

Published by the Astronomical League  
Vol. 71, No. 2 March 2019

# Reflector

REMEMBERING BILL BOGARDUS

PHOTOGRAPHING THE MOON

TREASURES OF THE LINDA HALL LIBRARY

THE COSMIC WEB



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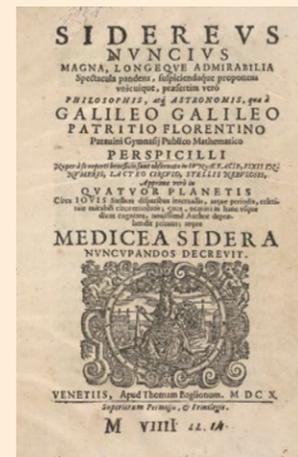
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**Cover image:** Andrew Klinger (Texas Astronomical Society) took this image of M31 from dark sites in Texas and Oklahoma using a William Optics GT81 (reduced to f/4.7, 382 mm) with a ZWO ASI1600MM-Cool CMOS camera.

## Reflector



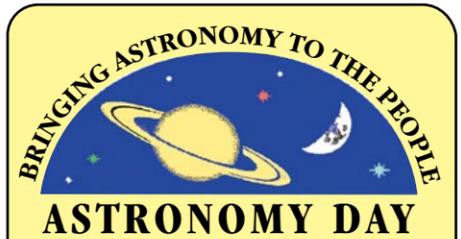
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A NON-PROFIT ORGANIZATION  
To promote the science of astronomy

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

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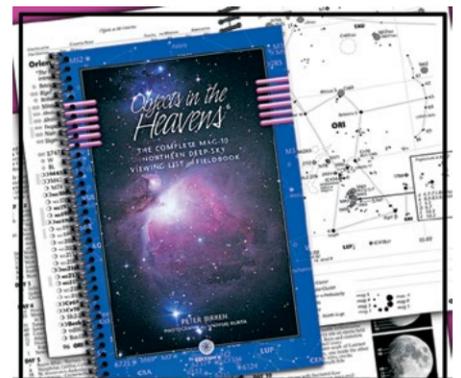
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# Reflector

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|                 |           |
|-----------------|-----------|
| March issue     | January 1 |
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## Reflector Mail

### To the League Board of Directors:

On behalf of the Everglades Astronomical Society, Inc., I want to thank you for bestowing upon our community the Jack Horkheimer Library Telescope.

After much and careful consideration, our board decided to award the telescope to the Collier County Library System. The library has a program that allows each library branch throughout the system to borrow the telescope. This gives access of the telescope to the whole community. In addition, our society and the library are working in partnership to train staff and present astronomy programs to the community.

Our deepest appreciation goes out to all those who have made this gift possible.

—Denise Sabatini

*President, Everglades Astronomical Society*

## 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](mailto:leagueoffice@astroleague.org), ASAP. We are concerned that we haven't heard from you, as the dues were payable several 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!

## President's Corner

As I write this column in early January, my thoughts wander to the previous six months. Bill Bogardus was elected League president in July, the same time I was elected to vice president, Maynard Pittendreigh became executive secretary, and Bill Dillon was elected new treasurer. Four of the five national officers were either elected or appointed and we were all eager and willing to fulfill the duties assigned by our bylaws and to serve the members of the League.

By the end of November, the League president passed away, the vice president became president

(rules of succession per our bylaws), and Carroll Iorg, past president, was appointed the new vice president. This was the first time in our 70+ years that an officer died in office. A very sad time indeed. It was encouraging to see that our bylaws covered such an event, and the positions were filled rather smoothly. We are developing plans for our future growth and look forward to the years ahead.

I want to thank John Goss for his contributions and leadership as president for the past four years and appreciate his wisdom during these trying times. I also wish to thank Carroll Iorg for accepting the role of vice president. His prior experience as both president and vice president made him a logical choice for the appointment.

We are working on ALCon 2019, which Bill Bogardus initially proposed. A unique idea, combining our annual convention with a three-day Bahamas cruise, was readily accepted by the executive council. If you plan to attend, note that most of the rooms on the ship have been filled, and there are only a handful remaining at our very special price. Once the specially priced rooms are gone, the only rooms remaining at that time will be at full retail price.

This ALCon will be different in other ways. The Star-B-Que will be held indoors (Holiday Inn, Titusville, Florida), and will include the awards ceremony and keynote speaker. There will be no banquet and no vendors on the ship (you can order T-shirts and caps on the convention registration form). Three separate registrations are required: for the ship, for the hotel, and for the convention itself. The convention registration form is on our website ([astroleague.org](http://astroleague.org)) and in this issue of the *Reflector*, just like a regular ALCon, but with the addition of the boat rooms. And, just like a regular ALCon, there will be observing...on the ship. Bring your binoculars or small telescopes (there is very limited storage space in the sleeping quarters). Do not bring your 16-inch SCT or 32-inch Dob. Remember, you will be on a moving boat!

We are looking at several new initiatives in the future. One of the most exciting is the securing of grants to fund additional programs within the League. This program is not yet finalized, but we are already looking for a volunteer who has demonstrated success in grant writing at the local, regional, and national level. If you have this talent, check out the "Volunteers Needed" section of From Around the League.

There is another volunteer position available. Our information technology manager, Vern Raben, has decided to retire after many years in this

position with the League. There is an immediate opening for his replacement. If you wish to support your League, requirements are in the From Around the League section, under "Volunteers Needed."

Clear skies and smooth sailing,

—Ron Kramer

*Astronomical League President*

## International Dark-Sky Association

### LIGHTING UP THE NIGHTTIME

Amateur and professional astronomers have long known artificial light at night has to be reduced. The health and ecological effects of light pollution and light trespass are just now being more widely recognized by scientists other than astronomers and a small cadre of biologists concerned about the effects of nighttime lighting on plants, nocturnal animals, and insects.

The November 16, 2018, issue of *Science* has an "Insights" article (pages 744–746) by Kevin J. Gaston of the Environment and Sustainability Institute, University of Exeter, Penryn, Cornwall, United Kingdom, titled "Lighting up the Nighttime: Artificial Light at Night Needs to Be Reduced to Limit Negative Environmental Impacts." This is a very good read and nicely summarizes the negative environmental impact of outdoor nighttime lighting. I highly recommend you read the article, which may be available through your local library. If time and money permit, I also recommend you subscribe to the journals *Science* and *Nature*. (These can also be read for free at many public and academic libraries.) I get both. While I rarely read or understand the main scientific articles in these journals, I thoroughly enjoy the commentaries, editorials, and insight articles that also fill the journals, one of which I am now summarizing.

Images of the nighttime Earth taken by astronauts demonstrate the proliferation of electric lighting from industrial, commercial, municipal, and domestic sources. Nighttime images of Earth from the International Space Station (ISS) are available from many sources, a good one being the YouTube video at [youtube.com/watch?v=ev9oPUNaqXE](https://www.youtube.com/watch?v=ev9oPUNaqXE). These images are thought to provide a good estimate of local population, energy use, urbanization, and economic

activity. According to Gaston, "explicit steps need to be taken to limit these impacts [of artificial light at night], which vary according to the intensity, spectrum, spatial extent, and temporal dynamics of this lighting."

There are two components of artificial light at night: direct emissions from outdoor lighting sources and skyglow. Direct emission of light from unshielded sources can travel for miles, making this light a problem in both urban and rural areas. Skyglow is caused by upward-emitted light that is scattered by dust, gas, and water in the atmosphere. Skyglow is enough to obscure the Milky Way, which may be used for orientation by some nocturnal animals. The bright direct emissions in suburban and urban areas can be strong enough to confuse the diurnal and nocturnal rhythms of many animals. The illuminance levels in urban and suburban areas from direct emission of lighting vary from about 10 to 100 lux. These levels are limited to the immediate vicinity of the emitting source. Bright skyglow is around 0.2 to 0.5 lux, which is not trivial, considering the full moon on a clear night has an illuminance of around 0.1 lux.

Biological responses to lighting are spectrum dependent. A wide spectrum emission increases the likelihood of affecting an organism's sensitive spectral range. Poorly designed high-intensity lighting, particularly that which is bright in the blue end of the visible spectrum, induces a variety of human stress responses, disrupting sleep patterns, sleep quality, and circadian rhythms. It may increase cancer risk. These effects are difficult to study and quantify as it is hard to know the relative importance of outdoor versus indoor lighting, particularly the effects of computer monitors, tablets, and cell phones. For many reasons, it is probably a good idea to reduce our use of screens in the evening before bedtime.

Satellite images of Earth at night show an amazing amount of light shining up into space. Perhaps one-fourth of the global land area of the Earth is covered by skyglow, and over 80 percent of the human population lives under light-polluted skies and most likely is also bothered by various forms of light trespass. I doubt there is any place in the continental United States where you can stand on a tall hill and not see skyglow from a distant town. Certainly most of the population of the United States under the age of 60 has never seen the Milky Way unless they grew up in or traveled to a rural area.

No doubt many if not all migrating birds

are affected by artificial light at night. In some cases, they are attracted to lit buildings, bridges, and towers, endlessly circling them until they become exhausted and fall to the ground. In other instances, they are injured or killed by flying into lit structures. Some birds lose their stellar landmarks, causing them to use more energy than necessary to find their way along their migration paths.

In some regions, there has been a catastrophic loss in insect population compared to earlier decades. The cause and extent of this is unknown, but this phenomenon is just now being studied and is most concerning. Moths that are attracted to light or are mostly active at night may have been especially affected. There is considerable anecdotal evidence that nocturnal light that attracts circling insects alters the balance of the insect population in an area and attracts predators, such as other insects, lizards, and toads, which have an easier time catching prey than previously.

Light pollution tends to decrease over urban areas over the course of the night, while in a more natural environment, the sky becomes lighter as the Moon rises and darker as it sets. This alteration of the natural swings in darkness may affect the biological activity of animals and insects, and it may also alter the flowering and budding of plants. Similar effects are claimed for climate change, and it is unknown how much of that might be from artificial light at night and how much these two forces, artificial light at night and climate change, could affect biological activity in the coming decades.

The "good" aspect of light pollution is that its cause is known and its solution is simple: turn off unnecessary lights. For many years, I have said that if we can't solve light pollution, how do we expect to solve more complex forms of environmental pollution? It is also probable that the negative effects of artificial light at night, when corrected, will result in reasonably fast recovery, compared with the decades it will take for carbon dioxide to be reduced in the atmosphere, even if we stopped emitting it today.

Gaston suggests five major initiatives to ameliorate artificial light at night. First, light should not be introduced casually into areas that are now dark, particularly where dark spaces are rare, such as Western Europe, the eastern United States, and East Asia. Second, the lowest realistic levels of lighting should be used. Third, lighting should be limited to where it is actually required and, fourth, only at times when it is needed, not throughout the night if it is not

required. Fifth, the color quality of the lighting has to be considered, with lower correlated color temperature (less than 2400 K) preferred in most cases.

All in all, this *Science* article summarizes the known and potential environmental harm from artificial light at night. It states the case and recommends societal changes that have long been advocated by those dedicated to fighting light pollution. It is gratifying to see such work prominently displayed in one of the world's foremost scientific publications.

—Tim Hunter  
Co-founder, IDA

## Deep-Sky Objects

### VIRGO'S BEST BARRED SPIRAL GALAXY

Virgo is the second largest constellation by size. It follows Hydra and is slightly larger than third-place Ursa Major. The constellation contains three percent of the celestial sphere. One might think such a large constellation would contain myriad galactic star clusters, wondrous nebulae, a plethora of globular star clusters, and scores of galaxies. But alas, none of the above is true!



When we look at the constellation Virgo, we are looking towards high northerly galactic declinations, almost as far away from the plane of the Milky Way as possible. So there are virtually no galactic star clusters. Of the 677 NGC objects cataloged in Virgo, not one is an open cluster. Virgo has no NGC nebulae and only one globular star cluster (NGC 5634).

Even my above statement of Virgo possibly containing scores of galaxies is off: the constel-

lation does not just contain scores of galaxies; it contains hundreds of galaxies. Almost every one of the 677 NGC objects in Virgo is a galaxy.

Virgo is known for some pretty impressive galaxies. It contains great elliptical galaxies like M84, M86, and M87. It also holds impressive spiral galaxies like the Sombrero Galaxy (M104). Overall there are 11 Messier galaxies in this bountiful constellation.

Two less-mentioned Messier galaxies in Virgo are M58 and M90. These galaxies are the only Messier objects in Virgo classified as barred spiral galaxies. I find M58 to be the more interesting of the two since it appears face-on. This orientation allows for better views of the central bar and spiral arms.

Most spiral galaxies contain a dense core of stars surrounded by spiral arms. Barred spiral galaxies contain a bar of stars with the spiral arms originating from the ends of the bar. Spiral arms typically contain gas and dust as well as numerous nebulae and star clusters. Bars contain just stars and appear to lack gas and dust. Few spiral galaxies more than seven billion years old contain bars, and some astronomers think bars may be a transient, recurring phase in spiral galaxy evolution. Up to two-thirds of modern galaxies may contain bars. Even our home galaxy, the Milky Way, is a barred spiral galaxy.

Charles Messier discovered M58 in 1779. It was one of 14 spiral “nebulae” known to exist before 1850. The galaxy is located near the northern edge of Virgo. It lies about one-third of the way along a line from the star Vindemiatrix (Epsilon Virginis) to the star

Denebola (Beta Leonis). The galaxy lies near and in between several other brighter galaxies: M60, M87, M89, and M90.

Brightness estimates for M58 average around 9.7. The galaxy is 5.5 by 4.5 arcminutes in size. In small telescopes, the galaxy may look similar to its elliptical companions. Eight-inch telescopes will begin to reveal its central bar as well as brighter areas of its spiral arms. The galaxy lies 75 million light-years away, about 50 percent farther

than the other Messier objects surrounding it on the celestial sphere. Were it located at the same distance, it would rival those galaxies in apparent brightness.

My image of M58 was taken with a 10-inch f/6.9 Newtonian using an SBIG ST-2000XCM CCD camera. The exposure was 180 minutes. North is up and east is to the left. To the right of the galaxy lies the brightest star in the image, eighth-magnitude SAO 100179. The faintest stars in the image are dimmer than magnitude 18. The fuzzy “star” located near the lower left corner is spiral galaxy IC 3604, magnitude 15.3.

Note how tightly wound M58's spiral arms are. The spiral arms are not uniform in brightness, resulting in bright arcs rather than complete spiral arms visible to the eye in larger amateur telescopes. The bar appears to have a central bulge, perhaps indicating the galaxy is in transition to or from an ordinary spiral galaxy.

The constellation Virgo offers a smorgasbord of galaxies to view each spring. No menu is complete without spying the constellation's best barred spiral galaxy, M58.

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

## Night Sky Network

### ASTRONOMY TOOLKITS FOR OUTREACH EVENTS

Sidewalk astronomy is one of many types of outreach that clubs perform. Astronomy clubs receive invitations year-round to visit schools, libraries, scout camps, and take part in various community events. Telescopes are usually requested, but often volunteers are also asked to give a talk, share a science demonstration, or otherwise engage with kids in hands-on activities. Events may be scheduled for the middle of the day, inside, or both. Some events, like school STEM fairs, happen rain or shine. The resources provided by the Night Sky Network's outreach toolkits are perfect fits for outreach situations such as these where telescopes might not work out so well, and can even help enrich regular club meetings and stargazing activities right alongside volunteers with telescopes.

Outreach kits are one of the cornerstones of the NSN program. These collections of hands-on activities, handouts, ready-to-use presentations, models, posters, and other demonstrations focus

on a particular space science topic and related NASA missions. A wide variety of resources are packed into each kit. Suggested scripts for individual resources are included in each toolkit to help folks get started – especially useful for those new to outreach – but club members regularly remix and personalize them for their audiences.

Clubs that regularly schedule and log their events to the NSN website receive a new kit every quarter. When clubs receive every available kit, they have the option to request refresher materials to replace lost or damaged items. We try to keep each set of materials contained in one medium-size box to aid in transport and storage. Most of our kits include large, robust vinyl posters. These giant posters are very eye-catching and draw the eyes of curious visitors at outreach events.

We have developed toolkits dedicated to many astronomy topics. The NSN's current kit lineup includes:

- **Exploring the Solar System:** Model planets and dwarf planets are packed into this kit, scaled to match the accompanying 1-meter square vinyl poster of the Sun. These props make for great Solar System walks! The poster's other side features a top-down map of the Solar System on which you can mark the current positions of planets and notable NASA missions.

- **Life in the Universe:** Who doesn't get asked about aliens? This kit features a dive into astrobiology, extremophiles, and the story of life on Earth. The vinyl banner features an Earth timeline activity on one side, and the other side showcases some of the watery worlds of our Solar System. Accompanying “Life in the Extreme” cards help visitors contemplate how life can survive and even thrive in seemingly inhospitable environments.

- **Space Rocks:** Asteroids, comets, and meteorites are the focus of this popular toolkit. The “Meteor-

ites or Meteorwrongs?” activity is one of the most popular demos, in which participants determine which rocks from a selection are from space and which are from Earth. The kit also includes a giant Moon banner highlighting the best lunar features to observe during various lunar phases; the other side highlights impact sites on Earth to facilitate discussions about the potential dangers of near-Earth objects.

- **Our Magnetic Sun:** A favorite companion for solar observing events, this kit is focused on space weather and solar science, and it includes demonstrations on solar storms, ultraviolet radiation, and sunspots. An eye-catching multiwavelength “3-D” solar poster with a detachable model of the Sun is included.

- **Shadows and Silhouettes:** What are eclipses and transits, and how can we observe them? One of our handiest demos is included in this kit: the “Yardstick Eclipse” model, which uses scale models of the Earth–Moon system to allow folks to demonstrate both lunar and solar eclipses. Other activities show how planets are discovered around other stars.

- **Telescopes: Eyes on the Universe:** Why do we put telescopes in space, and how do they enhance and surpass human vision? This kit discusses the science behind telescopes and includes “Why can't we see the flag on the Moon?” an activity demonstrating not just the difference between magnification and resolution, but also the limits of our earthbound telescopes.

- **Glass and Mirrors:** How do telescopes work? How do lenses and mirrors combine to make these incredible tools? This kit contains a portable light bench setup that can be configured to create open models of reflector and refractor style telescopes.

- **Supernova:** What is the life cycle of stars, and how does the death of giant stars both trigger the birth of new stars and create bizarre objects like neutron stars and black holes? How do the objects

commonly observed in a backyard scope fit into the lifecycle of a star? This kit includes a poster illustrating the life cycle of stars as well as a fun, hands-on outreach activity that demonstrates how our atmosphere shields us from dangerous particles and radiation.

None of these kits could have been made without the assistance and feedback of the NSN community during their development. Their tireless real-world testing helped give these resources the extra polish that helps them shine during outreach!

We've made many of our resources available for download on our website. Even if you aren't a member of an NSN club, you can still download, print, and share handouts and other materials and activities for your own outreach. You can check them out by going to the NSN resource page at [bit.ly/nsnresources](http://bit.ly/nsnresources) and searching by keyword, topic, or toolkit. The Night Sky Network is always free to join if your club's volunteers find our resources useful.

—Dave Prosper

Program manager for amateur astronomy outreach at the Astronomical Society of the Pacific in San Francisco, California

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*Astronomical League President*

# William Bogardus

1949 - 2018



Ambassadors Program, and viewing total solar eclipses in China and the South Pacific. Of course, he and his family witnessed the August 21, 2017, eclipse from Casper, Wyoming. It was Bill's image of the solar eclipse in China that graced all Astronomical League commemorative lapel pins and materials for the 2017 spectacle. He also traveled to view the southern skies from Bolivia and Chile and observe auroras from Sweden. His dabbling in astro-photography led to his image of Eta Carinae, below, which earlier appeared on the cover of the June 2015 *Reflector*.

Bill led a big life, playing many parts. He started his community role while in high school in Morristown, New York, by being a guitarist in a local band, The Mustangs. After graduating from SUNY Potsdam, he became a high school physics teacher and eventually a principal. Later, he served as an emergency medical technician, a fire department chief, and a town justice for Morristown and Greenport, New York. Bill was a classic car and airplane enthusiast.

He obtained his pilot's license and taught as an instrument rated certified flight instructor. He was an aspiring apiarist.

Surviving are his wife, Kim S. Palermo-Bogardus; three daughters: Nicole (Andrew) LaPlante, Peru, New York, Mandy Bogardus, Saranac Lake, New York, and Katie (Tim) Kyle, Wethersfield, Connecticut; one stepson, Dave (Jesse Heider-Ayling) Ayling, Toledo, Ohio; one stepdaughter, Becca Bley, Cheektowaga, New York; four grandchildren; three brothers: James (Penny) III, Morristown, New York, Bob (Helga), Holly Springs, North Carolina, and John (Fran), Delmar, New York; one sister, Ann (David) Fenlong, DeKalb Junction, New York; and several nieces, nephews, and cousins.

Amateur astronomy and the communities he called home were lucky to have had Bill Bogardus play very active roles. His star will always shine brightly in our hearts. Bill is and will be sorely missed. ★

—John Jardine Goss

*Past President, Astronomical League*



Astronomical League president Bill Bogardus passed away on Saturday, November 24, after a year-long illness. His wife, Kim, was at his side, and members of his family had comforted him over the Thanksgiving holidays.

Bill had been in active service to the Astronomical League ever since he received his Master Observer plaque at ALCon 2006 in Arlington, Texas. He often remarked that his experiences at that event led him to actively participate in the Astronomical League. He encouraged his club, the Amateur Observers' Society of New York, to host ALCon 2009. After chairing that conven-

tion, he ran for Astronomical League office, becoming secretary in 2009, then vice president in 2014. This past summer, Bill was elected Astronomical League president.

In addition to his leadership roles in the League, he created and administered the Radio Astronomy Observing Program and revitalized and administered the Master Observer Plaque Program. In 2013, Bill received the G.R. Wright Award for Outstanding Service to the Astronomical League.

A few of his astronomy-related but non-League activities included being chosen in 2016 for the Astronomy in Chile Educator

## ALCON 2019 Registration Information:

July 24, 25, 26, 27, 28 & 29



Mail completed form with your check made payable to **ALCON 2019** to:  
Astronomical League, ALCON 2019  
9201 Ward Parkway, Suite 100  
Kansas City, MO 64114

Please use one form for each attendee. One check is acceptable for your group. You may also register at [alcon2019.astroleague.org](http://alcon2019.astroleague.org) and make remittance with PayPal.

**Wed. and Thu. hotel accommodations:  
Holiday Inn Titusville: (321) 383-0240**

Name: \_\_\_\_\_

Name and Title for ALCon badge \_\_\_\_\_

Email address: \_\_\_\_\_

Mailing address: \_\_\_\_\_

City: \_\_\_\_\_ State: \_\_\_\_\_

Telephone: \_\_\_\_\_

Astronomical League Club Affiliation, or MAL or Lifetime, or Patron?

### Registration Schedule

Please enter your registration amount.

|                       |             |              |
|-----------------------|-------------|--------------|
|                       | AL Member   | Non-AL mem.  |
| Individual :          | (\$60)_____ | (\$100)_____ |
| Couples registration: | (\$90)_____ | (\$130)_____ |
| Students:             | (\$20)_____ |              |

Children under 12 years of age who accompany registered adults: FREE registration. (They will need to pay for the optional KSC tour, however.) Please give their names for ID badges.

**If you are booked on the Royal Carribean cruise, you MUST also register for ALCon.**

To reserve your cruise cabin aboard the Royal Carribean ship with a \$100 deposit, please contact Marsha at Lin-Mar Travel, 631-736-1049, [marsha@travelwithlin-mar.com](mailto:marsha@travelwithlin-mar.com)

**Remember: All cruise passengers must have a passport valid through January 2020!**

### ALCon 2019 Registration Summary

|   |
|---|
| Registration_____ +   |
| Star BQ and Awards Ceremony on Thursday night (\$38)_____ + |
| Kennedy Space Center Tour Adult (\$70)_____ +               |
| Children (\$60)_____ +                                      |
| Friday Bus to Pier (\$36 per person, round trip)_____ +     |
| League Donation (Thank you!)_____ =                         |
| <b>Grand Total: \$_____</b>                                 |

Thursday July 25 **Kennedy Space Center Tour and Bus** (\$70 per person 12 years & older; \$60 for 3 - 11 years old)  
Total: (\$70 per person 12 & older, \$60 under 12) \$ \_\_\_\_\_

Thursday Night Star-B-Que and Awards Ceremony, Holiday Inn: (\$38 per person) \$ \_\_\_\_\_  
Keynote Speaker Derek Demeter

Are you an AL Master Observer?\_\_\_\_\_, if yes # \_\_\_\_\_

Have you already received a Master Observer plaque? \_\_\_\_\_

**Please help the League help amateur astronomy** by making a tax deductible donation! \$ \_\_\_\_\_

*The organizers reserve the right to make changes to the event as necessary due to circumstances beyond their control.*

# FROM AROUND THE LEAGUE



## DAMIAN A. PEACH WINS 2018 LESLIE C. PELTIER AWARD

Damian A. Peach, FRAS, is a British amateur astronomer, astrophotographer, lecturer, and author. He is best known for his photographs of a variety of astronomical objects, and his career in the field spans nearly thirty years.

Peach's passion for astronomy began in 1988 when he was inspired by books in his school library. Twelve years later, he joined the British Astronomical Association, and since then has contributed many observations to its various observing sections. He has also written and coauthored many papers in the organization's journal.

He has provided astronomical images for magazines and books throughout his career. His images and articles on astrophotography have been featured in *Astronomy*, *Sky & Telescope*, *Astronomy Now*, and *Sky at Night* magazines.

He was a coauthor on several professional scientific papers on planetary astronomy, with a special focus on Mars and Jupiter.

Peach's work has been used by NASA and ESA to illustrate what ground-based telescopes can achieve in photographing the planets and the support they

can provide to professional space probe missions.

Congratulations, Damian, for receiving the 2018 Leslie Peltier Award!

## 2019 PELTIER AWARD NOMINATIONS OPEN

The Astronomical League's Leslie C. Peltier Award committee requests nominations for 2019.

The award was established in 1980 to honor the man Harlow Shapley once called "the world's greatest living amateur astronomer." It is presented to an amateur astronomer who has contributed to astronomical observations of lasting significance.

Scott Roberts of Explore Scientific generously sponsors the award, which is presented annually at ALCon. Details of the award, and a list of past recipients, may be found on the Astronomical League webpage at [astroleague.org/al/awards/peltier/peltiers.html](http://astroleague.org/al/awards/peltier/peltiers.html).

Nominations must be received before April 1, 2019. Unsuccessful nominations will be kept on file for consideration in subsequent years.

Nominations may be sent to the committee chair, Roger S. Kolman, PhD, at [rskolman@abcglobal.net](mailto:rskolman@abcglobal.net).

## ASTRONOMICAL LEAGUE'S 2018 MABEL STERNS NEWSLETTER EDITOR AWARDS

Mabel Sterns was the Astronomical League's first newsletter editor and this is the seventeenth year of granting the Newsletter Editor Award in her honor. The award recognizes one of the most important people in any club, a person who is a primary source of beneficial

information to club members: the newsletter editor.

Most of the time, newsletter editors don't get much recognition for their steady task of keeping the membership informed about what goes on in their astronomy clubs. They publish newsletters, despite often not having enough material to fill the edition, magically creating interesting articles at the last minute.

With this competitive award, the strengths and weaknesses of each newsletter must be weighed. Many attributes might be considered, from specific forms of content such as membership information, meeting information, or astronomical calendars to more subjective ones such as the appearances of its masthead and layout.

The 2018 Mabel Sterns Newsletter Editor Award winners were:

- 1st place: **Terry Dufek**, Popular Astronomy Club
- 2nd place: **Brian Thieme**, Warren Astronomical Society
- 3rd place: **Dave Thomas**, Roanoke Valley Astronomical Society

## THE 2019 WEBMASTER AWARD

The Astronomical League's Webmaster Award acknowledges the club webmaster who does an outstanding job of website design and maintenance.

- The webmaster of any current Astronomical League member club is eligible.
- The website will be judged on its content, appearance, ease of navigation, and ability to attract people.
- Club presidents, please send webmaster nominations and the

club's website address by April 1 to [webmaster@astroleague.org](mailto:webmaster@astroleague.org).

## DEADLINE APPROACHES FOR THE 2019 MABEL STERNS NEWSLETTER EDITOR AWARD

The Mabel Sterns Newsletter Editor Award recognizes the work of club newsletter editors across the country. The deadline for submissions is March 31, 2019. The nomination package should contain a letter from the club president or vice president telling why their newsletter editor should be considered for the award, a recent issue of the newsletter, and a photo of the newsletter editor, preferably taken in an astronomical setting. Including the URL where electronic copies of past newsletters are posted on the club's website would also be helpful. In addition, the postal address of the newsletter editor should be included. The names of both the newsletter editor and the nominating club officer must appear on the general membership roster of the Astronomical League. The newsletter nomination materials may be submitted by any of these three methods:

1. The preferable method is emailing the materials. The supporting club letter and an issue of the newsletter should be attached in Adobe PDF format, although Microsoft Word format is acceptable. The editor's photograph should be attached as a high-resolution JPEG file. Please email entries to [SternsNewsletter@astroleague.org](mailto:SternsNewsletter@astroleague.org).
2. If electronic submission is impossible, paper copies may be mailed through the postal service to the League's national office. Four copies of the letter of recommendation and four copies of the

newsletter are required. Only one copy of the photograph is needed.

3. If the newsletter is available on the club's website, then its web address (URL) should be given along with any password required to access it. The editor's photograph (JPEG) and club recommendation letter (PDF) can be submitted in an email as instructed in method 1.

It is strongly recommended that the Astronomical League's logo be prominently displayed in the newsletter, preferably on the front page.

For complete information about the 2019 Mabel Sterns Newsletter Editor Award program, please see [astroleague.org/al/awards/sterns/sternss.html](http://astroleague.org/al/awards/sterns/sternss.html).

## 2018 ASTRONOMICAL LEAGUE WEBMASTER AWARD WINNER

Congratulations to **Shawn Loescher** and **Curt Lambert** of the Back Bay Amateur Astronomers ([backbayastro.org](http://backbayastro.org)) on their selection as the winners of the 2018 Astronomical League Webmaster Award.

The selection committee evaluated the submitted websites on their content, ease of navigation, and ability to attract people. The Back Bay Amateur Astronomers are fortunate to have such a wonderful and informative website.

## 2018 ASTRONOMY DAY WINNERS

- Large Metro Area, \$150: No winner
- Medium Metro Area, \$150: **Roanoke Valley Astronomical Society**
- Small Metro Area, \$150: **Travelers Science Dome at the Gengras Planetarium**
- Best New Idea, \$50: **Roanoke Valley Astronomical Society**

Astronomy Day presents an excellent opportunity to increase science awareness in an interest-

ed 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 for these helpful Astronomy Day materials: the Astronomy Day Handbook ([astroleague.org/al/astroday/astrobook.html](http://astroleague.org/al/astroday/astrobook.html)) and Outreach Downloads ([astroleague.org/content/outreach-downloads-astronomical-league](http://astroleague.org/content/outreach-downloads-astronomical-league)).

If you would like to help administer this great program of bringing astronomy to the people, please contact Gary Tomlinson, [gtomlins@sbcglobal.net](mailto:gtomlins@sbcglobal.net).

Astronomy Day 2019: May 11 and October 5!

# Volunteers Needed

## CHAIR OF THE ASTRONOMICAL LEAGUE WEBMASTER AWARD

The Astronomical League is seeking a qualified individual who would like to chair the Webmaster Award. Duties for this position include placing announcements in the *Reflector* and in social media, assembling a team of judges, collecting the nominations, reviewing the eligibility of the nominees, sending nomination materials to the judges, tallying the results, notifying the winner, writing a brief announcement for the *Reflector* and social media, and ordering and mailing the award plaque.

This is your chance to help the Astronomical League help amateur astronomy by recognizing some of those individuals who make astronomy happen. Interested? Please contact either AL immediate past president John Goss, [goss.john@gmail.com](mailto:goss.john@gmail.com), or

AL interim vice president Carroll Iorg, [vicepresident@astroleague.org](mailto:vicepresident@astroleague.org).

## INFORMATION TECHNOLOGY MANAGER

After 12 years, the League's information technology manager is retiring. We have immediate openings for candidates with experience in:

- Unix/Linux and the Ubuntu operating system
- Configuring firewalls and host-based intrusion detection systems (HIDS)
- Apache web server configuration and SSL certificates
- Administration of a Drupal content management system and programming Drupal modules

Contact [president@astroleague.org](mailto:president@astroleague.org) if you are willing to take on this challenge.

## GRANT WRITER

We have a new volunteer position for a grant writer. The qualified individual will have demonstrated success in writing and securing financial grants at the local, regional, corporate, and national levels. These grants will enable your League to develop additional programs in outreach, observing programs, expansion of the *Reflector*, STE(A)M, and a host of other projects. The League does many things with an annual budget of about \$100,000. Imagine what we could do with an additional \$25,000 or \$50,000 per year – literally, the sky's the limit! Contact [president@astroleague.org](mailto:president@astroleague.org) if you can assist.

## CALL FOR LEAGUE OFFICER NOMINATIONS

The two-year term of the office of secretary, and the three-year term of the office of executive secretary, end on August 31, 2019. (The one-year appointment of the current executive secretary ends on August 31.)

If you are interested in using your talents to serve in one of these important positions, we would like to hear from you. Please volunteer!

For specific information regarding the duties and responsibilities of these two offices, please refer to the League's bylaws, which can be accessed on the League website at [astroleague.org](http://astroleague.org).

Candidates should send the nominating committee chair, Carroll Iorg, [vicepresident@astroleague.org](mailto:vicepresident@astroleague.org), background statements explaining why they are interested along with a photo of themselves for publication in the *Reflector*. Please limit statements to approximately 250 words. All nomination materials must be submitted by March 31, 2019.

## ASTRONOMICAL LEAGUE OFFICER SUCCESSION

William Bogardus, 34th president of the Astronomical League, passed away on Saturday, November 24. He was active in the Astronomical League since 2006 and held the offices of secretary and vice president. He was elected president this past summer and began his term on September 1. The Astronomical League was very fortunate to have him as an active member and as an officer. Bill will be missed.

Astronomical League bylaws provide a course for officer succession in the event of the death of the president:

1. Article II, Sect. 4.b. "The Vice-President shall assist the President in the discharge of his/her duties and perform them in the case of absence, death, disability or resignation of the President."

2. Article II, Sect. 4.f. "In the event of death, resignation or disability of any executive officer other than the President, the

President shall appoint a successor to fill the unexpired term.”

3. Article II, Sect. 3.c. “For purposes of this subsection appointment or succession to an office with more than one (1) year remaining in an term shall be regarded as a term of office.”

Following the succession outlined in the bylaws, AL vice president Ron Kramer became the 35th president of the Astronomical League effective November 24. This will begin his first term holding that office. President Kramer has appointed Carroll Iorg to serve as vice president.

## Astronomy Outreach Through Social Media

At 40 years old and a member of Generation X, I bridge the gap between a time when the Internet did not exist and an increasingly Internet-connected world. Social media is the next exciting frontier on the Internet where the younger generation lives. Unfortunately, amateur astronomy is having difficulty connecting with young people via outreach through social media. I would like to share with you the



ways in which I have found success engaging with young people, primarily those at the college level, using social media.

Younger generations do not use email as much as their predecessors. Even college professors face difficulty reaching students via email, so amateur astronomers should not make the same mistake. Sharing information through email and text messages is being replaced by sharing on social media platforms.

**It is time for amateur astronomers to become familiar with how to use Instagram, Facebook, Snapchat, GroupMe, and YouTube for outreach.** For instance, Snapchat allows location-based video sharing via a heat map interface that can be used to publicly promote an event as it is happening. Facebook, Instagram,

and YouTube all have live video streaming options by which you can share astronomy virtually in real time. The Baton Rouge Astronomical Society, to which I belong, uses Facebook to live stream the Moon at public events. Many college students use GroupMe for classes, so they already have the app on their phones. I use GroupMe to announce observing sessions and satellite passes. Sharing an event on social media can reach more people than those that can attend in person, especially if the link is shared widely.

The most important step toward introducing young people to astronomy is to go directly to them. Set up in places they frequent, even if light pollution is a problem. Be proactive in bringing people to the eyepiece by clearly

and excitedly announcing what you are showing. Next, make it possible for them to share photos via social media. Attach a universal phone cradle to an eyepiece for taking photos of targets like the Moon or planets. Always let passersby know you are specifically set up for sharing photos to Instagram, Facebook, or Snapchat. Allow them to take photos themselves, so they can say “I took that photo,” but assist if necessary.

**What you think you know about young people may not be true, nor will it be consistent from one year to the next.** They do love space and astronomy. Neil deGrasse Tyson is a superstar to younger generations, after all. Embrace live streaming as an alternative to traditional outreach. Share your own astronomy images via these same platforms. Keep people coming back by inviting them to follow you on social media. Your enthusiasm must be both contagious and Internet-connected. Go forward with the idea that we cannot reach everyone, but, as advocates for the scientific community, we have an obligation to introduce young people to astronomy through social media.

—Coy Wagoner

Baton Rouge Astronomical Society

## AAVSO



**American Association of Variable Star Observers**

*Discover the universe through variable stars and contribute to science*

**Join today!**

[www.aavso.org](http://www.aavso.org)

## Staunton River Star Party - Spring 2019

IDA Dark Park

\*March 4 - 10, 2019\*

New Dates – A Full Week

Staunton River State Park  
Scottsburg, VA (near South Boston)

Fall Star Party October 21 – 27, 2019

For more information or to register: [www.stauntonriver-starparty.org](http://www.stauntonriver-starparty.org)

Full Party: \$70
Weekend: \$35
Sponsored by: CHAOS

## Observing Awards

### Advanced Binocular Double Star Observing Program

No. 31, **Don Knabb**, Chester County Astronomical Society; No. 32, **Michael C. Neal**, Echo Ridge Astronomical Society

### Arp Peculiar Galaxies Northern Observing Program

No. 91-V, **Jeff Hoffmeister**, Olympic Astronomical Society

### Asterism Observing Program

No. 48, **Charles E. Allen III**, The Evansville Astronomical Society; No. 49, **Douglas Smith**, Tucson Amateur Astronomical Society

### Asteroid Observing Program

No. 52, **Vincent Michael Bournique**, Regular, Lifetime Member; No. 53, **Tom Gazzillo**, Regular, Chesmont Astronomical Society

### Beyond Polarix

No. 19, **Michael C. Neal**, Echo Ridge Astronomical Society; No. 20, **Carlos Gramajo**, North Houston Astronomy Club; No. 21, **Joana Tan**, North Houston Astronomy Club

### Binocular Double Star Observing Program

No. 138, **Matt Allen**, Omaha Astronomical Society; No. 139, **Charles E. Allen III**, Evansville Astronomical Society; No. 140, **Edward Swaim**, Central Arkansas Astronomical Society; No. 141, **Jerelyn Ramirez**, Kansas Astronomical Observers; No. 142, **Kristine Larsen**, Springfield Telescope Makers

### Binocular Messier Observing Program

No. 1155, **Ken Wilson**, Richmond Astronomical Society; No. 1156, **Dan Delzell**, Prairie Astronomy Club; No. 1157, **Fernando Torres**, The Albuquerque Astronomical Society

### Binocular Variable Star Observing Program

No. 32, **Becky Ramotowski**, The Albuquerque Astronomical Society

### Caldwell Observing Program

#### SILVER AWARDS

No. 251, **Steve Goldberg**, Houston Astronomical Society; No. 252, **Alfred Schovanez III**, Astronomical Society of Eastern Missouri; No. 253, **Alan Scott**, The Albuquerque Astronomical Society; No. 254, **Seth Jelen**, Rose City Astronomers; No. 255, **Charles E. Allen III**, Evansville Astronomical Society

#### GOLD AWARDS

No. 31, **Alan Scott**, The Albuquerque Astronomical Society

### Carbon Star Observing Program

No. 97, **Robert Harrison**, Patron Member; No. 98, **Stephen L. Snider**, The Albuquerque Astronomical Society

### Comet Observing Program

No. 102, **Ed Valla**, Silver, Tallahassee Astronomical Society; No. 103,

**Stephen Andrews**, Silver, Kern Astronomical Society; No. 41, **George J. Robinson**, Gold, Member-at-Large

### Deep Sky Binocular Observing Program

No. 403, **Daniel Otte**, Southern Oregon Skywatchers; No. 404, **Charles E. Allen III**, Evansville Astronomical Society

### Double Star Observing Program

No. 617, **DeWayne Carver**, Tallahassee Astronomical Society; No. 618, **Steve Benham**, Rose City Astronomers; No. 619, **Will Young**, Astronomical Society of Southeast Texas; No. 620, **Doug Lively**, Raleigh Astronomy Club

### Flat Galaxy Observing Program

No. 34, **Marie Lott**, Honorary, Atlanta Astronomy Club; No. 35, **Mark Simonson**, Honorary, Everett Astronomical Society

### Globular Cluster Observing Program

No. 316-V, **Alfred Schovanez III**, Astronomical Society of Eastern Missouri; No. 317-V, **William Kocken**, Minnesota Astronomical Society; No. 318-V, **Russell Carpenter**, Sonora Astronomical Society; No. 319-V, **Robert Harrison**, Patron Member; No. 320-V, **Lisa Wentzel**, Twin City Amateur Astronomers

### Lunar Observing Program

No. 1039, **Michael R. Martin**, Roanoke Valley Astronomical Society; No. 1040, **Charles E. Allen III**, Evansville Astronomical Society; No. 1041, **Allen Klus**, Tucson Amateur Astronomy Association; No. 1042-B, **Rick Eberhart**, Binocular, Rose City Astronomers; No. 1043, **Stephen Rand**, New Hampshire Astronomical Society; No. 1044, **Mike Reitmayer**, Rose City Astronomers; No. 1045, **Jason Brant Dodson**, NASA Langley Exchange Skywatchers; No. 1046, **Angelo Serra**, Member-at-Large

### Mars Observing Program:

No. 1, **W. Maynard Pittendreigh**, Lifetime Member; No. 2, **Mark Simonson**, Everett Astronomical Society; No. 3, **Aaron Clevenson**, North Houston Astronomy Club

### Master Observer Award

#### OBSERVER

**Daniel Otte**, Southern Oregon Skywatchers

#### MASTER OBSERVER

No. 216, **Charles E. Allen III**, Evansville Astronomical Society

#### BINOCULAR MASTER OBSERVER

**Steve Boerner**, Member-at-Large; **Nora Jean Chetnik**, Member-at-Large; **Rakhal Kincaid**, Haleakala Amateur Astronomers; **Al Lamperti**, Delaware Valley Amateur Astronomers; **David Whalen**, Atlanta Astronomy Club

### Messier Observing Program

No. 2787, **Mike Reitmayer**, Honorary, Rose City Astronomers; No. 2796, **Brian McGuinness**, Regular, Northern Colorado Astronomical Society; No. 2797, **Phyllis Eide**, Regular, Spokane Astronomical Society

### NASA Observing Challenge – InSight

**Steve Boerner**, Member-at-Large; **Scott Cadwallader**, Baton Rouge Astronomical Society; **Aaron Clevenson**, North Houston Astronomy Club; **Dan Crowson**, Astronomical Society of Eastern Missouri; **W. Maynard Pittendreigh**, Lifetime Member; **Gregory T. Shanos**, Local Group of Deep Sky Observers; **Mark Simonson**, Everett Astronomical Society

### Nova Observing Program

No. 3, **W. Maynard Pittendreigh**, Silver, Lifetime Member; No. 4, **Michael A. Hotka**, Gold, Longmont Astronomical Society; No. 5, **W. Maynard Pittendreigh**, Gold, Lifetime Member; No. 6, **Brad Young**, Gold, Astronomy Club of Tulsa

### Outreach Observing Award

No. 498-M, **Steve Layman**, Charlottesville Astronomical Society; No. 513-S, **Susie Stahlhut**, Northeast Florida Astronomical Society; No. 536-S, **Steve Arthurton**, Oklahoma City Astronomy Club; No. 543-S, **David Huntz**, Oklahoma City Astronomy Club; No. 547-S, **William Murrell**, Oklahoma City Astronomy Club; No. 608-S, **Russ Wheeler**, Oklahoma City Astronomy Club; No. 695-S, **Ed Averyt**, Oklahoma City Astronomy Club; No. 701-S, **Chris Petroff**, Oklahoma City Astronomy Club; No. 760-S, **Joe Khalaf**, Houston Astronomical Society; No. 767-M, **Stephen H. Rand**, New Hampshire Astronomical Society; No. 797-M, **Donald Morris**, Fort Bend Astronomy Club; No. 817-M, **Charles Hale**, Fort Bend Astronomy Club; No. 849-O, **Rand Bowden**, Roanoke Valley Astronomical Society; No. 864-S, **Anika Patel**, Fort Bend Astronomy Club; No. 865-S, **Sanjiv Patel**, Fort Bend Astronomy Club; No. 945-S, **Jeff Bennett**, Fort Bend Astronomy Club; No. 948-S, **Michael Neal**, Echo Ridge Astronomical Society; No. 995-S, **Patrick Birck**, Prescott Astronomy Club; No. 998-S, **Jerry Shaw**, Prescott Astronomy Club; No. 1009-S, **Scott Cadwallader**, Baton Rouge Astronomical Society; No. 1014-S, **Andy Flowers**, Tallahassee Astronomical Society; No. 1017-S, **Stephen L. Snider**, The Albuquerque Astronomical Society; No. 1021-S, **Ed Magowan**, Escambia Amateur Astronomers Association; No. 1059-O, **Joshua Johnson**, Big Bear Valley Astronomical Society; No. 1060-O, **Peter Detterline**, Member-at-Large; No. 1061-O, **Jim McDowell**, Prescott Astronomy Club; No. 1062-O, **Gregory T. Shanos**, Local Group of Deep Sky Observers and Museum Astronomical Resource Society; No. 1063-O, **Dwight Willman**, Prescott Astronomy Club; No. 1064-O, **Daniel Otte**, Southern Oregon Sky Watchers; No. 1065-O, **Paul Jones**, Ancient City Astronomy Club; No. 1065-S, **Paul Jones**, Ancient City Astronomy Club; No. 1065-M, **Paul Jones**, Ancient City Astronomy Club; No. 1066-O, **Robin Jones**, Ancient City Astronomy Club; No. 1066-O, **Josh Jones**, Ancient City Astronomy Club; No. 1067-O, **Anil Ketkar**, Fort Bend Astronomy Club; No. 1068-O, **Annabella Quesada**, Fort Bend Astronomy Club; No. 1070-O, **Sonny Manley**, Fort Bend Astronomy Club; No. 1071-O, **Mark Chapman**, Minnesota Astronomical Society; No. 1072-O, **John Walker**, Escambia Amateur Astronomers Association; No. 1073-S, **Dennis H. Hausch**, Escambia Amateur Astronomers Association; No. 1074-O, **David Decker**, San Diego Astronomy Association; No. 1075-O, **Graham Smith**, Fort Bend Astronomy Club; No. 1076-O, **Glenn Smith**, Fort Bend Astronomy Club; No. 1077-O, **Annie Wargetz**, Fort Bend Astronomy Club; No. 1078-O, **Tina Fraizer**, Oklahoma City Astronomy Club; No. 1079-O, **Tony Fraizer**, Oklahoma City Astronomy Club; No. 1080-O, **Andy Fryhover**, Oklahoma City Astronomy Club; No. 1081-O, **Mike Mitchell**, Oklahoma City Astronomy Club; No. 1082-O,

**Raymond Petroff**, Oklahoma City Astronomy Club; No. 1083-O, **Richard Mannarino**, Escambia Amateur Astronomers Association; No. 1084-O, **Daryl Stager**, Member-at-Large; No. 1085-O, **Ed LaBelle**, Psalm 19 Astronomy Society; No. 1085-M, **Ed LaBelle**, Psalm 19 Astronomy Society; No. 1086-O, **Chris Lasley**, Central Arkansas Astronomical Society; No. 1087-O, **Jane Wood**, Ancient City Astronomy Club; No. 1088-O, **Jeffrey Corder**, Ancient City Astronomy Club; No. 1089-O, **Joe Komiathy**, Ancient City Astronomy Club; No. 1090-O, **Judy Dolehanty**, Ancient City Astronomy Club; No. 1091-O, **Kalwant Grewal**, Ancient City Astronomy Club; No. 1092-O, **Lilian Rodriguez**, Ancient City Astronomy Club; No. 1093-O, **Linda Paul**, Ancient City Astronomy Club; No. 1094-O, **Lisa Baird**, Ancient City Astronomy Club; No. 1095-O, **Lyle Guzman**, Ancient City Astronomy Club; No. 1096-O, **Lynne Pouliot**, Ancient City Astronomy Club; No. 1097-O, **Margy Lang**, Ancient City Astronomy Club; No. 1098-O, **Mike Napper**, Ancient City Astronomy Club; No. 1099-O, **Neal Brown**, Ancient City Astronomy Club; No. 1100-O, **Robert Huerbsch**, Ancient City Astronomy Club; No. 1101-O, **Rod Paul**, Ancient City Astronomy Club; No. 1102-O, **Sharon Flemings**, Ancient City Astronomy Club; No. 1103-O, **Skip Whitford**, Ancient City Astronomy Club; No. 1104-S, **Beth Mansbridge**, Ancient City Astronomy Club; No. 1105-S, **Bob Wolski**, Ancient City Astronomy Club; No. 1106-O, **David Penney**, Ancient City Astronomy Club; No. 1107-O, **Gary Charnoski**, Ancient City Astronomy Club; No. 1108-O, **Amy Dornier**, Astronomical Society of Southeast Texas; No. 1109-O, **Doug Dornier**, Astronomical Society of Southeast Texas

### Planetary Nebula Observing Program

No. 36, **Alfred Schovanez III**, Basic, Manual, Astronomical Society of Eastern Missouri; No. 73, **Valorie Whalen**, Advanced, Atlanta Astronomy Club

### Radio Astronomy Observing Program

No. 19-S, **Fred Schumacher**, Member-at-Large; No. 20-S, **Dennis Farr**, Museum Astronomical Resource Society; No. 21-S, **Mike Stewart**, Astronomical Society of Kansas City; No. 10-G, **Aaron Clevenson**, North Houston Astronomy Club

### Sketching Observing Award

No. 29, **George J. Robinson**, Member-at-Large; No. 30, **Thomas Baskins**, Central Arkansas Astronomical Society; No. 31, **Peter Detterline**, Member-at-Large; No. 32, **Charles E. Allen**, Evansville Astronomical Society

### Sky Puppy Observing Program

No. 52, **Jakob Ridings**, Houston Astronomical Society; No. 53, **Danielle Emmons**, Member-at-Large; No. 54, **Miles Grzyb**, Member-at-Large; No. 55, **Matthew Palmeri**, Kansas Astronomical Observers; No. 56, **Alaina Bruce**, Kansas Astronomical Observers; No. 57, **Evelyn Bruce**, Kansas Astronomical Observers

### Two in the View Observing Program

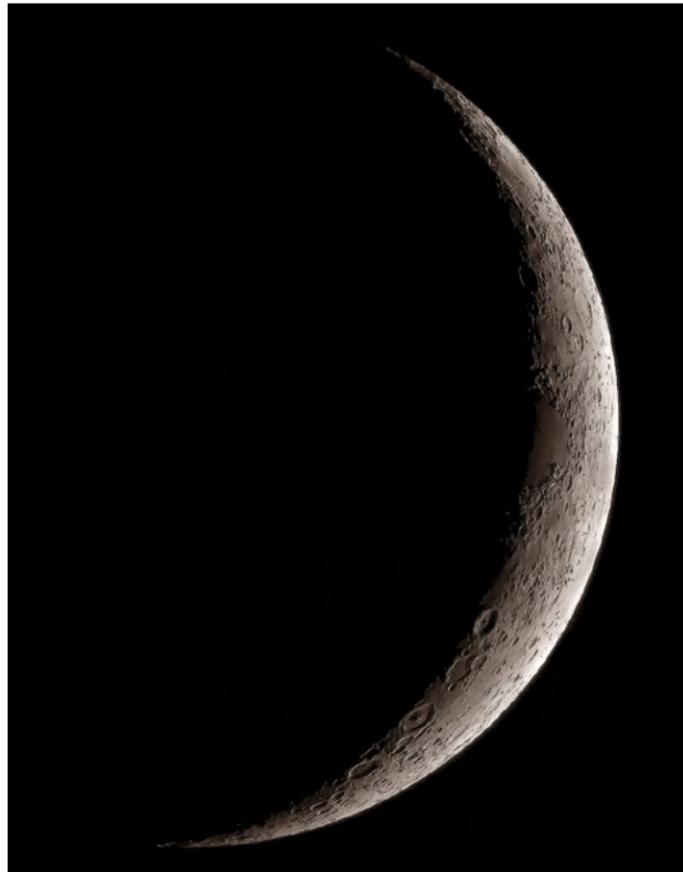
No. 34, **Bill Kocken**, Minnesota Astronomical Society

### Variable Star Observing Program

No. 31, **Raymond B. Howard**, Patron Member; No. 32, **David Whalen**, Atlanta Astronomy Club

# Basic Small-Scope Lunar Imaging

By Jamey L. Jenkins



lowly 2.4-inch (60 mm) telescope, possessing less resolving power, can perform well. I use a 5-inch f/18 achromatic scope and 4-inch f/7 ED refractor for lunar and solar observing. "Achromatic" means the objective lens has two elements, usually one of flint glass and the other of crown glass, bringing different colors of light to nearly the same focus. "ED" is an acronym for extra-low dispersion; the 4-inch has two lens elements of a more exotic glass, bringing refracted colors to an even closer focus than an achromatic lens. Some high-end refracting telescopes have three or four elements to the objective lens; these are called apochromatic (meaning colorless) and can easily bust your budget. While there are reflecting and catadioptric (lens/mirror) telescopes in the "small" category, most of these telescopes are a bit larger; still, the suggestions in this article

will also apply to those medium-sized telescopes.

## GETTING STARTED

Let's say you've set up your small scope to view the evening first-quarter phase Moon. During the session you decide it might be a great idea to snap some pictures to share with fellow club members via email, Facebook, or perhaps through a favorite e-group; after all this is why we do casual imaging, to inspire fellow observers and to share!

You must have a camera to record the view through the telescope. Frankly, just about any camera will do. I've seen increasingly acceptable Moon shots taken with a cell phone held up to an eyepiece. This is fine if you are content with only the occasional "lucky" photo, but if you want to show the world what can really be seen through your telescope,



"Supermoon" from November 14, 2016. A single frame shot with the 102 mm f/7 refractor and a Nikon D3000 DSLR.

June 8, 2016, Moon with DMK41 camera and William Optics 102 mm f/7 refractor. This is a two-frame mosaic shot through a K2 yellow filter.

*Amateur astronomical photography, or imaging in today's vernacular, used to be a craft pursued by only a few ambitious hobbyists. However, the digital camera revolution of the 1990s changed that forever by opening the door for novices to capture impressive pictures of celestial bodies. While some types of astro-imaging are better suited to large light buckets and exotic cameras, interesting and educational images of our nearby Moon can be made with small backyard telescopes and inexpensive digital or video cameras. That is what we will discuss in this article: capturing basic Moon photos with a small backyard scope.*

## HOW LARGE IS SMALL?

In this article, we will consider a small telescope to be one of 5-inch aperture or less. Often, these are refractors, usually portable and equatorially mounted with a tracking mechanism. Dobsonian or tripod-mounted alt-azimuth telescopes can be used, but the ability to follow the Moon across the sky with an equatorial mount is definitely a plus. The theoretical resolution of a 5-inch telescope is one arcsecond, capable of providing a detailed view of lunar features (although imperfect seeing usually prevents capturing images this sharp). Even the

more planning is necessary. These days, two possible solutions top my list for capturing consistently clear and detailed lunar images: a digital single-lens reflex (DSLR) camera or a dedicated "webcam" imager intended for solar, lunar, and planetary work.

## PRIME FOCUS IMAGING

**The most basic form of telescopic imaging with either a DSLR or Solar System camera is the direct objective or prime focus technique.**

In prime focus imaging, a camera minus its lens is inserted in place of an eyepiece at the telescope. Light gathered by the telescopic objective is focused directly onto the light sensitive chip of the camera, using your telescope as a large telephoto lens. The size of the Moon at focus is determined by the focal length of the telescope; the longer the focal length, the larger the Moon. You can calculate the approximate lunar diameter formed on the chip by multiplying the focal length by 0.009. Advantages with this type of imaging include superior definition and highest light transmission. In other words, prime focus imaging is the fastest and sharpest optical arrangement for capturing pictures. A disadvantage of prime focus, however, can be the small size of the Moon; this can be counteracted by inserting an amplifying positive or negative lens system into the optical path to enlarge the Moon. Nevertheless, I always recommend an observer start with prime focus imaging, and master that skill before attempting any amplifying techniques.

## WORKING WITH A DSLR

Modern DSLRs have many features that vary between models, so you must be familiar with your particular camera's operation before going out under the night sky. I can note what has worked with my

specific equipment, and then you can apply that experience to your circumstances. I use a low-cost Nikon D3000 purchased in 2009 from a local Wal-Mart. The primary advantage of this DSLR is its large sensor, enabling me to take wider-field shots than is possible with a webcam imager.



Nikon D3000 DSLR with T-ring and 2-inch focuser adapter. Button device in foreground is for remote hands-off shutter activation.

An adapter called a T-ring is necessary to attach a DSLR, minus its camera lens, to a telescope. Another accessory with a nosepiece of the appropriate size (1.25 or 2 inches) screws into the T-ring to connect the camera to the focuser. These nosepieces are often threaded to accept standard eyepiece filters, an advantage that will be useful as you gain experience. In order to reduce the effects of vibration in the telescope/camera combination, the camera should allow a delayed shutter release or the use of remote activation.

The idea here is to trip the shutter without your fingers being in contact with, and shaking, the camera. Some cameras may still have a source of vibration from a dysfunction called mirror slap or bounce. Mirror bounce is prevented by locking the mirror in an up position before the shutter is activated; some models allow this. Vibration from the shutter mechanism itself may be avoided by using a fast shutter speed.

**Begin by centering the Moon in the camera's viewfinder and focusing carefully.** If you find it difficult to tell if an accurate focus is obtained, then focus-bracket your shots. To do this, find a position clearly just inside proper focus and adjust incrementally to the outside of proper focus, shooting pictures at each position as the focus is advanced. Invariably some pictures will be in focus. Use a slow ISO setting of perhaps 100 - there is plenty of lunar light at prime focus, so there is no need for ultra-sensitive CCD chips. Optimal exposure time is determined by the optical system's focal ratio. The faster the telescopic system, the less exposure is needed. Be certain to set the camera to manual mode, starting with a medium range exposure (such as 1/100 second) and adjusting accordingly, faster or slower, until the image appears properly exposed. Watch for saturation at the limb where the Moon appears brightest, which may wash out detail. Use remote shutter activation or whatever technique is necessary to prevent vibrations from ruining the picture. Take dozens, if not more, pictures! The number one rule of successful lunar photography is to shoot as many pictures as possible, being prepared to throw away most of them because of poor focus or atmospheric smear. That's about all it takes to capture basic Moon images at prime focus with a DSLR.

## SOLAR SYSTEM CAMERA

While impressive lunar images are possible with the typical DSLR, my experience is that consistent high-quality pictures result when using a dedicated video Solar System camera, commonly known as a webcam. Generally, a dedicated video camera will have finer pixels, more pixels (in the monochrome version), and the

ability to create a video with a high frame rate, a requirement for overcoming the poor seeing of a turbulent atmosphere. Webcams are compact affairs, sometimes weighing no more than a modern eyepiece, therefore avoiding balance issues with the telescope.

Many makes and models of Solar System cameras are on the market, and I cannot instruct you on the use of your particular camera. I use an Imaging Source DMK41 monochrome camera for my pics, but most of my recommendations are also suitable for other webcams. Attachment to the telescope is accomplished with the correct size of screw-in nosepiece.

A webcam requires a computer to run image capture software to obtain either a single snapshot or a multiple-frame video of the moon. Adjustments to the live camera view are made via this software controlling the sensitivity, contrast, exposure time, and frame rate (the number of frames captured per second) of the camera.



Lightweight DMK41 video camera

Most cameras come with their own proprietary capture software; custom software can also be used for image capture. One very popular free-ware is FireCapture, developed by Torsten Edelmann. A unique feature of FireCapture is the log sheet created for each video. The log contains data such as observer, location, scope, camera, date, details of the exposure, and



Last-quarter Moon with the 102 mm f/7 refractor and DMK41 camera, October 23, 2016

settings of shutter, gamma, and gain. Generation of the log sheet frees the observer from making copious notes during an imaging session.

Because the Moon is a bright object, I typically keep the gain setting to a minimum in order to minimize noise within the image. Gamma is usually at a setting that maintains a normal balance in image contrast. These adjustments can be tweaked to suit the observer. Focus is accomplished on the computer screen via the live camera view. Set the frame rate as high as possible considering the amount of light available from the Moon. I've found that successful images are best created from videos of several hundred to several thousand frames. Poor seeing necessitates capturing many frames,

so that there are enough of the best frames to justify processing. Good seeing also encourages capturing many frames because many high-quality frames are then available for stacking, improving the detail seen in the image.

Exposure is adjusted so that the brightest regions of the image do not saturate. The histogram feature of FireCapture is great for graphically depicting exposure characteristics; do not let the bar extend beyond 80 or 90 percent, to the right of the histogram. Again, the best practice is to always record as many individual videos as is practical. This will increase chances of capturing sharp images.

### POST-PROCESSING IMAGES

After the single snaps or videos are obtained, it is

necessary to edit the images with appropriate software. The sharpest frames from a video are combined into a single frame in a process known as stacking. (Single pictures from a DSLR can also be stacked.) Freeware options for stacking include RegiStax, Avi-Stack, and AutoStakkert!, the last being the current favorite among Solar System imagers. Software downloads and instructional videos of their use are easily found online.

**Stacking of images is done to reduce noise, while increasing signal strength, thereby improving detail and resolution.** The single or stacked image will be further adjusted using image-manipulating software. Quality digital photos require calibrating in order to even out pixel sensitivity and remove artifacts created during the imaging process. In my lunar photos I've found that the dark and bias frames can be neglected, particularly because we are not creating "science" images, just casual snaps to share with friends. However, flat frames, which highlight uneven chip sensitivity, dust particles on the chip, and imperfections of the optical system, are best utilized by the lunar photographer. Again, this article is not the place for detailed how-to instructions, so if you are not versed in obtaining flat frames, please consult one of the many tutorials available online.

Adobe Photoshop is a standard tool for editing image characteristics such as cropping, histogram adjustment, and sharpening. Freeware alternatives to Photoshop include GIMP, the GNU Image Manipulation Program. Most images will be improved with a stretching of the dynamic range of the photo and at least a mild sharpening. Make the adjustments to suit your preference, taking care to avoid over-sharpening the image, which can create

an artifact called "ringing" where the edge of a feature (such as the lunar limb) takes on an unnatural appearance. Save the original file in TIFF format and make copies for posting in JPEG format, which is usable in practically all applications.

### TIPS AND TRICKS

There are a few tricks the beginning lunar imager can implement to insure successful results. The elevation of the Moon



The same area of the Moon taken under different lighting conditions. Near Mare Nectaris we see the rugged crater trio of Theophilus, Cyrillus, and Catharina. Theophilus is 61 miles in diameter, and its central four mountain peaks are approximately 1400 meters high. The smallest craters visible on the floor of Mare Nectaris are two miles in diameter. Top: April 13, 2016, imaged with a 125 mm f/18 refractor and DMK41 camera. Bottom: June 2, 2017, with a 125 mm f/18 refractor, K2 yellow filter, and DMK41 video camera. These images were cropped from the author's larger images.

above the horizon is an important consideration. The higher the elevation (optimal is the zenith) the better in order to reduce the amount of atmosphere that lunar light passes through before reaching the telescope. Thicker atmosphere produces more

turbulence, a dimmer view, and increased atmospheric dispersion (smearing white light into a rainbow). To combat those issues, when possible, image the Moon high in the sky. Lunar images are more-or-less grayscale images with extremely weak colors. Introducing deep yellow, orange, or red filters into the optical train when producing grayscale images tends to improve seeing conditions and limit dispersion. Early

lunar phases are best imaged in the springtime with the Moon higher in the western evening sky. Another practical tip is to attempt imaging a bit before the Sun has set, continuing throughout twilight; seeing is often better during this period, before the sky gets completely dark.

Less-than-superb images can be salvaged by pasting several together into a mosaic. The field of view will be much wider and,

when reduced to a standard viewing size, the overall image will appear to have better resolution. Therefore, when planning your pictures, always consider having some overlap between nearby regions to allow the creation of a mosaic.

### GIVE IT A TRY

Imaging the lunar surface with a small telescope can be a fun and educational activity. Besides

sharing the images with friends, I like to identify features in my pictures using lunar maps. As I learn the names of craters, mountains, domes, and valleys, I note the tiniest craters visible in my images to discover just how fine the view was on the evening I observed. Sometimes it's amazing because many of these tiny areas just don't catch the eye's attention until the final image is studied intently on the computer screen. ★

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# The Vault of Heaven

## Treasures of the Linda Hall Library



By Bob Kerr

**The comfortably appointed room in which I sat was quiet, lit well, and furnished with broad tables of polished wood.**

At the far end, opposite the entryway, were long, waist-high bookcases filled with substantial looking reference books. Behind these were three wall-sized windows showcasing thousands of rare books crowding shelves that reached from floor to ceiling. Here, safely held and tightly secured, were a great many of astronomy's most irreplaceable and cherished works. This was the rare book reading Room of the extraordinary Linda Hall Library of Science, Engineering and Technology in Kansas City, Missouri.

This 220,000-square foot mid-century modern complex is home to a staggering collection of some two million books, journals, and documents, with strong primary and secondary holdings in geology, paleontology, natural history, engineering, mathematics, and the physical sciences. On the library's lower level, the William N. Deramus III Cosmology Theater delights visitors with images from the Hubble Space Telescope and

NASA science missions. Members of the Astronomical Society of Kansas City regularly benefit from special library access nights and attend featured lectures and exhibitions.

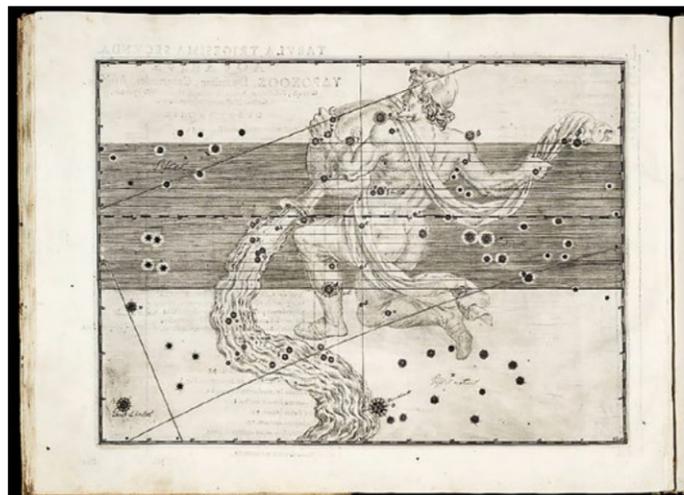
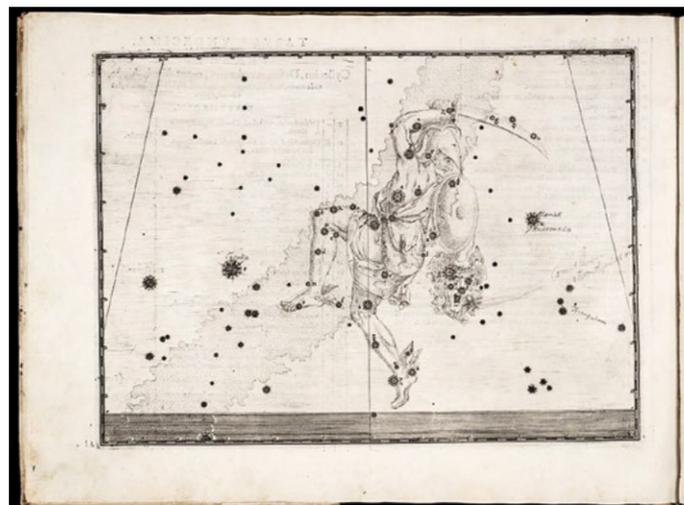
This day, I was visiting to experience firsthand the astronomy-related publications within its History of Science Collection. The collection's catalog features over 10,000 items, but my particular interest was the library's world-class collection of over 100 historic star atlases.

On the table in front of me, its delicate binding cradled between wedges of foam rubber, the librarian had carefully placed Johann Bayer's famous 1603 star atlas, *Uranometria*. I could not help but wonder how many hands had turned through these 400-year-old pages. Many were worn and dog-eared, and some bore fine handwritten notations, almost hidden among the resplendent figures of 48 heroes, fair ladies, and monsters populating its pages. In 1824, more than 200 years after its publication, someone had made a notation on the map of Perseus, just below Algol on Medusa's left cheek, marking the position of a comet. Twenty

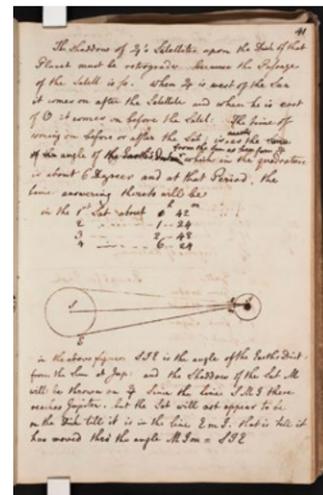
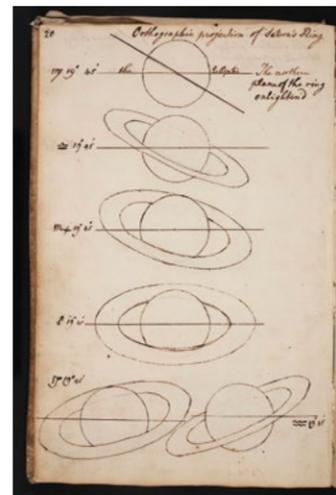
years after that, on September 21, 1843, someone had recorded the position of Uranus on the plate of Pisces, beneath the tail of the westernmost fish. But these were serendipitous finds, and time constrained me from looking further. Many other such historic notations must lie hidden, unseen for hundreds of years, among the pages of these well-used star catalogs awaiting discovery.

Next, I turned my attention to

the 1759 "Commonplace Book," once the property of William Herschel. It is a large notebook-like volume dressed in a white leather cover. Within, his bold script conveyed purpose as he had recorded formulas and sketches relating to optics and observations. My eye was drawn to a precisely rendered illustration he had labeled "A Reflecting Microscope." About a third of the book remained unused, and I pondered with what



Pages from Johann Bayer's *Uranometria*



Pages from Herschel's 1759 commonplace book

Herschel might have eventually intended to fill these empty pages.

**The Linda Hall Library (LHL) is an exceptional resource.** And what is particularly remarkable is the library has placed nearly a quarter of a million digitized, high-resolution images of books, maps, photographs, and manuscripts, such as I had been reviewing, freely available online. The catalog and easily searchable database can be found at [lindahall.org](http://lindahall.org).

The breadth of the library's collection has also inspired fascinating astronomy-themed public exhibits, now available in digital form. "Out of This World: The Golden Age of Celestial Cartography," "The Face of the Moon: Galileo to Apollo," and "Thinking Outside the Sphere: Views of the Stars from Aristotle to Herschel" may be found online. For amateur astronomers, there is a treasure trove here awaiting our discovery and exploration (in many ways like the night sky itself).

The library, a not-for-profit, privately funded institution, traces its roots back to the philanthropic vision of Herbert and Linda Hall, who bequeathed their estate for the purpose of establishing an important cultural center for the people of Kansas City. Their six-million-dollar

bequest stipulated that a free public library was to be located on the grounds of their estate and named in honor of Linda. In the early 1940s, a board of trustees recommended the creation of a library concentrating on science and technology. My sense is this vision has certainly been fulfilled, if not greatly surpassed.

Lisa Browar, president of the Linda Hall Library and Library Foundation, rightfully proclaims the realization of that vision: "The Linda Hall Library has become an international destination for research and scholarship in science, engineering, technology and their histories. Additionally, the Library provides a cultural space in which public understanding of science and its role in contemporary life may flourish."

One frequent researcher of the library's extensive collection of books and celestial cartography is renowned author and lecturer Nick Kanas. He is widely recognized for his authoritative book, *Star Maps: History, Artistry, and Cartography*, and uses the LHL online catalog regularly. Several years ago, Nick visited the library, and he compliments the staff for their knowledge and helpfulness.

Similarly, Ian Ridpath, a leading authority on mythology and star lore and author of the popu-

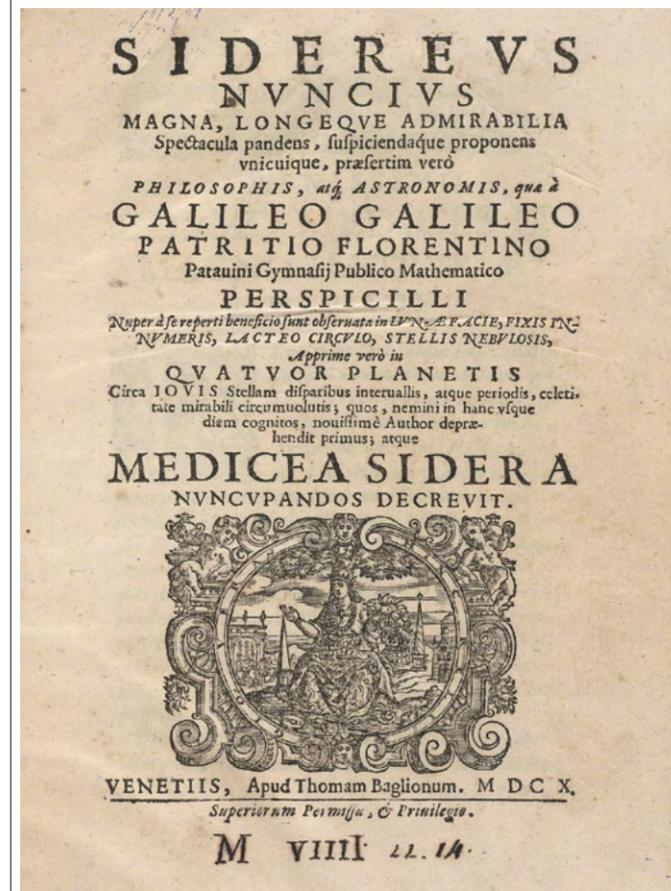
lar book *Star Tales*, often uses the library's freely accessible online collections. Ian encouraged me to add, "If you're looking for scans of the great books and star atlases of the past, their holdings are extensive and the place to start."

Space allows only an abbreviated listing of the priceless books held in the library's vault. The 1540 *Narratio Prima* by Georg Rheticus and Nicholas Copernicus's 1543 *De Revolutionibus Orbium Coelestium* are two of the library's most prized holdings. These are closely followed by Ptolemy's *Almagestum*, printed in 1515, a first edition of Isaac Newton's 1687 *Principia*, and Galileo Galilei's 1610 *Sidereus Nuncius* and 1632 *Dialogo*. Add in Johannes Kepler's 1606 *De Stella Nova*, Tycho Brahe's 1603 *Astronomiae Instauratae Progygnasmata*, the 1620 *Instauratio Magna* of Francis Bacon, and Charles Darwin's 1859 *On the Origin of*

*Species* and you have a sampling for which the term "rare books" is arguably an understatement.

Impressive as its collection of rare astronomical books is, LHL considers its sizable collection of historic star maps and atlases among its most important holdings. Its remarkable inventory of lavishly illustrated sky maps showcases not only humankind's measured advancements in celestial discovery, but also changes in scientific illustration and printing techniques over the centuries. Sky maps are undoubtedly some of the most exquisite examples of design, copperplate engraving, and printing to be found. They capture our earliest dreams and concepts of the heavens while impressing us with their stunning beauty. When inspected close-up in their original form, their magnificent artistry cannot help but stun the eye.

Dr. William B. Ashworth Jr. is a consultant for the Linda





Hall Library's History of Science Collection and is an associate professor in the Department of History at the University of Missouri-Kansas City (while LHL is located near the university, it has no organizational relationship with it). Ashworth is an authority on celestial cartography and has conducted research and written extensively on the library's collection for many years. I thank him for giving generously of his time and expertise to assist me in preparing this article.

While the library houses over 100 atlases, Ashbrook defines the two hundred years spanning 1603 to 1801 as the period during which the finest star atlases were produced. He considers the five most important or "grand" celestial atlases of this era to be, chronologically, Johann Bayer's *Uranometria* (1603), Julius Schiller's *Coelum Christianum* (1627), Johannes Hevelius's *Firmamentum* (1690), John Flamsteed's *Atlas Coelestis* (1729), and Johann Bode's *Uranographia* (1801).

Before examining these ambitious works, it's important to recognize that these atlases find as their foundation the early influential writings of the Greek astronomer Claudius Ptolemy of Alexandria (about 100–178 CE). In what came to be known as the *Almagest* (a later Arabic title meaning "the greatest work"),



Ptolemy documented contemporary astronomical knowledge and the thinking of earlier Greek astronomers, notably Eratosthenes and Hipparchus. The *Almagest* of Ptolemy cataloged 1,028 stars and organized them into 48 constellations. And, building upon the work begun by Hipparchus, Ptolemy crafted the basic one-through-six stellar brightness scale still used (with modification) today. In another innovation, Ptolemy took a first step toward furthering the accuracy and utility of star maps. He accomplished this by describing, in manuscript form, the location of every important star within each constellation figure, such as noting Algol's position as being "the bright one in the head of the demon."

The following are examples of influential works found in the library that were forerunners of the grand atlases.

### Poeticon Astronomicum, 1482

Printed in Venice, this handsomely illustrated work was based on the ancient literary writings of second century Roman historian Hyginus. During the Renaissance, it became the primary source for visualizing what the Ptolemaic constellations might look like. The *Poeticon* was the first to actually represent mythological characters by using simple woodcuts randomly decorated with stars in a fashion pleasing to the printer

but with no relationship to their actual positions in the night sky. While these crude figures were attempts at mythological depictions, they were not constellations in our modern understanding. However, these characterizations did inspire future cartographers.

### De le Stelle Fisse, 1540

Scholars acknowledge the first true star atlas was Alessandro Piccolomini's *De le Stelle Fisse*, also printed in Venice. As the first atlas to actually place stars on maps in accordance with the positions described by Ptolemy, Piccolomini's atlas enjoyed wide popularity and contributed significantly to the future development of celestial cartography. Piccolomini pioneered the idea of providing stars with their own unique identifiers; in this instance, brighter stars within each constellation were assigned lowercase Roman letters. Howev-

er, in a prescient foreshadowing of modern, clutter-free star maps, Piccolomini showed only star patterns and did not include constellation figures.

### Grand Atlas 1: Uranometria, 1603

Sixty years after Piccolomini, Augsburg lawyer Johann Bayer created his masterful *Uranometria* atlas showing the positions of more than 2,000 stars. It presaged the future of celestial cartography and became the template on which subsequent atlases would be modeled and compared. Bayer brilliantly depicted the original 48 classic Ptolemaic constellation figures, each occupying a generous map measuring over 14 inches across. He also introduced 12 southern constellations, including Grus, Phoenix, and Tucana, first conceived by Dutch navigator Pieter Dirkszoon Keyser from his catalog of 135 stars.



Hand-colored page from *Poeticon Astronomicum*, 1482

Unlike the awkward woodcuts of earlier years, Bayer's exquisite *Uranometria* maps were printed from fine copper engravings. They were accompanied by tables containing the nomenclature, descriptions, and magnitudes of the stars in each constellation, based on Tycho Brahe's 1602 greatly expanded and improved catalog of 1,005 stars. Inventively, Bayer designated the brighter stars in each constellation with letters from the Greek alphabet according to their perceived magnitude: alpha, beta, gamma, delta, etc. When the 24-letter Greek alphabet was exhausted, Bayer used Roman letters.

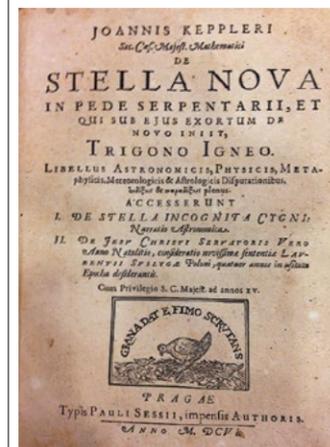
But a difficulty arose from the manner in which Bayer depicted a number of his constellation figures. Rather than illustrating his 48 constellations, Ptolemy originally had described them in manuscript form, referencing the stars within his constellations as though the figures were being viewed face-on. For instance, Ptolemy had characterized Rigel as "the bright star in the left foot of Orion." In the *Uranometria*, Bayer curiously reversed the view of figures such as Orion and Aquarius so they were seen from behind, rendering the Ptolemaic descriptions inaccurate. Confusing as this may have been for users of his time, in so doing, Bayer had (likely unintentionally) taken a step away from reliance on mythological underpinnings and, by using the Greek alphabet to identify stars, toward an era of more precise methods of stellar identification.

### De Stella Nova, 1606

The essential function of these early star maps was to provide a reference for tracking and plotting the movements of the Moon, planets, and comets. But something new was about to be added. LHL has a copy of the 1606 book Johannes Kepler published in

Prague, *De Stella Nova*, relating to the "new star" that had appeared several years earlier in the constellation Ophiuchus.

Kepler included a constella-



tion map based on the *Uranometria* but he reoriented Bayer's backward figure to a Ptolemaic frontal view and placed the nova in Ophiuchus's right (read correct) foot. On the same map, Kepler plotted a triple conjunction of Mars, Jupiter, and Saturn. (An unrelated LHL map, the 1690 *Globi Coelestis*, marks the path of a 1682 comet through the right foot of Boötes, as discovered by Cassini. In time, this comet came to be known as Halley's Comet.)

### Grand Atlas 2: Coelum Christianum, 1627

Julius Schiller's imaginatively fashioned *Coelum Christianum* was the first major atlas after Johann Bayer's *Uranometria*. Although his craftsmanship and accuracy were inspired by Bayer, Schiller's atlas differed in one unique way: never before or since have Ptolemy's Greek constellations been entirely swapped with other figures. Schiller replaced Bayer's Ptolemaic characters with superbly engraved constellation maps based on the Christian Bible. For example, the zodiacal constellations became the 12 apostles, Argo Navis was transformed into Noah's Ark, and the archangel Gabriel replaced Pegasus. Interestingly, Bayer assisted Schiller in the preparation of his

*Coelum Christianum*. It comes as a surprise, then, that Schiller used numbers (not so-called Flamsteed numbers – more on that later) rather than Bayer's Greek letters to identify his stars. The atlas was also the first to show the "Little Cloud," now known as M31, likely a result of Simon Marius's telescopic observations in 1612.

It is worth remembering the historic context within which these early star maps came into existence: Aristotle's teaching that perfect heavenly bodies were carried upon nested crystal-line spheres with the Earth at the center still found wide-ranging support. Copernicus was reviled, and Galileo condemned. But all this held little consequence for the cartographer, his two-dimensional universe being unaffected by such matters.

A brief mention should be made about the role star globes played in the development of star maps. Star globes had become very popular as showpieces, often

lary, had emerged from the design of star globes. But a key departure for cartographers would be one of orientation. Should the celestial sphere be portrayed as though observed from a distant point in the heavens looking down upon the Earth, as depicted on star globes (called external or mirror-reversed), or was a geocentric orientation preferable – that is, should the map represent the view from Earth looking up at the heavens?

Several creators of star maps preferred the former and chanced confusion in presenting mirror-reversed maps which did not correspond to what the user saw when observing the night sky.

### Grand Atlas 3: Firmamentum, 1690

According to Ashworth, the atlas of Johannes Hevelius was the first to rival Bayer's *Uranometria* in accuracy, innovation, and influence. However, Hevelius did produce it with the somewhat confusing mirror-reversed orientation. It was exquisitely



William B. Ashworth Jr. (right) and the author with Bayer and Flamsteed atlases. Note rare book vault in background.

paired with terrestrial globes in the ornate libraries of royalty and the drawing rooms of the wealthy classes. A number of conventions used by cartographers in their creation of flat celestial maps, such as graphic style and vocabu-

engraved by Hevelius himself with 56 large, double-page star maps showcasing 71 constellations. Unlike Bayer, Schiller, and other previous authors who relied on the star catalogs of others, Hevelius was an active observational

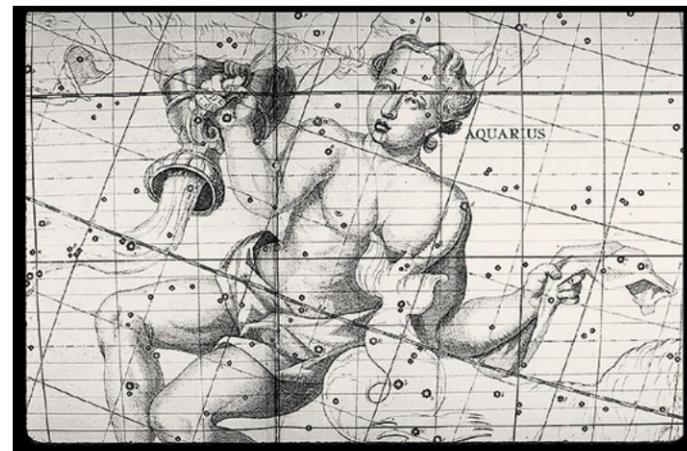
astronomer and made his own measurements. However, fearing defective results from optical aid, he resolutely insisted on naked-eye, “plain sight” observations rather than relying on telescopic sights now in use by others.

Even though Hevelius followed this traditional path, his experienced eye produced extremely accurate measurements. Using neither letters nor numbers on his maps, he relied on Ptolemaic-type descriptions in his accompanying catalog. Hevelius did create 11 new constellations,

constellation called Triangulum Minor, and others specialized in ill-conceived phantasms such as Montgolfier’s Balloon. Mercifully, most were ignored by subsequent map makers.

#### Grand Atlas 4: *Atlas Coelestis*, 1729

This atlas of astronomer John Flamsteed distinguished itself from previous atlases by the unprecedented accuracy of his stellar measurements and the fact that the *Atlas Coelestis* was the largest atlas ever published. Flamsteed’s constellation figures



Page from Flamsteed’s 1729 *Atlas Coelestis*

seven of which still exist today, including Leo Minor, Canes Venatici, and Scutum, and he was the first to incorporate into an atlas the 341 southern stars observed by Edmund Halley in 1676.

Each celestial atlas in the LHL collection is unique in some way and tells a story about celestial cartography’s evolution in artistry, accuracy, and usefulness. In terms of original constellation concepts, there were a fair number of dead ends, as unlikely enhancements came and went. Commonly, the creators of star maps felt empowered to tamper with the orderliness of Ptolemy’s 48 classic constellations. In one example, Boötes is seen adorned in a winter coat and fur hat, another cartographer assumes the necessity for a new

were all shown face-on, correcting what he considered to be the unpardonable breach of tradition committed by Johann Bayer and perpetuated by Hevelius. However, fairly unattractive renderings plagued his characters, which were crude in comparison to the elegance of Bayer’s.

Flamsteed’s story began 53 years earlier, in 1676, when King Charles II founded the Royal Observatory at Greenwich and installed him as the first Astronomer Royal. Charles assigned Flamsteed the monumental task of undertaking the most precise celestial measurements ever made, with great anticipation that they might lead to the much sought-after solution for determining longitude at sea. From the outset, the observatory was

poorly equipped, and Flamsteed often used his own meager funds to purchase or improve its modest equipment. He began in 1677 with a seven-foot equatorially mounted sextant carrying twin telescopic sights used as a meridian instrument. It wasn’t until 1688 that he finally procured a well-crafted, reliable seven-foot meridian mural arc constructed of the finest materials available, with which he was able to finally achieve the stability and, therefore, the precision he demanded.

For over 40 years, Flamsteed doggedly compiled his great catalog of 3,000 stars, eventually titled *Historia Coelestis Britannicae*. An early, incomplete version of this catalog was appropriated and prematurely printed by Isaac Newton and Edmund Halley in 1712, with preliminary numbers added by Halley to Flamsteed’s partial list of observed stars. This unauthorized printing apparently became the inspiration for the so-called “Flamsteed numbers.” It seems as though it had never been Flamsteed’s intention to formally introduce a numbering system, as neither his 1725 *Historia Coelestis Britannicae* catalog nor his 1729 *Atlas Coelestis* contain numbered stars. Curiously, while Flamsteed numbers are found in several 18th-century star catalogs produced by others, they do not appear on any star maps during this era. In fact, the first LHL star maps in which Flamsteed numbers actually appear is a set of six 1831 star charts titled *The Constellations*.

According to Wolfgang Steinicke, an astrophysicist and graduate in historical astronomy, William Herschel used a Flamsteed *Historia Coelestis Britannicae* catalog and *Atlas Coelestis* when he conducted his observing campaigns of 1781–1785. Steinicke’s research led him to conclude that Herschel personally

numbered the stars in his copy of Flamsteed’s catalog. His sister Caroline then transferred these numbers in fine pen and ink into Herschel’s copy of Flamsteed’s atlas.

In 1776, a Flamsteed-derivative edition titled *Atlas Celeste* was published in French by celestial globe maker E. J. Fortin. It featured reengraved plates, a smaller, utilitarian size, and more artistically pleasing constellation figures. Charles Messier used maps from this Flamsteed/Fortin atlas to record and publish paths of his comet discoveries. The library has Messier’s 1782 “Carte Celeste” map showing the path of the comet he discovered in 1779 tracking through Hercules, Corona Borealis, Boötes, Coma Berenices, and Virgo. The map also plots the positions of 28 “nebulous objects” that Messier labeled with designations such as “nebula 1777” and “nebula 1780.”

A number of historic star maps survive to this day, but it is uncommon to find these star maps in color. Since none were originally printed in color, each individual map had to be arduously hand-embellished with watercolors by expert artists. These tend to be remarkable works of art that only royalty or the wealthiest patrons could afford, generally being practical only for display.

#### Vorstellung der Gestirne, 1782

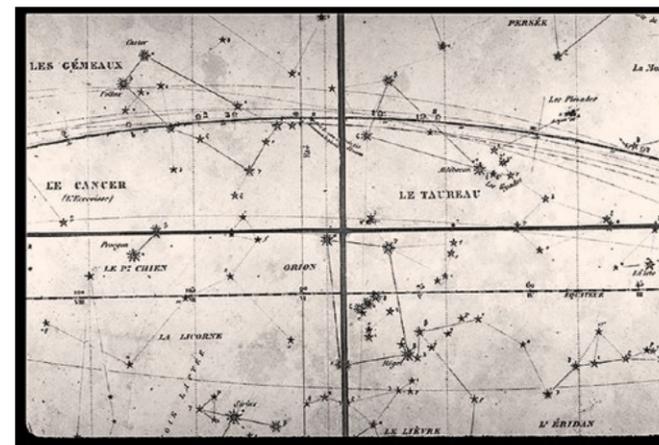
Like John Flamsteed, Johann Elert Bode was an accomplished astronomer and was director of the Berlin Observatory. Bode’s first atlas was a Flamsteed-derivative German language edition similar to the smaller French Fortin mentioned above. The *Vorstellung der Gestirne* featured newly engraved plates and maps of star clusters and nebulae and was populated by 1,500 new stars, bringing the total atlas count to over 4,400.

Unquestionably, the edition’s most relevant feature is that Bode was the first cartographer to confine his constellations within boundary lines.

Other cartographers eventually followed the idea, but boundary lines continued to meander from map to map, according to the inclinations of the cartographer. The confusion over constellation boundaries persisted until 1922 when the International Astronomical Union finally capped the official number of constellations at 88 and published a book of standardized boundaries in 1930.

#### Grand Atlas 5: *Uranographia*, 1801

Johann Elert Bode’s next atlas, the all-new, extraordinary *Uranographia*, made its debut in 1801. It was the largest, finest, and most comprehensive and costly star atlas ever published. Its 20 double-page plates provided the most accurate positions to date for over 17,000 stars, thousands more than other celestial maps. These included all naked-eye stars, as well as many telescopic stars to eighth magnitude. He indulgently crowded the *Uranographia* with over 100 entirely redesigned constellation figures that elbowed their way around the northern and southern hemispheres. Bode also sandwiched in 2,500 nebulae discovered by William Herschel.



Pages from Charles Dien’s 1831 atlas

#### Vorstellung der Gestirne, 1805

Four years later, Bode published a redesigned edition of his 1782 *Vorstellung der Gestirne*. With a more compact size and fewer embellishments than the *Uranographia*, printing was less costly, allowing the atlas to find a larger market. In it, Bode introduced a new constellation invented by Hungarian astronomer Maximilian Hell commemorating the seven-foot telescope with which Herschel had discovered Uranus in 1781. Bode called it Telescopium Herschelii and wedged it uncomfortably between the head of Castor and the right shoulder of Auriga. As with other such heavenly curiosities, it proved transitory and eventually disappeared.

According to Ashworth, Johann Elert Bode’s 1801 *Uranographia* marked the end of the era of the grand celestial at-

lases launched by Johann Bayer’s *Uranometria* 200 years earlier.

Bayer had begun simply with the 1,000 stars and the 48 constellations of Ptolemy. Bode, by nesting 17,000 stars and 2,500 nebulae amidst the likes of Bernice’s fulsome tresses and Virgo’s feathery appendages, had taken celestial obscurity about as far as it could go (or sensibly had a right to go).

Hunting down dim nebulae and faint stars among these heavenly flotsam and jetsam had become both constraint and nuisance for serious observers. With the evolution of the telescope and the elevation of astronomy to an esteemed discipline, star maps ultimately were severed from their fanciful mythological underpinnings. By the mid-19th century, the time had arrived for star maps to claim their rightful place as instruments of science (some

could rightfully argue losing the charm flowing from their ancient heritage in the process).

The Linda Hall Library’s collection of atlases wonderfully showcases how celestial cartography achieved maturity. On maps from 1811, 1839, and 1843, constellation figures are no longer depicted by prolifically rendered engravings, but simply appear as demure outlines. More familiar to modern eyes will be the 1827 atlas of Johann Bartak and the 1831 atlas of Charles Dien, where no representations of constellations figures can be found at all. Both exclusively employ lines to connect each constellation’s primary stars, producing geometric shapes. They are recognizable precursors to contemporary “stick figure” images now seen in monthly magazines or displayed on smartphones.

**The next time you open your favorite astronomy app, don’t think of it so much as a quick link to the evening’s cosmic smorgasbord, but rather consider it a sort of digital wormhole,** transporting you back to a time when humans first gazed upon the vault of the heavens and dreamed. And, unless you’re fortunate enough to live in Kansas City, jump into the Linda Hall Library’s digital collection – it’s the next best thing to being there! ★

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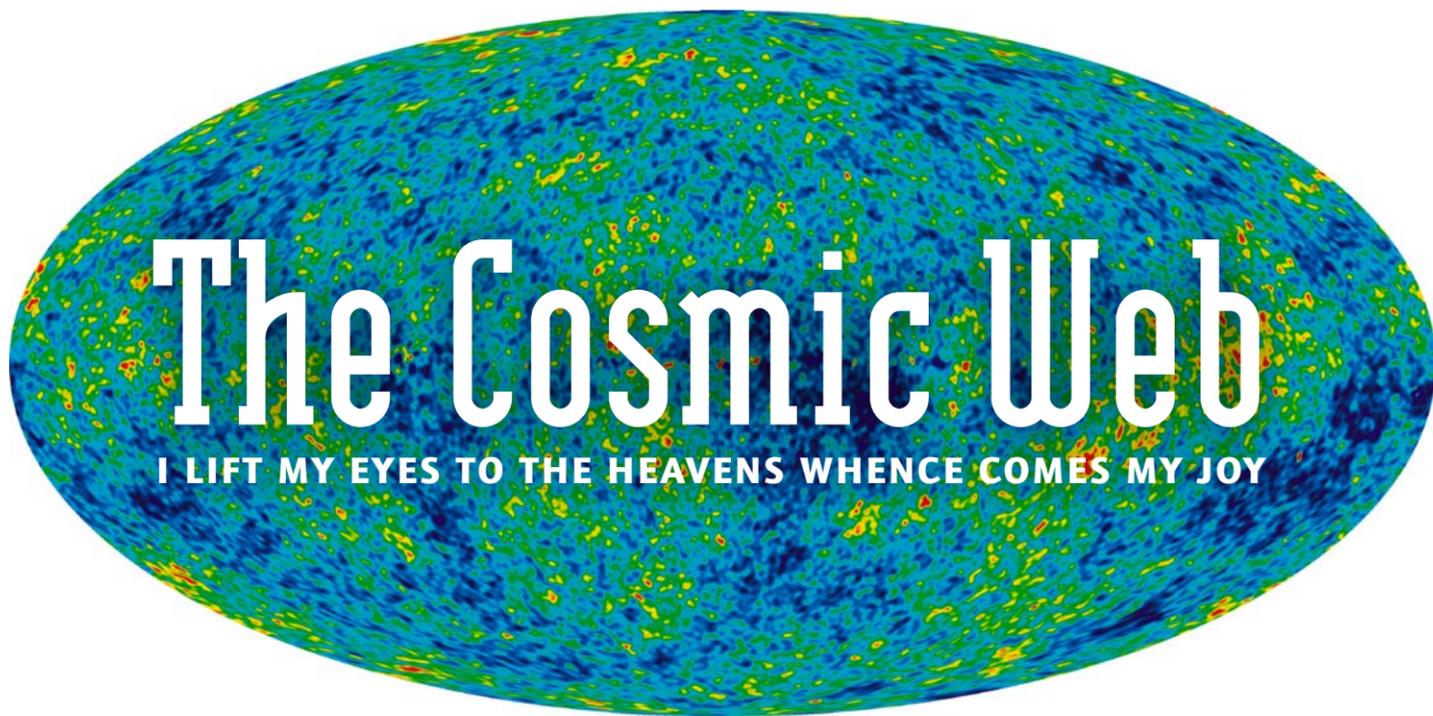
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# The Cosmic Web

I LIFT MY EYES TO THE HEAVENS WHENCE COMES MY JOY

The image above, created from seven years of WMAP data, depicts the infant universe. 13.7-billion-year-old temperature fluctuations (shown as color differences) correspond to the seeds that grew to become the galaxies. The signal from our galaxy was subtracted using multi-frequency data. This image shows a temperature range of  $\pm 200$  microkelvins. Credit: NASA / WMAP Science Team.

## By Dave Tosteson

What's on the map? We can see it! On a driving trip, digital car maps project positions onto a road with minimal sights and markers. Since their function is to get us safely and efficiently to a destination, the distraction of detail is minimized.

### But when I arrive at a place, especially a new one, I like to get the "lay of the land."

Maps on our handheld devices are accurate, up to date, and convenient, but their small size limits the scope of view, so a large, printed version is hard to beat. At a glance, one gets an impression of a region to put sights in relation to one another. Maps are also history, condensations of topography through time. In them both, the work of those past and the dreams of the future are held. They show an understanding of place in time, no different on our planet than the utmost reach of space. In them, we have grown from Ptolemy to Copernicus, and from the star-gage galaxy

of Herschel to the dimensional filamentary cosmic network of the present. Our perceptions are in flux as we slowly peel back layers of mystery, with representations evolving to keep pace, not merely cater to "Have Alias, Will Travel." To paraphrase my home state's recently minted Nobel laureate, "Space-times, they are a-changin'."

Given the vast amount of research, studies, publications, and conferences, it might seem most new ideas and discoveries about the Cosmos had been proposed. Few things may prove more untrue. A recent editorial by David Eicher in the November 2016 *Astronomy* puts things in perspective. He recalls the proposals of Czech-American astronomer Martin Harwit from the early 1980s about the percentage of discoveries of potential astronomical phenomena that had been made, a conjecture informed by experience and insight. With the forces and fields and particles known, the technology then available, and accounting for likely advancements in the near future, Harwit

concluded they had developed one percent of foreseeable observational capacity to fully explore these phenomena. With even such limited ability he speculated they had uncovered between one-tenth

and one-third of the total. No offer was made in the editorial as to an increased percentage known with current technology, as the piece emphasized optimism and opportunity for future finds. Prediction



At first glance, the scatter of pale dots on this NASA/ESA Hubble Space Telescope image looks like a snowstorm in the night sky. But almost every one of these delicate snowflakes is a distant galaxy in the cluster MACS J0717.5+3745 and each is home to billions of stars. This apparently placid scene also hides a storm of epic scale. This picture shows a region where three galaxy clusters are merging and releasing enormous amounts of energy in the form of X-rays. These distant objects are around 5.4 billion light-years from Earth, and were imaged during the Massive Cluster Survey, a project to study distant clusters of galaxies using Hubble. Credit: ESA/Hubble, NASA and H. Ebeling.

remains an exercise bookended by challenge and motivation.

Starting a century ago, just two decades saw profound shifts in our understanding about space and time, from relativity and quantum mechanics to the expansion of the Universe and the proposal of dark matter. In the late 1920s, Edwin Hubble, among others, showed our Universe to be expanding. A few years later, Fritz Zwicky conjectured that an unknown substance held galaxies gravitationally together within clusters. Without it, their speed would have caused them to fly apart. Vera Rubin provided confirmation of dark matter in the 1970s with her studies of galaxy rotation curves, showing most galaxies were surrounded by a large halo of unseen matter. The Cosmic Background Explorer (COBE) satellite mapped the cosmic microwave background radiation in the early 1990s, revealing how tiny quantum fluctuations in the early Universe grew into the "web" of matter seen today: strings and clusters of galaxies distributed along dark matter filaments. Finally, the Hubble Space Telescope (HST) and large ground-based instruments allowed detailed imaging and spectroscopy to unearth the three-dimensional distribution of galaxies and the relativistic lensing effects of mass-bent light to map this unseen matter within their clusters. All four of these revolutionary ideas combined in a recent study of a distant metacluster of galaxies in eastern Auriga concerning the density and shape of this unlit framework of our Universe.

Matt Mountain was director of the Space Telescope Science Institute in the early 2000s and proposed using the HST to extend the boundaries of distance one last time. Its famous Deep and Ultra Deep Fields had shown us galaxies to



Abell 2218, a rich galaxy cluster composed of thousands of individual galaxies. It sits about 2.1 billion light-years from the Earth (redshift 0.17) in the northern constellation of Draco. When used by astronomers as a powerful gravitational lens to magnify distant galaxies, the cluster allows them to peer far into the Universe. However, it not only magnifies the images of hidden galaxies, but also distorts them into long, thin arcs. Credit: NASA, ESA, and Johan Richard (Caltech, USA). Acknowledgment: Davide de Martin and James Long (ESA/Hubble).

within a billion years after the Big Bang, and Mountain and his colleagues were unaverse to using a novel technique to push the venerable instrument further. By imaging dense galaxy clusters at medium-deep distances (5–6 billion light-years), Hubble and its earthbound cousins could use the magnifying effect of gravitational lensing within these clusters to study galaxies from the very early Universe. MACS J0717.5+3745 is a group of colliding galaxies at a redshift of 0.55 (light travel time 5.4 billion years) that was one of six Hubble "Frontier Fields" used in this capacity. HST scientists studied it over several years and found the growing cluster to have several interesting properties.

### MACS J0717 is the largest known gravitational lens.

It appears to contain four merging clusters, creating an area just under one arcminute of strong lensing. This is where gravity produces drawn-out arcs of background galaxies seen in many of Hubble's images of galaxy clusters, including Abell

2218, 370, and 2267. This small region uses  $7 \times 10^{14}$  solar masses for its effect. A larger area (up to 4 megaparsecs in diameter) surrounds it where weak lensing can be studied. This phenomenon is determined by a statistical analysis of the shapes and orientations of background galaxies seen within the field of a galaxy cluster. Dark matter's milder distorting effects on these galaxies allowed mapping this unknown substance within the cluster. In 2003, Mezzidini used the CLASH study (Cluster Lensing and Supernova Survey with Hubble) to do a complete lensing analysis of the MACS J0717 area. As one of the most dynamically disturbed clusters known, it is suffused with energy that gives it the highest X-ray temperature in the MACS catalog of about 124 members. At  $2.8 \times 10^{15}$  solar masses, it is the most massive cluster with a redshift over 0.5, significant for constraining theoretical limits of galaxy cluster growth.

The Frontier Fields Program to image these six galaxy clusters,

along with nearby "parallel fields" for comparison and companion study, was allotted a large block of Hubble's time: 540 orbits, or 630 hours of imaging. MACS J0717 was imaged in visible light by HST, in X-ray by Chandra, and in radio by the National Radio Astronomy Observatory.

A composite image of these wavelengths shows a chaotic mix of energized gas and galaxies. The brightest galaxy in the field, a giant elliptical, shows a set of bipolar radio jets similar to those of Cygnus A, proceeding for hundreds of thousands, if not millions, of light-years away from the central galaxy. I am uncertain if it is a cluster member or a foreground object. Harold Ebeling of the University of Hawaii, one of the principal investigators, stated this cluster "is actively growing, and thus a prime target for a detailed study of the cosmic web."

The results of the COBE satellite in the 1990s, along with refinements from subsequent spacecraft such as the Wilkinson Microwave Anisotropy Probe (WMAP) and Planck, have shown the early Universe was imperfectly smooth. The small variations in energy seen on their all-sky maps are an imprint of quantum fluctuations in the fabric of space at the time of the Big Bang. Think of an ocean with tiny, inherent ripples, never smooth even on a windless day. As the Universe expanded, gravity acted on these areas, and they grew in density and mass. The Cosmos developed a sponge-like character, with relatively empty "voids" surrounded by filaments at the intersections of the edges of these bubbles, evolving into what is known today as the cosmic web.

These collections of matter are dominated by a substance that interacts only through gravity and emits no electromagnetic radiation. Almost 90 percent of the Universe's mass is dark matter,



Okie-Tex Star Party okie-tex.com

and researchers are vigorously attempting to discern its identity. Its structure forms the backbone of the Universe, causing clusters such as the Virgo Supercluster that includes our Milky Way, and others such as Coma and Hercules, to coalesce. Without dark matter, clusters, galaxies, and we may never have had a chance to form before the expansion of the Universe reduced the matter density below a critical level. We avoided the void. Since dark matter produces no light, what effects can amateurs see of this mysterious substance?

The town of Kenton, Oklahoma, sits a half mile or so west of the Okie-Tex Star Party. Its highlight is the town museum, in a house where its curator, Fannie Jones, lived as a child nearly nine decades ago and again for many years after she was married. It is studded with fascinating artifacts, including Civil War-era wedding dresses, photographs of the area through the Dust Bowl years, and even dinosaur track casts. She emphatically stated the population of Kenton was 19, not 20! The map on the wall was a plastic relief-type, showing elevations of the surrounding geologic

structures including the highest point in Oklahoma, Black Mesa, a few miles away, to the Cimarron River bed. Its three-dimensional structure added a layer of understanding harder to appreciate in flat depictions. When I recently attended that star party in far western Oklahoma near the New Mexico and Colorado borders, I drove the few miles to the other side of Black Mesa to the marker where the three states meet.

**Navigating cautiously around the cattle that owned the road, I found the tri-state marker surrounded by hills and caves and mesas in a region of historically diverse geologic activity.**

As I placed my hand on this spot, I mulled the intersection of culture, history, and topography coming together as might three voids to form a galaxy cluster.

Across the border in New Mexico lays the Raton-Clayton volcanic field, a picturesque region encompassing the Sierra Grande shield volcano at 8720 feet and the young, steep-sided Capulin Monument cinder cone. Dated at 60,000 years old, this area was a worthy day trip from the star party, with

its one-mile walking loop around the monument providing elevated views of the surrounding plains. A number of the over one hundred cinder cones that dot the area are visible from the edge of Capulin crater, and a short, 0.2-mile trail descending 100 feet to the crater floor is accessible to those in moderate shape. It seemed a suitable spot to consider the juxtaposition of how Earth's formation and its remnants of internal



Capulin Volcano National Monument Credit: R.D. Miller, USGS - USGS Photographic Library

energy produced the volcanoes, mountains, and elevations where gravity causes water to flow and collect between them, with how forces molding the voids, dark matter and baryons forged galaxies in such distant clusters as the Frontier Fields.

In the July 4, 2012, issue of *Nature*, Jörg Dietrich published the first identification of a dark matter filament between two galaxy clusters, Abell 222 and 223, where Jonah stayed. Several months later Mathilde Juazac used weak lensing to map the dark matter in a filament extending southeast from the center of the MACS J0717 cluster. Their spectroscopic data gave redshift distances to reconstruct the first three-dimensional shape of any dark matter filament. Jean-Paul Kneib, who was also involved in the research, stated the "challenge was to find a model of the cluster's shape which fitted all the lensing features that we observed." The conclusion of the group was that the dark matter filament had a sinuous shape, curving beyond the plane of the cluster's central portion as it proceeded east-southeast, and then

back toward us. At the tip, like a "J," it started bowing back away again at its southeastern terminus. Its length was an astonishing sixty million light-years, and it carried a density so high that, if all proposed filaments were similar, they would contain more than half the mass of the Universe.

Observing galaxies in MACS J0717 has been one of my observing projects, and at the 2010 Okie-Tex Star Party I used my 32-inch f/4 reflector to view its area 6.8 degrees northwest of Castor, and 26 arcminutes northeast of the 15th-magnitude spiral CGCG 176-34. On a below-average night I was able to recover only one galaxy, what I termed the Brightest Cluster Galaxy (BCG). Its actual membership in the MACS cluster is unknown, but close examination of Hubble's deep image shows circumferential, strongly lensed arcs centered on it, an indication of belonging. For amateurs without spectroscopic redshift data, color and size of galaxies give limited hints about cluster membership. Since the cluster is at northern declinations, I did not attempt viewing it at the 2016 Okie-Tex event, thinking I could re-observe it from my Minnesota home. Though the western Oklahoma site is more than one magnitude darker, the seeing is more consistent at my home during the fall. I was about to get a lesson on persistence. With the target placed at eighty degrees elevation, I awoke at 4 a.m. on October 9, 2016, to a perfect sky. The stars were rock steady to near the horizon, and the windless and moonless night offered only a hint of humidity. I set up my large reflector, and, after collimating and recovering the field, my first look in the eyepiece was stunning.

On the Palomar Observatory Sky Survey (POSS) plates (second version, red), the BCG is magnitude 17.5 (average of

red and blue), and all the others are 18.3 or fainter. But on that morning, many fields had several galaxies readily visible, or just at the edge of averted vision. Pushing the magnification to 650x and beyond, over several minutes I was able to count ten galaxies in the central portion of the MACS J0717 cluster, mostly to the west and north of the BCG, whose coordinates are 07h 17m 37.21s, +37d 44m 23.1s. I then viewed the three clumps extending to the southeast that populate and define the dark matter filament. The closest of them is located 1.4 arcminutes east-southeast of the BCG and revealed two galaxies.

The clump 4.2 arcminutes southeast was the smallest of the three but showed four of its members to me, and the largest clump 8.5 arcminutes south-southeast gave up six galaxies. Many of these 22 galaxies were seen with direct vision, or within a few seconds using averted vision. A few took 30–60 seconds to be certain. Overall, I spent about an hour observing this cluster. With such a beautiful sky I closely examined the POSS and HST images of the area later that morning and estimated with more time likely a dozen additional galaxies would have been in range. On reviewing Hubble's color image, eight of the 22 galaxies I viewed were red in color, with the others appearing blue or white.

**Our visual and cognitive maps of the Universe have added a piece, an extrusion of knowledge about the framework on which galaxies are constructed.** It is, in several ways, a foundational discovery to be built upon. I experienced a profound excitement to have caught the tiniest thread of this web in the eyepiece and hope, like Harwit, to glimpse many more discoveries that transcend our current comprehension. ★

## Coming Events

### MARCH 2

**\*Tri\*Star\***, Guilford Technical Community College, Jamestown, North Carolina, Greensboro Astronomy Club and the Cline Observatory. [gtcc.edu/community-engagement/cline-observatory/special-lectures-and-events/tristar.php](http://gtcc.edu/community-engagement/cline-observatory/special-lectures-and-events/tristar.php)

### MARCH 30

**All-Arizona Messier Marathon**, Salome Emergency Airfield, La Paz County, Arizona. [saguaroastro.org/all-arizona-messier-marathon](http://saguaroastro.org/all-arizona-messier-marathon)

### APRIL 4–5

**Northeast Astro-Imaging Conference**, Rockland Astronomy Club, Suffern, New York. [rocklandastronomy.com/neaic.html](http://rocklandastronomy.com/neaic.html)

### APRIL 4–7

**Southern Star Astronomy Convention**, Charlotte Amateur Astronomers Club, Little Switzerland, North Carolina. [charlotteastronomers.org/southernstar](http://charlotteastronomers.org/southernstar)

### APRIL 4–7

**South Jersey Astronomy Club Spring Star Party**, Belleplain, New Jersey. [sjac.us/starparty.html](http://sjac.us/starparty.html)

### APRIL 5

**Pickett Astronomy Day**, Pickett-Pogue Dark Sky Park, Jamestown, Tennessee. [tnstateparks.com/events/details/#/?event=night-sky-program-3-8-19](http://tnstateparks.com/events/details/#/?event=night-sky-program-3-8-19)

### APRIL 6–7

**Northeast Astronomy Forum and Solar Star Party**, Rockland Astronomy Club, Suffern, New York. [rocklandastronomy.com/neaf.html](http://rocklandastronomy.com/neaf.html)

### APRIL 12–13

**North Carolina Statewide Star Party**, 40+ public skywatching sessions from the North Carolina mountains to the coast. [ncsciencefestival.org/starparty](http://ncsciencefestival.org/starparty)

### APRIL 28–MAY 5

**Texas Star Party**, Fort Davis, Texas. [texasstarparty.org](http://texasstarparty.org)

### MAY 3–5

**NCRAL Convention**, Moline, Illinois. [nightsky.jpl.nasa.gov/event-view.cfm?EventID=97447](http://nightsky.jpl.nasa.gov/event-view.cfm?EventID=97447)

### MAY 10–13

**Star Gaze XXVI**, Trap Pond State Park, Delaware. [delmarvastargazers.org/event/star-gaze-star-party-2019](http://delmarvastargazers.org/event/star-gaze-star-party-2019)

### MAY 11

**Astronomy Day**, Nationwide. [astroleague.org/astronomyday/spring](http://astroleague.org/astronomyday/spring)

### MAY 30–JUNE 2

**2019 Bootleg Astronomy Star Party**, Green River Conservation Area, Harmon, Illinois. [bootlegastronomy.com](http://bootlegastronomy.com)

### MAY 30–JUNE 2

**Wisconsin Observers' Weekend**, Hartman Creek State Park, west of Waupaca, Wisconsin. [new-star.org/index.php?option=com\\_content&view=category&layout=blog&id=38&Itemid=82](http://new-star.org/index.php?option=com_content&view=category&layout=blog&id=38&Itemid=82)

### MAY 30–JUNE 4

**Logan Valley Star Party**, Malheur National Forest, Oregon. [sites.google.com/view/loganvalleystarparty](http://sites.google.com/view/loganvalleystarparty)

### MAY 31–JUNE 2

**Michiana Star Party 11**, Dr. T. K. Lawless Park, Michigan. [michiana-astro.org](http://michiana-astro.org)

### JUNE 8

**Apollo Rendezvous**, Dayton, Ohio. [mvas.org](http://mvas.org)

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## Coming Events, Continued

**JUNE 22-29**  
**Grand Canyon Star Party: North Rim,**  
Fredonia, Arizona. [saguaroastro.org  
/grand-canyon-star-party](http://saguaroastro.org/grand-canyon-star-party)

**JUNE 26-29**  
**Green Bank Star Quest XVI,**  
Green Bank National Radio Observatory,  
West Virginia. [greenbankstarquest.org](http://greenbankstarquest.org)

**JUNE 26-30**  
**Rocky Mountain Star Stare,** Gardner,  
Colorado. [rmss.org](http://rmss.org)

**JULY 25-29**  
**ALCon,** Kennedy Space Center, Florida.  
[astroleague.org](http://astroleague.org)

**AUGUST 1-4**  
**Stellafane Convention,** Breezy Hill,  
Springfield, Vermont. [stellafane.org](http://stellafane.org)

**SEPTEMBER 19-22**  
**RTMC Astronomy Expo,** YMCA Camp Oakes,  
Big Bear City, California.  
[rtmcastronomyexpo.org](http://rtmcastronomyexpo.org)

An exciting GAM is just around the corner, join the party and register your event in this year's special Apollo 100 celebration!

# Global Astronomy Month April 2019

[www.gam-awb.org](http://www.gam-awb.org)



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# GALLERY

*Jeffrey O. Johnson  
(Astronomical Society  
of Las Cruces) took  
this image of M33  
from his backyard  
in Las Cruces,  
New Mexico,  
with a Takahashi  
TOA-130F refractor  
with a QSI 590wsg  
CCD camera.*

*Bill Neubert  
(Astronomical Society  
of Eastern Missouri)  
took this image of  
NGC 2403 from Buford  
Mountain Conser-  
vation Area using a  
Celestron C6-N (f/5,  
750 mm) with a QSI  
683wsg-8 camera.*

All Gallery photos  
© their named  
creators

# GALLERY

Terry Hancock  
(Western Colorado  
Astronomy Club) took  
this deep image of  
M45 from Grand Mesa  
Observatory using a  
Takahashi FSQ-130  
with a QHY367C  
camera.



Dan Pelzel (Back Bay  
Amateur Astronomy  
Club) took this image  
of the Bubble Nebula  
(NGC 7635) using  
an 8-inch Ritchey-  
Chrétien with a ZWO  
ASI1600MM-Cool  
CMOS camera and  
H-alpha and O III  
filters.

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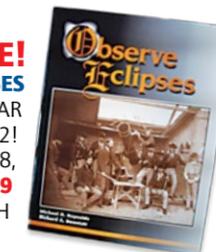
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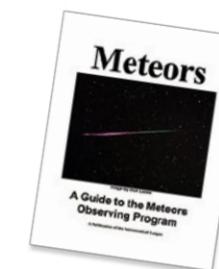
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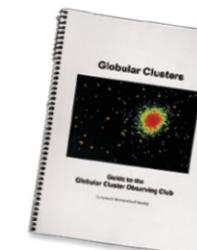


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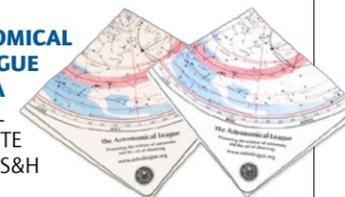
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