledgling scientist, and in the interest of journalistic accuracy as well, it is incumbent upon me to request that the parties responsible for the written content in question take a moment to review the source materials.

Credit being given where credit is due is essential. Though the points in question really are quite minor in scope, they are important, as there are people whose contributions may be overlooked if I don't address them.

The crux of the issue is that my mentor and youth leader, Rick Bryant, and I were both founding members of the BYA (Bartian Youth Astronomers). I collaborated with and assisted him to organize and start the affiliate youth group of the Bartlesville Astronomical Society. It's a bit flattering of some to say it was solely me, but it's nonetheless inaccurate. My extensive application was quite clear on these points and I believe all would agree that the difference in an "article" versus a "definite article" can make a very great and meaningful difference. "A" founding member or "one of the" founding members versus "the" founding member is only a couple of letters off, but its impact to the omitted party might be hurtful and the implications are completely different for each form of the article.

That said, I would simply ask that the source materials are revisited and appropriate corrections are made. Thank you again for your attention to this matter.

— Abigail Bollenbach

To the Editor:

Not often does an article capture my imagination or pluck a harmonic resonating chord, but after reading of humble Tumbleweed's rebirth, I sat in my chair and smiled. Peggy's article was at once most satisfying and gratifying. The accompanying photos lend so much to the narrative's chain of events that it was almost like being there and helping out. It is so cool folks spent the time and effort to help keep the legacy of amateur astronomy popularizer John Dobson alive and viable. This is, to me, akin to the restoration of Ireland's Leviathan of Parsonstown.

The photos also indicate what can be accomplished by dedicated amateur astronomers who are on a budget and prove that one doesn't need to be a millionaire to get started in this hobby. Although never meeting any of the people who made this happen, I am proud of what they collectively accomplished and feel that they deserve special "outreach" recognition.

Way to go!

— Steve "Bookie" Bookout
Astronomical League Member

Dues Reminder

AN IMPORTANT NOTICE FOR CLUB TREASURERS AND ALCORS

If your club has not yet paid its 2018–2019 Astronomical League dues, please contact the national office, *leagueoffice@astroleague.org*, ASAP. We are concerned that we haven't heard from you, as the dues were payable five months ago. We know you want to continue receiving AL benefits without interruption — and we certainly don't want to lose your club as an Astronomical League member!

About Our New Look

The *Reflector's* new look is the work of our new design/production person, Michael Patterson, a Vermonter, a member of the Springfield Telescope Makers (Stellafane), and a semi-retired designer of advertising and packaging. He can be reached at *michael.patterson@stellafane.org.* The look will continue to evolve, and feedback is welcome.

Astronomical League Trust Fund

As of September 29, 2018, the Astronomical League Trust Fund balance is $92,916.01. These funds are divided into two CDs, a money market

account, and a stock fund. At the last council meeting at ALCon 2018, past president and trustee Jim Fox was reelected as a trustee. In order of expiring terms, the current trustees are John Wagoner (2019), Tim Hunter (2020), Bob Gent (2021), Terry Mann (2022), and Jim Fox (2023).

Since the League is a 501(c)(3), all donations to the trust fund are tax deductible to the fullest extent of the law. In addition to cash or check donations, we can also accept donations of stock.

—Respectfully submitted, Bob Gent
ALTF Treasurer and Past President

Reflections

Astronomy may not be my primary career, but it is indeed a passion. It is something that I have enjoyed since my first real exposure to it as a Boy Scout. Volunteering to be the new editor for the *Reflector* is just one of several things that I do to make sure that I continue to have a regular and healthy dose of astronomy in my life. Making the transition from observing the night sky, alone and in the dark, to joining the bright and public astronomical community is only something that I have only recently done. Doing so has exposed me to the experiences and challenges of others who share this passion. When I think about my journey from Boy Scout to editor, I realize that I am fortunate. And I have also realized that others may not have been as fortunate as I have been.

I never received much encouragement to explore and pursue astronomy, but I also did not need it. I had a natural passion and curiosity fueling my motivation to pursue it. While I might not have been encouraged to enjoy astronomy, I was never discouraged from doing it. And I believe that this is an important factor for many people when making personal or career choices. I was discouraged from pursuing some things in my younger years. However, this discouragement was not based on gender, age, or race. Of course, encouragement is a good thing. It has an important role in motivating people. But in today's society, encouragement is plentiful and thusly dilute, so it can be easily washed away with a small amount of negativity. And by default, people do not need any external motivation to pursue that which they love. What they do need is an equal opportunity and a fair chance.

Throughout my 26-year career in information technology, I have observed the impact that biases and discouragement can have. Discouragement can be overt and direct, but it is most often subtle and perhaps even subconscious. Personal biases may lead to a forgotten meeting invitation, lack of inclusion in group selection, or missed recognition for a job well done. A bias may influence decisions for advancement, assignment, or belief in the validity of work that is being done. All of these biases can lead to discouragement. It has become obvious to me that these biases plague the astronomical fields as well.

A recent article published by *Nature* features strong anecdotal evidence supporting findings that women with PhD degrees in astronomy are leaving the industry at a rate 3–4 times greater than that of men (Zastrow, 2018). Having the intelligence, skills, and incredible determination to obtain a PhD in a field of study as difficult as astronomy is something to be admired and respected. Spending nine or more years of your life obtaining this degree to pursue a career in the astronomy-related fields isn't something that someone does on a whim. The decision to leave this field likely isn't something one does on a whim as well. It must be the result of deterring forces.

I do believe that there is observable hope within the next generation. Inclusion and awareness of biases seem to be on their radar.

In a recent Nielsen study, the Millennial generation expresses more optimism that women will have equal consideration in the workforce, and also reports that the elimination of gender roles is the key factor ("Want More, Be More: When It Comes to Gender Equality, Millennial Women Are More Optimistic About Closing The Gap," 2017). When it comes to defocusing on gender and focusing on abilities and talents, we can learn a lot from them. If the universe had a consciousness, I am sure that it would not consider the gender, age, or skin color of those living on the pale blue dot in the arguably average galaxy of those that want to study it. We shouldn't either.

References:

Want More, Be More: When It Comes to Gender Equality, Millennial Women Are More Optimistic About Closing The Gap. (2017, March 8). Retrieved from *https://www.nielsen.com/us/en/insights/news/2017/when-it-comes-to-gender-equality-millennial-women-are-more-optimistic-on-closing-the-pay-gap.html*.

Zastrow, M. (2018, October 15). Astronomy is losing women three times faster than men. Retrieved from *https://www.nature.com/articles/d41586-018-07018-4?linkId=58212769*.

—John Martin
Editor, Reflector

President's Corner

A NEW OPPORTUNITY

When amateur astronomers think of the Astronomical League, they typically imagine the *Reflector* magazine, the Observing Programs, the Award programs, Youth in Astronomy efforts, Astronomy Day, the battle against light pollution, the Library Telescope Program, and ALCon.

What more could the Astronomical League be?

At some point in our pursuit of learning about the celestial realm, many of us have secretly dreamt of experiencing what it was like during the early days of telescopic observational astronomy. We mentally picture being part of the first discoveries made by peering through telescopes late at night, slowly uncovering mysteries of the cosmos.

We know that not too long ago there was a blur between amateur and professional astronomy, when amateurs could – and did – make important contributions. Then we wonder how, in today's highly technical and big-budget world, individuals again can play such a role.

The Astronomical League has wondered this, too. How can the League encourage and develop this desire – the desire of the dedicated amateur observer to contribute to the science of astronomy, and subsequently advance our hobby?

The League already has programs in place that either partner with or direct observers to well-established organizations: variable star measurements in conjunction with the AAVSO, occultation timing measurements through IOTA, and light pollution measurements for Globe at Night. For many years, the League has recognized ALPO as the place to report systematic observations and measurements of celestial bodies close to home. Many amateurs have contributed their time and "eyes" to SETI@home, Stardust@home, and Galaxy Zoo.

What else can be done? How can the Astronomical League help the Astro-Leaguer ➞

participate to an even greater extent? How about considering the vast potential of "citizen science?"

The League wants to assemble a committee to develop an avenue so interested amateurs can pursue citizen science, allowing them to be part of discovery and the accumulation of knowledge. The committee will first need to arrive at a clear definition of citizen science: what is it, and what steps are needed to conduct it? This will not be a variation of an observing program, but a new component of participation in our hobby – one that depends, according to the specific program, on the careful collection and analysis of data.

What advantages do amateurs have that professionals don't?

How can amateurs contribute if they don't have access to large, ground-based observatories, or to telescopes in space?

What amateurs have that the professionals don't is the time to devote to collecting or examining vast amounts of specialized data for statistical analysis. They are also a group of people who are relatively large in number, meaning that many amateurs could interact with one professional, greatly enlarging the "scope" of the professional's research ability.

In what fields and in what meaningful ways could Astro-Leaguers participate? While that determination would be the responsibility of the committee, some possibilities could entail, for example, the collection and analysis of the light curves of extrasolar planets and supernovae or the imaging of interacting galaxies for tidal streams.

As you all surely know, the League is primarily run by volunteers, and without them little would be accomplished. Fortunately, Aaron Clevenson, AL National Observing Program Director, has enthusiastically stepped forward to initiate the Citizen Science Committee.

If you dream of being part of a greater sense of discovery, if you yearn to learn how doing astronomy must have felt to astronomers of yesteryear – and if your interest is piqued by the possibility of joining an Astronomical League citizen science effort, then please contact Aaron at *aaron@clevenson.org*.

(Thank you to Aaron Clevenson and John Goss for contributing to this first installment of the "President's Corner.")

— Bill Bogardus
Astronomical League President

International Dark-Sky Association

THIRTY YEARS OF IDA

Unfortunately, most people today live in communities filled with light pollution. They have not experienced the dark skies that were found everywhere in the United States a generation ago. Unless someone has lived on a farm, gone camping in the mountains or woods away from the city, or joined an astronomy club, he or she has no idea what constitutes a dark sky or what has been lost in the last generation. Light pollution is a pernicious evil that has slowly crept up on us. Older people remember what it was like to see the stars at night, even in the middle of a city. They more acutely feel the loss of the stars, as they did not grow up with bright yellow night skies.

When I was young – a very long time ago in the 1950s and 1960s – I was an active amateur astronomer. I had a 4-inch reflector, which I bought for $50 in 1956. I lived in the suburbs of Chicago and was more concerned about the elm trees surrounding our house blocking my view of the sky than I was about light pollution. The Milky Way was easily visible through the trees. Only gradually did I become that aware the stars were disappearing from urban and suburban areas due to increasing light pollution. Unfortunately, the elm trees and the stars are long gone from my boyhood home.

In 1985 I had an unexpectedly large tax refund. It was like free money, even though I knew it was my own money I overpaid. It was a form of savings for which I received no interest. I decided to buy a piece of land in a dark-sky location for a large telescope. I had talked about this for years, but had never actually done anything. One thing led to another, and I purchased 20 acres of land 40 miles southeast of Tucson on a high grassland plateau at 5000-foot altitude. Thus started the Grasslands Observatory *(www.3towers.com)*.

As the observatory developed, I realized my amazingly dark sky was a very precious and fragile resource. I noticed what seemed like a lot of bad lights around Tucson. Moreover, University Medical Center in Tucson converted its old, dim, globe-style lights into unshielded low-pressure sodium (LPS) lighting. I was aghast. It was bright and spoiled the sky. How could this happen? I asked the hospital director about it, and she told me astronomers had recommended this lighting.

At that time the Dark Sky Office at Kitt Peak National Observatory was headed by Dr. David Crawford, an internationally renowned astronomer famous for being the project leader for the largest telescope on Kitt Peak and for his work on stellar photometry. Professional astronomers preferred LPS lighting as its monochromatic spectrum was easy to filter. That was fine with me as long as the light fixtures were shielded. An unshielded LPS fixture is just as bad for an amateur astronomer as any other poor lighting design.

Of course, now we are concerned with the light-emitting diode (LED) revolution, which is rapidly replacing the lighting that concerned me in 1985. In those days, I had several meetings with Dave Crawford and Bill Robinson, who ran the Dark Sky Office at Kitt Peak, about my concerns with their lighting recommendations. What started off as a contentious discussion developed into a friendship and a mutual goal of protecting the night sky. We exchanged slides, and I began to learn about lighting, light trespass, and light pollution.

I realized light pollution is a relatively easy environmental problem to solve, but nobody was doing anything about it. Finally, one day I said we ought to form an organization to address this issue to help ourselves and others. I had recently completed the process of incorporating the Tucson Amateur Astronomy Association as a nonprofit corporation in Arizona. I recommended we found an organization devoted to combating light pollution, radio-frequency interference to astronomy, and space debris. Dave agreed, and we were on our way. I filed the papers for IDA's incorporation and came up with the IDA acronym.

The International Dark-Sky Association, Inc. (IDA) was incorporated in Arizona in 1987 as a tax-exempt nonprofit organization, exclusively for educational and scientific purposes within the meaning of Section 501(c)(3) of the United States Internal Revenue Code of 1987. It received its 501(c)(3) approval from the IRS in 1988. Dave rolled the new IDA goals into his then-professional work and thereafter, for many years, devoted most of his waking hours to IDA, developing it into the wonderful organization it is today.

IDA has far outgrown its founders, who have not been involved in its daily operation for many years. It has surpassed our every hope for it, no doubt because of the excellent staff and

worldwide supporters IDA has garnered the last thirty years. Are we winning the war against light pollution? Hardly, but we are losing it less badly than if IDA had not been founded.

—Tim Hunter
Co-founder, IDA
The International Dark-Sky Association, Inc.(IDA)
3223 N. First Avenue, Tucson, Arizona 85719-2103
Phone: 520-293-3198 Fax: 520-293-3192
Email address for IDA office: ida@darksky.org
Webpage: darksky.org

Night Sky Network

NASA'S NIGHT SKY NETWORK: ASSISTING CLUBS WITH OUTREACH SINCE 2004!

Astronomy outreach to the public is, for many of us, one of the most social and fun parts of amateur astronomy. For astronomy clubs in particular, outreach programs provide a reliable avenue for publicity and attracting new members. NASA launched the Night Sky Network (NSN) program in 2004 to assist clubs with outreach.

Based on input from club leaders across the United States, the NSN aimed to make outreach easier and more accessible to all members of astronomy clubs, regardless of their individual levels of experience. In addition, NSN provided a set of tools to help clubs manage their volunteers and events, and by extension, their club rosters, messaging, and general day-to-day management needs.

The Night Sky Network's most famous feature is the astronomy outreach toolkits: portable kits of easy-to-use astronomy outreach resources, specifically designed for amateur astronomers to use in the field. These toolkits offer great activities for club meetings, public star parties, and indoor or daytime events. The toolkits provide vital backup activities in case of bad weather—something we very much appreciate ourselves, since we are headquartered in the notoriously foggy San Francisco Bay Area! These kits are free to NSN member clubs that regularly report on their events using the NSN website's logging system, and are shipped out quarterly.

A visitor to Johns Island County Park takes a tactile tour of the solar system with help from members of the Lowcountry Stargazers. Photo Credit: Jay Messeroff

Toolkits are sponsored by NASA and the National Science Foundation to bring the big ideas of astronomy down to Earth, and help clubs inspire the next generation of space scientists. Topics covered by the kits include gravity and black holes, the search for exoplanets, our Solar System, meteorites and space rocks, telescopes, life in the universe, eclipses, and even space weather and solar storms. While you may not think of exoplanets as the hottest topic at the telescope, amateurs report a lot of questions about these other worlds (and, of course, the possibility of alien life on them) and these outreach toolkits provide helpful ideas and demonstrations to turn the conversation to the actual science of how scientists are searching for new worlds.

We fit the various toolkit props and reference materials into medium-size boxes, and many kits also include large, eye-catching vinyl banners shipped in separate cardboard tubes. In addition to banners, kit materials usually include customizable handouts, official NASA lithographs, models, manuals on suggested practices for using the materials, and even a DVD filled with demos of the toolkit activities – handy if you still have a physical player available. Links to electronic versions of these materials, assembly guides, and archives of the training videos can also be found on the program website; they are freely available to everyone at *nightsky.jpl.nasa.org*.

Aside from toolkits, there are other substantial benefits to participation in the NSN program. We offer members-only monthly webinars with NASA scientists working on the latest missions. Some of our recent webinars featured mission scientists from the Transiting Exoplanet Survey Satellite (TESS), Parker Solar Probe, Lunar Reconnaisance Orbtier (LRO), and Europa Clipper. Members are also offered "enrichment" webinars focused on education and outreach: citizen science participation, inclusive ways to work with young girls and all audiences at the telescope, featured toolkit activities, and shared outreach stories and techniques.

And there is even more! The NSN offers online tools to help astronomy club leaders manage their clubs and events. The NSN website features include a custom calendar and RSVP system, a volunteer hour tracker, a roster management tool, and a messaging system. When available, the club can also receive printouts from NASA and other science partners, discounts on astronomy magazines, and the ability to request "refresher" materials from toolkits – all provided, of course, that your event reports and club contact information is up to date.

Ken De Silva of the Mount Diablo Astronomical Society discusses the Solar System with some Girl Scout Daisies at a Loma Vista STEAM Night. Photo Credit: Ken De Silva/ Mount Diablo Astronomical Society

We ask NSN members to frequently report on their events using the website's event log system. Event reports help us inform NASA about the kinds of outreach that astronomy clubs are performing, confirm participation in the program, and help us judge what outreach materials are the best fits for member clubs' outreach programs. Member reports enable us to show NASA the effective reach of NSN member clubs to the general public and are the program's lifeblood.

One final thing: one of our favorite traditions at the Night Sky Network is the annual "Outreach Award Pin," which features a fresh design every year. We want to reward individual club members with pins and certificates for all of their hard work in outreach, and we rely on club coordinators to keep track of their members' volunteer hours and report on their events to qualify. We do have to charge a nominal fee to cover the cost of the pins and shipping, but we strive to keep costs as low as possible, and every club that has reported on events for the previous year qualifies for three free pins. Some folks have accrued quite an impressive collection of pins over the years due to their hard work.

We are always working hard to find great ways to help clubs share the latest in NASA science. See this space next time, as I'll feature more useful NSN resources to help your astronomy outreach. May you have clear, dark skies!

— Dave Prosper

Dave Prosper is the program manager for amateur astronomy outreach at the Astronomical Society of the Pacific, in San Francisco, California. Born and raised under the dark skies of the Adirondack foothills in northern New York State, he came to love the night sky at a young age and has been watching the stars ever since.

Full STEAM Ahead

A FIRST GIANT STEP

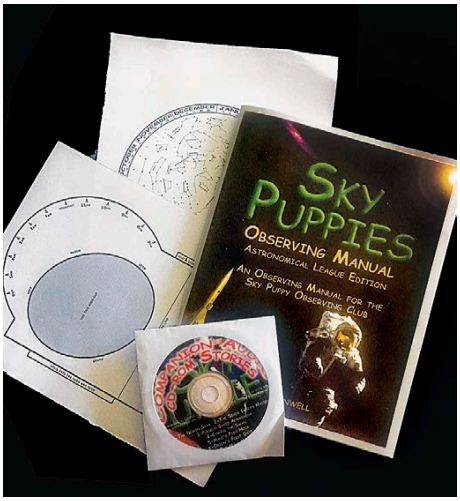
Fall and winter are a great time to engage families in night sky observing. Since it is getting dark earlier, it will not take long to get some observations in before bedtime. Of course, the temperatures are cooler, and you'll need a jacket or some layers, but the air at this time of year tends to be drier, making the viewing crisp and clear. But the best reason to get out there is that Orion and friends are making their annual appearance!

A great way to get started is the Sky Puppies Astronomical League Observing Program, which is suited for upper elementary students in third to fifth grades. Because skills such as logging, writing, and handling of binoculars are required, it is more of a challenge for younger students. This program gives an initial overview of star lore, constellations, star clusters, bright stars, deep-sky objects, the Milky Way, planets, and lunar surface features. It requires naked-eye, binocular, and some telescopic observations. Contact Aaron Clevenson, at *aaron@clevenson.org*, to request a copy of the manual.

The Sky Puppies manual comes with a CD that includes constellation stories from different cultures and a star wheel (planisphere) located at the back of the manual. The star wheel, once assembled, will help you locate the constellations that are covered in the manual. This program asks the participant to draw constellations freehand, describe the major stars, tell two different constellation stories, identify either the North Star

or Southern Cross, and sketch planets and lunar craters.

For older students in the family and the adult novice, Beyond Polaris is nearly the same observing program as Sky Puppies but is designed for middle-school-age and older participants. The first step is to go to Astronomical League's main page at *www.astroleague.org/observing.html,* scroll down to "Terms of Common Usage in Astronomical League Observing Programs," and review the terminology of "Seeing and Transparency." This is required for the log sheets. Beyond Polaris also explains star party etiquette, since many families enjoy attending these events to get an opportunity to view the night sky. Again, this program will cover constellations, stars, meteor/meteoroid/meteorites, a planisphere (star wheel), phases of the Moon, and dark-sky advocacy, similar to Sky Puppies.



To make sure that we cover the whole family, your primary students and differently abled children with special needs may find the next few resources quite engaging. While the older siblings are learning about the Moon and constellations, I highly recommend David Chandler's "The Night Sky Matching Game," available at *www.david-chandler.com/games.* This is perfect for primary students, and they will feel included with the rest of the family. It's played like the card game "Memory." Also consider the website's planispheres if you live in the far northern or southern United States because you can select one specifically for your latitude. This is important when it comes time to identify the constellations. If you need help determining your latitude, check out *latlong.net*.

Another fun resource is the NASA Space Place monthly Star Finder game, at *spaceplace.nasa.gov/starfinder*. This site has lots of activities and great ways to engage your little ones so that everybody in your family can become obsessed with astronomy.

FLOUR MOON ROCKS

The following recipe is a great tactile activity for kids, making your own "Moon rock" out of flour dough. (Warning: If your child has a gluten intolerance, please substitute Play-Doh for flour dough.)

1. Mix 1/2 cup of flour, 1/4 cup of salt, small amount of black tempera paint, and a small amount of glitter; have different sizes of beads off to the side.

2. Add just enough water to make it the consistency of Play-Doh.

3. Shape the dough into the shape of a rock.

4. Press beads into the dough to make craters, then remove.

5. Allow the dough to dry.

Children can use this image that shows the shapes and characters you can see on the lunar surface: *en.wikipedia.org/wiki/Man_in_the_Moon#/media/File:Man_In_The_Moon2.png.* Point out the darker, smoother maria and brighter cratered areas on a full Moon. I've personally used this resource for those times schools would book a STEAM school night on a full-Moon evening! Not only would they look at the Moon through a filtered eyepiece, but while waiting in line, they would try to identify these shapes and even make up some for themselves on the full Moon's surface.

Hopefully ALCORs, outreach astronomers, homeschool educators, science teachers, Boy and Girl Scout groups, and parents will consider using the Sky Puppies and Beyond Polaris programs (and NASA Space Place) as ways to introduce your members, students, and children to the hobby and science of astronomy. There are many programs available, and this is just "a first giant step" you can take to learn how to observe with the Astronomical League.

—Peggy Walker

All Things Astronomical

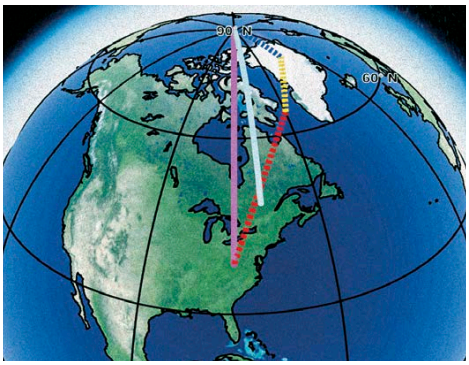
SCIENTISTS IDENTIFY THREE CAUSES OF EARTH'S SPIN AXIS DRIFT

A typical desk globe is designed to be a geometric sphere and to rotate smoothly when you spin it. Our actual planet is far less perfect—in both shape and in rotation.

Earth is not a perfect sphere. When it rotates on its spin axis—an imaginary line that passes through the North and South Poles—it drifts and wobbles. These spin-axis movements are scientifically referred to as "polar motion." Measurements for the 20th century show that the spin axis drifted about 4 inches (10 centimeters) per year. Over the course of a century, that becomes more than 11 yards (10 meters).

Using observational and model-based data spanning the entire 20th century, NASA scientists have for the first time identified three broadly-categorized processes responsible for this drift—contemporary mass loss primarily in Greenland, glacial rebound, and mantle convection.

"The traditional explanation is that one process, glacial rebound, is responsible for this motion of Earth's spin axis. But recently, many researchers have speculated that other processes could have potentially large effects on it as well," said first author Surendra Adhikari of NASA's Jet Propulsion Laboratory in Pasadena, California." We assembled models for a suite of processes that are thought to be important for driving the motion of the spin axis. We identified not one but three sets of processes that are crucial—and melting of the global cryosphere (especially Greenland) over the course of the 20th century is one of them."



The observed direction of polar motion, shown as a light blue line, compared with the sum (pink line) of the influence of Greenland ice loss (blue), postglacial rebound (yellow) and deep mantle convection (red). The contribution of mantle convection is highly uncertain. Credit: NASA/JPL-Caltech

In general, the redistribution of mass on and within Earth—like changes to land, ice sheets, oceans and mantle flow—affects the planet's rotation. As temperatures increased throughout the 20th century, Greenland's ice mass decreased. In fact, a total of about 7,500 gigatons—the weight of more than 20 million Empire State Buildings—of Greenland's ice melted into the ocean during this time period. This makes Greenland one of →

the top contributors of mass being transferred to the oceans, causing sea level to rise and, consequently, a drift in Earth's spin axis.

While ice melt is occurring in other places (like Antarctica), Greenland's location makes it a more significant contributor to polar motion.

"There is a geometrical effect that if you have a mass that is 45 degrees from the North Pole – which Greenland is – or from the South Pole (like Patagonian glaciers), it will have bigger impact on shifting Earth's spin axis than a mass that is right near the Pole," said coauthor Eric Ivins, also of JPL.

Previous studies identified glacial rebound as the key contributor to long-term polar motion. And what is glacial rebound? During the last ice age, heavy glaciers depressed Earth's surface much like a mattress depresses when you sit on it. As that ice melts, or is removed, the land slowly rises back to its original position. In the new study, which relied heavily on a statistical analysis of such rebound, scientists figured out that glacial rebound is likely to be responsible for only about a third of the polar drift in the 20th century.

The authors argue that mantle convection makes up the final third. Mantle convection is responsible for the movement of tectonic plates on Earth's surface. It is basically the circulation of material in the mantle caused by heat from Earth's core. Ivins describes it as similar to a pot of soup placed on the stove. As the pot, or mantle, heats, the pieces of the soup begin to rise and fall, essentially forming a vertical circulation pattern – just like the rocks moving through Earth's mantle.

With these three broad contributors identified, scientists can distinguish mass changes and polar motion caused by long-term Earth processes over which we have little control from those caused by climate change. They now know that if Greenland's ice loss accelerates, polar motion likely will, too.

The paper in *Earth and Planetary Science Letters* is titled "What drives 20th century polar motion?" Besides JPL, coauthor institutions include the German Research Centre for Geosciences, Potsdam; the University of Oslo, Norway; Technical University of Denmark, Kongens Lyngby; the Geological Survey of Denmark and Greenland, Copenhagen, Denmark; and the University of Bremen, Germany. An interactive simulation of how multiple processes contribute to the wobbles in Earth's spin axis is available at *vesl.jpl.nasa.gov/sea-level/polar-motion/.*

— Esprit Smith

Deep-Sky Objects

PERSEUS'S BRIGHTEST GALAXY

The constellation Perseus was named after the Greek hero known for slaying Medusa, the Gorgon, whose head he is pictured holding on classical constellation charts. The variable star Algol depicts one of Medusa's eyes. Perseus is also the hero who rescued Andromeda from the sea monster Cetus.

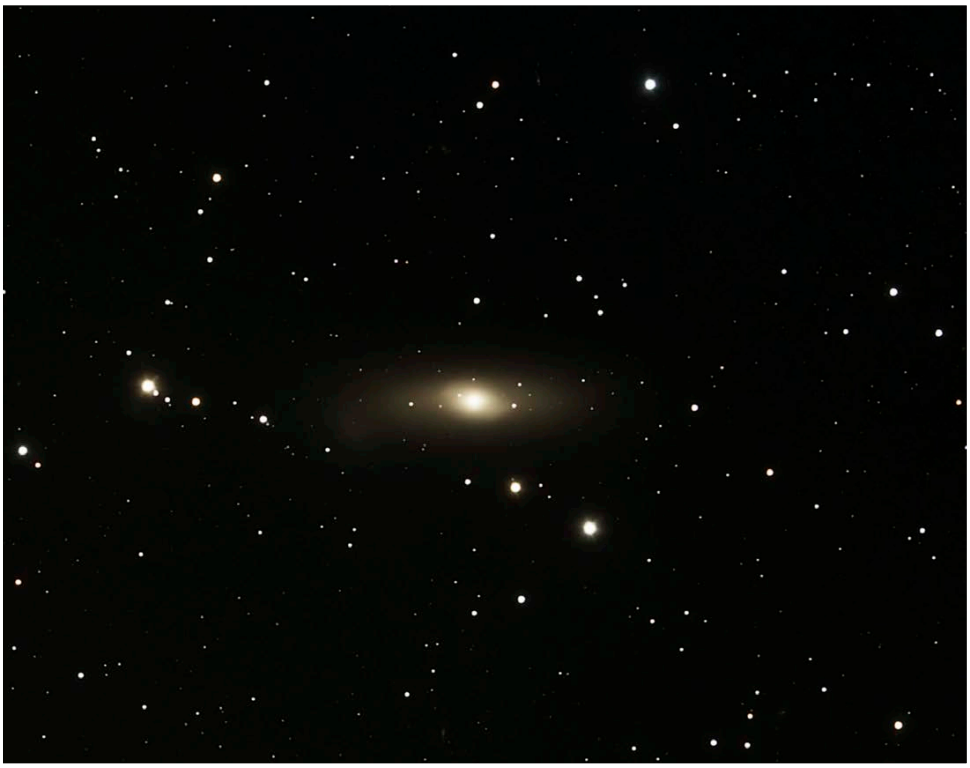
The constellation Perseus is contained within the plane of the galaxy, so visually its stars lie along the swath we commonly call the Milky Way. Besides the intriguing variable star Algol, the constellation is known for the bright star Mirfak, the California Nebula (NGC 1499), myriad double stars, and a multitude of open star clusters. The best open star clusters are the bright, wide cluster M34 and the famous Double Cluster (NGC 869 and NGC 884).

Perseus lies between the constellations Auriga and Cassiopeia, but it also borders Andromeda, Triangulum, Taurus, and Camelopardalis (my favorite constellation name!). The constellation culminates at 8:00 p.m. in early January, well after the end of astronomical twilight for North American observers.

With the plethora of star clusters in this Milky Way constellation, one might expect a majority of the New General Catalog (NGC) entries for Perseus to be galactic star clusters. But they are not. Of the 95 NGC objects located in Perseus, 71 of them are listed as galaxies! Unfortunately, the gas and dust in the plane of our home galaxy substantially dims these galaxies. Of the 71, only one is brighter than magnitude 10. That galaxy is NGC 1023. NGC 1023 lies 5.75 degrees west-southwest of the star Algol. It resides on the border of Perseus and Andromeda, just north of Triangulum. The galaxy is cataloged at magnitude 9.5 and is roughly 8 by 3 arcminutes in size. Brightness estimates for galaxies vary considerably, not because the galaxy varies in brightness, but because different astronomers use different techniques to estimate galaxy brightnesses. Some estimate NGC 1023 to be as bright as magnitude 8.7, while dimmer estimates are near 10.35. Likewise, distance estimates to galaxies vary considerably, too. The best estimate for the distance to NGC 1023 is 20 million light-years, but this estimate varies by a factor of 2.

Like the Milky Way Galaxy, which is a member of a group of galaxies located together in space (conveniently called the Local Group), NGC 1023 is a member of a group of galaxies located together in space. The NGC 1023 group contains NGC 891, NGC 925, NGC 1058, and NGC 1239. The two galaxy groups are next-door neighbors and both part of the Virgo Supercluster.

Most galaxies are classified as elliptical, spiral, or irregular in shape. In an 8-inch telescope, NGC 1023 appears to be elliptical. Many citations of NGC 1023 list it as an elliptical galaxy. Howev-



er, larger instruments reveal that NGC 1023 has an elongated disk, thus it is sometimes classified as a spiral galaxy. In reality, NGC 1023 is a barred lenticular galaxy of Hubble classification SB0. Lenticular galaxies are a category of galaxies in between spiral and elliptical. They have disks and central bulges. Some even have dust lanes or bars, but they lack spiral arms. Lenticular galaxies may have been spiral galaxies at one time, but they have used up all the material for star formation and contain very old stars, like most elliptical galaxies.

My accompanying image of NGC 1023 was taken with a Discovery 10-inch f/6 Newtonian with a Tele Vue Paracorr Type 2 coma corrector using an SBIG ST-2000XCM CCD camera. The telescope uses a Paramount ME German equatorial mount. The exposure was 60 minutes. North is up and west to the right. The diffuse galactic bar extends from upper left to lower right while the major axis of the galaxy runs east-west. The asymmetry is a consequence of the tilt of the plane of the galaxy to our line of sight. The brightest star in the field lies to the east (left) of the galaxy and is magnitude 9. The second brightest star located southwest of the galaxy is magnitude 10. Both are easily visible in 6- to 8-inch telescopes, framing this unique celestial island of stars.

This winter, when exploring the magnificent star clusters in the constellation Perseus, take a quick detour to spy Perseus's brightest galaxy, NGC 1023. Test your own eyes as to whether the galaxy appears more like an elliptical galaxy or a spiral galaxy.

— Dr. James R. Dire
Kauai Educational Association for Science and Astronomy

BRINGING ASTRONOMY TO THE PEOPLE

ASTRONOMY DAY

October 13, 2018 and May 11, 2019

For entry forms:
www.astroleague.org
Click on "Astronomy Day"
Scroll down to "Astronomy Day Award Application"

For additional information, contact:
Gary Tomlinson
Astronomy Day Coordinator
gtomlins@sbcglobal.net

SPEED-DATING ASTRONOMY STYLE

It was a full house on a stormy night in July when the Delaware Valley Amateur Astronomers held an astronomy speed-dating event, also billed as an astronomy fair. What better way to spend your time in such horrific weather? The evening included something for everyone, from the novice stargazer to the experienced observer. We promised those wondering how to get into astronomy that we would show them the first steps, and we would help others advance to the next level. Attendees were urged to let their specific interests guide them to explore as many or as few of the topics as they would like, "speed-dating" style.

It was a departure from the usual monthly meeting format, which includes announcements, updates on upcoming events, an observing report, and a guest speaker. The goals of the format were:

- To facilitate social interactions between folks with similar interests
- To interest members and nonmembers who are not frequent attendees by offering an alternative meeting format
- To provide regular meeting attendees the chance to explore new and possibly unfamiliar areas of astronomy
- To recognize club experts who have deep knowledge of specific topics, and to allow attendees to associate members with their topics of expertise as a starting point for future questions and interactions
- To stimulate interest in other club activities

We decided to take advantage of the inevitable specialization that develops in any amateur astronomy club and invite our local experts to set up hands-on demonstrations on their favorite topics. The concept proved popular among the club members, and the list of potential topics was quickly filled with volunteer experts on the following topics:

- Astronomy Apps
- Go-To Telescopes
- Buying Your First Telescope
- Binocular Astronomy
- Solar Observing
- Observing Without a Telescope
- Collimation Demo
- Astrophotography
- Astronomical League Observing Programs
- Amateur Telescope Making
- Observing the Moon
- Moon Landing Memorabilia
- Light Pollution Abatement

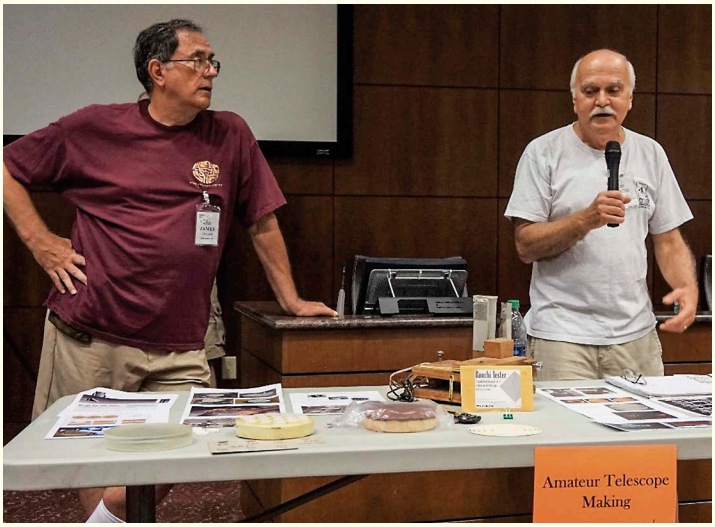
The event was publicized through Facebook, newspapers, radio, and the club website and newsletter, and attracted about 20 newcomers who had never previously graced our meeting space. A couple of them joined as new club members. Attendees were invited to visit the demonstrations of their choice, and spend as much time or as little as their interests dictated (thus the speed-dating moniker). An added bonus was that in seeking information on a particular topic, attendees with common interests also found each other.

For clubs in search of an alternative to the usual meeting format, this idea is relatively easy to execute and immune to bad weather.

—Janet Rush and Al Lamperti

DVAA Observing Chair Andrew Hitchner helped attendees approach their first telescope purchase. Photo by Irv Schlanger

DVAA member and local school district planetarium director Adam Chantry put his teaching skills to good use with a hands-on collimation demonstration. Photo by Mitch Berger



Tom Nolasco and James Taylor share their passion for amateur telescope making.

DVAA veep Jeff Oaster with his favorite astronomy tools.

Jim Sweeney shared what to do, and what not to do, when observing the Sun.

Jeff Kahler revisited memorable moments by sharing his extensive collection of publications recounting milestones in space flight.

Past president Joe Lamb showed newcomers how to make the most of the lunar cycle for great observing.

ASTRONOMICAL LEAGUE'S YOUTH AWARDS 2019—PREPARE NOW!

It is time to start thinking about who might be nominated for next year's National Young Astronomer Award, or the two Jack Horkheimer Youth Service Awards (Horkheimer/Parker Youth Imaging Awards and Horkheimer/O'Meara Journalism Awards). There are two additional awards: the Horkheimer/Smith Service Award and Horkheimer/D'Auria Service Award.

If you know of a young person who has been involved in an astronomy-related research project or a club service activity, who would like to write about astronomy, or who has done astrophotography, please consider nominating that person.

See our website awards page, *www.astroleague.org/al/awards/awards.html,* for details.

The deadline for the National Young Astronomer Award and the Horkheimer awards is March 31, 2019. Now is the time for potential candidates to work on their projects and complete the applications available on our website. If are a club officer, nominate them. Let's make 2019 another great year for our youth.

ASTRONOMY DAY

Astronomy Day presents an excellent opportunity to increase science awareness in an interested (but often misinformed) public, to spark interest in the young, and to promote your club, all simply by personally introducing people to the wonders encountered in amateur astronomy.

Look on the AL website, *www.astroleague.org,* for these helpful Astronomy Day materials: the Astronomy Day Handbook and outreach downloads.

Astronomy Day will be held on May 11 and October 5, 2019. If you would like to help administer this great program of bringing astronomy to the public, please contact Gary Tomlinson at *gtomlins@sbcglobal.net.*

MABEL STERNS AWARD

The newsletter editor performs the primary function of informing astronomy club members about what is happening in their club. Often the editor is forced to become quite creative in filling the allotted space for each issue when the call for articles does not quite fill up the publication.

In acknowledgement of the important role of the newsletter editor, the Astronomical League established the Mabel Sterns Newsletter Award in 1988 to recognize these essential people. The award is named in honor of the first newsletter editor of the League, Mabel Sterns, who served in that capacity ➡

from 1948 to1952.

To qualify, club presidents should email a copy of the designated issue of the club's newsletter as a PDF file to *sternsnewsletter@astroleague.org*, along with a cover letter of recommendation (also as a PDF) that includes the postal address of the nominee. In addition, a photo of the newsletter editor, preferably in an astronomical setting, should be sent electronically in JPEG format to the same email address. All items are due by March 31, 2019. The names of both the newsletter editor and the nominating club officer must appear on the general membership roster of the League.

This year's winners:

- First place: *Reflections,* edited by Terry Dufek, Popular Astronomy Club
- Second place: *The WASP,* edited by Brian Thieme, Warren Astronomical Society
- Third place: *Newsletter of the RVAS*, edited by Dave Thomas, Roanoke Valley Astronomical Society

THE ASTRONOMICAL LEAGUE'S ASTRONOMICS SKETCHING AWARD

Why not try your hand at sketching tonight? Sketching the impression of a celestial scene allows an observer to see more detail and to better enjoy our amazing avocation.

The League's Astronomics Sketching Award provides cash awards for first place ($250), second place ($125), and third place ($75). The exciting details can be found at *www.astroleague.org/al/awards/awards.html.* This program is made possible by the generosity and vision of Astronomics, *www.astronomics.com.*

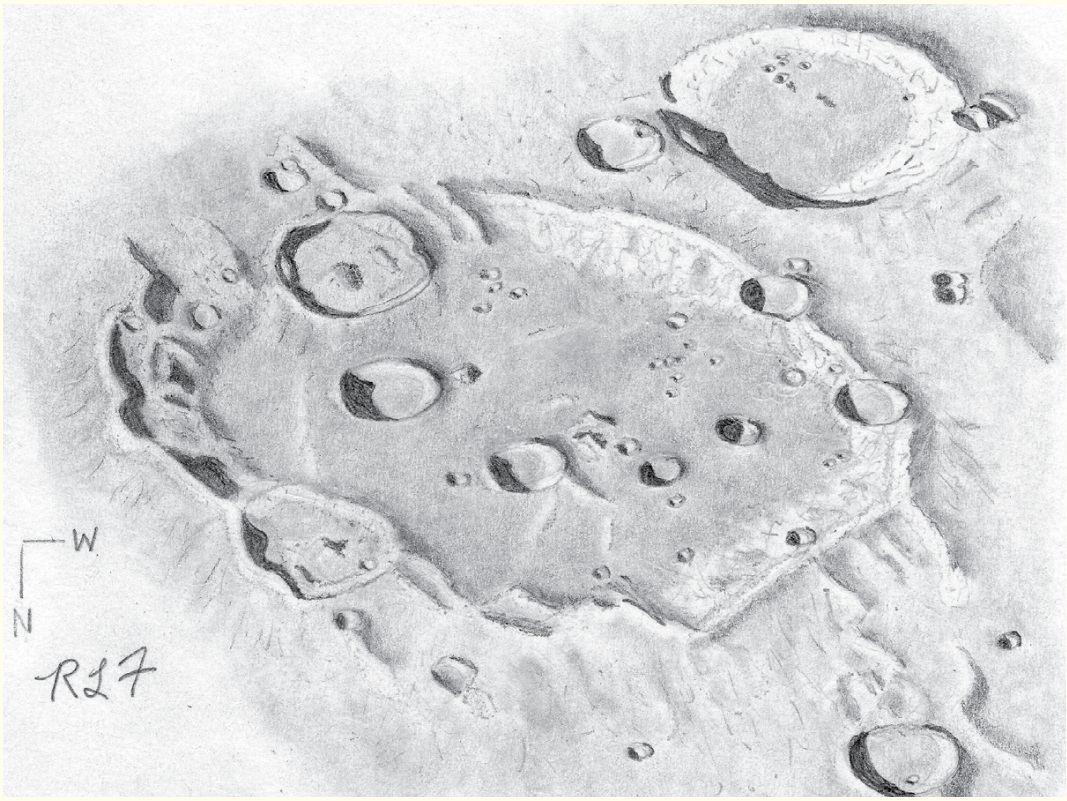
2018 ASTRONOMICS SKETCHING AWARD WINNER

First Place: $250. "Clavius Crater System," (shown below), pencil on paper, by Richard Francini, Neville Public Museum Astronomical Society. Using a 13-inch Dobsonian in De Pere, Wisconsin, most of the sketching was done on January 28, 2018, 2:00 to 6:30 UT, with additional work done on December 29, 2017, and January 29, 2018. Seeing during the major sketching on January 28 was a (1–) and improved to 1 for about 90 minutes (near perfect seeing conditions!); transparency was 18.7 magnitude per square arcsecond measured by SQM with 2/3 moon. Rock-steady images with 5.5 mm and 4.8 mm eyepieces giving 300 and 355 power. Total sketch time was about 9 hours! Congratulations, Richard!

YOUR ASTRONOMICAL LEAGUE JUST GAVE AWAY NINE LIBRARY TELESCOPES!

Through the vision of the Horkheimer Charitable Fund, the Astronomical League again offered a free Library Telescope to a lucky Astronomical League club in each region, plus one to a member-at-large.

The Library Telescope is a 4.5-inch Dobsonian reflector fitted with an 8–24 mm zoom eyepiece and a name plate commemorating the late Jack Horkheimer. The value of this opportunity is approximately $300; the potential is enormous.



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

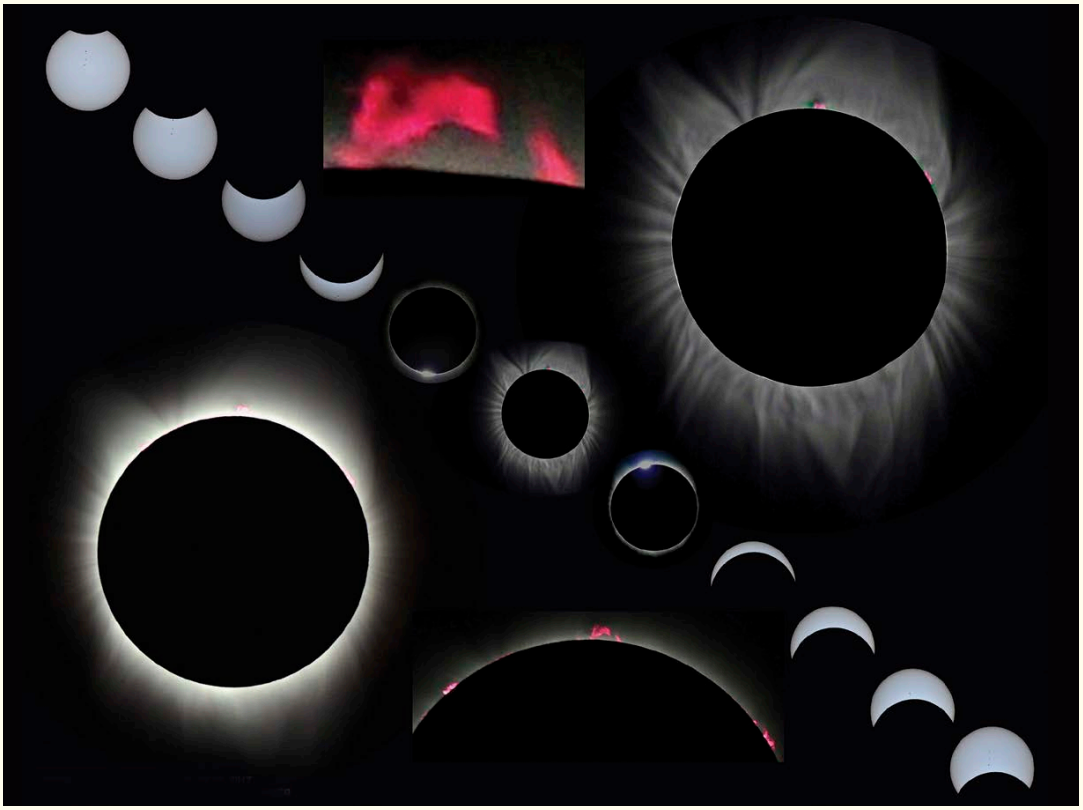
The winning entries were announced at ALCon 2018 in Minneapolis. Thank you to the Horkheimer Charitable Fund, Orion Telescopes, and Celestron for making this wonderful program possible!

Congratulations to the 2018 winners:

- St. George Astronomy Group, MARS
- Echo Ridge Astronomical Society, MERAL
- Island County Astronomical Society, NWRAL
- Bartlesville Astronomical Society, MSRAL
- Everglades Astronomical Society, SERAL
- Marquette Astronomical Society, NCRAL
- Valley Astronomical Society, NERAL
- Millstream Astronomy Club, GLRAL
- Jim Zappa, Member-at-Large

2018 ASTRONOMICAL LEAGUE/OPT IMAGING AWARDS

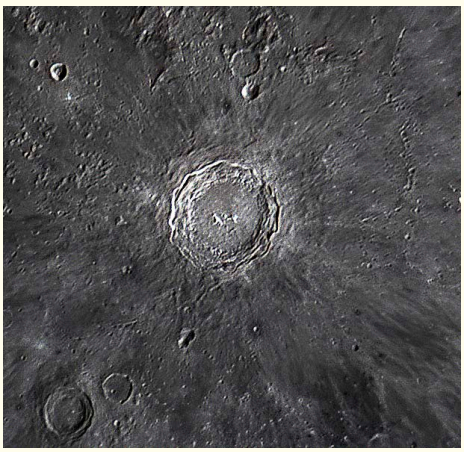
NOTE: MOST OF THESE IMAGES HAVE BEEN CROPPED TO EMPHASIZE CENTRAL FEATURES. ALL IMAGES COPYRIGHT 2017 OR 2018 BY THEIR RESPECTIVE CREATORS.

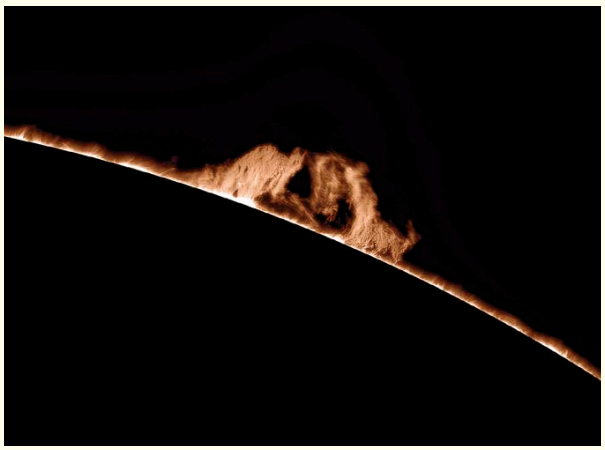


TOP: SOLAR SYSTEM FIRST PLACE, JAMES WEHMER, *Champaign-Urbana Astronomical Society, "Total Solar Eclipse Sequence," August 21, 2017; Nikon D3100 and Meade LXD75; Totality 1/1250 to 1/60 second; partial phases 1/1250 second with mylar full-aperture filter. Pellett method was used to enhance totality in Photoshop. Seeing: V (Antoniadi scale). Transparency: 5.*

LOWER RIGHT: SOLAR SYSTEM SECOND PLACE, RANDALL SHIVAK, *Big Bear City Astronomical Society, "Grand Soleil" solar prominence, August 9, 2017; Astro-Physics 152 mm f/8 refractor with DayStar Quantum PE 0.5-angstrom H-alpha filter, ZWO ASI174 video camera, AP1200 mount. 3,000 frames, 10 millisecond exposures, were stacked using AutoStakkert!. False color, sharpening, and masking were added using Photoshop. Seeing: good. Transparency: good.*

LOWER LEFT: SOLAR SYSTEM THIRD PLACE, GREGG RUPPLE, *Astronomical Society of Eastern Missouri, "Copernicus," one of the most prominent lunar craters, imaged during the waxing gibbous phase, December 29, 2017. Celestron C8, f/10, AP900 mount, ASI120MC camera. AVI video captured with SharpCap 3.0, processed using AutoStakkert! and RegiStax 6, sharpened using Photoshop. Best 600 of 3,000 frames were used. Seeing: fair. Transparency: good.*





OPPOSITE PAGE TOP LEFT: DEEP SKY FIRST PLACE, JOEL SHEPHERD, *Seattle Astronomical Society, "M27," July 6 and 12–14, 2017. M27 is a planetary nebula that can be readily observed even under light-polluted skies, and is an inviting astrophotography target in both RGB and narrowband.8-inch Celestron EdgeHD, Astro-Physics Mach1GTO mount; Atik 460EX mono camera; Astrodon 5 nm H-alpha, S-II, and O-III filters. 15 x 600-second exposure on each channel (7.5 hours total exposure). Processed in PixInsight: Synthetic luminance made by a weighted average of the individual narrowband stacks, without rejection. Applied deconvolution, noise reduction, and local histogram equalization to the synthetic luminance. Used "tone mapping" (star removal) technique on the narrowband channels to enable strong noise reduction and stretching of the individual stacks before combination into an RGB master, to avoid star bloating and bring out faint detail and nebulosity. Mapped H-alpha and S-II to red and O-III to green and blue, then applied luminance. In Photoshop, applied gentle unsharp mask to highlight the knots and ripples in the nebula.*

OPPOSITE PAGE MIDDLE LEFT: DEEP SKY SECOND PLACE, DAN CROWSON, *Astronomical Society of Eastern Missouri, "Van den Bergh 34," a reflection nebula in Auriga approximately 1500 light-years away, December 15 and 19, 2017. SBIG STF-8300M, Astro-Tech AT12RCT; Software Bisque Paramount Mxt, Baader filters. 24 x 600 seconds luminance, 8 x 300 seconds RGB. Processed in Adobe Photoshop. Seeing: 3–4 of 5. Transparency: 4 of 5.*

OPPOSITE PAGE TOP RIGHT: DEEP SKY THIRD PLACE, WILLIAM NEUBERT, *Astronomical Society of Eastern Missouri and St Louis Astronomical Society, "Messier 78," the reflection nebula full of young blue stars, multiple dark nebulae, and a large area of red emissions from Barnard's Loop, November 24 and December 15, 2017. Stellarvue SV80 ST 80 mm aperture apochromat, 0.8x focal reducer to 384 mm, QSI 683wsg-8 camera with Astrodon RGB filters, Celestron Advanced VX mount, auto-guided. Total exposure time of 5 hours 20 minutes; L: 12 x 10 minutes (1x1); RG: 6 x 10 minutes (binned 2x2); B: 7 x 10 minutes (binned 2x2) with 15 dark, bias, and flat frames. Processed in PixInsight. Seeing: 4 of 5. Transparency: 4 of 5.*

OPPOSITE PAGE BOTTOM LEFT: WIDE FIELD FIRST PLACE, PAUL SCHULZ, *Arizona Desert Skygazers, "The Milky Way Rises" with planets, Scorpius, and a meteor framed by an old-fashioned windmill, March 16, 2018. Canon 6D Mark II, 28 mm Rokinon lens at f/2.2, tripod. Exposure 15 seconds at ISO 2500. Seeing: 4 of 5. Transparency: good.*

OPPOSITE PAGE BOTTOM RIGHT: WIDE FIELD SECOND PLACE, TERRY MANN, *Miami Valley Astronomical Society, "Stillness in Motion," stacked image of star party with star trails, observatory, and people with telescopes, September 23, 2017. 70 images, 20 seconds each, stacked using StarStaX. Seeing: good. Transparency: good.*

OPPOSITE PAGE MIDDLE RIGHT: WIDE FIELD THIRD PLACE, MARK SIMONSON, *Everett Astronomical Society (WA), "Conjunction" – Moon, Venus, and Mercury over Whidbey Island, March 18, 2018 Canon 60D DSLR, Canon 18–55 mm f/3.5–5.6 IS II lens set at 55 mm, Godox EZ-C1 timer, tripod. Exposure 3 seconds at ISO 400.*

NOT SHOWN...

VIDEO FIRST PLACE, FREDERICK STEILING, *Astronomical Society of Eastern Missouri, "ISS Transit of the Moon," March 3, 2018, The ISS, while in Earth's shadow, transits the Moon at an angular size of 42 arcseconds. Mineral details across the lunar mare are brought out by this RGB composite.Orion 8-inch f/3.9 Newtonian Astrograph, Celestron CGEM, ASI120MM with ZWO 1.25-inch LRGB filters, MoonLite 2-inch CR focuser with Mini V2 controller.*

VIDEO SECOND PLACE, MIKE KRAWCZYNSKI, *Astronomical Society of Eastern Missouri, "An Explosive Time-Lapse!," September 8, 2017. A nearly full waning gibbous moon lights the scene. The camera was pointed north-northwest to capture a time-lapse video of a steaming volcano (Shiveluch Volcano, Kamchatka, Russia) and a clear sky full of stars when the volcano erupted mid-video! Nikon D7200, tripod, intervalometer, 18–105 mm zoom lens.*

OUTREACH IS A PRO/AM PRIVILEGE

By Kristine Larsen

Giving back to the public is one of the greatest joys of being a pro/am astronomer. I proudly call myself a pro/am because despite the fact that I have the great fortune to be an astronomy professor, I very much consider myself an amateur (literally one who loves) at heart. I am a member of the Springfield Telescope Makers (the Stellafane people!) and am currently on the figuring stage of a 12.5-inch mirror (my 8-inch was completed many years ago). I am an "eyeball-on-glass"/starhopper rather than a go-to person or an imager; taking part in a Messier Marathon with 105 objects nabbed manually in one night was a proud moment for me.

I also submit visual observations of both solar activity and more traditional variable stars to the American Association of Variable Star Observers (AAVSO). Equally fulfilling is moving through the Astronomical League's Observing Programs. In past years I completed the Messier and Binocular Messier Programs, as well as the basic levels in both Outreach and Meteor Observing. In late 2017, I completed the Master and Stellar levels of the Outreach Program and the Binocular Variable Star Program, and I have the Herschel 400 and Binocular Double Star Programs well underway.

You might be a tad confused at this point, because the topic of this essay is my public outreach. But my work on AL Observing Programs is very much germane to my outreach. Allow me to explain. In November 2012, I traveled to Australia to observe what was then my third total solar eclipse. Although I only saw a few seconds of totality through the clouds, the trip was hardly a disappointment, because I was able to observe the Southern skies for the first time. As I stood in an open field and gazed upward at the Magellanic Clouds and Southern Cross, observing Orion upside-down and becoming utterly lost among constellations I had never viewed before, I laughed and cried at the same time.

For the first time in decades I experienced exactly what the general public does when I help them look through a telescope for the first time, or give a presentation on some mind-blowing aspect of astronomy. For a moment I was a student, a beginner, taking my first baby steps in learning a sky I had never seen before. This is the value of the AL Observing Programs to my outreach. It allows me – it actually pushes me – to observe objects that I have never seen before, or to observe old celestial friends in a new way. It puts me in the place of the very people I serve when they come to a star party, or public lecture, or when I do workshops or planetarium shows for school children.

"Sharing the wonders of the universe with the public is something I am passionate about."

The AL Programs are also an important reminder that I need to keep my outreach fresh and exciting by pushing myself to create new activities, especially those that involve popular culture. I've done workshops on the astronomy of Harry Potter and developed planetarium shows based on both Harry Potter and the astronomy of Middle-earth. I actually did one planetarium show in costume and partially in character portraying Aurora Sinistra, the astronomy teacher at Hogwarts! I always encourage people to invent their own constellations and constellation stories, because making the sky personal is a great way to learn your way around it.

Whether it is showing the public views through our telescopes or helping a high school student with a science fair project, giving a talk at a local library or talking about recent discoveries on a local station, sharing the wonders of the universe with the public is something I am passionate about. For example, I was privileged to speak at Career Day at St. Paul School in Berlin last year. The two groups of fifth graders who attended were enthralled by the meteorites I passed around, as well as the reproduction astrolabe, and could not contain their enthusiasm when they got to look at the overhead lights through diffraction grating glasses and learned about how we discovered the composition of stars. It only took two hours of my time, and if I am really lucky, it might have made a lifetime of difference to one young girl or boy. Hopefully I might see some of these young people in my classroom in seven years.

So this pro/am wants to send out a heartfelt thanks to the members of the public for allowing me to serve them in this capacity, and to the Astronomical League Observing Programs for pushing me to be the very best astronomy ambassador that I can. The universe belong to us all. If I can, in any way, help anyone to understand it just a little bit better, it is my honor and pleasure to do so. ★

Kristine Larsen is professor of astronomy at Central Connecticut State University, immediate past-president of the AAVSO, and an assistant editor of the Reflector.

Dr. Larsen's Children's Workshops at Stellafane Convention. Photos by Ken Slater

ORBITAL TILTS AND HIGH-FLYING MOONS

UNDERSTANDING THE GEOMETRY OF LUNAR AND SOLAR DECLINATIONS

By Bill Romanishin

Mention the words "tropical zone" and most people conjure up images of drinks with little paper umbrellas and bodies covered in sand and SPF-50 sunscreen. Astronomically, the tropical zone is defined as the area on Earth where the Sun can be seen directly overhead, at the zenith, at some time during each year. Outside this band, which spans the area between about 23.5 degrees north and south latitude, the Sun never reaches the zenith. No part of the continental United States is in the tropical zone, so even in the hottest deserts of the southwest U.S., the Sun can never be seen directly overhead.

In fact, the width of the tropical zone is shrinking very slowly, as the Earth's tilt, or obliquity, changes (*Sky & Telescope,* June 1 '98, p. 36).

What if, instead of asking where on Earth the Sun can be directly overhead, we ask where on Earth we can see the Moon directly overhead? We might call this the Earth's "lunar zenithal zone." If the Moon's orbit around the Earth were in the same plane as the Earth's orbit around the Sun (the ecliptic plane), then the tropical zone and the lunar zenithal zone would be exactly the same. However, the Moon's orbital plane is tilted by about 5 degrees to the ecliptic plane. Because of this 5-degree tilt, the two zones are quite different.

Two planes tilted with respect to one another always intersect in a straight line. In the Sun-Earth-Moon system, the line of intersection of the ecliptic plane and the plane of the Moon's orbit around the Earth is called the line of nodes. Solar or lunar eclipses can only happen when the Moon is near the line of nodes and thus near the ecliptic. Only at this time can the Sun, Earth, and Moon line up in the nearly straight line necessary for an eclipse to take place. If the line of nodes were fixed in space, then we could only have solar and lunar eclipses around the same two times each year, as the Earth's motion around the Sun would position the line of nodes near the Earth-Sun line regularly twice a year. Of course, eclipses do not follow such a seasonal pattern. This is because the line of nodes rotates in space, as seen by an outside observer, due to the "wobble" of the Moon's orbital plane. This rotation of the line of nodes takes about 18.6 years to complete.

The rotation of the line of nodes obviously has a critical role to play in determining the dates of eclipses. A less-well-known consequence of the rotation of the line of nodes is that the maximum and minimum, or the range, in declination that the Moon reaches each month varies with the same 18.6-year periodicity. Declination, of course, is the angle between a spot on the sky and the celestial equator, while latitude is the angle between a spot on the Earth and the Earth's equator, as seen from the center of the Earth. For a celestial object at the zenith, the declination of the object is equal to the latitude of the observer. If the Moon orbited in the Earth's equatorial plane (as many moons orbit their planets), the Moon would always have the same declination.

If the Moon followed the Sun's path in the sky along the ecliptic, the range in lunar declination would be the same as the Sun's, about 23.5 degrees north and south, for a total range of about 47 degrees. But because of the 5-degree tilt between orbital planes, the Moon is sometimes found up to 5 degrees farther from the Earth's equatorial plane than the Sun, and at other times up to 5 degrees closer. Thus, when the orbital planes are oriented so that the Sun is at maximum declination north or south, and the Moon's orbit is tilted so that the Moon is at a more extreme equatorial angle than the Sun, the Moon can be seen overhead at a latitude up to about 28.5 degrees north or south. When the Moon is closer to the equatorial plane than the Sun, the Moon's declination range can be as low as about 18.5 degrees north and south. These effects cause the lunar zenithal zone to vary significantly in width in latitude, from a minimum about of 37 degrees (twice 18.5) to a maximum of 57 degrees (twice 28.5) with an 18.6-year periodicity.

To illustrate the readily observable results of this phenomenon, I used the HORIZONS system provided by NASA's Jet Propulsion Laboratory to calculate the position in the sky of the Moon, the illuminated fraction of the Moon, and the Earth-Moon distance for every hour of every day between the start of 2014 and the start of 2034. This period spans a little more than one period of the nodal rotation. The sky ➞

positions are for a hypothetical geocentric observer located at the center of the Earth. The actual declination of the Moon as seen by any particular observer on Earth will differ from the geocentric positions by up to about 1 degree due to parallax. However, if we want to ask where the Moon passes directly overhead, the geocentric positions are fine, as an observer seeing the Moon directly overhead would be on the line between the center of the Earth and the Moon, so would have no parallactic correction to the Moon's position as compared with geocentric coordinates.

There are many ways to look at this huge list of numbers. The maximum northerly declination reached by the Moon occurs on March 7, 2025, when the Moon is at declination of +28.71 degrees and is about 60 percent illuminated. (All dates are given in Universal Time, so they may differ one day from local dates.) For southern hemisphere observers, the maximum southerly declination is −28.72 degrees on March 22, 2025, with the Moon 52 percent illuminated. However, these are not particularly unusual occurrences, as there are many dates when the Moon reaches almost as far north or south.

Undoubtedly the greatest visual effect of the Moon's changing declination occurs when the Moon is full. So I plotted the times and Moon declinations for the 247 full Moons between the beginnings of 2014 and 2034. During 2015 and 2016 there is a broad minimum in the Moon's declination range, as the declination of the full Moons range from roughly 18.5 degrees north to 18.5 degrees south. During the 2024–2025 period the nodal rotation next brings the Moon to its farthest point from the equator, and the full Moons range in declination up to about 28.5 degrees north and south. During the current year, 2018, the maximum lunar declination starts to increase noticeably. The full Moon on January 2, 2018, was the first full Moon above +20 degrees declination in about 5 years. Over the next 7 or 8 years the full Moons near the December solstice will pass a little higher in the sky each year for northern hemisphere observers.

I present two plots, each of which shows the declinations of full Moons and the declination of the Sun.

The first figure is for years 2015, 2016, and 2017. The date and declination of each full Moon is shown as a filled circle. The solid line is the declination of the Sun as a function of time. As the full Moon is always opposite in the sky from the Sun, the declination of the full Moon and Sun are roughly mirror images of each other.

For northern hemisphere observers, the middle of each year brings summer, and the Sun rides high in the daytime sky and the full Moon rides low in the nighttime sky. Near the end of each year, close to the December solstice, the positions are reversed. Note that the range in declination of the full Moons is less than the range of declinations for the Sun during the years 2014 to 2016. The second plot shows the same data for the years 2024, 2025, and 2026. The range of declination for the full Moons is now clearly larger than that for the Sun. For the years between these plots (more plots can be found on my website), the early northern winter full Moon will cross the meridian a little higher in the sky each year. Thus the width of the lunar zenithal zone is smaller than the tropical zone in 2014–2016 and larger than the tropical zone in 2024–2026.

The northernmost full Moon will occur on December 15, 2024, at a declination of +28.22 degrees. In the continental United States, southern parts of Florida and Texas will be able to see the Moon pass directly overhead, and the Moon will pass the meridian as close to the zenith as is possible for most U.S. observers. The closer an object is to the zenith, the less atmosphere it is seen through, and the brighter it appears, so the full Moon should appear a little brighter than usual for people in the continental U.S. But of course the brightness of the full Moon depends primarily on its distance from Earth. The Earth-Moon distance varies from about 357,000 to 405,000 km. The distance varies in a complicated way that is not in sync with the phase or declination of the Moon. The full Moon of December 15, 2024, will be at a distance of 370,400 km, which is somewhat closer than average, but certainly not a particularly close approach.

Are there any upcoming particularly close full Moons that will also be at extreme northerly or southerly declination? The term "supermoon" has been applied to full Moons that are particularly close to Earth. There are various definitions of supermoon, but one is that the full Moon is closer than 90 percent of all full Moons.

I made a list of the closest 10 percent of full Moons over the 2014–2034 period and compared

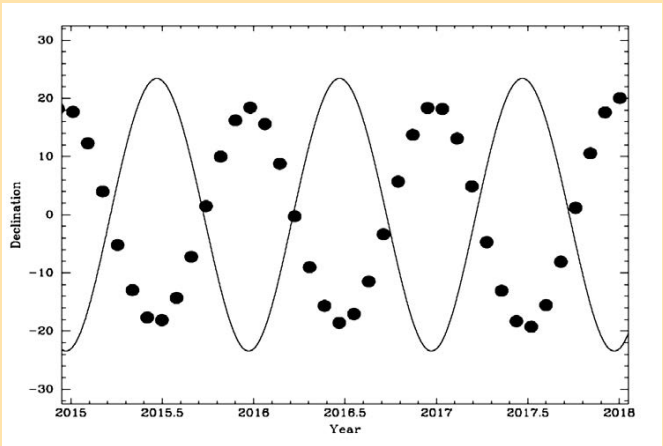


Figure 1: Sun and full Moons, 2015–2017. The date and declination of each full Moon is shown as a filled circle. The line is the declination of the Sun. During these years, the declination range of the full Moons is at its minimum. The full Moons do not reach as far north and south as does the Sun.

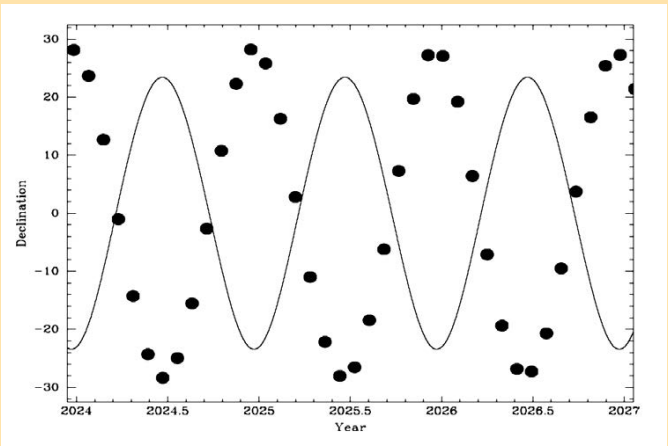


Figure 2: Sun and full Moons, 2024–2026. During these years, the declination range of the full Moons is at its maximum. As seen from the Earth, the full Moons clearly range farther north and south than does the Sun.

this to the list of high-declination Moons. Four full Moons stand out. The full Moon of December 24, 2026, will be not only the third most northerly full Moon (+27.29 degrees) but will also be the fifth closest of the 247 full Moons between 2014 and 2034! This full Moon will come within a scant 304 km (0.09 percent) of the closest the Moon approaches Earth in the entire 21st century. The closest approach between the Moon (any phase) and the Earth in the 21st century will occur on December 6, 2052, at a center-to-center distance of 356,421 km (*Sky & Telescope*, August 1981, p. 110). The full Moon on December 4, 2025 (+27.25 degrees) will come within 800 km (0.22%) or so of the closest Moon. For observers in the southern hemisphere, the full Moon of July 13, 2022, (−26.20 degrees) will be about 1000 km (0.27%) farther than the closest Moon, and the full Moon of June 14, 2022 (−25.88 degrees) will be within 1200 km (0.36 percent) of the closest the Moon comes in the 21st century. These combinations of particularly high (or low) declination and close distance should make these full Moons just about the brightest possible for northern or southern hemisphere observers at mid-latitudes.

The full Moon closest to Earth during the 2014–2034 period was that of November 14, 2016. This full Moon was only about 101 km (0.03 percent) farther than the closest 21st-century Moon approach. The full Moon of January 2, 2018, was the second closest full Moon of the 2014–2034 period, only about 90 km farther from Earth than the November 2016 full Moon.

These nights of bright, high-flying full Moons would be particularly bad nights to look for faint galaxies or nebulae. They would even be poor nights to look at the Moon through a telescope, as the lack of shadows of lunar features near full Moon makes the Moon look flat and uninteresting. These nights would be good for some nighttime hiking or cross-country skiing, and for contemplating the many motions of our magnificent Moon.

More detailed plots and various lists of full Moons and hourly lunar positions can be found at my website, *hildaandtrojanasteroids.net*. ★

Dr. William Romanishin is emeritus professor of astronomy at the University of Oklahoma and a visiting scholar at Northern Arizona University.

GALLERY

More GALLERY can be found on pages 29–30

NOTE:
We can't do this image justice at this size in the magazine. At full size, mapped to 300 pixels per inch, the Moon's diameter would be over 17 inches!

Thomas Spirock
(Springfield Telescope Makers)

Full Moon, July 28, 2018, taken with the Warner & Swasey / Brashear 6-inch refractor at Mt. Wilson Observatory, operating at f/15, with a ZWO ASI1600MM camera and a wide-band red filter.

Initial data was twelve 30 second (~200 images) videos – four sections of the Moon each captured with 2, 4, and 6 millisecond exposures. Each video was converted to a single image with AutoStakkert!, using the best 32 images.

RegiStax was used for wavelet processing.

Each group of four images was stitched together with Adobe Photoshop, to make three complete images of the full Moon, at 2, 4, and 6 millisecond exposures.

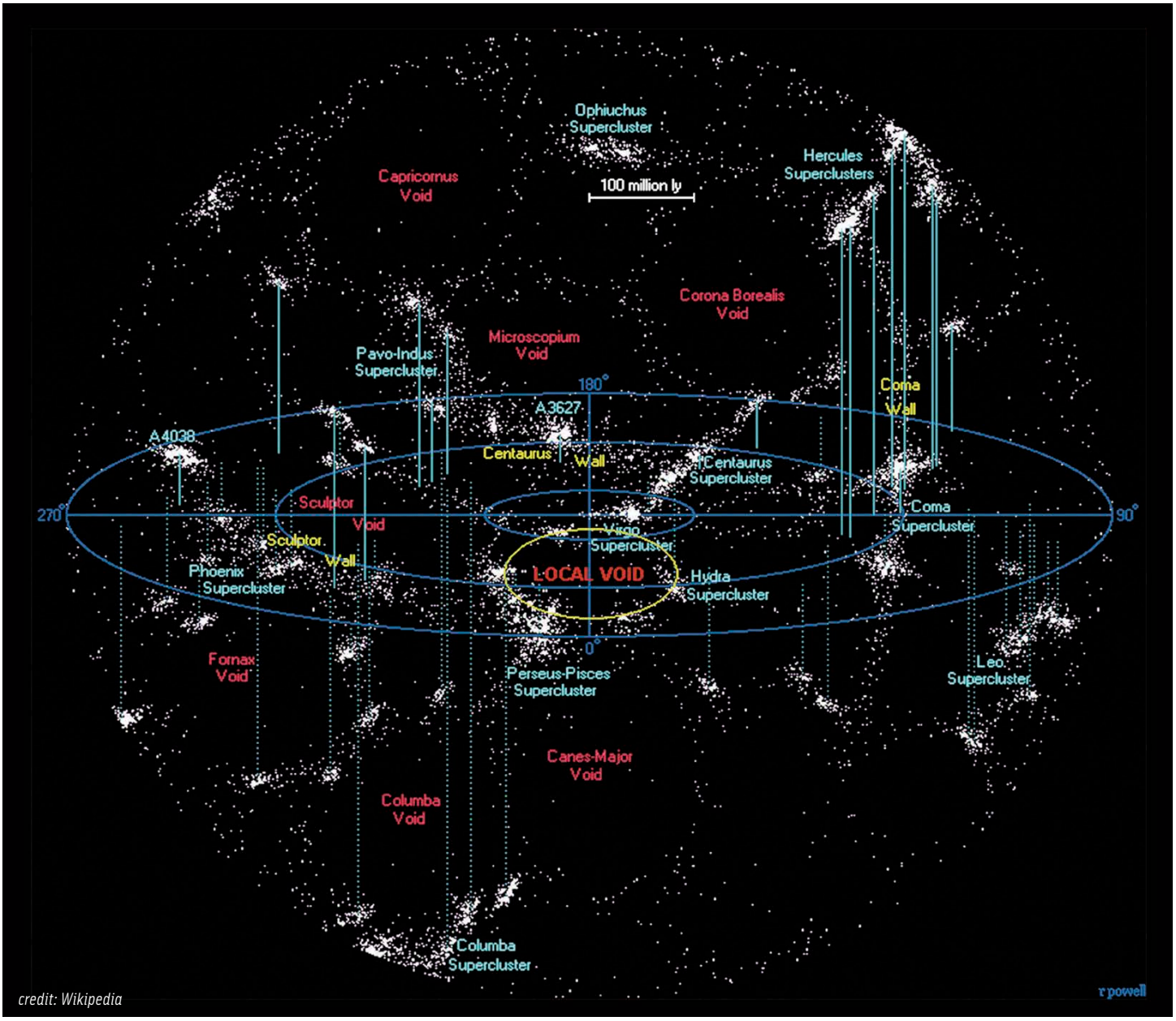
The three images were then combined into one HDR image using Photomatix Essentials.

Things to a Void

SOME PARTS OF THE UNIVERSE ARE EMPTIER THAN OTHERS

By Dave Tosteson

We sit at the edge of an ocean. Not of water, but of empty space. And it is getting larger. Our Milky Way galaxy is engulfed in structures moving away from what is called the Local Void. In cosmic terms, its near edge is close, twenty million light-years, just a few diameters the size of our Local Group of galaxies. Imagine standing near Oregon's west coast and gazing



credit: Wikipedia

toward Asia on the other side of the Pacific. Unlike that largest body of water, the Local Void is expanding, with galaxies on the far side receding from its center. How and why this is occurring informs the expansion of the Universe, mysterious dark energy and familiar gravity. As observers, we have a front row seat to *de Cipher du Mer*, a play of unfolding pelagy where we shall not see nothing.

"(The Local Void) is so large that if our Milky Way had been situated on its own within the void's core, discovery of external galaxies might not have occurred until the 1960s."

In 1987, Brent Tully and Rick Fisher announced the discovery of an area of space adjoining ours that was distinctly lacking in galaxies. Though not the first of its kind identified, this Local Void in the direction of eastern Hercules and Aquila extended for at least 150 million light-years. Recent studies have suggested it could be much larger, up to a billion light-years across. It is so large that if our Milky Way had been situated on its own within the void's core, discovery of external galaxies might not have occurred until the 1960s. In 1997, Nakanishi and colleagues used redshifts to study motions of 828 galaxies in the area around the Local Void to assess its boundary dynamics. Our Local Group of galaxies is part of what is termed the Local Sheet, 23 million light-years in length and roughly centered on the Milky Way. In 2007, Tully and others described the "peculiar motion" of our Local Group and Sheet away from the Local Void with a velocity of 260 km per second. In 2011, Iwata and Chamaraux presented research consistent with galaxies on the far side of the void also receding from its center.

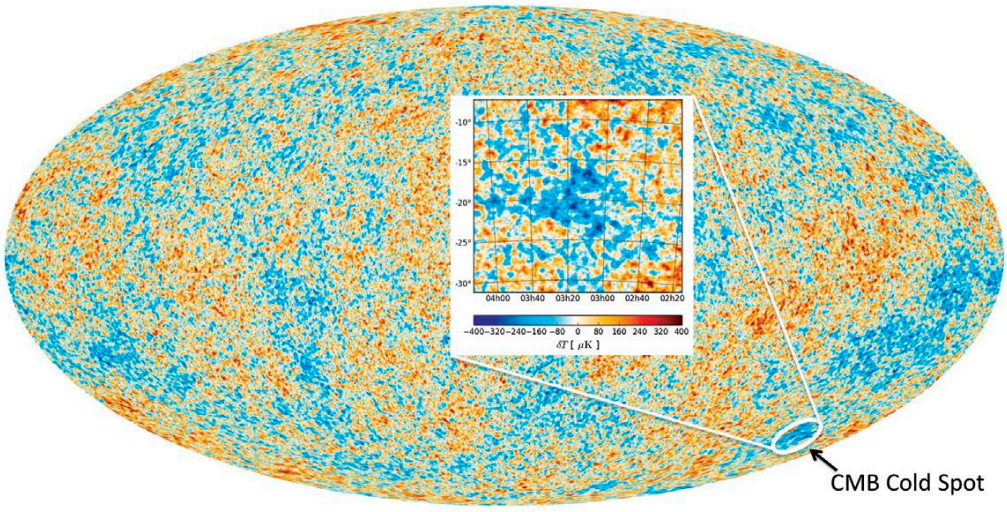
In a 1981 issue of *Astrophysical Journal*, Robert Kirshner and others published research on a "million cubic megaparsec void in Boötes," convincing early researchers in this field of their existence. Located several hundred million light-years from us, it was 250 million light-years across and revealed only 60 galaxies in a space normally containing 10,000. As clarity followed better data, the number of galaxies identified within the Boötes Void rose from the initial count. The Hercules Supercluster containing Abell galaxy clusters 2147, 2151, and 2152 seems to sit on the near side of this void.

The Eridanus Supervoid is so large at almost 1 billion light-years across, it was considered to correlate with a cold spot on the Wilkinson Microwave Anisotropy Probe (WMAP) cosmic microwave background radiation (CMBR) map. Further studies in 2017 suggested the cold spot is not one giant supervoid, but more likely a collection of smaller ones. One of the largest known voids is in the direction of the constellation Canes Venatici. This "Giant Void" is 1.2 billion light-years across and 1.5 billion light-years away. Voids likely evolve through mergers of their own, so discovering their galactic muster with deep surveys to spot faint dwarf members may improve our perception of that process. Current estimates suggest they contain from 5 to 20 percent of the mean space density of galaxies.

Although voids were initially thought deserted and empty after their discovery in 1978, studies quickly found faint galaxies in them, similar to small islands of the Aleutian arc or the Hawaiian chain. We can envision galaxies within voids related to dark matter filaments as being counterparts to underwater architecture supporting what is seen above the surface. In his book *Over the Edge of the World*, Laurence Bergreen described the vast liquid desert of a becalmed Pacific Ocean, and the hardships Magellan's crew endured attempting its maiden crossing.

Their very survival was in jeopardy when they underestimated its breadth by a factor of three and missed finding any substantial islands dotting its interior. They were saved only by spotting Rota and Guam in the Northern Mariana Islands. Their journey to the "Spice Islands" of what is now Indonesia would soon fill, for Europe, the void of fleeting trade left by China's recalled Treasure Fleet.

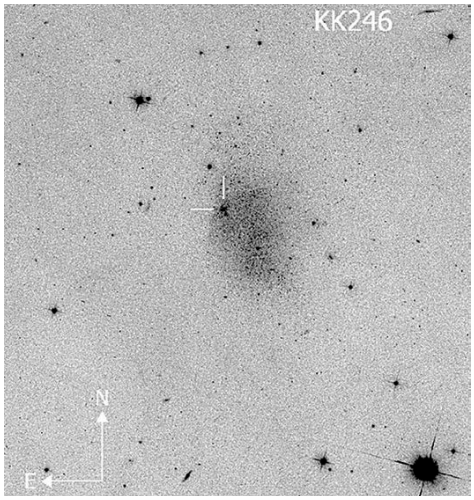
With a few adjustments, the ocean analogy may help visualize voids' relationships. Consider a flat representation of Earth, as on a Mercator map. If the Pacific is used to represent the Local Void, with the conservative estimate of 150 million light-years for its breadth at the latitude of mid–North America, then our home is one-seventh of its diameter from the edge, or in the middle of Montana. An elevated lookout could see beacons of light representing galaxies to great distances. Many galaxies would sit between us and the near edge of the Local Void at Seaside, over six hundred miles away, and we would strain to see the dim lights of the far side at Hokkaido, Japan, five thousand miles west.



credit: ESA/Durham University, UK

"On the void-facing hemisphere, nighttime would be a vast, starless desert."

Imagine the night sky on a planet in the outer halo of a galaxy within such a Tenebrae. On the void-facing hemisphere, nighttime would be a vast, starless desert. Without a small telescope, the nearest external galaxies would be invisible, several hundred times fain ter than the naked eye could see. As our ability to spot fainter dwarf galaxies within voids has improved, so estimates of their galactic density have increased. ➡



KK 246 (ESO 461-36) credit: HST, NASA

NGC 7077 credit: Sloan Digital Sky Survey

CGCG 84-14 credit: Sloan Digital Sky Survey

The Galaxy and Mass Assembly survey (GAMA) found what researchers term "tendrils" within voids, strings of galaxies at the limit of detection, rather like discovering underwater mountain chains just below the surface of an ocean. Alpaslan and colleagues suggest we are seeing the tip of the galactic density iceberg within these voids, and, as our surveys improve, more accurate counts will surface. There are more things in heaven to unearth (a ratio) than are imaged in our telosophy.

What causes voids to form, and how are they changing with time? Tiny quantum fluctuations imprinted in space-time just after the Big Bang 13.8 billion years ago grew into density variations noted in the cosmic microwave background radiation. From these humble clumps within the dark matter backbone that underlies and guides their growth, individual galaxies and clusters have evolved. Voids may form when gravity within this spine contracts and feeds unused gas and smaller structures along filaments into clusters and superclusters, the hubs of galaxy formation. Clues may be emerging about the roles in their growth played by dark energy and the general expansion of the Universe. As time passes, a greater percentage of space is being occupied by voids. Nine billion years ago they constituted only 9 percent of space. By seven billion years ago, the halfway point in our Universe's lifetime, this was 28 percent, and presently voids make up more than half its volume. In the far future, we'll be as polar bears drifting apart on receding Arctic islands of ice, victims of an altered infrastructure.

Since amateurs cannot directly appreciate distance at the eyepiece, what is there for visual observers to see?

How do we put these concepts in perspective? Just as we cannot discern overall structure in superclusters of galaxies in our telescopes, so it is with voids. They are too large to appreciate within the small fields of view of our instruments, so we need galactic distances to piece together their three-dimensional structure. Future observers may use redshift or distance indicators to show unequivocally which are near the front edge of the Local Void, which reside within it, and which outline its distant border.

Tully's data from 2008 show galaxies within the Local Void, including the ghostly dwarf KK 246 (ESO 461-36) moving toward us with voidbreak velocity. Only faintly visible on the POSS 2 red plate, this 17th-magnitude, low-surface-brightness wraith was descried in my 32-inch reflector under moderately poor conditions. NGC 7077 is a 14th-magnitude peculiar S0 galaxy at the northern border of Aquarius that I spotted in my 25-inch scope from my home in 1993. NGC 6503, an 11th-magnitude spiral 3.6 degrees north of NGC 6543 in Draco, is visible in small telescopes. The 9.5-magnitude face-on spiral NGC 6946 may sit on the near edge of the Local Void. It is a large, low-surface-brightness object, and would be more spectacular if not located directly behind the dust plane of the Milky Way.

In a 2011 *Astronomy & Astrophysics* paper, Iwata identified galaxies on the far side of the Local Void, including two 15th-magnitude objects, CGCG 84-14 and UGC 11417, that should be readily available to moderate-size instruments. Grogin and Geller published an *Astronomical Journal* article in 2000, and from their Center for Astrophysics redshift survey data I was able to espy four of their galaxies noted within three prominent voids: MCG+4-2-1, MCG+4-2-2, Markarian 305, and UGC 12066. Interest by astronomers in voids has been mounting in the last decade, reflected in the numbers of papers with galaxies accessible to amateur visual observation.

In September 2014, our "home" got a remodel. Tully and his colleagues published a new map of the Local Supercluster, enlarged to contain 100,000 galaxies stretched over 500 million light-years. The Supercluster was given the liltingly beautiful name "Laniakea," Hawaiian for "immeasurable heaven." It seemed an ironic choice, having just done so. I could feel my paradigm shifting, as I was visually and conceptually comfortable with our old neighborhood. But new journeys and rewards await the open-minded. There is a ship on the frontispiece of Francis Bacon's 1620 book *The Great Instauration,* embarking on a voyage of discovery onto an apparently empty ocean. As we navigate its increasingly recognized structure, sweet tendrils and archipelagos to a void may turn just desert into just desert. ★

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PHOTOGRAPHING THE MOON IN DAYLIGHT

By John Duchek

I am an "evening" astronomer and enjoy getting my sleep. Apparently, so are many of us, as most lunar observing is done on the waxing moon, not the waning moon. One can see many more photos of the waxing Moon in magazines, on websites, and even NASA's lunar impact monitoring program has caught fewer impacting meteoroids in the early morning hours than in the evening.

One night several years ago I had my Orion 10-inch reflector out at 3 a.m. and took pictures of the Moon until dawn. As the Sun rose, the pictures deteriorated very quickly. When I went to put the equipment away, I could feel a lot of differential heating on the metal tube. The side in the sunlight was quite warm to the touch while the side in shadow still held the night's chill. I figured that was why I saw the quick loss of resolution as the Sun rose.

This summer I was having difficulty with sunlight streaming into my house and heating my study. I went to Lowe's and purchased some of their Reflectix reflective roll insulation. It worked well in my room, and when I thought back to my problem with the Orion reflector, I realized this might be part of the answer.

From years of taking pictures, I know that the higher the Moon is in the sky, the better it is for viewing and photos. I usually don't bother if the Moon is below about 45 degrees altitude. My camera for infrared use is a monochrome ZWO ASI120MM-S camera. I put a 1.25-inch infrared pass filter on it and went out to capture the daylight Moon. The purpose of the infrared pass filter is to cut out all of the visible light from the picture, remove the light scattering, and give dark edges to the pictures.

Skywatcher 7-inch f/15 Mak-Cas mounted on Losmandy G11, taken on August 4

On August 4, the last-quarter Moon was high in the sky at dawn – 57 degrees high and transiting at about 7 a.m. – so I got out there at 7:45 a.m. The Sun had been up since about 6 a.m. I went out and tested my idea using my insulation-wrapped 7-inch Mak-Cas Sky-Watcher. I took a series of photos from prime focus. Since this was a test, I only took about 1500 images and stacked about half. Normally I would take ten times as many images. The picture in this article shows an unusual view of the Straight Wall. Pictures of the waxing Moon show it as a dark shadow. This picture catches it in bright sunlight. I felt all of the pictures were quite successful, although more frames would have given me less noise. I took 28 pictures that morning and saw no degradation as the time progressed.

After that success, I decided to use my Orion ED80 to get a picture of the complete last-quarter Moon on August 5. These pictures were also taken at about 8 o'clock in the morning. I wrapped my Orion ED80 and took images covering the complete Moon. For each picture I took 10,500 frames and used about 10 percent of the frames. It took two pictures to capture the entire Moon. The image of the complete last-quarter Moon was stacked in AviStack 2.0, deconvolved in Astra Image, and photomerged in Photoshop CS3.

Since the time that I took these, I purchased a used 9.25-inch Schmidt-Cassegrain telescope from a man in Texas. He had wrapped the scope in Reflectix and told me that it cooled faster this way. I suspect that isn't the correct explanation, but the result may well be the same.

The Reflectix likely slows the cooling so much that the optical tube assembly stays at essentially the same temperature as ➡

Mare Nubium test image (1300 frames) taken on August 4. Note the appearance of the Straight Wall in the different lighting of the waning Moon

when he brought it out, just as it did in my daytime use. Since the whole tube assembly is at a uniform temperature (although not equilibrated with the outside temperature) he got very good images with this setup.

I am trying to test that idea now by putting a thermometer probe under the Reflectix and seeing how this temperature compares with the outside air temperature as an evening progresses, and how that affects the imaging. ★

Credits: All pictures were taken by John R. Duchek, PhD, near Carrizozo, New Mexico. The author thanks his wife, Barbara, for proofreading the article.

Orion ED80, taken on August 5

Photomerged images of the last-quarter Moon (10,500 frames each). The photo is reproduced here significantly cropped in order to allow detail to survive our printing process.

RADIO ASTRONOMY FOR AMATEURS

By Steve Tzikas

In 1981, the Society of Amateur Radio Astronomers (SARA) was founded as the first national amateur organization dedicated to radio astronomy. There are over 400 SARA members worldwide, from people wanting to learn the field who have no prior knowledge, to radio technology enthusiasts and professionals. Every summer SARA holds its annual conference at the Green Bank Observatory in Green Bank, West Virginia, where participants hear cutting-edge lectures covering the latest innovations in amateur radio astronomy and are treated to distinguished radio astronomer keynote speakers, including Nobel laureates. On top of that, participants have access to the 20-meter and 40-foot radio dishes and get a tour of the GBO facilities. A spring conference is also held in the western part of the United States.

The starting cost for a radio telescope is about $100, but the cost can, of course, rise much higher. Access to large, professional, remote radio telescopes is possible through various programs. Amateur radio telescopes usually require someone to construct or assemble them. Afterward, getting them to work properly, and understanding the data gathered, can require some time. There is something to fit everyone's level of experience in radio astronomy. Some of the more sophisticated projects might challenge a PhD in electrical engineering. Getting involved in radio astronomy will offer the individual a lifelong learning experience, and will allow a person to pursue their interest day or night, and under rainy, clear, or cloudy skies.

The space needed for a radio telescope can be small, like that of an optical telescope, or much larger, requiring a decent-size backyard. There are three basic components to a radio telescope: the antenna, the receiver, and the output display or device. Like optical telescopes, radio telescopes vary in performance depending on many factors. However, a modest-cost radio telescope used for a specific purpose, such as SuperSID (solar/ionospheric) or Radio Jove (Jupiter) observations, can be quite sufficient for its purpose. While many amateurs collect their own data through their personal pursuits, some data is collected for the benefit of professionals. Other data, or projects, are published in the SARA Journal and are read by both amateurs and professionals.

For an amateur backyard radio telescope, there are many sources of potential interference: appliances, fluorescent lights, electric fences, lawn mowers, radio towers, satellites, cell phones, the radio telescope itself, and reflections, to name a few. However, this is not to say that interference will be detected, or that the interference will cause a problem for an observation. Interference is specific to a certain frequency, so if an astronomical target radiates at a different frequency, one just needs to understand the output and what is being observed. Some ideas for mitigation of interference can include shielding, filters, recognizing the periodicity of the interference, and using calibration noise sources to gauge the sensitivity of the system.

It is possible for amateurs to observe the Sun, the Moon and planets, galaxies, molecular clouds, galactic hydrogen, masers, satellites, pulsars, spectroscopic peaks, supernovae, and occultations. Amateurs also delight in honing their analytical skills and building their radio telescopes. Signal quality can become an issue when trying to detect weak astronomical targets, especially at an accurate flux density. Proper calibration, observation techniques, instrumentation accessories, observing parameters, and signal processing can help.

Since radio astronomy is a relatively new field, there is only limited amateur-level literature available to guide an amateur radio astronomer. That's where SARA is extremely helpful—an active email listserv is invaluable for discussing technical issues. Visiting the SARA website (*radio-astronomy.org*) is often the first step in discovering the world of amateur radio astronomy. ★

Observing Awards

Editor's Note: Congratulations to all these outstanding astronomical observers! All awards, except for the Herschel 400 and Sky Puppies, require current Astronomical League membership for eligibility. If you have questions about an award, please contact the corresponding Observing Program chair. Their contact information can be found on the Observing Program website at* www.astroleague.org/observing. *If further assistance is required please contact either of the national Observing Program coordinators.

Advanced Binocular Double Star Observing Program

No. 28, **Rakhal Kincaid**, Haleakala Amateur Astronomers; No. 29, **David Whalen**, Atlanta Astronomy Club; No. 30, **Paul Harrington**, Member-at-Large

Beyond Polaris

No. 17, **Vincent Michael Bournique**, Member-at-Large; No. 18, **Steve Boerner**, Astronomical Society of Eastern Missouri

Binocular Double Star Observing Program

No. 31, **Becky Ramotowski**, The Albuquerque Astronomical Society; No. 137, **Brook Belay**, Atlanta Astronomy Club.

Binocular Messier Observing Program

No. 1142, **Gary Dietz**, Astronomy Enthusiasts of Lancaster County; No. 1143, **Robert J. Olsen**, Member-at-Large; No. 1144, **Janet Rush**, Delaware Valley Amateur Astronomers; No. 1145, **Dale Eason**, Minnesota Astronomical Society; No. 1146, **Mike Conley**, Night Sky 45 Astronomy Club; No. 1147, **Matt Allen**, Omaha Astronomical Society; No. 1148, **Joe Comiskey**, Kalamazoo Astronomical Society; No. 1149, **Arya Jayatilaka**, Kalamazoo Astronomical Society; No. 1150, **John Cassidy**, Ventura County Astronomical Society; No. 1151, **Edgar G. Fischer**, The Albuquerque Astronomical Society; No. 1152, **Susan Johnson-Roehr**, Member-at-Large; No. 1153, **Neil Perlin**, Member-at-Large; No. 1154, **Gus Gomez**, Tucson Amateur Astronomy Association

Binocular Variable Star Observing Program

No. 27, **Russell F. Pinizzotto**, Southern Maine Astronomers; No. 28, **Steve Boerner**, Member-at-Large; No. 29, **Antone G. Gregory**, Minnesota Astronomical Society; No. 30, **Chuck Stewart**, Rose City Astronomers; No. 31, **Mark Simonson**, Everett Astronomical Society

Carbon Star Observing Program

No. 95, **Dan Posey**, Hill Country Astronomers; No. 96, **John L. Goar**, Olympic Astronomical Society

Comet Observing Program

No. 40, **Becky Ramotowski**, Gold, The Albuquerque Astronomical Society; No. 100, **Raymond B. Howard**, Silver, Member-at-Large; No. 101, **C. Ward Trussell Jr.**, Silver, Northern Virginia Astronomy Club

Constellation Hunter Observing Program (Northern Skies)

No. 208, **Rich Krahling**, Richland Astronomical Society; No. 209, **Brian McGuinness**, Northern Colorado Astronomical Society; No. 210, **Terry Trees**, Amateur Astronomers of Pittsburgh

Dark Sky Advocate Observing Award

No. 13, **Vincent Michael Bournique**, Member-at-Large

Deep Sky Binocular Observing Program

No. 400, **Gary Whelan**, Member-at-Large; No. 401, **Robert Abraham**, Shreveport-Bossier Astronomical Society; No. 402, **Christen K. Slotten**, Olympic Astronomical Society

Double Star Observing Program

No. 613, **Gordon Pegue**, The Albuquerque Astronomical Society; No. 614, **Fernando Torres**, The Albuquerque Astronomical Society; No. 615, **Mark Teran**, Member-at-Large; No. 616, **Al Hamrick**, Raleigh Astronomy Club

Earth Orbiting Satellite Observing Program (EOSOC)

No. 35, **Marilyn Perry**, Member-at-Large

Flat Galaxy Observing Program

No. 34, **Marie Lott**, Regular, Atlanta Astronomy Club

Globular Cluster Observing Program

No. 314-V, **Gordon Pegue**, The Albuquerque Astronomical Society; No. 315-V, **Seth Jelen**, Rose City Astronomers

Herschel 400 Observing Program

No. 595, **Rene Scandone Gedaly**, Houston Astronomical Society; No. 596, **Alan Scott**, The Albuquerque Astronomical Society; No. 597, **Ron Ziss**, Naperville Astronomical Society; No. 598, **Orv Wiens**, Houston Astronomical Society; No. 599, **Gary Fugman**, Northeast Nebraska Astronomy Club

Herschel Society

No. 1, **Al Lamperti**, Gold, Delaware Valley Amateur Astronomers; No. 2, **Michael Hotka**, Silver, Longmont Astronomical Society; No. 3, **Ted Forte**, Silver, Huachuca Astronomy Club; No. 4, **Brad Young**, Silver, Astronomy Club of Tulsa; No. 5, **David M. Douglass**, Silver, East Valley Astronomers

Lunar Observing Program

No. 1033, **Fernando Torres**, The Albuquerque Astronomical Society; No. 1034, **Charles Fry**, Astronomy Enthusiasts of Lancaster County; No. 1035, **Bill Hennessy**, Neville Public Museum Astronomical Society; No. 1036, **Brian McGuinness**, Northern Colorado Astronomical Society; No. 1037, **Carlos Gramajo**, North Houston Astronomy Club; No. 1038, **Joana Tan**, North Houston Astronomy Club

Lunar II Observing Program

No. 89, **Phil Harrington**, Member-at-Large; No. 90, **Linda Huffman**, Member-at-Large; No. 91, **Vincent Giovannoni**, Member-at-Large

MASTER OBSERVER AWARD PROGRAM

Observer Award

William Bogardus, Amateur Observers' Society of New York; **Jean Napp**, Iowa County Astronomers; **Stephen L. Snider**, The Albuquerque Astronomical Society

Master Observer Award

No. 215, **Chuck Stewart**, Rose City Astronomers

Advanced Observer Award

William Bogardus, Amateur Observers' Society of New York

Master Observer Award — Silver

Nora Jean Chetnik, Member-at-Large

Master Observer Award — Platinum

Aaron Clevenson, North Houston Astronomy Club

Binocular Master Observer Award

Mark Simonson, Everett Astronomical Society

Messier Observing Program

No. 2791, **John Remaly**, Regular, The Albuquerque Astronomical Society; No. 2792, **Nicholas Rich**, Regular, Member-at-Large; No. 2793, **Raymond David Whatley**, Regular, Northeast Florida Astronomical Society; No. 2794, **Alfred Schovanez**, Honorary, Astronomical Society of Eastern Missouri; No. 2795, **Craig Lamison**, Honorary, Houston Astronomical Society

Meteor Observing Program

No. 187, **Pamela Lubkans**, 30 hours, Member-at-Large; No. 190, **Fred Schumacher**, 12 hours, Member-at-Large; No. 191, **Gergory T. Shanos**, 6 hours, Local Group of Deep Sky Observers

NEO Observing Program

No. 16, **Jeff Haidet**, Intermediate, Toledo Astronomical Association; No. 17, **Jeff Haidet**, Advanced, Toledo Astronomical Association

Nova Observing Program

No. 1, **Raymond B. Howard**, Gold, Member-at-Large; No. 2, **Michael A. Hotka**, Silver, Longmont Astronomical Society

Outreach Observing Award

No. 560-M, **Robert C. Pettengill Jr.**, Austin Astronomical Society; No. 726-M, **Robert Fish**, Boise Astronomical Society; No. 895-S, **Edward Fraini**, Houston Astronomical Society; No. 926-S, **Aneesa Haq**, Fort Bend Astronomy Club; No. 999-S, **Joel Cohen**, Prescott Astronomy Club; No. 1019-S, **Dewey Barker**, Escambia Amateur Astronomers Association; No. 1025-O, **Nora Jean Chetnik**, Member-at-Large; No. 1026-O, **John E. Swaim**, Central Arkansas Astronomical Society; No. 1027-O, **Teresa Bippert-Plymate**, Big Bear Valley Astronomical Society; No. 1028-O, **Claude Plymate**, Big Bear Valley Astronomical Society; No. 1029-O,

Corinne Shaw, Prescott Astronomy Club; No. 1030-O, **Derek Herrman**, Bartlesville Astronomical Society; No. 1031-S, **Brian McGuinness**, Northern Colorado Astronomical Society; No. 1032-O, **Denise Boyle**, Flint River Astronomy Club; No. 1033-O, **Rick Rader**, Roanoke Valley Astronomical Society; No. 1034-O, **Brett Boller**, Prairie Astronomy Club; No. 1035-O, **David Thomas**, Roanoke Valley Astronomical Society; No. 1036-M, **Linda Hoffmeister**, Olympic Astronomical Society; No. 1037-O, **Paul Oliver Caffrey**, Roanoke Valley Astronomical Society; No. 1038-O, **Matt Allen**, Omaha Astronomical Society; No. 1039-O, **Carolyn Alter**, Rose City Astronomers; No. 1040-O, **Bruce Alter**, Rose City Astronomers; No. 1041-O, **Richard S. Wright Jr.**, Central Florida Astronomical Society; No. 1042-S, **Johnny Scarborough**, Central Texas Astronomical Society; No. 1043-O, **Chris Kagy**, Northern Virginia Astronomy Club; No. 1044-O, **Tracy Beals**, Olympic Astronomical Society; No. 1045-O, **Salvator Jordano**, Prescott Astronomy Club; No. 1046-O, **Steve Johnson**, Big Bear Valley Astronomical Society; No. 1047-O, **Greg Lutes**, Prescott Astronomy Club; No. 1048-O, **Vincent Michael Bournique**, Member-at-Large; No. 1049-O, **Chris Griffin**, Popular Astronomy Club; No. 1050-O, **Liz Sierra-Griffin**, Popular Astronomy Club; No. 1051-O, **Eva Griffin**, Popular Astronomy Club; No. 1052-O, **Mae Smith**, Tucson Amateur Astronomy Association; No. 1053-O, **Gustavo Gomez**, Tucson Amateur Astronomy Association; No. 1054-M, **Dean Ketelsen**, Tucson Amateur Astronomy Association; No. 1055-O, **Cheryl Read**, Tucson Amateur Astronomy Association; No. 1056-M, **Fernando Torres**, The Albuquerque Astronomical Society; No. 1057-O, **Dave Eisfeldt**, Central Texas Astronomical Society; No. 1058-O, **Johnny Barton**, Central Texas Astronomical Society

Planetary Nebula Observing Program

No. 12, Imaging, **John Sikora**, Member-at-Large; No. 35, Basic Manual, **Kevin C. Carr**, Minnesota Astronomical Society

Sky Puppy Observing Program

No. 50, **Dominic Angelo**, Member-at-Large; No. 51, **Gianna Neckel**, Flint River Astronomy Club; No. 52, **Tyler Lavin**, Atlanta Astronomy Club

Two in the View Observing Program

No. 33, **Gordon Pegue**, The Albuquerque Astronomical Society

Urban Observing Program

No. 194, **Alan Scott**, The Albuquerque Astronomical Society; No. 195, **Seth Jelen**, Rose City Astronomers; No. 196, **Benjamin Jones**, The Albuquerque Astronomical Society

Variable Star Observing Program

No. 30, **Chuck Stewart**, Rose City Astronomers

Coming Events

JANUARY 30–FEBRUARY 3

Orange Blossom Special International Star Party, Withlacoochee River Park, Dade City, Florida; *www.stpeteastronomyclub.org/obs.php*

FEBRUARY 2

Regional Meeting of Amateur Astronomers, a.k.a. BoBfest, Catawba Science Center, Hickory, North Carolina; *www.catawbasky.org*

FEBRUARY 4–10

Winter Star Party, Camp Weesumkee, Big Pine Key, Florida; *www.scas.org/home/winterstarparty*

MARCH 31–APRIL 7

OzSky Star Safari (a.k.a. Deepest South Texas Star Safari), Coonabarabran, New South Wales, Australia; *www.ozsky.org*

APRIL 3–6

Mid-South Star Gaze and Astronomy Conference, French Camp, Mississippi; *rainwaterobservatory.org/events*

APRIL 12–13

North Carolina Statewide Star Party – 50 public skywatching events from the North Carolina mountains to the coast; *www.ncsciencefestival.org/starparty*

JUNE 8

Apollo Rendezvous, Miami Valley Astronomical Society, Dayton, Ohio; *www.mvas.org/node/5372*

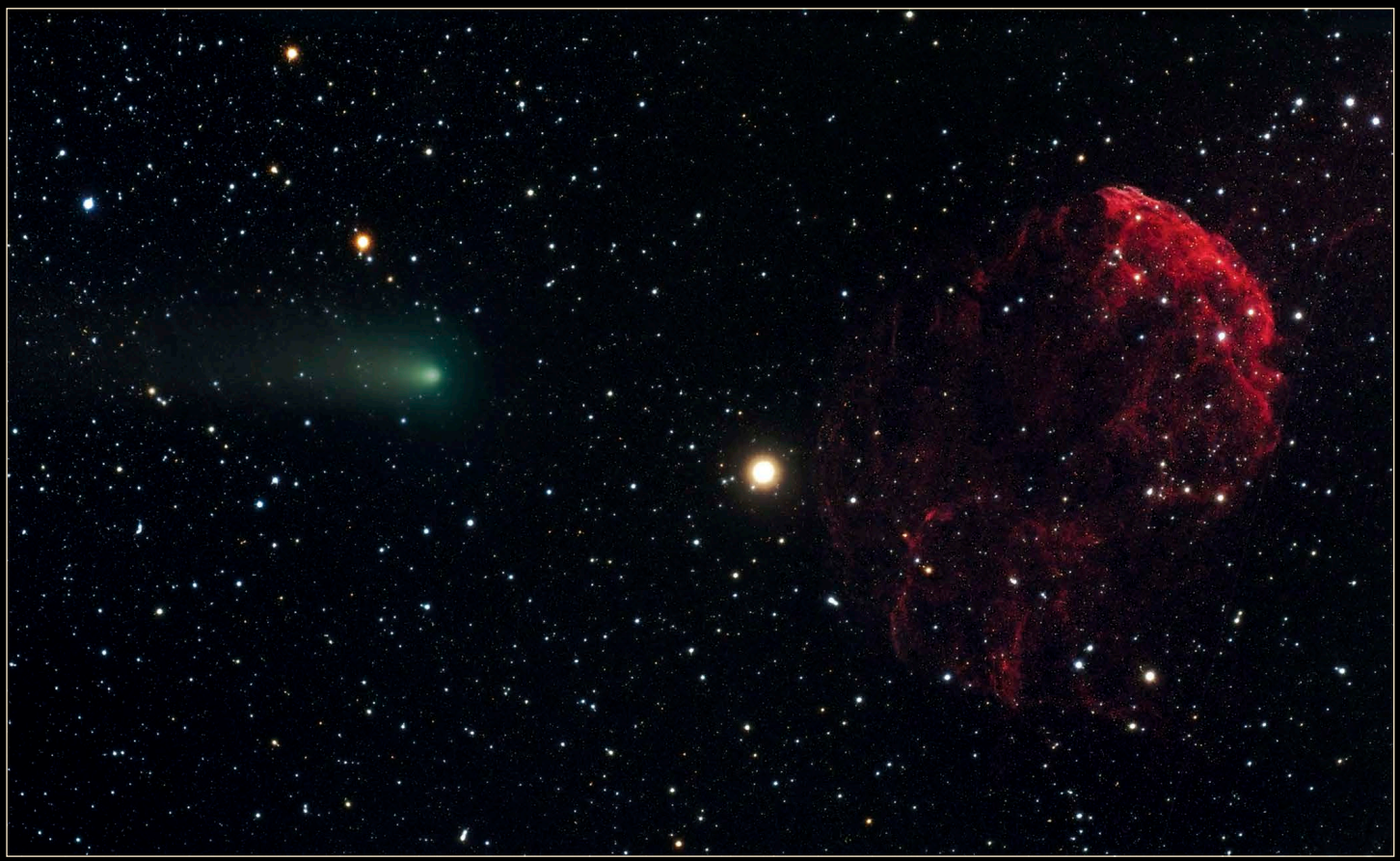
GALLERY

Ryan Jones (Astronomical Society of Eastern Missouri) took this image of M101 from the Danville Conservation Area using an Orion EON 130 refractor with a ZWO ASI1600MM camera on an iOptron CEM60 mount.

Paul Patterson (Greensboro Astronomy Club) took this image of the Iris Nebula (NGC 7023) using a Sky-Watcher Esprit 100 mm ED APO with a ZWO ASI1600MM CMOS camera on an iOptron CEM60EC mount.

GALLERY

Gregg Ruppel (Astronomical Society of Eastern Missouri) took this composite image of Comet 21P/Giacobini–Zinner and M35 from his remote observatory in Animas, New Mexico, with an f/3.8 ASA 10N Astrograph with a SBIG STL-11000M CCD camera.



Steven Bellavia (Amateur Observers' Society of New York) created this image of Comet 21P/Giacobini–Zinner and IC 443 using a William Optics Star 71 with a ZWO ASI183MC CMOS camera on a Celestron AVX mount.

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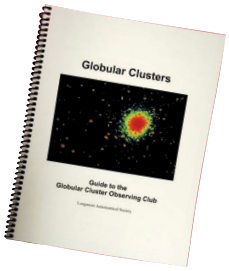

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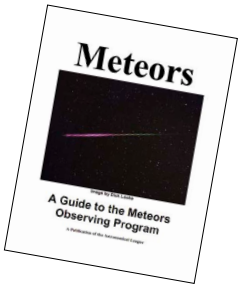

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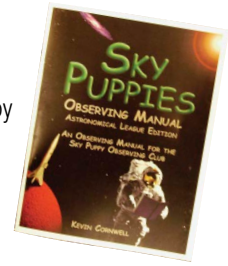

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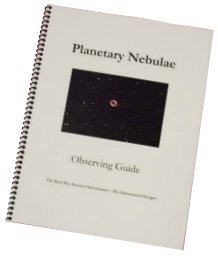

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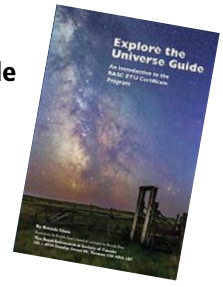

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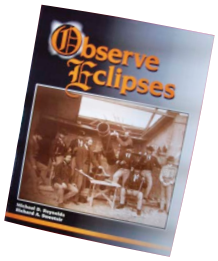

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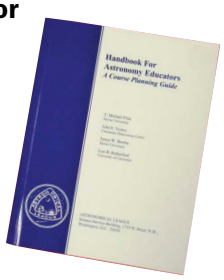

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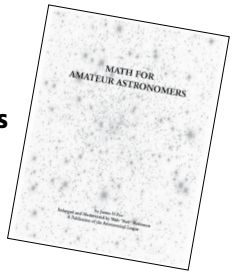

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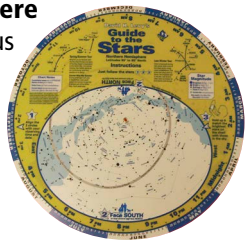

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