

# Reflector

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June 2017



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The front cover is an image of **M1** (the Crab Nebula), taken by **Brian McGaffney** at his **Nutwood Observatory** in L'Amable, Ontario, Canada. It was acquired with a 17-inch RCOS and an Apogee Alta U16M using 5 μm filters, and updated by adding H-alpha and O-III data. Image acquisition time was about 7 hours.

To our contributors: The copy and photo deadline for the September 2017 issue is July 1. Please send your stories and photos to our managing editor, **Ron Kramer** ([editor@astroleague.org](mailto:editor@astroleague.org)), by then.

The Astronomical League invites your comments regarding this magazine. How can we improve it and make it a more valuable resource for you, our members? Please respond to the editor's email address above.

## Reflector

The Astronomical League Magazine

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A NON-PROFIT ORGANIZATION

- To promote the science of astronomy
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OITHv5.2 is available exclusively from the author:  
[www.birrendesign.com/astro.html](http://www.birrendesign.com/astro.html)

# Reflector

QUARTERLY PUBLICATION OF THE  
ASTRONOMICAL LEAGUE

Issued by the Astronomical League in March, June, September, and December, the *Reflector* (ISSN: 0034-2963) is sent directly, either by postal mail or via a digital link, to each individual member of its affiliate societies and to members-at-large as a benefit of League membership. Individual copies of the *Reflector* are available at the following subscription rates, payable to the League's national office.

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Subject line: "Letter to Editor"

### Your Spot under the Sun

These June evenings present the last opportunity—at least until early morning hours in late September—to catch a good glimpse of a large, relatively bright galaxy that Messier missed. NGC 2903 lurks just outside the Sickle of Leo, now lying low in the west-northwest after 10 p.m. Each night it drops a little bit lower, its light passing through a thicker slice of our atmosphere, making it more difficult to study.

You anxiously await darkness, worried that an approaching storm system will interfere with your observing plans. You really want to see this particular galaxy, as it is one of a handful of items remaining on your Herschel 400 Observing Program list. If the storms stay away long enough, fine,

you will have added to your repertoire of celestial objects, you will have increased your observing skills, and you will have explored more of what the heavens have to offer.

While you may be

disappointed if the seeing conditions do indeed deteriorate, you know that there will be many more opportunities to catch NGC 2903 starting in just a few months. In fact, you will be able to see it off and on for years to come.

That is why certain celestial occurrences have a special significance, whether it is the sudden daytime appearance of a supernova, which hasn't happened in over four hundred years; an unexpected comet with its gossamer tail sweeping grandly across the heavens, which we all can't wait to happen again; or the historically significant transit of Venus, which won't happen again until 2117. If you don't act when the situation arises, you miss out.

That is why the coming total solar eclipse is special to all observers, novice and seasoned alike. If you miss totality, even by ten seconds, you miss out completely. Yes, you have another chance to witness one in the next couple of years, but not without spending a lot of vacation time along with a



substantial sum of travel money.

August's eclipse will be accessible to many thousands of amateur observers across the United States. It will also be viewed by millions of people who wouldn't normally give the Moon's position in the daytime sky

a second thought. The nation will be inundated by media coverage—some of it useful, some of it misleading.

This creates a dilemma. On one hand, it presents an excellent chance to interact with an already interested public and to advance the perception of science and amateur astronomy. The public—and local media—will be looking to amateurs to educate everyone on how to safely view the eclipse, and to explain what to expect. This

will be a wonderful opportunity to directly affect amateur astronomy in your area. (When Halley's Comet passed in 1986 with a lot of hoopla and with no grand



The Astronomical League brings you solar eclipse glasses, mementos, the Solar Eclipse Observing Program, AstroCon apparel, and, of course, AstroCon 2017!

sweeping tail, it resulted in a significant increase in attendance at many club meetings.) On the other hand, total eclipses in the U.S. are rather rare, and amateurs will understandably want to view it themselves, not wanting to allocate any portion of their scant 150 seconds showing others what can be seen through their binoculars and telescopes.

The solution? Take the time over the next few weeks to educate the public about the truth of solar eclipses and eclipse viewing. Tell them what it means. Tell them what they will see. Tell them how to do so safely.

When the eclipse hour finally arrives, find your spot under the sun, and enjoy the sight of this deeply personal experience. Feel the shadow!

John Goss, League President

**To the Editor:**

I am a member-at-large in the Astronomical League and have just completed the Sketching Observing Award. This is one program that, if you had asked me years ago if I would ever do it, I would have said no way! But I decided to give it a shot. I am no artist by any means of the definition, but the description on the AL website sort of put me at ease with my lack of talent and I decided... what do I have to lose?

I looked at many of the sketching lesson websites you suggested and it helped a lot! At least I now had an idea where to begin. And begin I did by going to the craft store and buying an artist's pack of tools (blending stump, graphite pencils, gummy eraser, etc.). I felt like I had a chance to complete the program at that point. I used paper, graphite pencil, sharpener, blending stump, some colored pencils, and of course, an eraser! This program helped me build confidence over time. By the end, I was feeling pretty good about what I had accomplished—though my sketches are at least hopefully “average” in appearance, I was proud of them. The sketching observing program really did make me slow down and take a close look at the object in the eyepiece. Thank you for that.

**Nora Jean Chetnik**, Martinsville, Virginia

**To the Editor:**

Just received our March *Reflector*. On page 11 is an article by Bert Stevens on Saturn. Just above the pictures of the spokes in Saturn's rings is the statement, “The mysterious spokes of Saturn's rings were first discovered by Voyager 1

in 1980. Since then, they had only been seen in Hubble images until the Cassini spacecraft arrived at Saturn in 2004.” Those are in-

correct statements. Attached is a sketch (A) of the spokes by Stephen O'Meara in 1976. He clearly saw the rings and sketched them. I recently observed the rings myself in my 15-inch telescope and did a short presentation to our astronomy club. I used O'Meara's sketch, the Voyager pictures (B), and my sketch (C) in my presentation.

I do hope you will correct this error and give credit where credit is due.

Regards, **Amelia Goldberg**

**To the Editor:**

While reading the March 2017 issue of the *Reflector*, I noticed an urban myth that has been perpetuated many times. In his column about the rings of Saturn, Berton Stevens wrote that the ring spokes can be seen only by spacecraft.

Wrong! My details might be a bit fuzzy, but sometime in the first half of 1984 I had my 6-inch Newtonian at the Texas Astronomical Society's observing site near Kaufman, Texas. After working on the League's Herschel list for a while, I took a break and pointed my scope at Saturn. I was shocked when Saturn showed something special: the ring spokes were not just visible, they were downright obvious! Almost disbelieving my eyes, I asked John Wagoner, who had his much larger reflector set up a few pads away, to look at Saturn. Yep, confirmed.

So, please put this myth to rest. Under the most favorable conditions, Saturn's ring spokes can be seen very easily with quite modest optical aid. The most favorable conditions just happen to be extremely rare.

**Jeff Carpenter**, Rockford Amateur Astronomers

**The author responds:**

I contacted Julius Benton, Saturn Section coordinator of the Association of Lunar and Planetary Observers ([www.alpo-astronomy.org](http://www.alpo-astronomy.org)). Dr. Benton indicated that you are correct and the spokes have been observed by amateur and professional astronomers many times from Earth. Before Voyager 1 sent back the first images of the spokes, observers would see

the spokes, but seldom reported them since they did not appear in photographs. Even now, some feel that they are optical illusions.

After Voyager 1, it was clear that spokes actually existed. Amateurs were more comfortable reporting them and they showed up more frequently in sketches in the ALPO and British Astronomical Association archives. The spokes are most visible when the rings' tilt toward Earth is between 8 and 12 degrees, but have been seen at other tilts as well.

Curiously, observers have also reported and sketched spokes in the A Ring, as well as in the B Ring where the Voyagers saw them. Sketches exist showing these A Ring spokes all the way back into the 1890s. Even further back, in 1780, William Herschel reported a “black list,” linear markings on the inner edge of the B Ring. Pierre-Simon Laplace suggested that Saturn has a large number of solid rings and computed their rotational period in 1787. This prompted William Herschel to work to determine the rotation period of Saturn's ring as 10 hours 32 minutes in 1789. Could Herschel have been timing spokes on the rings?

So the spokes are visible from Earth and have been since the telescope became good enough to bring them into focus. This is another example of how the observing power of the human eye has been much underrated. Nevertheless, some skeptics will never be convinced that the spokes of Saturn are visible from Earth. I suggest that anyone with a telescope should take a careful look at Saturn's B Ring as the rings begin to close again and see if they can spot the spokes themselves.

**To the Editor:**

This email is intended to satisfy a small request from my late Aunt, Maria Carvajal, a prestigious recipient (I should say) of an award (No. 152) from the Astronomical League, back in 2001. She passed away just under a year ago in her home town of Panama.

I just wanted to let you know because she was very proud of her work and the association she belonged to, the Astronomical League. She is the one that implanted the astronomy love bug in me, and I thank her so much for introducing me to a world I ignored for so many years, right above my head. Today, after having owned several telescopes, my last toy is a Takahashi FS-152.

Now, so much into astronomy, I am dazed that she named me as the inheritor of a true beauty of a telescope (no longer on the assembly line), an Astro-Physics StarFire 180 mm f/9 refractor. What happened to the refractor nowadays is in chapter two.

Anyway, I just want to thank you for recognizing her efforts and love for astronomy (though many years ago) as it was her wish to let the association know of her passing. She never gave me names of people I could contact, but what better way to do it but with you.

**Ricky P. Carvajal**, Sugar Land, Texas

**Corrections and Clarifications**

In the March 2017 issue, award recipient No. 566 of the Herschel 400 Observing Program should have been spelled “Kevin Nasal.”

On page 25 of the December 2016 issue, the images of Carl Wenning and Eric Fischer were switched.

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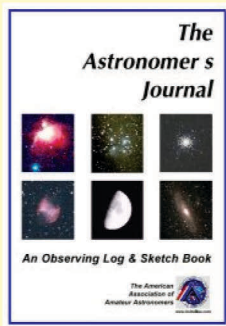
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### World's First Academic Center Dedicated to Dark Sky Studies

An IDA news feature dated February 14 (Valentine's Day!), 2017, announced the world's first academic center dedicated to dark sky studies. The University of Utah introduced its new Consortium for Dark Sky Studies (CDSS) which

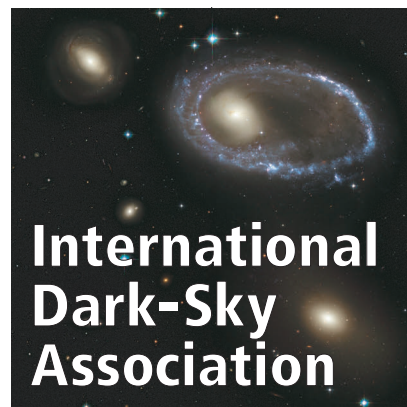
will be "dedicated to discovering, developing, communicating, and applying knowledge pertaining to the quality of the night skies." The consortium is based within the College of Architecture and Planning and is comprised of an interdisciplinary, multi-institutional research group. There will be more than 25 partners from academia, industry, communities, and government who will research light pollution. This research includes environmental, public health, and cultural impacts of losing dark skies.

John Barentine, IDA's program manager, is a part of the consortium steering group. John's has a background in professional astronomy. He earned a master's degree in physics at Colorado State University and a master's and PhD in astronomy from the University of Texas. From 2001–2006 he was on the staff of Apache Point Observatory in New Mexico. Very importantly from my point of view, John oversees the IDA's International Dark Sky Places, which I consider to be one of IDA's top success stories. Even better from our point of view, John is an amateur astronomer who appreciates the beauty of the night sky even as he has formally studied it as a professional astronomer.

The consortium has already formed a partnership with ALAN (Artificial Light at Night). The ALAN conference in November 2018 will be held at Utah's Snowbird Ski and Summer Resort. For information on ALAN 2018 see the conference website at [artificiallightatnight.org](http://artificiallightatnight.org).

John Barentine states "[the] establishment of CDSS is a strong sign that the academic study of dark skies has matured and will benefit in the future from organizational focus. I'm proud that IDA has had a seat at the table from the very beginning of this idea, and that together we can help shape the future of this important area of scientific research."

Like John, I am also very proud that IDA had a key role in the establishment of the consortium and will be an active participant



## International Dark-Sky Association

in it going forward. It has been one of my biggest frustrations over many years that the issues of light pollution and light trespass have been largely overlooked by the environmental movement and by architects. Professional lighting engineers have been very strong allies of ours, but most

environmental groups do not seem to focus on what happens after sunset. Architects, builders, and other designers often consider nighttime lighting to be an added accessory of no consequence, the only consideration being how it looks during the day, not how it functions at night.

I have to honestly attribute much of this "lack of respect" for the dark sky movement to our own shortcomings in not getting our message out more effectively. The idea for quality lighting and for protection of the night environment from harmful lighting practices is beginning to percolate into the consciousness of mainstream academic groups beyond astronomers and professional lighting engineers. This can only be good for all concerned. Be sure to read about the consortium on the University of Utah website at [unews.utah.edu/consortium-for-dark-sky-studies](http://unews.utah.edu/consortium-for-dark-sky-studies).

**Tim Hunter**, Co-founder, IDA

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### The Eclipse Megamovie Project

We're excited to announce an opportunity to contribute to a first-of-its-kind citizen science project: the **Eclipse Megamovie!** We're looking to get photographs of the upcoming August 21st total solar eclipse to build a movie of images from coast-to-coast. We need skilled photographers to help create the movie as well as support solar science. For more on the goals of the project, see **UC Berkeley's official press release**.

Our aim is to recruit over 1,000 amateur photographers and astronomers who will be on the path of totality on August 21, 2017. Team members receive training and submit a practice image before the eclipse. Once you qualify, you will receive a pin to designate your status as an official photographer for the project. Your name will also be included in the credits of the final **Eclipse Megamovie**. If you want to participate, visit our [eclipsemega.movie](http://eclipsemega.movie) and sign in to apply!

#### Basic equipment necessary for participating in the Eclipse Megamovie Project:

- Camera: Digital SLR or equivalent
- Telephoto or zoom lens: minimum focal length of 300 mm
- A stable and level tripod
- Ability to identify the GPS coordinates and time to the nearest second

**Are you ready for the**

eclipse? It seems that many millions of people across the United States and Canada will see at least a partial, and a rather large number (millions?) will be right in the path of totality.

Whether this is your first total eclipse, or your fourteenth, congratulations. You are about to see one of nature's wonderful displays of beauty. Just be certain to use your eclipse glasses, or a solar filter, both before and after totality. Take lots of pictures, duplicate Eddington's experiment, look for shadow bands and the closing of flowers, and listen to the stillness of the animals. Watch the corona, look for Baily's beads and the diamond ring, see the stars and planets during broad daylight, and just enjoy. It will be a wonderful experience.

If you are joining us at AstroCon in Casper, Wyoming, I hope to see you there. And don't forget, we still have a bunch of eclipse glasses and other materials available through our League store.

And don't even think about cloudy weather!

Changing subjects, I have been frequently asked, what are the requirements for an article or image to appear in an issue of the *Reflector*? While there are no "cast in stone" criteria, there are general guidelines for all article and image submissions.

**Articles**

Should be preferably written as a Microsoft Word document in .doc or .docx format.

Length can be anywhere from 400 to 4,000 words. We will perform the necessary editing for grammar, spelling, punctuation, formatting, etc. If there is a technical question, we will ask the author for clarification, or a rewrite, as necessary.

There should be a clear title for the piece, and the name and affiliation (club, member-at-large, etc.) of the author. If you would like, a very short biography can be provided, and should be placed at the end of the article, along with any contact information.

Headings or sub-headings should be either **bold** or *italic*.

**Mail**

Should be kept to under 400 words. Longer submissions will likely be edited for available space. Images can be sent, using the guidelines described below.

**Images**

Must be sent as separate JPEG or PDF files and not embedded in the Word document.

Minimum acceptable file size for images is 400 kilobytes. If you are submitting a potential front or back cover image, it must be 5 megabytes or larger.

Photo credit for all images must be provided. If the author or submitter took the image, this should be indicated.

Do not assume that because an image is on the Internet that it is in the public domain. Many Internet images are copyrighted and use without permission can lead to difficulties.

Captions for each image should be part of the Word document, and given at the end of the article (example: Image 1 of 4, NGC 2145, credit: Hubble Space Telescope). If you want an image placed in a specific location within the article, please indicate that with the caption.

Due dates for all articles, mail, and images are as follows: January 1 for the March issue, April 1 for the June issue, July 1 for the September issue, and October 1 for the December issue.

Material received after the due date will only be considered for future issues.

Finally, we received more than 1,450 emails and letters pertaining to this (June) issue. It is impractical to acknowledge receipt of every one. We will contact those authors and imagers whose articles and images will appear in each issue.

Don't be apprehensive about submitting an article or image. We look at everything received and offer a variety of images and articles. Amateur or professional, novice or "old-timer," we love getting new material and selecting what goes into each issue.

**Ron Kramer**, Editor

## Mid East Region of the Astronomical League

### MERAL ANNUAL MEETING

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## Attention Master Observers

The officers of the League would like to give special recognition to Master Observers who attend ALCon 2017 in Casper, Wyoming. At the awards banquet on Saturday evening, a special wall plaque will be presented in commemoration of your accomplishment. It does not matter what year you became a Master Observer.

Over the last two years, we have presented approximately two dozen Master Observers with special plaques, and, with great pleasure, we wish to repeat the honor this year as well as at future ALCons. If you will be attending, please contact vice president William Bogardus at [wfbogardus@yahoo.com](mailto:wfbogardus@yahoo.com) before July 1, 2017.

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### Paris, April 13, 2017 Fizzing Seas on Titan

The Cassini-Huygens mission revealed that there are seas probably composed of methane, ethane, and nitrogen on Titan, Saturn's largest moon. A previously unexplained phenomenon was detected in 2013 in radar images sent back by the Cassini orbiter: bright regions in Ligeia Mare (a sea on Titan) that appeared and then disappeared. This mystery, dubbed the "magic islands," has now been explained. An international team led by a researcher at the Molecular and Atmospheric Spectrometry Group (CNRS and University of Reims, France) has shown that a nitrogen/methane/ethane mixture is unstable at the pressures and temperatures expected in the depths of Ligeia Mare. Due to hydrodynamic circulation in the sea, mixing occurs between liquids at the surface and at depth. Part of the nitrogen-rich surface mixture flows down to the depths, which contain more ethane. The liquids then separate under the effect of pressure, and the gaseous nitrogen bubbles back up to the surface. The nitrogen bubbles are formed at a depth of 100–200 m, and can reach a diameter of four centimeters. Depending on Titan's marine weather, this phenomenon can spread over regions of sea several hundred square kilometers in area. According to the paper published in *Nature Astronomy*, this bubbling is a transient phenomenon, which explains why it is not systematically detected by Cassini's radar.

Bibliography: Bubble streams in Titan's seas as product of liquid  $N_2 + CH_4 + C_2H_6$  cryogenic mixture, Daniel Cordier, Fernando García-Sánchez, Daimler N. Justo-García, Gérard Liger-Belair, *Nature Astronomy* 1, 18 April 2017, doi:10.1038/s41550-017-0102.

### Florida, February 22, 2017 New Minor Planet Named

In a recent meeting, the Minor Planets and Comets Division (Division F Working Group Small Bodies Nomenclature) of the International Astronomical Union voted to give the minor planet (6117) 1985 CZ, the name Brevardastro to honor the Brevard Astronomical Society. 1985 CZ, was discovered on February 12, 1985, by H. Debehogne at the European Southern Observatory.

The IAU is the international astronomical organization that brings together more than 10,000 professional astronomers from almost 100 countries. Its mission is to promote and safeguard the science of astronomy in all its aspects through international cooperation. The IAU also serves as the internationally recognized authority for assigning designations to celestial bodies and the surface features on them. Founded in 1919, the IAU is the world's largest professional body for astronomers.

The Brevard Astronomical Society is a group of amateur astronomers dedicated to outreach. Main activities are holding public star parties for schools, libraries, scouts, and parks. The club maintains a special relationship with its neighbor, NASA's Kennedy Space Center, where club members provide sky viewing at public events.

If you would like more information about this topic, please contact David Guibert at [plutovip1@cfl.rr.com](mailto:plutovip1@cfl.rr.com).

### United Kingdom, March 30, 2017 New Research into Light Particles Challenges Understanding of Quantum Theory

Scientists have discovered a new mechanism involved in the creation of paired light particles, which could have significant impact on the study of quantum physics. Researchers at the University of East Anglia (UEA) have shown that when photons—the fundamental particles of light—are created in pairs, they can emerge from differ-



ent, rather than the same, locations.

The ground-breaking research could have significant implications for quantum physics, the theoretical basis of modern physics. Until now, the general assumption was that such photon pairs necessarily originate from single points in space.

Quantum entanglement—when particles are linked so closely that what affects one directly affects the other—is widely used in labs in numerous processes from quantum

cryptography to quantum teleportation.

The UEA team was studying a process called spontaneous parametric down-conversion (SPDC), in which photon beams are passed through a crystal to generate entangled pairs of photons.

Prof. David Andrews in UEA's School of Chemistry said: "When the emergent pairs equally share the energy of the input, this is known as degenerate down-conversion, or DDC.

"Until now, it has been assumed that such paired photons come from the same location. Now, the identification of a new delocalized mechanism shows that each photon pair can be emitted from spatially separated points, introducing a new positional uncertainty of a fundamental quantum origin."

The entanglement of the quantum states in each pair has important applications in quantum computing—theoretical computation systems that could potentially process big data problems at incredible speeds—as well as other areas of quantum physics.

The findings are also significant because they place limits on spatial resolution. Prof. Andrews said: "Everything has a certain quantum 'fuzziness' to it, and photons are not the hard little bullets of light that are popularly imagined."

The study, "Nonlocalized generation of correlated photon pairs in degenerate down-conversion," by Kayn A. Forbes, Jack S. Ford, and David L. Andrews, is published in the journal *Physical Review Letters*.

A copy of the full paper is available to download here: [www.dropbox.com/s/ltpxuq5bz9o24vx/proof\\_cover](http://www.dropbox.com/s/ltpxuq5bz9o24vx/proof_cover).

### Paris, February 22, 2017 An Exceptional System of Exoplanets

Seven Earth-sized planets revolve around the star TRAPPIST-1. In addition, at least three of them harbor conditions compatible with the presence of liquid water on their surfaces. The discovery was made by an international team led by a Belgian scientist and including researchers from the CNRS, the French Alternative Energies and Atomic Energy Commission (CEA) and the Université Pierre-et-Marie-Curie (UPMC), the Laboratoire d'Astrophysique de Bordeaux (CNRS/Université de Bordeaux), Laboratoire de Météorologie Dynamique (CNRS/UPMC/UPMC/École polytechnique/ENS Paris) and Laboratoire Astrophysique, Instrumentation et Modélisation (CNRS/CEA/Université Paris Diderot). The planetary system around the star TRAPPIST-1 is one of the most astonishing and promising yet discovered, especially with regard to its scientific potential: as well as determining the orbits and masses of the planets, it will be possible in the near future to detect the potential presence of atmospheres. The findings were published in the journal *Nature* on February 23, 2017.

In early 2016, high-precision brightness ("photometric") monitoring carried out by ESO's TRAPPIST telescope and NASA's Spitzer Space Telescope discovered three Earth-sized planets (TRAPPIST-1 b, c, and d) orbiting around the star TRAPPIST-1. Due to the orientation of the planetary

*Continued on page 27*



**B**oötes (pronounced boe-OH-teez) is one of the largest constellations in the Northern Hemisphere. It is the 13th-largest of the 88 constellations, occupying 907 square degrees of the celestial sphere. Six of Boötes' brightest stars—Alpha (Arcturus), Epsilon (Izar), Delta, Beta (Nekkar), Gamma (Seginus), and Rho—trace out the “ice cream cone” asterism. While many of us see Boötes as an ice cream cone, some observers see this asterism as a kite, 21 degrees tall and 10 degrees at its widest. At the southern tip of the ice cream cone lies the star Arcturus, the fourth-brightest star in the night sky. Alpha Centauri is slightly brighter than Arcturus. However, Alpha Centauri is a binary star, whereas Arcturus is not. Arcturus is actually brighter than either of the Alpha Centauri system components (Proxima Centauri is far enough away from the Alpha Centauri binary and so much dimmer that it is negligible here).

Boötes is depicted in the sky as a herdsman with two hunting dogs on leashes—Asterion and Chara (Canes Venatici). The dogs are chasing the Great Bear, Ursa Major, but never quite gain on it as all three constellations endlessly circle the north celestial pole. The name of Arcturus comes from the ancient Greek and means “guardian of the bear.”

Despite the size of Boötes, the constellation contains no Messier objects and no NGC open star clusters. The constellation hosts 263 NGC objects. Of those, 259 are galaxies, of

# DEEP-SKY OBJECTS

## BOÖTES' BEST STAR CLUSTER

By Dr. James R. Dire, Kauai Educational Association for Science & Astronomy

which only one is brighter than magnitude 11 (NGC 5248). Three NGC objects are stars or double stars. And then there is one sole globular cluster, NGC 5466. Thus, I feel safe proclaiming NGC 5466 is Boötes' best star cluster!

globular cluster M3, located in the neighboring constellation Canes Venatici.

NGC 5466 is a very small globular star cluster. Globular clusters are more compact than galactic (open) star clusters and usually contain



NGC 5466 lies on the western edge of Boötes. The cluster is 9 degrees west and slightly north of the star Izar and 9 degrees north and slightly west of Arcturus. The globular cluster and these two stars form an equilateral triangle, making it easy to point to NGC 5466 with a red dot finder. NGC 5466 is 5 degrees due east of the brighter

many more and much older stars. Their ages indicate that they formed billions of years ago. Unlike open clusters, globular clusters have enough mass to gravitationally hold onto all of their stars. The Milky Way has 150 to 200 globular star clusters, which form a spherical halo around the disk of the galaxy. William

Herschel discovered NGC 5466 on May 17, 1784.

NGC 5466 shines at magnitude 9 and may be captured in binoculars under ideal sky conditions. The cluster can be resolved into scores of 12th- and 13th-magnitude stars with 8- to 10-inch telescopes. At first glance, these stars give the appearance of an open star cluster. This is due to the cluster's great distance from Earth, 52,000 light-years. At this distance, many of the stars are too faint to be spied in the eyepiece. Comparing NGC 5466

to nearby M3 really demonstrates the effect of distance. M3 is 34,000 light-years away. Were NGC 5466 at the same distance as M3, it would be one magnitude brighter than it appears today. Sixth-magnitude M3 would still be two magnitudes brighter than the relocated NGC 5466. The extra brightness of M3 is because M3 contains many more stars than NGC 5466.

Visually, the denser core of M3

attests to that!

My image of NGC 5466 was taken with a William Optics GTF102 102 mm f/6.9 apochromatic refractor with an SBIG ST-2000XCM CCD camera. The exposure was 20 minutes. The image was processed to replicate the view through my 14-inch Newtonian telescope. The bright yellow star on the left (east) side of the cluster is SAO 83172, magnitude 6.9.

So, the next time you visit the bright globular cluster M3, take time to hop a few degrees to the east and check out Boötes' one and only star cluster,

NGC 5466. ☀

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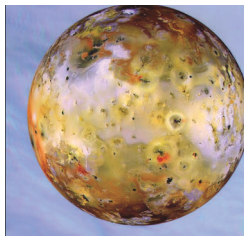
**By Berton Stevens**

**In 1968**, human beings saw their beautiful blue world rise above the stark, gray lunar surface from the Apollo 8 spacecraft. The resulting picture became an icon of the Space Age. The water oceans that form over two-thirds of the Earth's surface give it that predominantly blue color. However, while our planet has one of the largest percentages of ocean visible from space, it is not the only body in the Solar System with an ocean.

Jupiter has sixty-seven known moons in relatively stable orbits around this largest planet in the Solar System. Most of them are tiny objects, minor planets that came too close to Jupiter and were captured to become moons. The four moons that were discovered by Galileo Galilei in 1610 when he started observing the heavens are worlds in their own right. They are roughly the size of our Moon or a little larger.

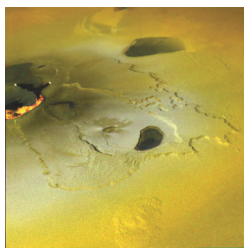
The Galilean moons—Io, Europa, Ganymede, and Callisto—are all quite different from each other. Some of the differences stem from their differing distances from Jupiter, and others arise from the compositions of the moons. Io is the closest to Jupiter. It is most affected by Jupiter's tremendous gravity field, always keeping the same face toward Jupiter, just as our Moon keeps the same face toward the Earth.

*Sometimes compared to a pizza in appearance, Io's surface is a very dynamic place, with many volcanoes spewing sulfur plumes into space that fall back to the surface. The subsurface magma ocean provides enough material to bury the entire surface every few thousand years. The red and black material mark areas that are only a few years old. This Galileo spacecraft image depicts the side of Io that is always pointed away from Jupiter.*



NASA/JPL

*The Galileo spacecraft orbited Jupiter for over seven years and on February 22, 2000, it captured this false-color close-up of Io's surface. The left side of the image shows an active volcanic eruption with lava flowing almost forty miles. The exposed surface of the lava cools down into a black area that splits into a "Y" shape. At the end of the Y's arms, the molten lava is again exposed as two bright spots at the toes of the flow.*



NASA/JPL

## Wanderers in the Neighborhood

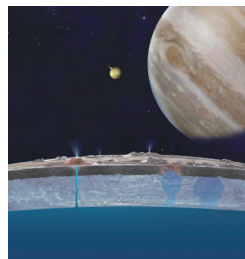
### The Oceans Around Jupiter

Early spacecraft observations showed a very young surface, devoid of the impact craters visible on many other Solar System objects. Another major discovery was a surface littered with volcanoes ejecting sulfur compounds into space. These compounds create the thin Ionian atmosphere and fill Io's orbit around Jupiter with sulfur ions.

The heat source for Io's geological activity comes not just from radioactive decay, but also from the tidal forces stretching and compressing the moon. When astronomers modeled the effects of the tidal forces on Io, they discovered that the model's volcanoes shifted westward by thirty to sixty degrees of longitude. This implied that something was transporting the heat under the surface from where it was generated to where the volcanoes are actually located. Most likely, it is an ocean of magma, a mix of molten and solid rock, flowing under the surface. The friction of the moving magma would generate extra heat as well.

While Io has an ocean of magma, Europa has a subsurface ocean of actual water. Europa is further from Jupiter, but it also is heated by tidal flexing as well as radioactive decay. It has the smoothest surface in our Solar System, covered with linear cracks but almost no craters. While water would normally be frozen this far from the

*Cryovolcanoes spew chloride salts 125 miles above Europa's surface. Before returning to the surface, the plumes absorb some of the sulfur being expelled by Jupiter's innermost large moon, Io.*



NASA/JPL-CALTECH

*Europa's gravity pulls the mix back down, creating a layer of frost that regularly renews the surface of the moon. The subsurface ocean that encircles the moon is thought to be capable of supporting some form of life.*

*Europa has one of the smoothest surfaces in our Solar System. Nonetheless, its surface is very diverse and includes long, linear cracks and ridges crisscrossing the surface. Blue or white areas contain rather pure water-ice, while reddish and brownish areas contain other elements in higher concentrations. In this mosaic from the Galileo spacecraft, the two polar areas at the left and right of the image are noticeably bluer, probably due to a different ice-grain size in these areas.*



NASA/JPL-CALTECH

Sun, tidal heating keeps most of the subsurface water liquid with some ice mixed in.

Europa also has eruptions, but they are not as predominant as Io's volcanoes. The Hubble Space Telescope has detected water vapor plumes coming from Europa, which can cover the surface with water-ice. The subsurface ocean not only interacts with the surface, but also the ocean floor, allowing the water to interact with rocky material, an important ingredient to the formation of life. If it is not cancelled, the Europa Lander may allow us to make direct observations about this potential home to extraterrestrial life.

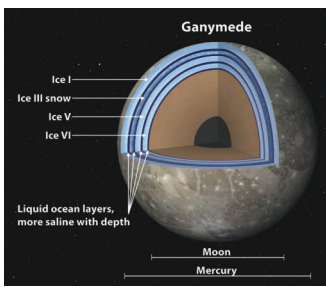
Ganymede is even farther from Jupiter, and also has a surface that is covered with water-ice. Like Europa, Ganymede has a subsurface saltwater ocean trapped between a surface layer of ice and a deep layer of ice covering the rocky mantle. There may be interleaved layers of ice and water, creating multiple oceans separated by the ice layers in different phases.

Ice can form at many different temperatures and pressures. There are seventeen different crystalline phases of water-ice that can form, depending on the environment. The hexagonal form of crystalline ice that is common here on Earth is very rare in space. Water is unusual in that at higher pressures, liquid water will not change into ice unless the temperature is actually below freezing (0° Celsius) due to the strong hydrogen bonds in H<sub>2</sub>O. Other liquids change to the solid state at higher temperatures than their freezing point as the pressure increases. In Ganymede's ocean, the increasing pressure causes different forms of ice to occur depending on the temperature at that depth. The final phase near the rocky mantle is presumed to be a tetragonal ice layer.

Ganymede is the largest of the Galilean moons and the only moon in our Solar System that has a sizable magnetic field. The existence of the magnetic field indicates a liquid iron-nickel core that is generating the field. The magnetic field captures solar wind particles and focuses them downward toward the poles, causing aurorae observed by the Hubble Space Telescope. These observations revealed distortions in Ganymede's magnetic field that imply a subsurface saltwater ocean. Ganymede may also be home to subsurface extraterrestrial life, possibly trapped in the lowest layers of its oceans.

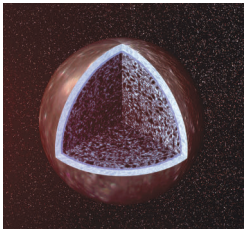
Io, Europa, and Ganymede are locked in resonant orbits. Io makes two orbits around Jupiter for each of Europa's orbits. Four Io revolutions occur for each one that Ganymede makes around Jupiter, which means Europa makes two orbits around Jupiter for each of Ganymede's orbits. Every time the moons get close to each other, the tidal bulges become substantially larger, just as we have higher tides

Ganymede has a more complex subsurface ocean structure than Europa. Instead of a single ocean, Ganymede has multiple



ocean layers at increasing depths separated by layers of ice. The deeper layers have increasing salinity and the ice layers differ in phase as pressures increase. The very bottom layer of salty ocean is up against a rocky surface, allowing interaction between the rocky minerals and the ocean water. This is important to the development of life.

Like Europa and Ganymede, Callisto also appears to have a subsurface ocean.



Varying magnetic fields near Callisto's surface imply that there may be a salty ocean under the surface can carry an electrical current sufficient to induce the magnetic field. The magnetic field was measured by the Galileo spacecraft's magnetometer as it made close flybys of the most distant of Jupiter's large moons. The measurements showed that the electrical currents reversed as Jupiter rotated, a key signature of electric currents in a salty subsurface ocean. Unfortunately, Callisto is only heated by radioactive decay and not tidal heating. This makes it too cold for life to form in the ocean.

when the Moon is in line with the Sun at full and new moon. This tidal stretching increases the heating to help keep these three moons warm.

Callisto does not participate in this tidal resonance and so it is internally cooler than its neighbors are. It appears to have an ice layer forming the surface of the moon, covering a possible salty water ocean mixed with ammonia or some other substance that acts like anti-freeze, lowering the freezing point of the water. If there is no ocean, there may be a thick layer of ice instead. Either would form a highly conductive layer that keeps Jupiter's magnetic field from penetrating it. The interior of Callisto is a mix of rock and ice, not differentiated into layers, but with more rocky material than ice nearer the core. This moon's surface is very old with many overlapping craters. The subsurface ocean never escapes to renew the surface and erase the older craters.

Galileo not only discovered four moons orbiting Jupiter when he turned his telescope on the giant planet, but he unknowingly discovered the homes of four oceans as well. Just as portrayed in 1984's *2010: The Year We Make Contact*, we may find the first extraterrestrial life not on Mars, but on Europa or one of the other large moons of Jupiter. ☀

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By William Bogardus

The Astronomy in Chile Educator Ambassador Program (ACEAP) 2016 made its journey to the Southern Hemisphere and back, and I was fortunate enough to be a part of it this year. The team of ten members was recruited, assembled, and conducted by Tim Spuck, AUI STEM Education Development Officer at Associated Universities Incorporated (AUI), in cooperation with the National Science Foundation (NSF) and the National Radio Astronomy Observatory (NRAO), with essentially two goals: 1) to highlight our country's investment in astronomical observatories in Chile, and, more importantly to me as an amateur astronomer, 2) to report on astro-tourism and why you should visit and take advantage of what Chile has to offer.

Ten ambassadors were selected from around the United States from various occupations and organizations. I was pleased to be able to go on behalf of the League. The ambassadors quickly bonded and struck out on a packed schedule to experience as much as possible in ten days. We met in Santiago at the Hotel Director Vitacura as our flights arrived from different cities. I was quickly impressed by the talent, intelligence, and vivaciousness of the other nine, and it reminded me of my arriving for the first time at college out of high school. I was one of a few members of the group that had visited Chile before. Even though I consider my Spanish to be only at a "baby-talk" level, I have not found that to be a huge impediment and I was quite comfortable being there.

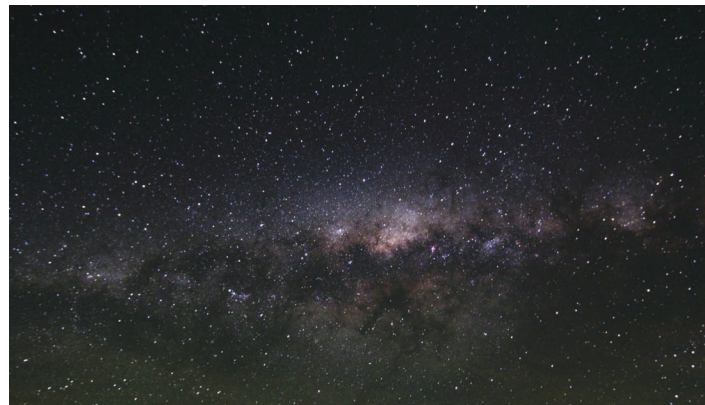
On the first evening, we were invited to a reception at the home of ALMA's (Atacama Large Millimeter/Submillimeter Array) director of education and public outreach, Valeria Fonca, whom we interacted with several times during our tour. Santiago serves as the administrative

center for many agencies from around the world that have large astronomical observatories in Chile. That is also where I met Sergio Cabezon, AUI/NRAO outreach officer in Chile—a fantastic guy. He traveled with us for the duration of the tour.

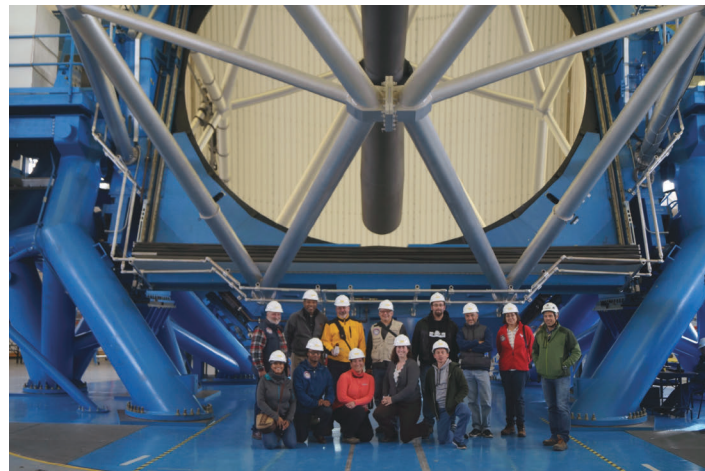
The following night, the group traveled into the nearby Andes Mountains to visit the Observatorio Astronomico

# Astronomy in Chile Educator Ambassador Program

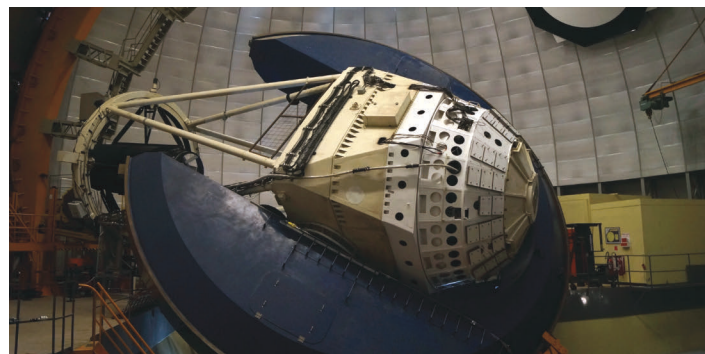
Andino. The sky was cloudy, but just the same, we were glad to get to see one of the many private observatories for astro-tourism. It was a first-class operation with clean, modern facilities and top-notch observing equipment that rivaled and surpassed my own. Especially impressive were the three 14-inch SCTs on computerized mounts with digital-imaging cameras and



Milky Way core taken from CTIO



The group at the Gemini telescope



The Blanco telescope

**The 2016 class of ambassadors** included Michelle Ferrara Peterson, program director at AstroCamp in Idyllwild, California; M. Josh Roberts, senior planetarium presenter, California Academy of Sciences in San Francisco; Sian Proctor, geology professor at South Mountain Community College in Phoenix, Arizona; William Bogardus, career educator and school administrator and adjunct professor at the State University of New York College at Oneonta; Derrick Pitts, chief astronomer and director of the Fels Planetarium at the Franklin Institute in Philadelphia; John Blackwell, observatory director and educator in science at Phillips Exeter Academy, New Hampshire; Geneviève de Messières, manager, astronomy education program at the Smithsonian National Air and Space Museum, Washington, D.C.; David Lockett, elementary school teacher at Mitchell Neilson Elementary in Murfreesboro, Tennessee; and Carmen A. Pantoja, professor of physics at the University of Puerto Rico in San Juan.

dedicated computers. It was an astrophotographer's delight. We were privileged to see this place. There are many others around the country, because Chile recognizes that it is one of the best places in the world from which to observe the southern skies. Location, location, location. The only thing working against us was the light pollution and temperate weather of the capital region. It was better to go north to the drier latitudes, and later, we did.

The following day, we boarded a flight to the La Serena airport so that we could visit the observatories in the Elqui Valley region. The city, a beach resort for many Chileans, is also home to the support personnel for Gemini and Cerro Tololo observatories. We were treated to tours of the science and engineering projects and presentations by the Gemini science staff. We met with representatives from several tourist observatories over lunch. As it turns out, the Elqui Valley is a premier location for this. On my two previous astronomical trips to Chile, this is where I observed, the first year at Elqui Domos and the second at the

Observatorio del Pangué.

Later that day, we packed into our van and headed up the valley to Cerro Pachón, the site of the Gemini Observatory, SOAR (Southern Astrophysical Research Telescope), and the not yet completed LSST (Large Synoptic Survey Telescope). We were privy to an extensive tour of Gemini and SOAR. From there, we could see nearby Cerro Tololo, where we would spend the next two nights. I had been to Cerro Tololo before on a previous vacation

but not for an overnight. They are open to the public for day visits with prior booking. It is best to go on a Saturday, as that is when they take general reservations. Be sure to bring your passport. I was excited for the chance to stay, but why on earth did we have to be here during a gibbous moon? Groan.

used one of the smaller scopes there for my research paper.

It was good that we spent two days there because we needed to acclimate. At 2200 meters elevation, breathing was difficult for those us who normally live near sea level. Even walking up the hill to the dining hall was an effort, but I needed to toughen up for the ultimate part of our trip to follow. If you are going to spend time at altitude, be sure to check with your doctor and talk

about medication that can help. There is a prescription drug that stimulates red blood cell production to help carry oxygen to your cells. I learned my lesson at Lake Titicaca, Bolivia, a few years ago, and three days of altitude sickness was not fun.

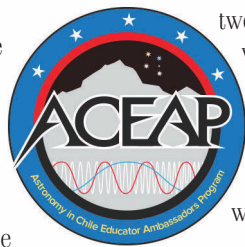
I say all of this because the remainder of the tour was further north in San Pedro de

Atacama at 2400 meters and higher. To get there, we flew into Calama and drove into the desert. Over the next two days we visited primary and high schools in the region and

ultimately ALMA. San Pedro is becoming a very popular place to visit, with many hotels, restaurants, curio shops, and several establishments dedicated to astro-tourism. The desert region there has little light pollution, and several hotels and tour companies offer observing.

It was a personal accomplishment to pass the medical examination at the ALMA visitor center in order to travel up the mountain ridge and visit the

*Continued on page 27*



The author, with oxygen



Cerro Tololo from Gemini

Fortunately, we did have a few hours of glorious moonless observing in the wee hours of the morning.

The next day, we were given a tour of the complex, which consists of many telescopes of modestly large apertures, a few of medium apertures, and the Blanco 4-meter telescope. The Cerro Tololo Inter-American Observatory (CITO) is dear to my heart as I once took an observational astronomy class at Stony Brook University and

# The Original Star Party



MILKY WAY & PERSEID METEOR OVER THE PORTER TURRET TELESCOPE AND STELLAFANE CLUBHOUSE - PHOTO BY DENNIS DI CICCO

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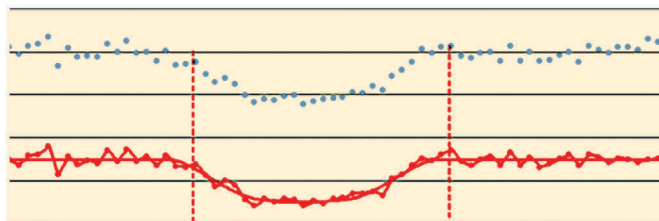
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## HARTNESS HOUSE WORKSHOP

THURSDAY, JULY 20, 2017



## EXOPLANETS

Advances in both camera and computer technology have brought the discovery and study of exoplanets, once beyond the detection limits of the most sophisticated professional telescopes, into the realm of serious amateur astronomers. Join us at Springfield's historic Hartness House, home of the Hartness Turret Telescope and the Hartness-Porter Museum of Amateur Telescope Making, for a day discussing a wide variety of exoplanet projects, at both amateur and professional levels. Meals included. Separate registration required.

FULL INFO AT STELLAFANE.ORG

*I consider a goal as a journey rather than a destination. And each year I set a new goal.*

—Curtis Carlson

### The Goal

Embracing Carlson's philosophy, I had set several goals for the past year—some professional and some personal. One goal was directly related to my love of rustic, out-of-the-way places, photography, and astronomy.

Over the course of several years, I had frequently driven past the small brown sign along Highway 15 north of Las Vegas, which simply read "Great Basin NP" in reflective white lettering. Nothing else, not even a mileage to indicate exactly how far up the road one would find this park.

I decided that a goal for 2016 would be to explore this elusive park.

### The Destination

Little did I know when I began my investigation that I would uncover an inspiring destination and accomplish triple goals of finding an out-of-the-way, rustic location with majestic scenery and a night sky filled with billions of stars with a clarity I had seen previously only when photographing above the Arctic Circle.

Great Basin National Park (GBNP) is a destination park, meaning you simply just don't stumble upon it or happen to drive by and decide to make a U-turn and drop in; you should make plans to actually get there. GBNP is in east-central Nevada, five miles west of the town of Baker.

Baker is located approximately 300 miles north of Las Vegas and 250 miles west of Salt Lake City. The nearest airports are in Ely, Nevada, 70 miles away, and Cedar City, Utah, 142 miles away. The nearest major airports are in Salt Lake City (234 miles) and Las Vegas (286 miles).

The new Great Basin Visitor Center is in Baker. The entrance

to Great Basin National Park and Lehman Caves is five miles west of Baker on Highway 488.

### The Park

Great Basin National Park was dedicated on October 27, 1986, making it one of the newer national parks. Given its location in eastern Nevada near the Utah border, GBNP usually ranks among the least-visited national parks in the lower 48 states.

The park is in the Great Basin Desert and contains most of the South Snake Range. The park encompasses an area of sublime, high mountain terrain. Cold, tumbling mountain streams,

# Setting Your Astronomical Goals for 2017

## Plan a Road Trip to a Dark Sky National Park

Al Marcella  
Astronomical Society of  
Eastern Missouri  
amarcella@mindspring.com

that encompasses 77,100 acres! Talk about having it all to yourself. What a feeling it was to have an entire national park to ourselves, open 24/7, and no entrance fee to boot!

Granted, traveling off-

alpine lakes, 4,000+ year old bristlecone pines, a miniature glacier, and limestone caverns are some of the attractions of this national park.

During a four-day visit to the park in late November and early December 2016, we encountered one hiker and three park rangers. That's it; we did not see another soul in a park

season is not for everyone, but if you want to experience solitude, no lines, no traffic, a quiet so intense you could hear the sound that a bird's wings make while in flight, and majestic views all to yourself, off-season is a wonderful time to visit and explore Great Basin National Park.

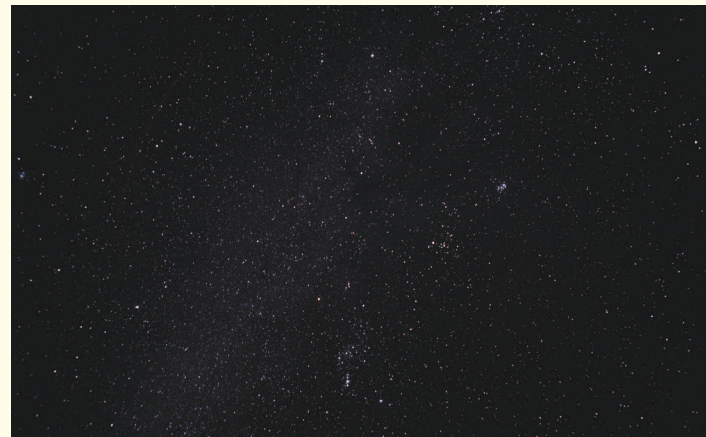
### The Night Sky

Two-thirds of Americans cannot see the Milky Way from their backyards, and nearly all of us live in places with measurable light pollution.

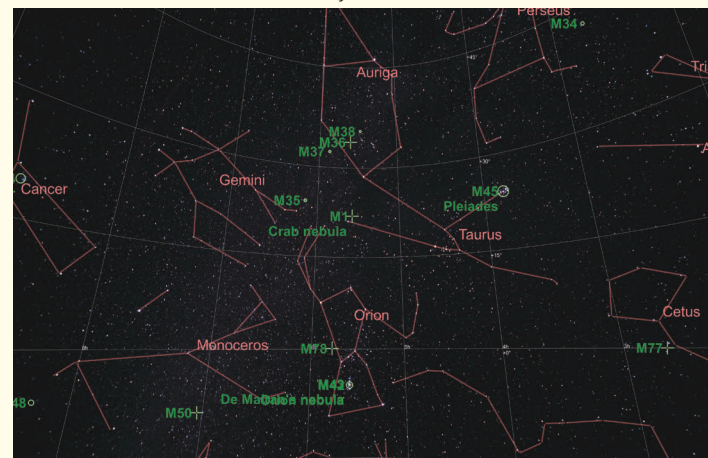
In spring 2016, Great Basin National Park was designated an International Dark Sky Park. The International Dark-Sky Association has recognized that Great Basin provides distinguished and significant opportunities to experience dark nights.

According to the Great Basin Dark Sky Park's light management plan, the park's location in one of the least-populated regions of the lower 48 states "enables it to have some of the darkest night skies in the continental United States. Due to its distance from major urban centers, and unique geographical placement" in the typical basin-and-range topography of the Great Basin, "it also maintains some of the clearest and steadiest atmospheric conditions. These conditions create superb transparency and stability in its skies. This combination produces the world-class night skies that make Great Basin an international destination for park visitors seeking a pure, primeval night sky experience." This also makes GBNP a prime destination for those interested in outstanding and unparalleled conditions for astronomical observation and astrophotography.

We planned our trip to coincide with the new moon and we were anxious throughout the day of our planned astrophotography shoot as low-hanging, wintry clouds filled



Great Basin National Park winter sky



Constellations and celestial objects visible on the evening of December 3, 2016, from Great Basin National Park

the sky. As evening approached, however, the temperature dropped to 12 degrees (Fahrenheit) and the clouds dissipated, revealing a crystal-clear sky and a multitude of stars.

As a dedicated Dark Sky Park, the conditions did not disappoint. After standing in awe, gazing at the winter sky ablaze with stars, we took our photos.

### The Images

The images accompanying this article were photographed using a Nikon D300, with a Tokina 11–16 f/2.8 mm lens set at 11 mm. Individual images were taken at ISO 320 with an exposure of 150 seconds. The D300 camera was mounted on an iOptron SkyTracker camera mount.

Both photographs are the composite result of five individual images, stacked using DeepSkyStacker software.

The top photo clearly shows the advantages for outstanding astronomical observation and astrophotography at a remote, dark location under optimal winter weather conditions.

The bottom photo is the annotated image with Messier objects and constellations labeled with the much appreciated help of fellow Astronomical Society of Eastern Missouri (ASEM) member Frederick (Rick) Steiling.

### The End

Now is the time to set your sights and a 2017 goal to visit an International Dark Sky Park (there are currently 13 in the United States—[darksky.org/idsp](http://darksky.org/idsp)). Go now and gaze upon a sky saturated with stars, one reminiscent of a night sky that amazed and inspired our ancestors. Whether you go simply to spread a blanket and look up at the heavens alight with countless celestial bodies or point your telescope at a distant planet or to engage in some astrophotography opportunities, you will not be disappointed. You will return with lifelong memories,

stunning images, and a sense of fulfillment, in having both experienced the wonder and awe visible in a truly dark sky and checking off one of your 2017 goals.

### The Logistics

Planning to get there is half the fun; however, actually being there and experiencing firsthand the majesty, splendor, and jaw-dropping beauty any one of these parks has to offer is breathtaking. Heading out at night and gazing into the depths of our universe ablaze with countless stars is an experience that can only truly be appreciated in person.

If heading out in 12-degree weather is not your idea of a lovely evening under the stars, but you still want to experience the wonder and awe of a sky overflowing with stars and other celestial objects (think planets, nebulae, star clusters, meteors, satellites, and so on), you might want to check out the annual **Great Basin Astronomy Festival**, held over several days and nights in September. The festival includes stargazing presentations, night sky photography workshops, and telescope observing each night.

So go, and make 2017 a memorable year in many ways! ☀

### How to Get There

- From Las Vegas (about 300 miles away), take I-15 north to US 93 north, then US 50 east to Nevada 487. At Baker, take Nevada 488 to the park entrance.
- From Salt Lake City, Utah (about 250 miles away), take I-15 south to US 50 west, then Nevada 487 to Baker and Nevada 488 to the park entrance.
- Airport: Ely (about 67 miles away)

### Contact the Park:

Great Basin National Park  
100 Great Basin National Park  
Baker, NV 89311  
(775) 234-7331, Park Headquarters Superintendent

### Accommodations in Baker:

Gateway Accommodations  
155 S. Nettie Ave  
Baker, NV 89311  
[GatewayAccommodations@gmail.com](mailto:GatewayAccommodations@gmail.com)  
[GatewayAccommodations.com](http://GatewayAccommodations.com)

# 10, 25, and 50 Years of the Astronomical League's Magazine

Compiled by Mike Stewart, *Astronomical League Historian*  
May 1967

## Messier Club Success!

On January 13, 1967, the first certificate for membership in the Astronomical League's Messier Club was given to Miss Catherine Delaney of the Amateur Astronomers Association of Pittsburgh for having seen 71 objects from the Messier Catalogue and recording dates of observing them with her 6-inch Newtonian reflector with a 46-inch focal length, using a one-inch Kellner eyepiece.

Miss Delaney, a Northerner, was the first recipient but the next six are from sunnier climes.

### Certificates for 70 Objects issued to:

Steve Hall—Dallas, Texas

Kurt Allback—Dallas, Texas

### Certificates for all 110 Objects to:

Karl Simmons—Jacksonville, Fla.

John H. Wulf—Dallas, Texas

David Gordon—Dallas, Texas

Ronnie Price—Dallas, Texas

*The Messier Program remains the Astronomical League's premier Observing Program. Observers can earn the Messier Program Certificate for observing and recording 70 objects, or they can earn the Honorary Certificate for observing the full catalog, which numbers 110 objects today.*



## May 1992

### CCD's: A Bright Future for Dim Objects

Charge-coupled devices, or CCD's, have liberated amateur astrophotographers from the drudgeries of the dark room and placed in their hands an extraordinary tool.

The CCD chips at the heart of most electronic imaging devices are used in two very different ways. In video cameras, the image is scanned at a rate of thirty times a second, and is usually output as an analog signal. On the other hand, slow-scan CCD cameras produce digital outputs that can be used by a computer system to produce a picture based on the intensity of the picture elements, or pixels.

Slow-scan CCD's are a remarkable technology, but at a price. A good package will cost roughly \$5000, including the CCD camera, a computer system with appropriate software, and interfaces. While a portable system is possible, a permanent observatory is the only way to go.

*In this 1992 article, Gary Hug from Topeka, Kansas, explained the "new" technology that astrophotographers were just then starting to use to capture images. The computer system he described had a mighty 40-megabyte hard drive and 2 megabytes of RAM.*



## June 2007

### Sasquatch has amazing powers!

Sasquatch, one of the names for the Bigfoot creature said to have astounding powers, is also the name of the Smoky Mountain Astronomical Society's 20-inch reflector telescope, which also has astounding powers.

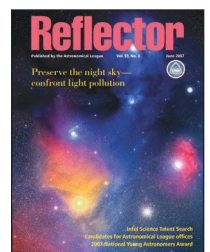
I've looked at various objects through Sas—as we affectionately call the scope—on two different nights now, and I can tell you two amazing things about the scope that you might miss if you haven't had it near you at a star party:

- Having your smaller scope sitting near
- Sas improves your smaller scope's light-gathering and resolving capabilities.
- Sas is a go-to scope that doesn't require batteries.

Of course, this is where several people may exclaim I'm full of it, but let me explain why I think of Sas as the most unbelievable 20-inch go-to finderscope I've ever seen for my little 6-inch Dobsonian.

My small Dob is what I've used while Sas was set up nearby at two star parties. I can tell you from experience that the way to use Sas is as a go-to scope. First, attempt to find your object in your small scope. If you can't seem to get a lock on it, look back towards Sas and say, "Has anyone pointed Sas at [insert deep sky object here]?" It's that easy. Amazingly enough, in quick order the big scope finds the specified object by using multiple and very friendly tracking computers—other club members.

*Amongst the more serious articles in the June 2007 issue was Mike Marcum's entertaining piece with a thoughtful message. Mike, like many of us have on the observing field, discovered that amateur astronomers are some of the most helpful, sharing people you'll ever meet, and one can locate amazing objects with a modest telescope.*



## Background

If you were sixteen years old in 1984 and a fan of science fiction, you have seen Arnold Schwarzenegger in the *Terminator* franchise, probably more than once. We are, of course, the *Star Wars* generation. The first *Terminator* sequel, *Judgment Day*, was released seven years later, which is a lifetime for a sequel. *Rise of the Machines* was released another twelve years afterwards—a testament to the enduring nature of that franchise.

I have no doubt that the faculty in the Department of Physics and Astronomy at the University of North Carolina were inspired techies and

first robotic telescopes were manufactured by RC Optical Systems. The UNC astronomy faculty and grad students began building the PROMPT network—meaning “Panchromatic Robotic Optical Monitoring and Polarimetry Telescopes”—in 2004. The figures grow daily, but a recent estimate shows that Skynet has taken over 16 million images for tens of thousands of users worldwide.

## Successful History of Fundraising

Most of the funding for Skynet has been awarded through the Major

# AMATEUR ASTRONOMY ONLINE

By Tom Finkenbinder

moviegoers; they conceived a project called “Skynet”—a nod to the reality of a world increasingly served by computers and the Internet. Not quite machines that are self-aware, Skynet is a collection of telescopes, filters, cameras, and retractable-roof observatories installed in remote mountainous locations that employ robotics to study the sky at night.

Skynet headquarters is in the Morehead Observatory building on campus at UNC in Chapel Hill, North Carolina. Skynet is funded by the National Science Foundation (NSF), NASA, and private donors. Skynet locations—with no on-site human operators—span four continents. New sites in North America are up for consideration every year, as the outreach curriculum written by UNC professors gathers interest from other colleges and universities, foreign government science programs, K–12, youth groups, and adult amateur astronomer communities—like us.

Skynet is truly a global scientific resource available to the public and academia through a web portal for PCs, laptops, tablets, and cell phones; a variety of related websites; and a Facebook page. The

Research Instrumentation (MRI) Program at the NSF. NASA and other collaborators have also contributed to the network. The first Skynet proposal, submitted in 2003, was turned down, although some of the scopes were already being assembled. The grant was slated to build telescopes and their clamshell domes at the Cerro Tololo Inter-American Observatory above La Serena, Chile, 30 degrees south latitude and 2200 meters (7000 feet) above sea level. A second proposal asked NSF to fund the construction of six Ritchey–Chrétien telescopes, figured with hyperbolic mirrors, suitable for professional astronomy, at \$100,000 per telescope. The first NSF award was made in 2004. Dr. Dan Reichart leads the program at UNC–Chapel Hill.

Two million dollars was raised via the American Recovery and Reinvestment Act (ARRA), awarded through NSF and allocated to several projects between 2010 and 2012. This included the addition of four new 17-inch RC scopes at the Siding Springs Observatory in New South



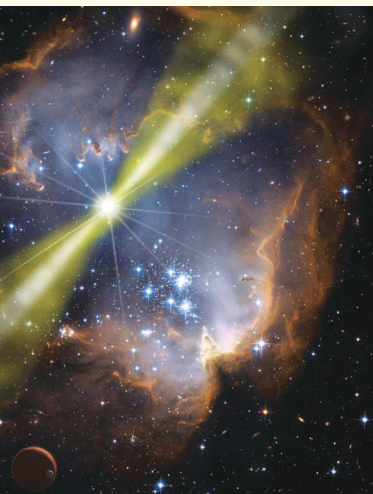
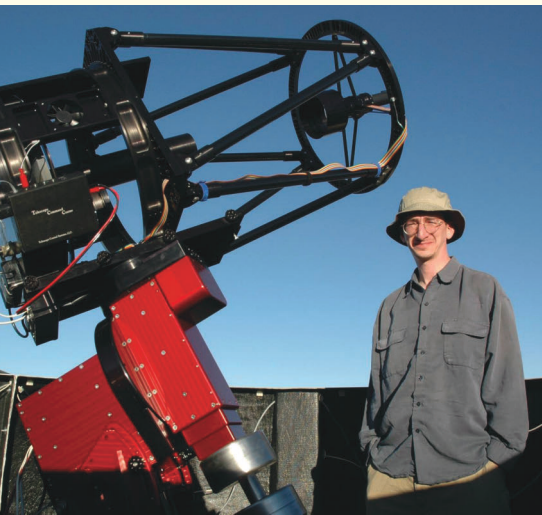
Wales, Australia. Some of the ARRA award was used in collaboration for the refurbishment of the 20-meter National Radio Astronomy Observatory telescope in Green Bank, West Virginia.

Typical of NSF grants, future funding will rely on the ability to self-fund Skynet’s operating budget in a pay-for-use model. For example, PROMPT 8 is a 24-inch RC telescope added in 2013 in partnership with the Government of Thailand, which pays for most of its use. This and paid time on the other Skynet telescopes now support most of the operating expenses for PROMPT. A 32-inch telescope has also been

completed at the Chilean site. It was funded entirely by Swiss manufacturer Astro Optik GmbH—for one of their own design, of course.

Altogether, eight PROMPT telescopes are now operating in Chile, and half a dozen at three sites in Australia and Canada. A few existing telescopes at universities are online. These include the recommissioned telescope at the Morehead site on the UNC campus, two telescopes at the Dark Sky Observatory near Appalachian State University, and the University of Chicago’s 41- and 24-inch telescopes at Yerkes Observatory in Wisconsin.





Top row, left to right: Morehead Observatory (credit Department of Physics and Astronomy, UNC–Chapel Hill); Dan Reichart at CTIO (credit Department of Physics and Astronomy, UNC–Chapel Hill); NRAO, Green Bank, West Virginia (credit Department of Physics and Astronomy, UNC–Chapel Hill).  
 Second row, left to right: SSO cluster (credit Department of Physics and Astronomy, UNC–Chapel Hill); GRB illustration (credit NASA); Author and his dad, Ron, at Gornergrat Observatory, Switzerland (credit author).  
 Third row, left to right: Moons of Uranus (credit Skynet/author); Ceres angular measurement (credit Skynet/author); Arp 153 (credit Skynet/Steve Tzikas).

### What Are Gamma-Ray Bursts and What Do They Have to Do with Skynet?

Simply put, we wouldn't have Skynet without gamma-ray bursts. GRBs exist in an epoch of the history of our universe when stars formed quickly, built heavier elements through fusion, spent their fuel, and collapsed under their own weight to form black holes. This is the most common model. While in the last stages of their lives, these rapidly spinning stars eject material at nearly the speed of light. If located inside a host galaxy, the explosive energy heats and ionizes dust and gas in the vicinity of the burst. This

is an oversimplification, but nonetheless, GRBs are acknowledged as the most energetic and cataclysmic events we know of in cosmology.

The professional astronomy community has been studying GRBs for years. On average, a burst is detected by satellites every few days. Gamma photons are emitted when shells of ejected stellar material crash into each other. These extra-galactic photons travel to us through space and time—in some instances, from near in time to the Big Bang. But the photons are blocked by Earth's atmosphere and cannot be observed from the ground.

Thanks to NASA and the European Space Agency (ESA), a handful of satellites were launched to study these and other high-energy particle phenomena. Onboard instruments can detect and locate GRB sources almost immediately. The positions are then radioed to the ground.

Downlink telemetry moves through a network gateway at NASA's Goddard Space Flight Center in Greenbelt, Maryland, and the GRB positions are relayed over the Internet to astronomers all over the world. Skynet operations is one of the endpoint recipients of the burst coordinates, and they use this information to initiate automated observing runs with the

PROMPT telescopes.

The duration of a GRB observed by the satellites is typically a few seconds. But the remnant effects can range in duration from a few milliseconds to several hours, and sometimes even several days. The initial burst is often followed by a longer-lived event in optical and infrared wavelengths. We call this "afterglow."

Burst afterglows are short-lived, too. With no other use, the PROMPT telescopes would be idle most of the time. And so the concept proposed to the NSF has always been to allow opportunities for observing with robotically controlled professional equipment, made available primarily as a teaching tool over the Internet.

### Nomenclature

*Skynet* is actually the name for PROMPT's control software, a web-based, dynamic, queue-scheduling application. This custom application is developed at UNC as are resources for the databases and storage space to accommodate images.

*Afterglow* is an astrometry and photometry software program that UNC created for use with FITS files to meet curriculum opportunities.

*FITS* (Flexible Image Transport System) is the data format used for analyzing scientific images. Pixel-count across the field of view of a CCD camera can be translated to the angular diameter of an asteroid, for example.

*Stellarium* is a freeware application you can download to your PC or smartphone to use with visible-spectrum astronomy. When planning an observing run, data input to the Skynet portal will need to accurately show what you are looking for, when and where to point the telescopes to find it. It is also required for the Skynet University labs.

*Skynet University* is the online curriculum for teaching basic and advanced courses in astronomy at UNC.

*Outreach* is a key component used by the NSF to evaluate requests for funding. Skynet University was a natural path to create education channels to reach other schools and the public.

### Skynet University

Use of the network assumes that

*Continued on next page*

subscribers are willing to learn how to operate Skynet via “how-to” tutorials, and then will set out on their own to create and fetch image files. UNC faculty are busy teaching at a large university. UNC faculty decided to make the telescopes and curriculum available through online courses. Hiring people for a help desk and manually grading work would quickly burn through the grant money.

New users can find tutorials for working with Afterglow through the Skynet University website as well. There are sample Skynet labs that are free to access before signing up for the formal curriculum. Perusing the labs, looking over the Skynet portal, and talking with current users are probably the best routes to take before creating an account on the network.

It is a bonus, when forming an interest group inside your club, if some of your club members have independently started to use Skynet.

The printed tutorials and YouTube clips show how to find an observable object, choose telescopes, select exposure length, and use filters. Lab 1 in particular is a must-see. A good start is to observe planets and their moons, deep-sky objects, asteroids, and minor planets—all in Lab 1.

“Astronomy With Skynet: Our Place in Space!” is the suggested starting point. It is a full-length course for amateurs, astronomy clubs, K–12 public and private schools, and youth programs. The course follows a structured curriculum. Students use tutorials with the Afterglow astrometry application to evaluate data.

Some simple algebra and geometry skills are needed. Enrolled students are given 30 minutes of observing time on PROMPT.

Astronomy 101/102 are the undergraduate courses taught at UNC for college credit. UNC decided to offer the lectures and curriculum free to the public, but not for credit or a certificate. Dan Reichart, an astronomy professor at UNC, suggests buying the course’s textbooks, but this is not a requirement. Students follow along with

Dan’s one-hour lectures on Skynet University’s YouTube channel, [www.youtube.com/introastro](http://www.youtube.com/introastro). Astronomy 101/102 courses do not require use of the network telescopes. But if you’ve made it this far into Skynet, you will probably want to have your own user account and telescope time for observing projects.

### Successful History and Ongoing Commitment to Outreach

The NSF requires a broader-impact component with all funding requests. UNC fulfills this by making the network available to the public. UNC started with high schools and colleges in North Carolina. Skynet’s user community now includes enrolled UNC students, and more than a dozen colleges in North Carolina and surrounding states. Some of these schools apply to have their telescopes connected to the network.

Skynet Junior Scholars was established in partnership with

that a new three-year, \$2.5 million NSF project has been approved to engage high school students with hearing and vision disabilities in astronomy-learning activities. Yerkes is the education and research center for the recently established IDATA—Innovators Developing Accessible Tools for Astronomy. Teams of students work with national leaders to design online imaging software that can be used by anyone—including, in particular, the visually impaired.

### What Our NOVAC User Community Does with Skynet

#### • Basic Imaging

Our local AL member community is the Northern Virginia Astronomy Club (NOVAC). We have a Skynet user group and we use Skynet to image Solar System, Messier, and Herschel objects. We can image outer planets and their moons with enough resolution for astrometry work. Some of the Skynet labs

require the imaging of asteroids and minor planets, measuring shape and size, and observing orbital position against a backdrop star field over a few nights.

The great thing about Skynet is that users can stay as basic or go as deep as they want into learning astronomy with professional tools and curriculum. The Skynet user portal is intuitive. Skynet is linked to SIMBAD, a database of more than 2.5 million objects, so that the guesswork (and the chance of accidentally missing the target) is taken out of locating precise celestial coordinates. The

portal screens guide users through easily understood fields to set exposure length and filter choices. An hour or two spent with the online tutorials and you should be able to program your first job.

We have about 25 NOVAC members in our group using the same Skynet account to program and retrieve jobs. I cannot recall, in over two years of managing the Skynet relationship for our club, any member needing to reach out for a significant amount of help with their

first run—provided they worked through the tutorials. We all communicate by email. Your club might want to reserve a room at a library in the evening to collectively become acquainted with the features. Even newly experienced users can run a demo. A Skype call would work, too.

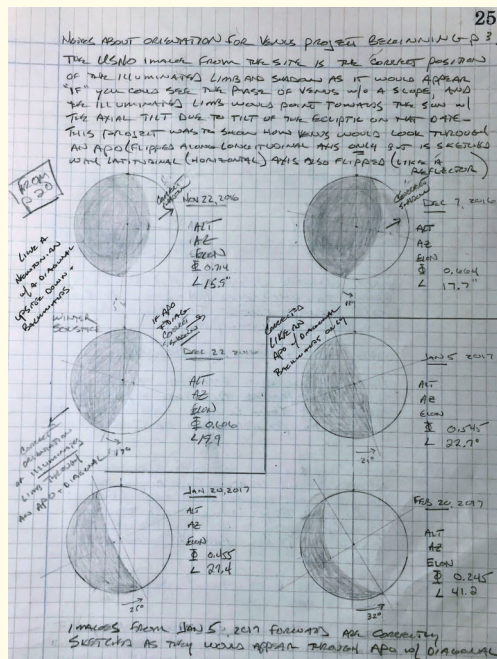
#### • Pursuing Astronomical League Certificates

Steve Tzikas, one of our NOVAC members, is working the Astronomical League’s Arp Peculiar Galaxy Observing Program. Most objects on the list are between 12th and 18th magnitude. Over 100 are fainter than 13.5 magnitude. The AL points out that the Arp program is suitable for “advanced amateurs” and suggests using a scope with more than a 12.5-inch aperture. The 16-inch telescopes meet those qualifications. We hope that employing remote, robotically controlled telescopes in Chile and Australia, through a web portal on a laptop at the kitchen table, qualifies as advanced amateur use!

The AL provides a list of 338 Northern Hemisphere observable objects. The AL added a Southern Hemisphere Arp list in 2010 with about 500 objects. Just over one hundred objects from the southern list are above 30 degrees south declination. An observer can reach this part of the sky from the mid-northern latitudes, but only at low elevation. From telescope sites 30 degrees south in Chile and Australia, the entire southern list can be observed. The southernmost objects are 85 degrees south declination, near the south celestial pole.

#### • The Venus Project—a.k.a. Tom’s Tangent

In Skynet University Lab 3, “The Galilean Revolution: Our Place in Space,” there is a discussion about Galileo’s discoveries that we all know cemented our modern understanding of the heliocentric Solar System first introduced by Copernicus. Galileo regularly studied the four Jovian moons. Why would they seem to stay in the same basic positions, moving around the orb, even as Jupiter moved from one zodiacal constellation to the next from year to year? And why did Venus have phases like the moon?



A page from Tom’s field book

several large 4-H clubs who conceived an astronomy program for youth in 2003 promoting STEM education. In three years, Skynet-trained educators provided professional development for 135 youth leaders from 25 states. More than 1400 youth are members of SJS, and their numbers are expected to grow threefold over the next few years.

The director of Yerkes Observatory, Dr. Al Harper (University of Chicago), announced in December

Why does it appear bright and high in the sky some seasons, fading and disappearing into the sun in others?

Galileo's observing records with the telescope that he built were made about 1610, then published in 1613. Lab 3 requires use of prepackaged, canned data for Venus observing since the planet appears too close to the sun as viewed from Earth much of the time. Skynet's control software will not allow the PROMPT telescopes to be pointed too close to the sun, even in twilight, to avoid damaging the CCD cameras.

So, I got an idea reading Lab 3, and decided to satisfy my curiosity by wandering off on my own Venus project in June 2015. I have mostly used a U.S. Naval Observatory website, "Apparent Disk of a Solar System Object," [aa.usno.navy.mil/data/docs/diskmap.php](http://aa.usno.navy.mil/data/docs/diskmap.php), that shows a computer-generated image of Venus at any point in time, correct in angular diameter and current phase.

I sketch the images from the computer screen in my field book

and make visual estimates of the angular tilt as it varies with the seasons due to tilt of the ecliptic. I make sketches about once a month, more frequently when the phase is changing quickly from week to week as it was in late March.

#### • Radio Astronomy

It was mentioned earlier that the 20-meter dish at Green Bank, West Virginia, was refurbished. Skynet added it to the network and enabled it through the user portal in 2016, bringing radio astronomy into the network and educational curriculum.

UNC and the team at the National Radio Astronomy Observatory in Green Bank will be publishing images and observing ideas this year. Some of our members have tried a few runs gathering plots of flux energy in certain frequencies of the radio spectrum. Favorite targets are the Sun, Virgo A, Cassiopeia A, Taurus A, and Sagittarius A, and I am sure new users could find more ideas on the Internet. We are looking forward to learning more in

this area of astronomical observing.

#### How to Get Started

The Skynet team welcomes and will respond to requests to join the community at [introastro@unc.edu](mailto:introastro@unc.edu). First, take a look directly at the user portal, [skynet.unc.edu](http://skynet.unc.edu). Spend some time with the Skynet University website and look at the FAQs there. On your own, it would be best to go to Skynet University and sign up for "Our Place in Space," since it includes 30 minutes of observing time. That might not seem like a lot, but good exposures require only a few seconds. Your quota is spent only for the time that the shutter is

open. Setup and slew time do not count against your budget.

For your club, find one or two champions to try the demo labs, then organize some group activities. UNC faculty recorded tutorial videos for lab instructors and group leaders, one for each lab in the "Our Place in Space" course.

We treat this all pretty casually inside of NOVAC. I occasionally make presentations for the club. We have not felt the need to have user group meetings. We are pretty spread out geographically as a club. The bulk of our members live within a 50-mile radius of Washington, D.C. ☀

Tom has been a NOVAC member since 2002. His academic and professional background in electrical engineering provided him with a strong foundation in communication systems during the explosive growth of the Internet. That work experience and a rekindled interest in astronomy from childhood created curiosity about automated observatories, whose use and availability grew with the spread of high-speed Internet access around the world. Tom completed his Messier Certificate in 2007, mostly at Camp Highroad, Virginia, with a 5-inch APO and O'Meara's well-known book, *Deep Sky Companions: The Messier Objects*. He has presented at NOVAC's annual star party in West Virginia, and arranged for Skynet professors to speak at monthly NOVAC meetings. He also presents to K-12 and adult education groups, and by invitation at George Mason University, NOVAC's academic sponsor.

## Help IOTA Measure Asteroids, Double Stars, the Sun, and More

By David W. Dunham

Technology now allows observers to record transient astronomical phenomena more precisely and to fainter magnitudes than ever before. A new small, inexpensive, yet very sensitive camera (RunCam Night Eagle Astro) will allow you to participate in the International Occultation Timing Association's (IOTA's) programs to accurately record occultations and eclipses, to measure the sizes and shapes of hundreds of asteroids, discover duplicity of both close double stars and asteroids with satellites, and measure the angular diameters of many stars, including the Sun (at the total solar eclipse in August).

The figure shows the results of an occultation of the 6th-magnitude red giant star LQ Aquarii by both components of the binary asteroid 90 Antiope recorded from 50 sites by IOTA observers in northern California and southern Oregon on

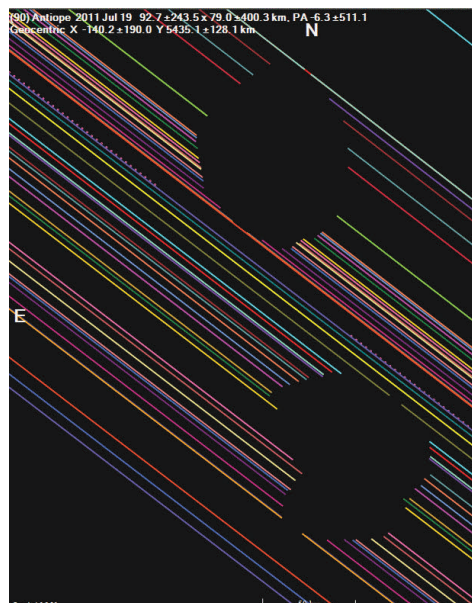
July 19th, 2011. Each line traces the path of the star across the plane of the sky at the distance of Antiope, interrupted when the star was behind one of the Antiope components. A large crater on the side of the southern component suspected from analysis of rotational light-curve and adaptive optics observations, was confirmed by the Pac-Man-like outline revealed by the occultation timings. In addition to the information about the Antiope components, the angular diameter of the star was measured from the gradual disappearances and reappearances of the star that lasted around half a second at most sites. There were fewer than 50 observers since some of them set up several remote video systems that automatically recorded the bright star.

Besides main-belt and Trojan asteroids, some IOTA observers are using integrating cameras with larger telescopes, some special ones designed to be packed in a standard suitcase, to observe the rarer and generally fainter occultations by trans-Neptunian objects. We also still record the much more common

lunar occultations with the main purpose to discover and measure close double stars. If a lunar occultation is observed from a zone only a few hundred yards wide at the northern or southern limit of the region of visibility, the star moves along a tangent line relative to the Moon's disk, disappearing and reappearing repeatedly among mountains and craters in the polar regions. Watch this striking example, a synchronized collage of five videos obtained during the Aldebaran grazing occultation last March, at [vimeo.com/209854850](http://vimeo.com/209854850).

During the next 3 months, the brightest star occulted by an asteroid will be 5.9-magnitude SAO 59794 (HIP 34358) by 930 Westphalia at 9:25 UT on August 14 in a path from Albuquerque to Minneapolis. Several other events are listed on page 250 of the 2017 Royal Astronomical Society of Canada's *Observer's*

*Handbook*, which also has lunar occultation data (with graze maps) on pages 162–178. A free Windows tool called Occult Watcher will alert you to the many more asteroidal events potentially visible from your observatory or area, while "Occult 4," another free program, can be used offline to make your own lunar (and other) occultation predictions. See IOTA's web site at [www.occultations.org](http://www.occultations.org) for information on obtaining these programs—under "Observing," then "Occultation Predictions." Check out the other tabs for observing methods, recommended equipment (such as the new RunCam Night Eagle Astro camera), observing the August total solar eclipse, and joining IOTA, which we encourage. Most of our software and services are available free to non-members, to encourage observations, including participation in the lively IOTA occultations Yahoo! Group! where current and future occultations are discussed, as well as observing methods and equipment; see [groups.yahoo.com/neo/groups/IOTAoccultations/info](http://groups.yahoo.com/neo/groups/IOTAoccultations/info). ☀



Story and photos  
by Dr. Alex Vrenios

I've completed over a dozen Observing Programs to date. The ones I enjoyed the most put me in the deep end of a field that is way outside of my comfort zone. The Analemma and Galileo Programs come to mind, as does the Radio Astronomy Observing Program, which is the subject of this article.

I am a longtime ham radio operator with strong interests in astronomy and photography. You might think getting into radio astronomy would be a natural for a guy like me, but I just never knew how or where to start. A couple of years ago, the Astronomical League introduced a Radio Astronomy Observing Program. The requirements seemed within my reach, so I decided to give it a try.

The Radio Astronomy Program describes five "projects" one can do: detection of solar radiation, sudden ionospheric disturbances

(SIDs), Jupiter's radio storms, radio meteor scatter, and galactic hydrogen radiation detection. One need only complete four of the five, but hydrogen

radiation detection must be one of them. Send in the results for one project and get a bronze-level certificate. Do a second project and advance to silver. Complete two more projects to achieve gold level. As a bonus, beautifully styled silver and gold pins accompany the silver and gold level certificates, respectively.

Some of the projects were easier than others because I could build the antennas from material I already had. But one of the projects had me digging through the literature, and ultimately asking for advice.

# The Radio Sky

What follows is my experience with each of the projects.

## Solar Radiation Detection

The Sun is a very powerful thermal energy source. As a way to detect its energy, the Radio Astronomy Observing Program's web page suggests building an instrument like the Itty Bitty Telescope, from plans available through the NRAO (National Radio Astronomy Observatory). A free-to-air satellite TV receiver I assembled several years ago, however, was ready to be repurposed anyway, and it seemed like a good way to detect solar energy. I hooked a



Figure 1

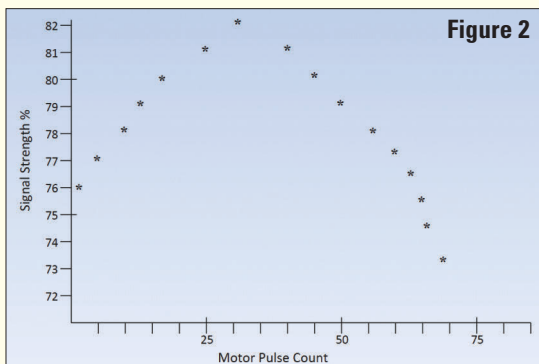


Figure 2

signal strength meter up to the dish, pointed it just east of the Sun, and pulsed the motor to make the dish scan incrementally to the west, across the face of the Sun. The signal strength gradually rose and then dropped off again (Figures 1 and 2). I did this on three separate days, sent in my results and my bronze-level certificate arrived soon afterward.

## Sudden Ionospheric Disturbances

An X-ray storm, as one example, improves the reception of very low frequency (VLF) signals

during daytime by briefly ionizing the Earth's upper atmosphere. An uneventful plot over a 24-hour period will show high VLF signal strengths during the evening hours and a low, nearly flat response during the day. When a SID occurs during daytime, the plot will show a spike in the received signal strength. A plot with such a spike is the goal of this project: evidence of SID detection.

VLF radio stations are used by militaries around the world to communicate with their submarines because these signals can be received under water. These communications are encrypted, so you may never extract any intelligence from them, but all we are really interested in here is the relative signal strength.

SARA (Society of Amateur Radio Astronomers) offers a "SIDs Kit" that includes a

newly designed receiver that is pre-built and tested (Figure 3). I built a big loop antenna (Figure 4) and hooked it up to the VLF receiver (Figure 5), but there were no VLF signals to be heard. I never did understand why the signals were so averse to coming into my backyard!

I've read the online postings and I understand there are plenty of SID monitoring stations out there that seem to be blessed with either a



Figure 3



Figure 4

strong VLF signal presence, a lack of interference, or both. I guess I was not meant to be one of them.

## Radio Meteor Scatter

I got involved with this activity decades ago, so I knew what it was about. The first thing I needed to find was an FM radio station as a source. It had to be just far enough away from my home that I couldn't receive it directly, but close enough that when a meteor streaked through the atmosphere, its signal would bounce off its ionization trail, and onto my receive antenna. I knew that the National Weather Service had stations continuously broadcasting weather forecasts scattered across the U.S., but I did not expect the delightful coincidence that I discovered.

I was looking at a list of cities from which weather forecasts are broadcast and I happened to notice that both Tucson and Flagstaff, Arizona, used the exact same frequency! I'm in Phoenix, which is just far enough away from both of them so as not to be able to receive either of them directly, yet close enough that a meteor's ionization trail would reflect a signal down to my location. This doubled my chances of success. Now, how to log the detection?

I have a good quality ham FM radio that receives the weather frequencies. An online search revealed a crossed dipole antenna to be a good choice for meteor reception. I found plans for one and built it from a plastic electrical box and some metal rods that I already had (**Figure 6**). I also found a USB data acquisition unit and ordered one online

Figure 5

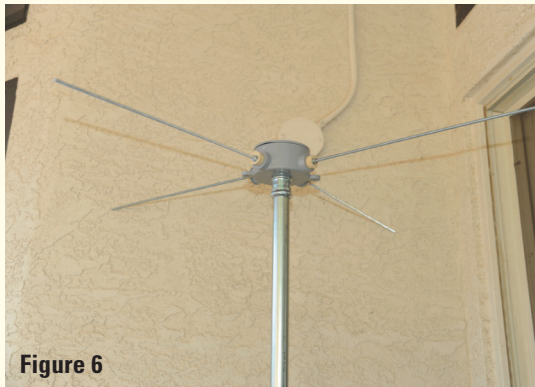
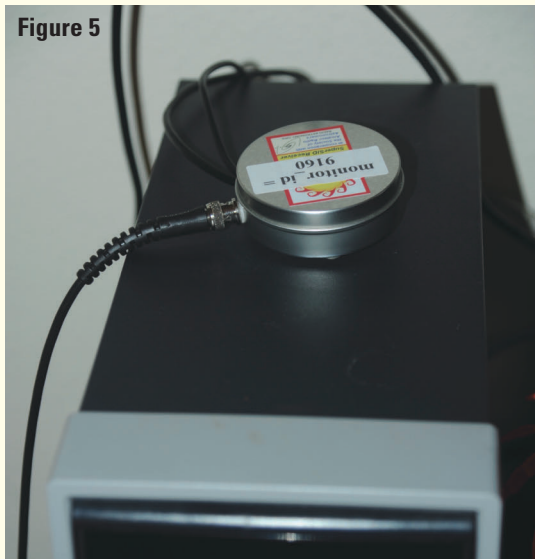


Figure 6

(*dataq.com*). I hooked up the antenna to my radio, split its audio output to a small speaker and the data acquisition unit's input, and started its oscilloscope-style software on my PC. It didn't take long before I recorded a short burst of a syllable or two from the familiar mechanical voice of the weather broadcaster (**Figure 7**). I took a screen shot of the plot and sent it in with the description of how

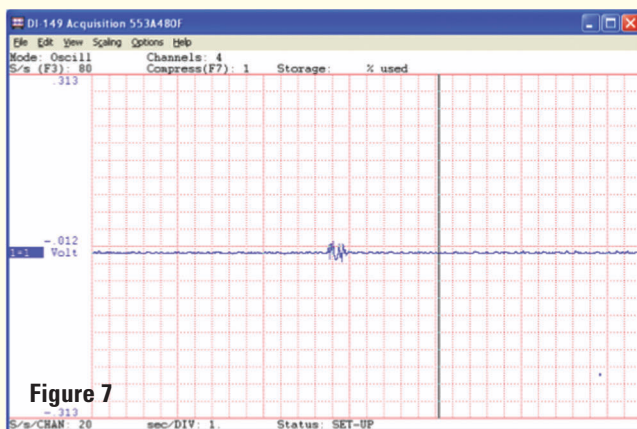


Figure 7

my receiving station worked. My silver-level certificate arrived, along with a silver pin depicting the original antenna that Jansky

used to explore the nature of static caused by near and distant thunderstorms.

## Jupiter's Radio Storms

When I read the project description I seemed to recall reading that Jupiter gave off strong radio frequency signals under certain circumstances, and that these radio storm signals could be heard on the high end of the HF (high frequency) radio band.

Both the AL web page and several online sources suggested that a simple dipole cut for the 15-meter band (about 20 MHz) would receive Jupiter's storm signals. Even better, a dual or directional dipole cut to that frequency would improve reception. But I found an even more interesting design.

I save magazine articles that are of interest to me. I happened to be looking through them for totally different reasons when I happened upon an article that was on the back of one I had saved. It showed a 25-year-old SARA design for a Jupiter radio storm receive antenna, employing a 21 MHz single loop and a backplane (*Sky & Telescope*, Dec. 1989, p. 628). I built it and connected it to my HF receiver

(**Figure 8**).

Jupiter storms are a lot more complex than they first appear to be. According to Radio-Jupiter Pro, a Radio-Sky software product, there are *sectors* on Jupiter's surface labeled A, B, and C. When one of these sectors is facing Earth, one may receive the storm's signals with high, medium, and low probabilities (A, B, and C, respectively). Also, if Jupiter's

moon Io happens to be in transit from Earth's perspective, the probability of reception is even greater. Radio-Jupiter Pro is software available from Radio-Sky Publishing (*radiosky.com*). You enter your location, in longitude and latitude, and it tells you when there is a high probability of receiving a signal from a Jovian radio storm.

There are two kinds of radio storm signals: long burst (L-burst) and short burst (S-burst). Long burst storm signals sound like "waves crashing upon the shore." Short burst signals sound like either a random ticking noise or a plastic shopping bag flapping in the wind. I reported hearing random ticking (**Figure 9**).

I put my Jupiter storm reception documentation on hold until I finished the galactic hydrogen detection project. Advancing to gold level requires two more completed projects, so I have to send them both in together. I had no idea at the time just how long this hydrogen line detection project would take me. Receiving the extremely weak radio signals at the extremely high 1.4 GHz frequency had its challenges. I met them, but I had to learn a lot before I was able to do so.

## Galactic Hydrogen Radiation Detection

The AL website has several references for novice radio astronomers like myself. There are online papers and websites that describe antennas for atomic hydrogen line (H-line) reception, including a few professional (large) antennas operated by the NRAO and others. I looked into the professionals first, but they cater to groups, like scouts, science classes, or astronomy clubs. I spent a lot of time reading websites and the papers by individuals who built modest H-line antennas. There were a few horn antennas, a lot of reworked dish antennas and a few Yagi antenna setups, which especially caught my interest.

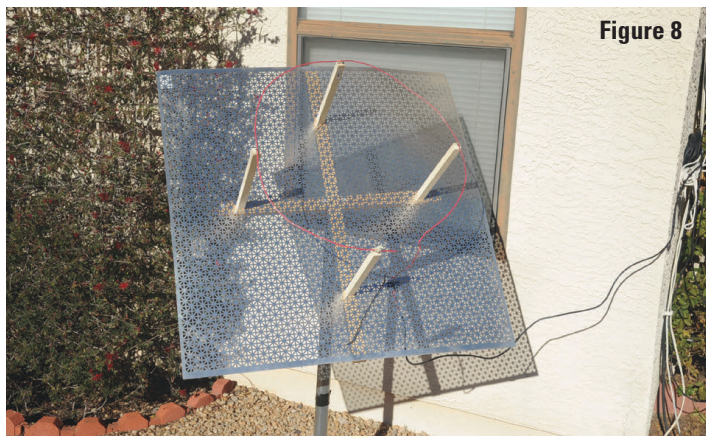


Figure 8

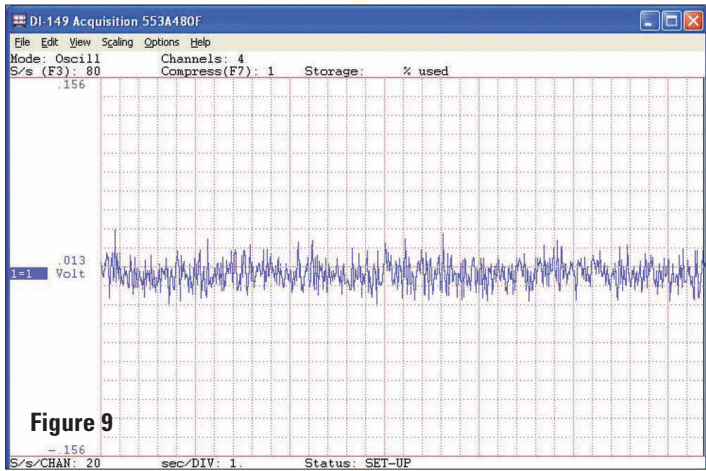


Figure 9



Figure 10

Finally, there was one paper in particular that got my attention, "Hydrogen-Line Radio-Astronomy as an Elementary-School Science Project," by Shanni Prutchi. (*Proc. 25th Ann. Meeting of SARA*, NRAO, Green Bank, WV, 2006, p. 91.) Prutchi built a dual Yagi antenna system that successfully received H-line signals

from the Milky Way, which, I'm told, is not as easy to receive as the others on the AL requirements list.

All these papers offered a variety of selections for the four major components required for an H-line detection system: the antenna, line amplifiers and filters, the receiver, and the logger. Prutchi's antennas are

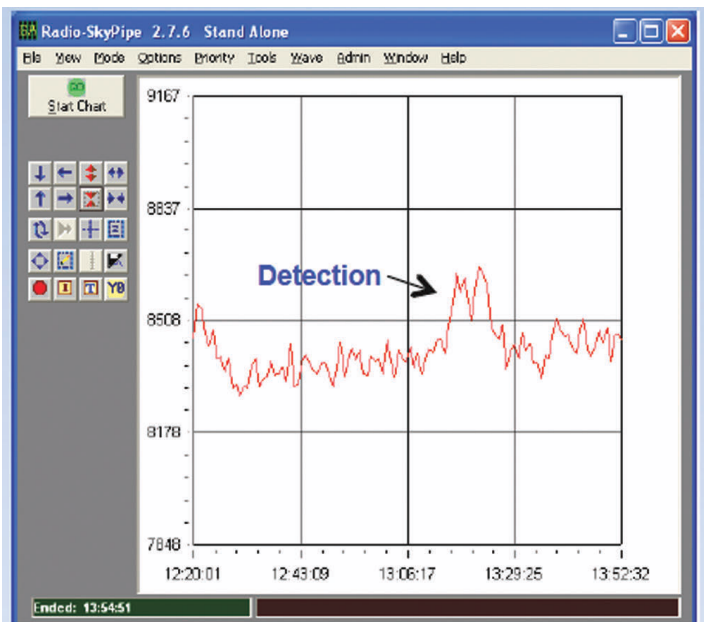


Figure 11

## Taurus A (M1)

available from *directive systems.com* and could be employed immediately, without modification. I bought just one, for starters (Figure 10). I purchased a couple of low-noise amplifiers (LNAs) from *downeastmicrowave.com*, and a bandpass filter from *radio astronomy supplies.com*. One of the dish antenna systems used a software-defined radio (SDR) to receive the 1.4 GHz H-line signal, a USB dongle controlled from SDR# software, which is a free download from *airspy.com*. For logging and plotting I chose another Radio-Sky Publishing product, their Radio-SkyPipe, from *radiosky.com*. I put everything together, pointed the antenna at a bright radio source (Sagittarius A), and got... nothing.

After a brief brooding period, I signed onto the SARA list and posted about my woes. One person responded by saying that, while my USB dongle was a terrific SDR, it didn't have enough bandwidth to be effective for radio astronomy at 1.4 GHz. He recommended instead the larger SDR from *airspy.com*, the R2. Cringing at the thought of good money after bad, I put the R2 on order. I was pretty much vested by then anyway.

I hooked up the R2, pointed the antenna at the Sun at local

noon, and got a very clearly defined hump! Even better, my single antenna showed a beam width of twice that of Prutchi's dual antenna setup, as expected. Not all of the several required galactic detections went smoothly, but many did (Figure 11). I eventually got them all, sent the plots in with my Jupiter logs, and finally got the long-awaited gold-level certificate and pin.

### Conclusions

I have a corkboard on my wall with all the pins I've earned from the Astronomical League, and a couple of notebooks full of project logs and certificates. With this project, beyond all the memorabilia, I've got a somewhat modest but effective 1.4 GHz radio astronomy antenna system.

What's next? I plan to add a second Yagi for a dual antenna system, and maybe even an elevation rotator, following Prutchi's design. That should give me a half-power beam width of 8 degrees, a much better resolution. ☀

*Dr. Vrenios is a retired computer scientist and a lifetime member of the Astronomical League. He currently proudly serves as vice president of his local astronomy club, the Phoenix Astronomical Society.*

# FROM AROUND THE LEAGUE

Are you ready for the eclipse in August? How can we possibly keep track of all the things we want to accomplish in the short time we have to observe it? The Astronomical League's Eclipse Checklist is the answer. It is available in English and Spanish, in black-and-white and color, on the AL website at: [www.astroleague.org/content/downloadable-certificates](http://www.astroleague.org/content/downloadable-certificates), or, under the Observe drop-down list, click Downloadable Certificates. Check it out.

## Hats Off to the Fort Bend Astronomy Club

The Fort Bend Astronomy Club in Texas has been busy working on outreach programs.

Until recently, that club had one member who had received a single Outreach Award. Leonard Ferguson was one of the first to receive the basic outreach-level award—number 10. For over ten years, he was the only one in that club to have earned an Outreach Award! All of that has changed.

Recently the Fort Bend club had a meeting and presented 131 certificates—66 Outreach Awards, 44 Stellar Outreach Awards, and 21 Master Outreach Awards. A total of 88 pins were distributed for the basic and master levels.

Let's put these numbers in perspective.

Last year I gave out 85 basic-level outreach pins. In one night, this club gave out 66. I've got two pins left—I sure hope the order for new pins comes soon!

Last year I gave out 16 Master Outreach pins. In one night, this club gave out 21. It took us three years from the program's inception for us to give out our 21st Master Outreach Award!

This club now has 66 members who have earned at least one level of the Outreach Award. That is more than any other club! Other clubs that have anywhere close to this number include the Flint River Astronomy Club in Georgia (47), the Northeast Florida Astronomy Society (45), the Omaha Astronomical Society and the Oklahoma City Astronomy Club (both have 40), and the Astronomical Society of Kansas City (39).

The Outreach Award submissions list their events, the hours they worked, and the number of participants who attended. Together this club has put in over 5,000 volunteer hours! Flint River has less than half that number.

I want to thank Jo Ellen Sutter of the Fort Bend Astronomy Club. She and I have been working together very closely on this project and she has done an incredible job keeping track of all the submissions. She has been a tremendous help to me in making sure every certificate was correct. Tracy Knauss is the ALCor of the Fort Bend club, and she is to be commended for her excellent work. I know there must have been many others who worked hard to put these events together.

**W. Maynard Pittendreigh**

*Outreach Award Coordinator, Astronomical League*

## 2017 Astronomics Sketching Award

**First Place: \$250. "M22" by Brian Chopp, Neville Public Museum Astronomical Society.**

9 x 12 80 lb. drawing paper, 2B, HB, and 2H pencils, and blending stumps. Inverted using Paint.NET and brightness/contrast adjustment; 15-inch Teeter Telescope, 132x.



*Brian Chopp and his telescope*

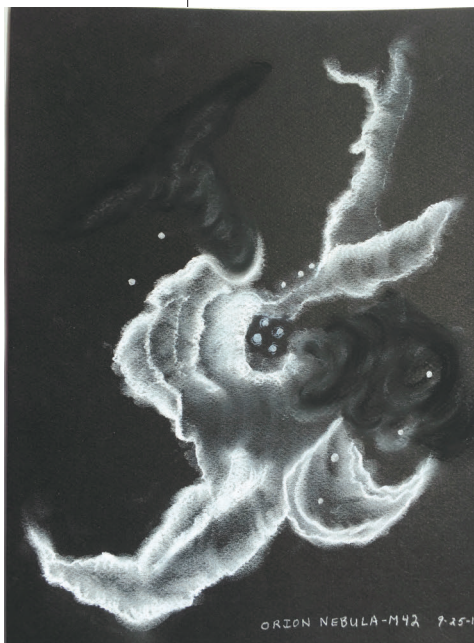


## Peggy Walker



**Second Place: \$125. "The Trapezium at the End of the Tunnel" by Peggy Walker, Astronomy Club of Tulsa.**

Black sketching/charcoal paper; white charcoal; white chalk pastel; white Prismacolor pencil; silver metallic colored pencil; black chalk pastel; black and three shades of gray color pencils; 18-inch Hubble Optics Truss Dobsonian; several Explore Scientific eyepieces (4.7 through 24 mm); Ultrablock, O-III, and H-beta filters.



# How Many Observing Pins Do You Have?



David Prosper of the Night Sky Network provided this image of AL observing pins. You know this had to take a lot of time to create!

## The Astronomical League Is Giving Away up to Eleven Library Telescopes!

Through the vision of the Horkheimer Charitable Fund, the Astronomical League is again offering a free Library Telescope to a lucky Astronomical League club in each of the ten AL regions. This year a new category is launched, for members-at-large!

This wonderful program consists of an Orion 4.5-inch StarBlast Dobsonian (or equivalent), a Celestron 8–24 mm zoom eyepiece (or equivalent), and a nameplate commemorating the late Jack Horkheimer. The value of the Library Telescope is approximately \$300; the potential of the program is enormous. Submit your completed entry form so that the Astronomical League national office receives it by July 31, 2017. If mailed, the entry must be postmarked no later than July 31, 2017. The winning entry for each region will be announced at the annual Astronomical League business meeting held at ALCon/AstroCon 2017 in Casper, Wyoming, on or about August 18. Full details of this program can be found at [www.astroleague.org/content/library-telescope-program](http://www.astroleague.org/content/library-telescope-program). The Library Telescope Program is a great club project—one that brings members together while benefiting their community. Indeed, it is the perfect outreach program!



On March 1, 2017, a Library Telescope was presented to the Scott County Library System, Eldridge, Iowa. (Left to right) Emily Arnold and Connie Owings of the Eldridge Branch accept the Orion StarBlast 4.5 from Popular Astronomy Club members Terry Dufek and Alan Sheidler.

## Candidate Statement: Office of Secretary—Bryan Tobias

I have been an amateur astronomer for well over 40 years, since I began looking at the Texas sky when I was five years old during the days of Apollo. I have been fortunate in my life, being able to experience many things in the aviation field as a pilot and technical advisor, another passion of mine. I have since decided to return to school full-time and work towards a PhD in astrophysics to begin professional work as an astronomer and educator while managing the university's observatory and public outreach programs.

I was chairman of the San Antonio Astronomical Association from 2003 to 2009 and a founding member of the San Antonio League of Sidewalk Astronomers (SALSA) from 2009 to present. In 2003 I was instrumental in the formation of the "Astronomy in the Park" program that takes place every Wednesday evening in a local park here, and it continues to take place today after 12 years of success. Another accomplishment that I am very proud to be part of is the implementation of the Texas Amateur Astronomers' Scholarship to the University of Texas at Austin's Astronomy Department. In January of this year we reached full endowment status for the scholarship and the first award to a deserving astronomy student will take place later this year. In 2017, I begin my fourth year as coordinator of the Astronomical League's Solar System Observers Program, and it has been an absolutely wonderful experience communicating with all who have applied for the award, sharing knowledge and experiences. This is only a small part of my experience of leadership and involvement in astronomy, and I would be extremely honored and humbled to continue to serve you as Secretary of the Astronomical League.

## Solar Eclipse 2017 Special Award

August 21, 2017, should be on your calendar. Over the course of 94 minutes, the shadow of the Moon will pass from Oregon to South Carolina. All of the continental U.S. will experience at least a 60 percent partial eclipse, but to see totality, you will need to travel to the path.

The Astronomical League will be offering a Special Observing Award certificate and pin to those who are up to the challenge. There will be general certificates for the public as well. The goal of the Special Observing Award is



to follow in the footsteps of astronomers of the past and to attempt to calculate the effect of the Sun's gravity on the path of the photons coming from stars close to the edge of the Sun.

This is an experiment that was done to test Einstein's general theory of relativity. The deflection of starlight near the edge of the Sun is expected to be less than about 2 arcseconds. Instructions and requirements will be posted on the AL website soon. You may use your own images or images from the Internet.

Aaron Clevenson, *Coordinator, Solar Eclipse Special Observing Award*

## Celestial Savings Program— Your Discount Purchasing Program

The Astronomical League is excited to announce its new **Celestial Savings Program** where all League members qualify for special discounts at participating vendors when purchasing equipment, accessories, or books. Please note that discount amounts may vary by vendor and by items purchased.

See the Celestial Savings Program ad included in this issue of the *Reflector* to determine participating vendors.

If you are a current AL member, you may obtain the discount codes by first logging into your AL member account. If you do not already have an account (your member account is separate from your store account) you may obtain one by visiting [members.astroleague.org/request\\_account](http://members.astroleague.org/request_account) and entering your email address. An email will be sent to you with instructions describing how to create an account.

Once you have an account established and log in to the AL website, you should select the "Members Website" tab. Next, click on "Celestial Savings." You will then see a listing of the participating vendors, the discounts they offer for their products, their current discount code numbers, their website URLs, and, if appropriate, telephone numbers. Simply provide the appropriate discount code number to the vendor's salesperson or include it in your website order.

We encourage you to share the existence of the Celestial Savings Program with your astronomy friends, AL members or not. However, please do not share discount codes with anyone.

# FROM AROUND THE LEAGUE

You're not an AL member? Contact an AL member astronomy club in your area and join through them. You'll find AL dues to be very reasonable, and many local clubs pay them for you.

The Astronomical League also has a member-at-large program detailed at [www.astroleague.org/al/general/memblarg.html](http://www.astroleague.org/al/general/memblarg.html).

For additional AL membership details and benefits, visit [www.astroleague.org](http://www.astroleague.org) and click the "Join" tab.

Questions? Write to the Celestial Savings director at [celestialsavings@astroleague.org](mailto:celestialsavings@astroleague.org).

## Want to Volunteer?

To maintain the quality of the AL's quarterly magazine, the *Reflector*, we are expanding. Two volunteer positions are available, and if you really want to assist the Astronomical League, this is a great way to start.

We are seeking an editor, who will be responsible for consolidating the necessary data for each quarterly issue. The ideal candidate should have some publishing experience and familiarity with Adobe InDesign and Photoshop and Microsoft Word and Excel. Typical time required is 30 to 40 hours per quarter.

We are also looking for a photo editor, who will collect and review the hundreds of images we receive for each issue, and select the front cover, back cover, and Gallery photos. Experience with Photoshop and Word is preferred.

If you are interested in either position, please contact the managing editor, Ron Kramer, at [managingeditor@astroleague.org](mailto:managingeditor@astroleague.org) with a brief description of your experience as it relates to the position.

**DEFENDING MARS**

PERCIVAL LOWELL'S  
**CANALS OF MARS  
DRY ERASE!**


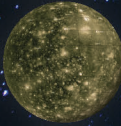

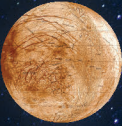
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REAL WORLD GLOBES

# Gallery



Joel Shepherd, with the Seattle Astronomical Society, imaged Sharpless 2-101 (the Tulip Nebula) from Seattle, Washington. He used an Atik 460EX monochrome camera with a Sky-Watcher Esprit 80 ED on a Celestron Advanced VX mount.



While testing his equipment in preparation for the upcoming solar eclipse, Brian Ottum (Toledo Astronomical Society) recorded this image. Talk about "right place, right time!"



M4 is a globular cluster approximately 7,200 light-years away in Scorpius. It is easy to find as it is about one degree away from Antares, which is at the left of this image. M4 is at the right and NGC 6144, another globular cluster, is at the top, left of center. These were imaged by Dan Crowson at the Danville Conservation Area in New Florence, Missouri, with an SBIG ST-8300M on an Astro-Tech AT90EDT.



Proving you don't need very expensive optical gear to take good astroimages, Michael J. Melwiki of the Kalamazoo Astronomical Society imaged the Moon with a handheld iPhone 5s through a homemade 10-inch f/6 Newtonian.

## Astronomy in Chile

antenna array at over 5000 meters (16,500 feet). We were privileged to go, given personal oxygen supplies, and monitored constantly for signs of hypoxia. Pictures don't do justice as to how cold and windy it was up there at a point where over half of the Earth's atmosphere is below you. Combined with an extremely low humidity, it is an excellent location for radio astronomy. It is just one more example of our astronomical investment in Chile.

We did some additional touristy things, but that concluded the astronomical portion of our trip. In conclusion, if you want to see (or photograph) the delights of the Southern Hemisphere and tour observatories that our country is invested in, consider a trip to Chile. You will not be disappointed. ☀

### Can't wait to display your 2017 Total Solar Eclipse attire?

Then order your ASTROCON 2017 apparel now and have them conveniently shipped to your home for early enjoyment.

Simply logon to the Infinitees website:  
[www.infini-tees.com/AstroCon2017.htm](http://www.infini-tees.com/AstroCon2017.htm)

## All Things Astronomical

system, the planets pass in front of the star during each orbit, causing a fall in brightness known as a transit. The amplitudes of the transits are used to determine the radii of the planets, while their periodicities indicate their orbital distances and hence their insulations (the amount of stellar radiation received at each planet's surface).

Following these initial findings, the star was systematically monitored to find out whether it contained any other planets. The result of this follow-up exceeded all expectations: TRAPPIST-1 has at least seven planets, all of which are Earth-sized (to within 15%). The six nearest planets (b to g) orbit their star in 1.5 to 12 days (the period of the seventh planet remains to be determined), and are 20 to 90 times closer to their star than the distance from the Earth to the Sun. At such distances, the tidal forces exerted by the star are considerable, locking the planets into synchronous rotation, which means that they rotate about their axis exactly once in one orbit, thus always showing the same face to their star (just as the Moon does relative to the Earth).

The planets of TRAPPIST-1 have insulations, and therefore average temperatures, similar to Earth's: the insolation of the innermost planet (b) is slightly higher than that of Mercury, while the outermost planets (g and h) have an insolation that is a little lower than that of Mars.

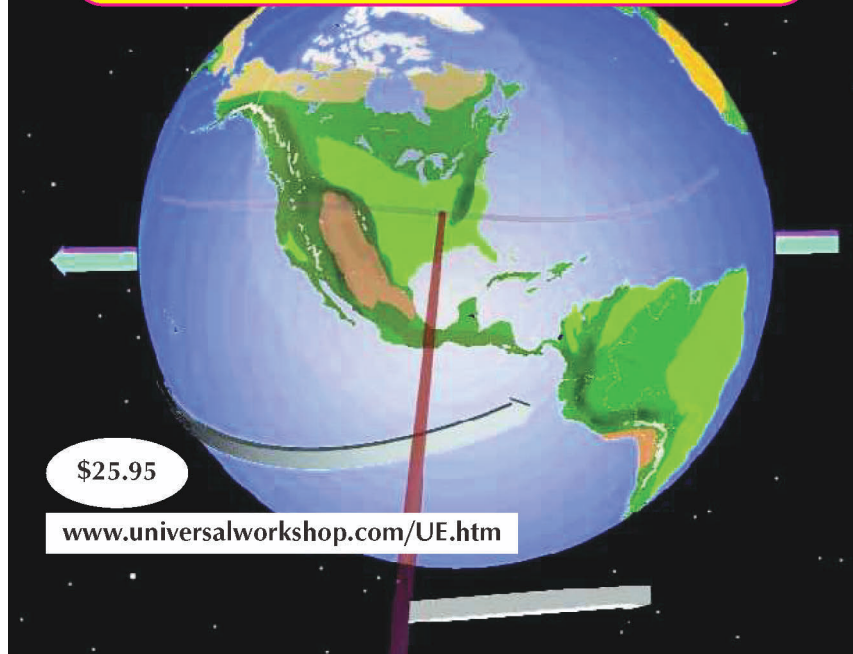
The insulations of at least three of the planets (e, f, and g) are compatible with the existence of liquid water on their surface for a wide range of atmospheric compositions, as is shown by numerical simulations of their climate. Due to their synchronous rotation, it cannot be excluded that the planets with the highest irradiation (b, c, and d) may harbor liquid water in temperate regions with little or no sunlight.

The TRAPPIST-1 planets are in orbital resonance: while planet g completes one orbit around its star, planets b, c, d, e, and f complete 8, 5, 3, 2, and 4/3 orbits, respectively.

# The Under-Understanding of Eclipses

Guy Ottewell

The NEW edition of this full and friendly guide to all eclipses focuses on the great USA eclipse of August 2017



This orbital architecture is thought to be a signpost of orbital migration, meaning that the planets were initially on more distant orbits but were brought closer to the star via interactions with their nascent disk of gas and dust. Because of gravitational attraction between planets, transits do not follow one another in a perfectly periodic manner, but occur early or late, sometimes by more than one hour. This effect makes it possible to constrain the planets' masses, which have not yet been determined very precisely, and hence their densities. Current data appear to indicate that some of TRAPPIST-1's planets are low-density and water-rich, a conclusion that will be refined with ongoing follow-up observations.

The planets around TRAPPIST-1 are in many ways reminiscent of the systems of moons around Jupiter and other gas giants in the Solar System, perhaps indicating similar

mechanisms of formation. TRAPPIST-1's very small size (roughly the diameter of Jupiter) and its low luminosity (0.05% of the Sun's) provide exceptional conditions for observing its planets. Using NASA and ESA's future James Webb Space Telescope, due to be launched next year, it will be possible to detect any atmospheres they may harbor and characterize some of their properties. Together with Proxima b, discovered last August, the TRAPPIST-1 planets constitute the most promising targets so far discovered for the remote detection of possible signs of life outside the Solar System. ☀

For those of you who are not aware of it, the Astronomical League is now on Facebook. We continue to build followers week by week, and we are becoming better known as the word spreads. We are also on Twitter: @AstronomyLeague.



### Celestial Savings Program Discount Purchasing Program - Participating Vendors

See the "From Around the League" section of this issue for additional details

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By Guy Ottewell

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



# Observing Awards

## Active Galactic Nuclei Program

No. 12-I, Brandon Jordan, Member-at-Large; No. 13-I, George Robert Kepple, Huachuca Astronomy Club

## Advanced Binocular Double Star Observing Program

No. 17, John E. Glover, Northern Virginia Astronomy Club; No. 18, Aaron Clevenson, North Houston Astronomy Club

## Arp Peculiar Galaxies Northern Observing Program

No. 86-V, Rodney Rynearson, St. Louis Astronomical Society; No. 87-C, Brandon Jordan, Member-at-Large

## Asterism Observing Program

No. 40, Mike Fowler, Atlanta Astronomy Club; No. 41, Jean Napp, Iowa County Astronomers

## Asteroid Observing Program

No. 48, Michael A. Hotka, Regular, Longmont Astronomical Society; No. 55, Jeff Haidet, Gold, Toledo Astronomical Association; No. 56, Brandon D. Jordan, Gold, Member-at-Large; No. 57, Marie Lott, Gold, Atlanta Astronomy Club;

## Binocular Double Star Observing Program

No. 118, Preston Pendergraft, Member-at-Large; No. 119, Paul Harrington, Member-at-Large; No. 120, John Dorio, Texas Astronomical Society of Dallas

## Binocular Messier Observing Program

No. 1104, Antoine G. Gregory, Minnesota Astronomical Society

## Binocular Variable Star Observing Program

No. 18, Douglas Smith, Tucson Amateur Astronomy Association

## Caldwell Observing Program

No. 27, Vincent Michael Bournique, Gold, Member-at-Large; No. 231, Bill Sanders, Silver, Central Arkansas Astronomical Society; No. 232, Melissa Adams, Silver, Member-at-Large; No. 233, Christopher Ober, Silver, Houston Astronomical Society; No. 234, Alex McConahay, Silver, Pomona Valley Amateur Astronomers; No. 235, David Whalen, Silver, Charlie Elliott Chapter of Atlanta Astronomy Club; No. 236, Mark Simonson, Silver, Everett Astronomical Society; No. 237, Kevin Carr, Silver, Minnesota Astronomical Society; No. 238, John Laning, Silver, Member-at-Large

## Carbon Star Observing Program

No. 79, Nora Jean Chetnik, Member-at-Large; No. 80, Valorie Whalen, Atlanta Astronomy Club

## Comet Observing Program

No. 36, David Hoover, Gold, Seattle Astronomical Society; No. 91, Coy Wagoner, Silver, Baton Rouge Astronomical Society; No. 92, David M. Douglass, Silver, East Valley Astronomy Club; No. 93, Maurice Massey, Silver, Oklahoma Astronomy Club; No. 94, Preston Pendergraft, Silver, Member-at-Large

## Constellation Hunter Observing Program (Northern Skies)

No. 186, Daniel Otte, Southern Oregon Skywatchers; No. 187, Steven Coltrin, Rio

Rancho Astronomical Society; No. 188, Jean Napp, Iowa County Astronomers  
**Dark Nebulae Observing Program**

No. 25, Rich Winters, Member-at-Large

## Deep Sky Binocular Observing Program

No. 387, Gerard J. Jones, Minnesota Astronomical Society

## Flat Galaxy Observing Program

No. 30, Honorary, Brandon Jordan, Member-at-Large

## Galileo Observing Program

No. 39, Marilyn Perry, Member-at-Large; No. 40, Laura Hintz-Keller, Indiana Astronomical Society; No. 41, Stephen A. Tzikas, Northern Virginia Astronomy Club

## Global Cluster Observing Program

No. 302-V, Ken Sperber, Tri-Valley Stargazers

## Herschel 400 Observing Program

No. 572, John Laning, Member-at-Large; No. 573, Scott Azmus, Member-at-Large; No. 574, William Kocken, Minnesota Astronomical Society; No. 575, Stephen A. Tzikas, Northern Virginia Astronomy Club; No. 576, Lisa Wentzel, Twin City Amateur Astronomers; No. 577, Jean Napp, Iowa County Astronomers

## Local Galaxy Group & Galactic Neighborhood Observing Program

No. 35, Lisa Judd, Manual, Denver Astronomical Society; No. 36, Steve Boerner, Device-Aided, Astronomical Society of Eastern Missouri

## Lunar Observing Program

No. 977, Karl Henry, Delaware Valley Amateur Astronomers; No. 978, John E. Glover, Northern Virginia Astronomy Club; No. 979, David Lawson, Member-at-Large; No. 980, David Downs, Albuquerque Astronomical Society; No. 981, Nikolay Kurtov, Member-at-Large; No. 982, John E. Riutta, Rose City Astronomers; No. 983, Dee Friesen, Albuquerque Astronomical Society; No. 984, Gordon Schaefering, Amateur Observers' Society of New York; No. 985, Terry Mealy, Amateur Astronomers Association of Pittsburgh; No. 986, Daniel Otte, Southern Oregon Skywatchers; No. 987, Robert J. Olsen, Member-at-Large; No. 988, Hans M. de Moor, Member-at-Large

## Lunar II Observing Program

No. 81, Becky Ramatowski, Albuquerque Astronomical Society

## Master Observer Award (Progression)

**Observer Award:** David Whalen, Atlanta Astronomy Club; Michael Neal, Echo Ridge Astronomical Society; Stephen A. Tzikas, Northern Virginia Astronomy Club

**Master Observer Award:** No. 188, Paul Harrington, Member-at-Large; No. 189, Kevin Nasal, Neville Public Museum Astronomical Society; No. 190, Barbara Biever, Rancho Bernardo/Murrieta Astronomical Society; No. 193, Gerard Jones, Minnesota Astronomical Society; No. 194, Stephen A. Tzikas, Northern Virginia Astronomy Club; No. 195, Dee Friesen, Albuquerque Astronomical Society

**Advanced Observer Award:** Jeff Hoffmeister, Olympic Astronomical Society; James Pryal, Seattle Astronomical Society; Bill Sanders, Central Arkansas Astronomical Society; Denise Terpstra, Member-at-Large

**Master Observer Award—Silver:** W. Maynard Pittendreigh, Brevard Astronomical Society; Jim Ketchum, Astronomical Society of Kansas City; Rodney Rynearson, St. Louis Astronomical Society

## Messier Observing Program

No. 2699, Daniel Otte, Honorary, Southern

Oregon Skywatchers; No. 2757, Michael Keefe, Honorary, Raleigh Astronomy Club; No. 2758, Mark Colwell, Regular, Member-at-Large  
**Meteor Observing Program**

No. 62, Jean Napp, Honorary, Iowa County Astronomers; No. 184, Paul Harrington, 6 hours, Member-at-Large

## NEO Observing Program

No. 11, Michael Hotka, Intermediate, Longmont Astronomical Society

## Outreach Observing Award

No. 10-M, Leonard Ferguson, Fort Bend Astronomy Club; No. 142-M, Dan Gava, North Houston Astronomy Club; No. 147-M, Rick Heschmeyer, Astronomy Associates of Lawrence; No. 212-M, Jim Barbasso, North Houston Astronomy Club; No. 349-M, Bruce Pollard, North Houston Astronomy Club; No. 353-S, Susan Pollard, North Houston Astronomy Club; No. 502-S, David Schmidt, North Houston Astronomy Club; No. 505-S, Rusty Hill, North Houston Astronomy Club; No. 507-M, Todd Sullivan, North Houston Astronomy Club; No. 690-M, David A. Warner, Colorado Springs Astronomical Society; No. 703-S, Bert Kelher, Huachuca Astronomy Club; No. 765-O, Dan A. Chrisman, Jr., Roanoke Valley Astronomical Society; No. 766-O, Jim Sommer, San Bernardino Valley Amateur Astronomers; No. 767-O, Stephen H. Rand, New Hampshire Astronomical Society; No. 768-M, Jason Wallace, Richland Astronomical Society; No. 769-O, David Downs, Albuquerque Astronomical Society; No. 770-S, Brian Chopp, Neville Public Museum Astronomical Society; No. 771-M, Brad Thomas, Fort Bend Astronomy Club; No. 773-O, Amanda K. Myers, Amateur Astronomers Association of Pittsburgh; No. 774-O, Barb Knabb, Chester County Astronomical Society; No. 775-S, Christy Wallace, Richland Astronomical Society; No. 776-O, Melissa Wallace, Richland Astronomical Society; No. 777-M, Marc Stowbridge, New Hampshire Astronomical Society; No. 778-S, Matt Lochansky, Raleigh Astronomy Club; No. 779-M, Barb Wiese, Fort Bend Astronomy Club; No. 780-M, Tony Wiese, Fort Bend Astronomy Club; No. 781-M, Jack McKaye, Fort Bend Astronomy Club; No. 782-M, Jeffrey Lepp, Fort Bend Astronomy Club; No. 783-M, Jim Jackson, Fort Bend Astronomy Club; No. 784-M, Joe Dellinger, Fort Bend Astronomy Club; No. 785-M, Justin McCullum, Fort Bend Astronomy Club; No. 786-M, Mary Lockwood, Fort Bend Astronomy Club; No. 787-M, Paul Noll, Fort Bend Astronomy Club; No. 788-M, Ralph Stevenson, Fort Bend Astronomy Club; No. 789-M, Susan Sailing, Fort Bend Astronomy Club; No. 790-M, Curt Lewis, Fort Bend Astronomy Club; No. 791-S, Susie Lewis, Fort Bend Astronomy Club; No. 792-S, Michael Fredette, Fort Bend Astronomy Club; No. 793-S, Jim Verboon, Fort Bend Astronomy Club; No. 794-M, Bill Spizzirri, Fort Bend Astronomy Club; No. 795-S, Connie Haviland, Fort Bend Astronomy Club; No. 796-M, David Haviland, Fort Bend Astronomy Club; No. 797-S, Donald Morris, Fort Bend Astronomy Club; No. 798-M, Don Sailing, Fort Bend Astronomy Club; No. 799-M, Jeff Parr, Fort Bend Astronomy Club; No. 800-M, Jo Sutter, Fort Bend Astronomy Club; No. 801-S, Jim Hutchison, Fort Bend Astronomy Club; No. 802-M, Rebecca Brewer, Fort Bend Astronomy Club; No. 803-M, Joel Brewer, Fort Bend Astronomy Club; No. 804-M, Steve Clayworth, Fort Bend Astronomy Club; No. 805-M, Stephen Walker, Fort Bend Astronomy Club; No. 806-O, Barbara Hassett, Fort Bend Astronomy Club; No. 807-O, Scott Hassett, Fort Bend Astronomy Club; No. 808-O, Pamela Cook, Fort Bend Astronomy Club; No. 809-O, Stephen Cook, Fort Bend Astronomy Club; No. 810-O, Anne Trujillo, Fort Bend Astronomy Club;

No. 811-O, Paul Erway, Fort Bend Astronomy Club; No. 812-S, Walt Cooney, Fort Bend Astronomy Club; No. 813-O, Brooks Runnels, Fort Bend Astronomy Club; No. 814-O, Laura Runnels, Fort Bend Astronomy Club; No. 815-O, Charlie Throop, Fort Bend Astronomy Club; No. 816-S, Dennis Grigassy, Fort Bend Astronomy Club; No. 817-S, Charles Hale, Fort Bend Astronomy Club; No. 818-S, Richard Schmidt, Fort Bend Astronomy Club; No. 819-S, Nathan Jones, Fort Bend Astronomy Club; No. 820-S, Yolando Balane, Fort Bend Astronomy Club; No. 821-S, Imelda Balane, Fort Bend Astronomy Club; No. 822-S, Terzah Horton, Fort Bend Astronomy Club; No. 823-S, Edward Balestrine, Fort Bend Astronomy Club; No. 824-S, Mac Hooton, Fort Bend Astronomy Club; No. 825-S, Jessie Phillips, Fort Bend Astronomy Club; No. 826-S, Paul Makinen, Fort Bend Astronomy Club; No. 827-S, Keith Montz, Fort Bend Astronomy Club; No. 828-O, James Wooten, Fort Bend Astronomy Club; No. 829-S, Wayne Wiegand, Fort Bend Astronomy Club; No. 830-S, Rosanne Dillon, Fort Bend Astronomy Club; No. 831-O, Madison Dillon, Fort Bend Astronomy Club; No. 832-O, Ken Lim, Fort Bend Astronomy Club; No. 833-O, Todd Sanders, Tallahassee Astronomical Society; No. 837-M, Tracy Knauss, Fort Bend Astronomy Club; No. 838-S, Judy McKaye, Fort Bend Astronomy Club; No. 839-O, Jim Erwin, Naperville Astronomical Association; No. 840-O, Stephen A. Tzikas, Northern Virginia Astronomy Club; No. 841-O, Pam Huddle, Fort Bend Astronomy Club; No. 842-O, Anna Leslie, Fort Bend Astronomy Club; No. 843-O, Miles Huddle, Fort Bend Astronomy Club; No. 844-S, Jerel Williams, Astronomical Society of Kansas City; No. 845-S, Kathy Machin, Astronomical Society of Kansas City; No. 846-O, Nina Baker, Omaha Astronomical Society; No. 847-S, Mark Hodges, Roanoke Valley Astronomical Society; No. 848-S, Brian Lippincott, Austin Astronomical Society; No. 850-S, Alicia Tristan, Fort Bend Astronomy Club; No. 851-O, Roland Fields, Fort Bend Astronomy Club; No. 852-S, Wes Whiddon, Fort Bend Astronomy Club; No. 853-S, James Billings, North Houston Astronomy Club; No. 854-O, Katelyn Stringer, Fort Bend Astronomy Club; No. 855-O, Jay Ford, Fort Bend Astronomy Club; No. 856-O, Rodney Ryneanson, St. Louis Astronomical Society; Nos. 857-O and 857-S, Dave Komar, Northern Virginia Astronomy Club; No. 858-O, Vincent Michael Bournique, Member-at-Large; No. 859-O, John Cavuoti, Fort Bend Astronomy Club; No. 860-O, Christophe Caille, Fort Bend Astronomy Club; No. 861-O, Steve Benton, Flint River Astronomy Club

**Planetary Nebula Observing Program**

No. 32, Terry N. Trees, Basic, Amateur Astronomers Association of Pittsburgh

**Sketching Observing Award**

No. 17, Jim Ketchum, Astronomical Society of Kansas City; No. 18, Rakhil Kincaid, Haleakala Amateur Astronomers; No. 19, Nora Jean Chetnik, Member-at-Large; No. 20, Cindy L. Krach, Haleakala Amateur Astronomers

**Sky Puppy Observing Program**

No. 48, Elizabeth Luther, Prairie Astronomy Club

**Solar System Observing Program**

No. 105, Stephen A. Tzikas, Northern Virginia Astronomy Club; No. 106, Michael C. Neal, Echo Ridge Astronomical Society

**Southern Sky Telescopic Observing Program**

No. 54, Vincent Michael Bournique, Member-at-Large

**Urban Observing Program**

No. 180, Marilyn Perry, Member-At-Large; No. 181, Antone Gregory, Minnesota Astronomical Society; No. 182, Mike Fowler, Atlanta Astronomy Club; No. 183, Albert A. Lamperti, Delaware Valley Amateur Astronomers

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**June 9–11**

**MSRAL 2017 Convention**  
Missouri State University  
[www.msral.org](http://www.msral.org)

**June 10**

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Dayton, Ohio  
[www.mvas.org](http://www.mvas.org)

**June 16–17**

**Stars Over Yellowstone**  
Madison Campground,  
Yellowstone National Park, Wyoming  
Eric Loberg, [eloberg@montana.edu](mailto:eloberg@montana.edu)

**June 17–24**

**2017 Grand Canyon Star Party**  
Grand Canyon National Park, Arizona  
South Rim: Tucson Amateur Astronomy Association

North Rim: Saguaro Astronomy Club of Phoenix  
[www.nps.gov/grca/planyourvisit/grand-canyon-star-party.htm](http://www.nps.gov/grca/planyourvisit/grand-canyon-star-party.htm)

**June 21–25**

**Golden State Star Party**  
Frosty Acres Ranch, Adin, California  
[www.goldenstatestarparty.org](http://www.goldenstatestarparty.org)

**June 21–25**

**Rocky Mountain Star Stare 2017**  
Colorado Springs Astronomical Society  
Gardner, Colorado  
[www.rmss.org](http://www.rmss.org)

**June 22–25**

**Cherry Springs Star Party**  
Cherry Springs State Park, Pennsylvania  
[www.cherrysprings.org](http://www.cherrysprings.org)

**June 22–25**

**Wisconsin Observers Weekend**  
Hartman Creek State Park, Waupaca, Wisconsin  
[www.new-star.org](http://www.new-star.org)

**June 23–25**

**Craters of the Moon Star Party**  
Craters of the Moon National Monument  
Arco, Idaho  
[www.ifaastro.org](http://www.ifaastro.org)

**July 18–22**

**Table Mountain Star Party**  
Eden Valley Ranch, Oroville, Washington  
[www.tmspa.com](http://www.tmspa.com)

**July 19–22**

**Green Bank Star Quest XIV**  
National Radio Astronomy Observatory,  
Green Bank, West Virginia  
[www.greenbankstarquest.org](http://www.greenbankstarquest.org)

**July 20–23**

**Stellafane**  
Breezy Hill, Springfield, Vermont  
[stellafane.org/stellafane-main/convention](http://stellafane.org/stellafane-main/convention)

**July 21–22**

**Stars Over Yellowstone**  
Madison Campground,  
Yellowstone National Park, Wyoming  
Eric Loberg, [eloberg@montana.edu](mailto:eloberg@montana.edu)

**July 21–24**

**Brothers Star Party for Oregon Observatory**  
Brothers, Oregon  
[www.mbsp.org](http://www.mbsp.org)

**July 21–25**

**Almost Heaven Star Party**  
Spruce Knob, West Virginia  
[www.ahsp.org](http://www.ahsp.org)

**July 23–28**

**Nebraska Star Party**  
Merritt Reservoir  
Valentine, Nebraska  
[www.nebraskastarparty.org](http://www.nebraskastarparty.org)



**July 25–30**

**Indiana Family Star Party**  
Camp Cullom,  
Frankfort, Indiana  
[www.indianastars.com/starparty](http://www.indianastars.com/starparty)

**August 16–19**

**Astronomical League Convention**  
Casper, Wyoming  
[astrocon2017.astroleague.org](http://astrocon2017.astroleague.org)

**August 25–26**

**Maine State Star Party**  
Cobscook Bay State Park  
Edmunds, Maine  
[www.downeastaa.com/mssp\\_2016](http://www.downeastaa.com/mssp_2016)

**August 25–27**

**Northwoods Starfest**  
Hobbs Observatory, Beaver Creek Reserve, Wisconsin  
[www.cvaastro.org](http://www.cvaastro.org)

**September 14–18**

**Iowa Star Party**  
Whiterock Conservancy's Whiterock Resort  
Coon Rapids, Iowa  
[www.iowastarparty.com](http://www.iowastarparty.com)

**September 15–17**

**Idaho Star Party**  
Bruneau Dunes State Park, Idaho  
[www.boiseastro.org](http://www.boiseastro.org)

**September 15–17**

**Connecticut River Valley Astronomers' Conjunction**  
Northfield Mountain Recreation and Environmental Center, Massachusetts  
[www.philharrington.net/astroconjunction](http://www.philharrington.net/astroconjunction)

**September 16–24**

**Okie-Tex Star Party**  
Kenton, Oklahoma  
[www.okie-tex.com](http://www.okie-tex.com)

**September 21–24**

**2017 Bootleg Astronomy Star Party**  
Green River Conservation Area, Harmon, Illinois  
[www.bootlegastronomy.com](http://www.bootlegastronomy.com)

**September 21–24**

**Acadia Night Sky Festival**  
Acadia National Park, Bar Harbor, Maine  
[www.acadianightskyfestival.org](http://www.acadianightskyfestival.org)

**September 21–24**

**Great Lakes Star Gaze**  
River Valley RV Park, Gladwin, Michigan  
[www.greatlakesstargaze.com](http://www.greatlakesstargaze.com)

**September 21–24**

**Hidden Hollow Star Party**  
Mansfield, Ohio  
[www.wro.org](http://www.wro.org)

**September 22–24**

**Black Forest Star Party**  
Cherry Springs State Park, Pennsylvania  
[www.bfsp.org](http://www.bfsp.org)

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Or join online at: [WWW.ASTROLEAGUE.ORG](http://WWW.ASTROLEAGUE.ORG)

# League Sales are online!

The League's online store is available at the website, [www.astroleague.org](http://www.astroleague.org). Click on the link for the store on the top right of the home page. The online store includes the latest shopping cart technology and accepts credit cards. Shipping & handling (S&H) is calculated at checkout. Merchandise is also available by mail order, payable by check. Please select your items, add the applicable S&H fee, and mail your order to:

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**VC600 Baseball Hat**  
Embroidered logo, adjustable;  
Colors: royal, maroon, khaki, navy;  
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### 2100 Baseball Hat

Embroidered logo, adjustable; "Sandwich" bill; Colors: sage w/stone trim, stone w/navy trim, navy w/stone trim;  
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**2050 Sportsman Bucket Hat**  
Embroidered logo, one size; khaki only  
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\$10: travel mug plus \$1.50 S&H



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Individual pairs of glasses are also available for \$1 each, plus shipping.

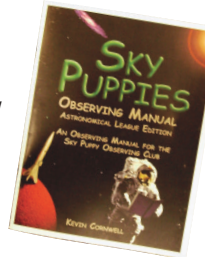
Available at <http://store.astroleague.org/>. Shipping rates will be added at checkout. Or call or email for shipping rates and options.

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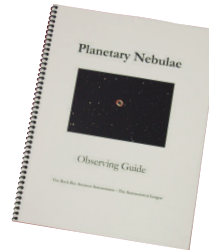
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For the Sky Puppy Observers Club  
Regularly \$15,  
**Sale price \$8**  
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### Planetary Nebulae

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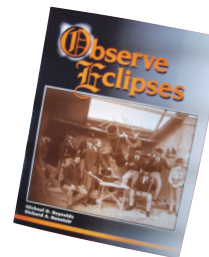
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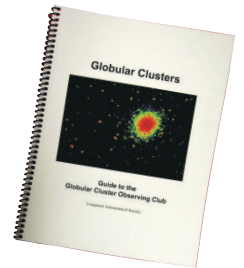
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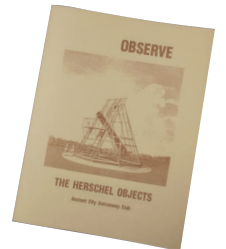
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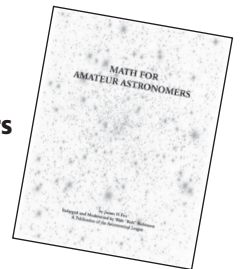
### Observe the Herschel Objects

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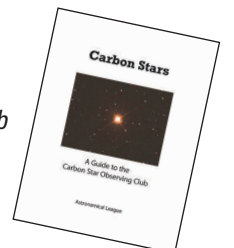
### Math for Amateur Astronomers

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