

# Reflector

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September 2016



**The Music of the Spheres**  
**Forbidden Radiation in**  
**Planetary Nebulae**  
**How Watergate Influenced**  
**Astronomy Day**  
**From Around the League:**  
**Astronomy Day and Youth Awards**

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This close-up image of the lunar craters **Langrenus** and **Petavius** was captured on April 13, 2016, at 00:47 UT. **Jamey Jenkins**, an ALPO member located in Homer, Illinois, used a 125 mm f/18 refractor and a DMK41AU02 camera.

To our contributors: The copy and photo deadline for the December 2016 issue is October 1. Please send your stories and photos to our magazine 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

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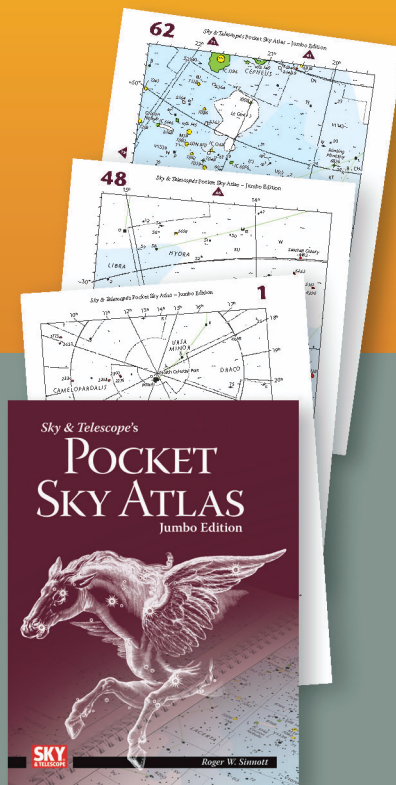
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#### All is change

Many variations of this quote, sometimes given as "No man ever steps in the same river twice," appear throughout history, after first being put forth by the Greek philosopher Heraclitus of Ephesus about 500 BC. Whatever the original wording, the sentiment still applies today.

Need proof that "all is change?" Consider the influence of the Internet.

Before the 1990s, the inquisitive observer found general astronomy information buried in books such as Norton's *A Star Atlas*, Burnham's massive three-volume classic *Celestial Handbook*, or Pasachoff's more manageable *Stars and Planets*.

Daily planetary events were given in Ottewell's *Astronomical Calendar*, in the *RASC Handbook*, and in both *Sky & Telescope* and *Astronomy* magazines. Those last two monthly publications also reported recent news in the world of astronomy and had extensive collections of advertisements spotlighting the latest in equipment.

Today, while most of those sources are still available and are still relevant, a great many people simply log on to any of the numerous websites that provide the information they want to know. Consequently, the printed material is used less and less, leading both *Sky & Telescope* and *Astronomy* magazines to develop engaging and informative websites.

"The only constant is change."

Just about anything and everything astronomy-related can be found online. Here are a few areas: notices of upcoming celestial events, such as planetary conjunctions and eclipses; alerts of asteroid occultations, solar flares and possible aurorae, and discoveries of supernovae; the latest news in astrophysical research and space exploration; amateur accomplishments of designing and building novel telescopes and home observatories; product reviews covering the latest observing accessories; accounts of star parties and other gatherings; and an abundance of fantastic astrophotographs, rivaling those from professional observatories of thirty years ago.

Because of the Internet, a solitary observer needs nothing else to advance in the hobby. Right?

Amateur astronomy clubs have always made themselves available to guide skywatchers in their journeys under the stars. With the Internet offering so much to so many, are clubs still



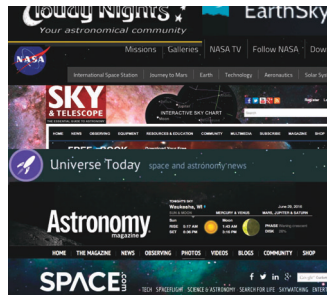
of interests.

Although carefully peering through the eyepiece is certainly a personal experience that affects all observers in different ways, the hobby of astronomy definitely has a social side. Individuals benefit by talking directly with other observers about what they have seen, what equipment works best, and what they hope to find on their next nighttime outing.

**2. Mentoring.** Some people join a club to learn firsthand about the hobby. They want a helping hand. They want to know how to find sky objects. They want the authentic observing experience.



Printed materials were the prime source of astronomy information for astronomers of a generation ago.



Today's observers find just about anything they need to know on the Internet.

relevant? Thus, the question, "What do clubs provide that the Internet cannot?" needs to be answered. So here are some answers:

**1. Social aspects.** Probably the single most important advantage that a club has over online astronomy is the camaraderie that comes from being with people who have a similar set

Other, more established members like to share their knowledge and experience by bringing newcomers along in the hobby. A club offers the means of bringing these two sides of the learning equation together.

**3. Hands-on experience.** Nothing beats evaluating a telescope in person. You often hear, "What telescope is best for me?" Club members' equipment lets folks see what is available and what is most suitable for them.

**4. Safety.** When observing from a dark location, some people feel more secure and comfortable by being in a group. Club observing sessions and outreach events give members a sense of safety

when they are at a distant site late at night, allowing them to fully focus on the heavens.

Amateur astronomers often speak about public outreach. While serving the community is certainly an important—and fun—part of being in a club, it is not the most important. An organization must make sure that it provides reasons for people to be members in order for it to remain relevant.

As time rolls on, this will always be a changing challenge that must be met.

"Nothing endures but change."

*John Goss*  
John Goss, League President

**Dear Editor:**

Many thanks for the June issue—it is awesome. The writing, layout, and photos are truly superb.

Being a Shakespeare aficionado and amateur astronomer, I especially enjoyed the "Fathom" essay by Dave Tosteson.

Anne Bauman

**To the Editor:**

In his article, "Measuring the Sky Brightness over Barnesville, Georgia," Richard Schumde speculates that tree growth may have been responsible for the small decrease in background night sky luminance he measured between 2009 and 2015. With my SQM I have also measured a decrease in sky brightness over the last few years, but have traced it to a different cause. Initially I suspected the SQM because the background sky appeared to have visually brightened at the same time the measured values indicated the sky to be darkening.

It is widely believed that the human eye cannot detect light beyond the 400–700 nm range, but this is not true. While visual sensitivity rapidly decreases outside that wavelength range, the 400–700 nm limit is the range where color perception changes with wavelength. Any light bright enough to see with a wavelength shorter than 400 nm, or longer than 700 nm, must be measured with a visual spectrometer since perceived color does not change outside the 400–700 nm range of wavelength.

I traced the inconsistency between apparent visual sky brightness and measured sky brightness to the utility-owned LED yard lights that are slowly replacing the high-pressure sodium yard lights (see picture) in this area. While there has been much written about "blue-rich" LED lighting, the fixtures being installed around here have very little blue in their spectra.

Instead, the whitish color is due to significant amount of ultraviolet emission between 400 and 350 nm. My SQM is blind to these wavelengths, but my eyes are not. Once this was recognized, it was easy to find LED illuminated surfaces (wall, tree trunk, etc.) that appeared brighter than the sky but measured darker.

I don't know how widespread the installation of these UV-emitting fixtures is. I'd be interested to hear from others who may have noticed any inconsistencies between visually apparent and measured sky background, especially if they have measured the visual spectra of the outdoor lighting in their area.

Doug Kniffen

doug.kniffen@yahoo.com

**To the Editor:**

I found Dr. Richard Schumde's article on "Measuring Sky Brightness over Barnesville, Georgia," in the June issue of the *Reflector* to be very interesting. The Sky Quality Meter manufactured by Unihedron does provide a quick assessment of sky brightness, and I have used one for two years now. The careful methodology and data collection are very nicely presented regarding his particular viewing site. The graph displaying sky brightness versus outside temperature suggests a slightly brighter sky at warmer temperatures in his locale. He mentions



## Reflector Mail

pollen in April as a possible mechanism that could impact brightness readings (along with other factors). A cyclical variation of mean sky brightness versus month is also presented graphically. Though I have not recorded data so methodically, I have noticed a difference in sky brightness based, I suspect, on smoke particles and dust here in Arizona. The effect of these particles on sky brightness

appears to be pronounced and varies night-to-night and even within a single night of viewing. I have been noticing this impact as I recorded my findings near the zenith while working on the Astronomical League's Herschel 400 and Herschel II projects within the last 18 months (these two programs represent 800 measurements with the SQM within an allotted time period). In a cursory review, my SQM readings vary as much as  $\pm 0.3$  arc mag/arcsec<sup>2</sup> night-to-night on clear nights even when humidity is in the single digits and "all else seems to be equal." Since winds and distant forest fires occur primarily in the spring and early summer here, I can only attribute the SQM variance to minute particles in the air. Thank you for sharing this data with us. I hope to make my own study of my locale in an effort to better understand viewing conditions.

Vincent Bournique, Thatcher, Arizona

**To the Editor:**

I completely agree with letter writer Bob Guzauskas that the best way to combat light pollution is to turn off lights. That is why, when I have a table at an Astronomy or Earth Day outreach event, my first message is "turn lights off," before "turn them down" and "cover them up." I have not yet had much luck with convincing law enforcement that nighttime lighting doesn't deter crime, or convincing businesses that their best advertisement is not night-lighting. When Mr. Guzauskas is successful in following France's lead in having lights turned off between 1 a.m. and dawn, what of the lights on between sunset and 1 a.m.? Would he not agree that full-cutoff is better at reducing light pollution than an unshielded glare bomb? Many of us feel that it is, so we work tirelessly to convince people, box stores, and electric companies to only produce and install, where it is deemed necessary, full-cutoff lighting fixtures. This means a shielded light source so no light is emitted above 90 degrees, flat lens, no tilt, and a maximum color temperature or CCT of 3000 K for LED lights.

Thank you,

Laura Graham, 3115 Judes Ferry Road,  
Powhatan, Virginia

Co-Leader, Virginia Chapter of the International  
Dark-Sky Association

**Corrections and Clarifications**

The Maria Mitchell article in the June issue states that Maria's father made observations for the U.S. Coast Guard. The Coast Guard was called by several different names in the 1800s and did not receive its U.S. Coast Guard designation until 1915. It appears Mr. Mitchell made his observations for the U.S. Coast Survey, which is a separate organization. The "Coast Guard" error has been repeated in several journals, articles, and newspapers, including several of the references used for the article. Thanks to Dr. James Dire for finding the error.

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### AMA Adopts Community Guidance to Reduce Harmful Human and Environmental Effects of High Intensity Street Lighting

Major cities, including New York, Chicago, Los Angeles, and Phoenix, are in the midst of, or actively plan on, completely replacing their current street lighting systems with light-emitting diode (LED) fixtures. LED technology has matured to the point where the installation and operational costs are no longer prohibitive, and LEDs can lead to savings in energy and maintenance costs.

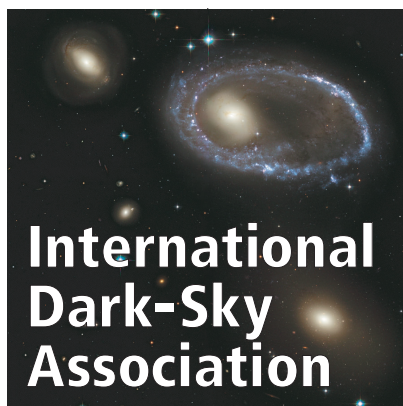
LEDs have a number of advantages: long lifespan, better directional control of light, little deterioration of illuminance over the lifetime of the fixtures, and the ability to dim or turn off each fixture individually through remote control software systems. The LED revolution has a good news/bad news aspect. The good news is that these fixtures can produce excellent lighting with minimal light trespass and light pollution if they are properly designed, situated, and maintained.

The bad news is that LED fixtures can be misused. Their small micro-lenses produce sharp, well-defined beams of light that are very bright when viewed from certain angles. Therefore, an overly bright LED fixture can produce considerable glare, particularly as one is approaching the fixture or looking up into it. There is also the tendency to "overlight" with these fixtures, as they are incorrectly perceived as being so energy efficient that one can bump up the lighting levels to far beyond what is reasonable or necessary for the task.

There is considerable evidence that the color temperature of a light is important for human comfort, safety, and well-being. The higher the color-corrected temperature of an emitter, the more blue light is emitted. Most LEDs come in a color range from 2800 Kelvin to 5000 Kelvin, the latter being very "blue" and metallic-looking. The latter produces more glare, is possibly more harmful to wildlife and human health, and is considered too harsh by many people.

On June 14, 2016, the American Medical Association (AMA) released its suggested guidance standards for reducing harmful human and environmental effects of high intensity street lighting. The AMA feels that "some LED lights are harmful when used as street lighting. The new AMA guidance encourages proper attention to optimal design and engineering features when converting to LED lighting that minimize detrimental health and environmental effects."

LED designs that emit a large amount of blue light create worse nighttime glare than conventional lighting. Discomfort from intense, blue-rich LED light can decrease visual acuity and safety, according to the AMA statement. They may create



## International Dark-Sky Association

road hazards for drivers and pedestrians. Blue-rich LED streetlights also operate at wavelengths that most adversely suppress melatonin during sleep, therefore having a greater impact on circadian sleep rhythms than conventional street lamps. Large public surveys found brighter residential nighttime lighting is associated with reduced sleep times and

sleep quality, possible impaired daytime functioning, and even obesity.

I like to take a very conservative approach to medical claims that are hard to prove and are based on somewhat subjective data. Nevertheless, it seems to me there is considerable anecdotal evidence that blue-rich (4000 Kelvin and higher) LED nighttime lighting is unfavorably perceived by the public as too harsh, producing glare and possibly sleep disturbances. LED lighting around 2700–3500 Kelvin is considered "warmer" in color, giving a more natural white rendition, less blue and more yellow.

The AMA has previously taken a strong stand against poor nighttime lighting. A good summary, "AMA Addresses Light Pollution," can be found on *Sky & Telescope's* website: [www.skyandtelescope.com/astronomy-news/ama-addresses-light-pollution/](http://www.skyandtelescope.com/astronomy-news/ama-addresses-light-pollution/).

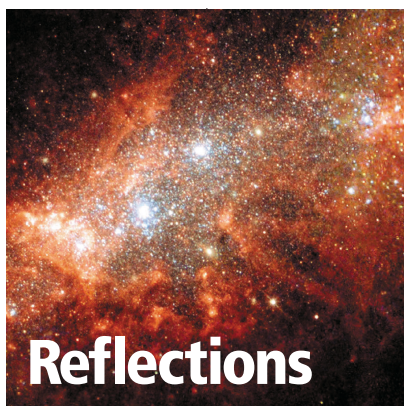
The AMA press release, "AMA Adopts Community Guidance to Reduce the Harmful Human and Environmental Effects of High Intensity Street Lighting," can be found at [www.ama-assn.org/ama/pub/news/news/2016/2016-06-14-community-guidance-street-lighting.page](http://www.ama-assn.org/ama/pub/news/news/2016/2016-06-14-community-guidance-street-lighting.page).

To quote the AMA again, "Recognizing the detrimental effects of poorly-designed, high-intensity LED lighting, the AMA encourages communities to minimize and control blue-rich environmental lighting by using the lowest emission of blue light possible to reduce glare. The AMA recommends an intensity threshold for optimal LED lighting that minimizes blue-rich light. The AMA also recommends all LED lighting should be properly shielded to minimize glare and detrimental human health and environmental effects, and consideration should be given to utilize the ability of LED lighting to be dimmed for off-peak time periods."

In summary, the AMA supports the goal of IDA and professional lighting engineers—that is, for the LED revolution to improve outdoor nighttime lighting, producing less light and using this light more effectively on the ground where it is needed for public security and safety. The goal is for the color rendition to be around 2700–3000 Kelvin so the light is pleasing and less likely to produce excessive glare or the harmful effects from light that is bluer.

**Tim Hunter**, Co-founder, IDA  
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**I am writing this** on July 3, one day before Juno's first close encounter with Jupiter. As I sit in my home office, reading about the mission, and all the uncertainties about whether the spacecraft will survive the strong magnetic fields and intense radiation environment around our largest planet, I reflect



still like the word "manned") missions back to the Moon and even to Mars, with expectations of landing within the next 10 to 25 years.

We are also finding planets at an amazing rate. Estimates imply there may be more planets in the Universe than stars! Imagine the

possibilities for future generations once science finds a way to travel through space at speeds approaching a reasonable percentage of the speed of light. Consider that some of our early spacecraft have been in space more than 40 years. In the future, that would be adequate time to reach the stars.

A little closer to home, as this issue goes to press, we are preparing for ALCon 2016 in Arlington, Virginia, on August 10–13. In addition to some great speakers there are several tours planned and it should be a great event. Hope to see many of you there.

We are also working on AstroCon 2017 in Casper, Wyoming, scheduled for August 16–19, 2017. On Monday, August 21, 2017, there will be a total solar eclipse visible from Casper, as well as from other points throughout the United States. Hotel rooms are very limited in Casper, so you should book as quickly as possible.

Volunteers are needed at the Casper event for public outreach—observing both the Sun and the night sky. Please contact Alan Corey of the Central Wyoming Astronomical Society, [alancorey1979@msn.com](mailto:alancorey1979@msn.com), if you're interested. Use of a personal telescope is required.

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**Ron Kramer**, Editor

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Located near its apex above the southern horizon as evening twilight fades this month is an interesting galactic neighbor known as Barnard's Galaxy. Cataloged as NGC 6822, Barnard's Galaxy is a dwarf irregular galaxy located in the northeastern corner of the constellation Sagittarius. It is located halfway between Rho Sagittarii and Alpha Capricorni. The galaxy is 16 by 12 arcminutes in size and has an integrated magnitude of 9.4. In a telescope–eyepiece combination with a one-degree real field of view, planetary nebula NGC 6818, the Little Gem Nebula, can be seen at the same time as Barnard's Galaxy.

Barnard's Galaxy is a member of the Local Group. It is 1.6 million light-years away. The galaxy is classified as an irregular galaxy, similar to the much closer Small Magellanic Cloud. Edward Emerson Barnard discovered the galaxy on August 17, 1884, using a 5-inch refractor. Edwin Hubble discovered 15 variable stars in Barnard's Galaxy, eleven of which were Cepheid variables. Using the newly discovered Cepheid period–luminosity relationship, Hubble calculated the distance to Barnard's Galaxy, the first galaxy beyond the Magellanic Clouds to have its distance determined. Hubble's 1925 paper, "N.G.C. 6822, A Remote Stellar System,"

# DEEP-SKY OBJECTS

## BARNARD'S GALAXY

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

was one of the greatest classical studies of the 20th century. He solved the great debate over whether galaxies (then called

Like the Magellanic Clouds, NGC 6822 has myriad active star forming regions. These H II regions appear very colorful in



long-exposure CCD images. Due to its close proximity to the Milky Way, Barnard's Galaxy's H II regions and OB associations have been extensively studied. It is one of the few galaxies in which individual stars can be resolved by relatively small ground-based research telescopes.

Irregular galaxies are typically small galaxies (most are dwarf

nebulae) were part of the Milky Way Galaxy or were unique galaxies of their own, far beyond the edges of the Milky Way.

Hubble also discovered three star clusters in NGC 6822, which he assumed were ancient star clusters like the hundred or so globular clusters in the Milky Way. Follow-up studies showed one of the three to contain very old stars, one intermediate-aged stars, and one very young stars. Perhaps globular star clusters are still being born.

galaxies) that have no distinct spiral or elliptical shape. Many of them get their irregular shape from gravitational interactions with a nearby massive galaxy. Others rotate too slowly to flatten out into disks, as spiral galaxies do. Barnard's Galaxy, like the Magellanic Clouds, has probably been distorted by the massive gravitational force of our Milky Way Galaxy.

Because of its low surface brightness and lack of a bright central core, Barnard's Galaxy

can be very challenging to find without a go-to telescope. The best way to star hop is to find the Little Gem Nebula and pan 40 arcminutes south and 10 arcminutes east. Low magnification can place both in the same field of view and the increased dark area around the galaxy will make it stand out more. I have viewed it in telescopes of various sizes, but all views were unimpressive except from my 14-inch f/6 Dobsonian reflector at 82x, where I could collect enough light to see some shape to the galaxy. Although many people report the galaxy to appear rectangular, it looks more elliptical to me. This is due to a bar-like feature in the galaxy, running north–south.

My image of NGC 6822 was taken with a 190 mm (7.5-inch) f/5.3 Maksutov–Newtonian with a SBIG ST-2000XCM CCD camera. The exposure was 170 minutes, barely enough time to capture faint detail, yet more detail than can be seen at the eyepiece. Several H II regions are visible in the image as the pink nebulosity. Most of the resolved stars are actually foreground stars in the Milky Way. However, some may be very bright massive stars, or associations of stars not quite resolved, located in Barnard's Galaxy.

The next time you point a telescope towards Sagittarius, take a break from all the splendid star clusters and nebulae and grab a look at one of our closest galactic neighbors. ☼

**The Shreveport Regional Arts Council** hosted an exhibit called "Astrophotography: an astronomical photographic view of the night sky," a collection of astronomical photographs created at the Worley Observatory by the members of the Shreveport–Bossier Astronomy Society (SBAS). Artspace in Shreveport, Louisiana, hosted this exhibit from June 6 through July 6, 2013, and it was sponsored by Classic Reprographics Inc.

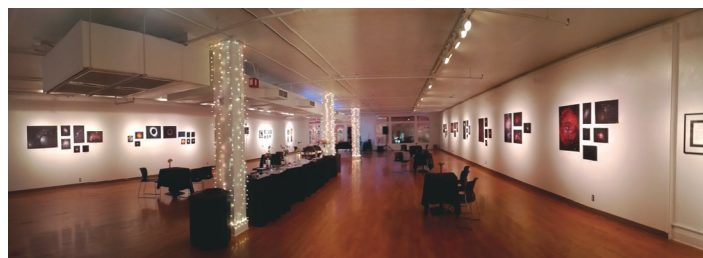
The astrophotography exhibit was the idea of Shreveport artist Jody Raney. He is a portrait artist and Mardi Gras float designer and was 2013 SBAS president. SBAS members were producing an abundance of astrophotographs but had nowhere to show them. Raney thought this would be an excellent opportunity for outreach to local schools and the community. He contacted the Shreveport Regional Arts Council and they jumped at

## An Astrophotography Exhibit

the opportunity to exhibit the club's art.

Don Razinsky, reprographer at Classic Reprographics Inc., printed and mounted all of the photography. Most pieces were 30x42, 24x36, or 11x17 inches in size, and all were full color. We had a section for old film photos as well. The photos were arranged on the walls in themed groups, but were also arranged for visual color and contrast.

Opening night at Artspace was outstanding! Walking up the stairs and stepping into the gallery, one could see that the exhibit was going to be "of astronomical proportions." Star lights sparkled on the columns, and star- and planet-shaped cheese and crackers were served with wine. The old wood floors, white walls, and contrasting draped black tablecloths made the gallery look special



with an astronomy theme. Despite some rain, we hosted around 200 to 250 people that night. The artists were excited about displaying their work. The guests enjoyed the show and several photos were sold.

Photographs in the exhibit were by Terry Atwood, Ron Dilulio, Trent Dupuy, Paul Goodwin, Austin Grant, Sidney Grimes, Nick Hobbs, Cran Lucas, Pat Madden, Joey Matheson, Jody Raney, Coy Wagoner, Don Walters, Stan Westmoreland, and Reid Williams.

The show continued until July 6, and was held over an additional week due to its popularity. This was an excellent, and slightly unusual, outreach program. We thank our sponsor, the members of the SBAS, and the Shreveport Regional Arts Council for an excellent show.

**Jody Raney, Astronomical League Outreach Award recipient, Shreveport–Bossier Astronomical Society**



**Thirty-six years into this great hobby**, there are now fewer amateur astronomers observing outside at all, and more of those who are out there are imaging. You can spot the imagers because they are strolling around, telling all the visual observers that the sky looks weak. Or you don't see them at all, as they went to bed at sunset. Every so often, they will wake up to check that the tracking system is still on point. A few weeks later, they post a Hubble-esque image of NHI 563 (the 563rd entry in the Never Heard of It catalog). They provide technical details about how they took one hundred 25-minute exposures and then spent 125 hours in post-production. And then they are

# John Henry Owned a Dobsonian

By Brad Young

not seen during the fuller phases of the moon while they retire to a seedy hotel to sell another organ to afford the newest camera or mount. Forever trapped on the "dark side," they live—no, exist—chained in front of the computer screen trying to chase the dragon. They just need one more fix, that is, update of Adobe Mirage Maker.

This isn't exactly a new complaint by a stargazer, but there is a serious side to consider. Visual astronomy seems to be dying off more quickly than amateur astronomy is declining in general. Again, this is not news to most of you, but some of the recent trends are troubling.

The Astronomical League provides more than 50 observing programs to give amateur astronomers a structured path to help them enjoy their hobby more, hone their skills, and perhaps inspire them to try something new. For most of their history, these programs were purely visual. In fact, many of them required you to star hop—no digital setting circles or go-to scopes were allowed. Now there are many programs and observing challenges that require imaging. For years, many of the programs offered were practically impossible to complete without imaging, but at least they did have the visual option available. This isn't just the usual problem of having to buy a bigger scope or trying to find truly dark skies; this is a sea change in the way you observe.

Other amateur opportunities are becoming nonvisual also. A program to watch out for near-Earth objects, or NEOs, requires imaging for reports to be valid. I don't know about you, but if someone finds one of these objects visually, and we are able to determine a way to avoid disaster, I will be just fine with that. For years now, "serious" amateur involvement has moved away from visual astronomy because it is seen as being too subjective and not worthy of use for "real science."

Unfortunately, most amateurs coming into the hobby lack the resources and the background to dive directly into imaging. It can be a daunting decision to face.

On the classic path, you can spend your time and money on a reputable beginner's scope or binoculars, learning the sky and how it works. Along the way, you slowly build up a deeper understanding of the universe we inhabit, and what we can practically see

and enjoy, along with a lifetime of experience. Later, you may choose to delve into imaging. Using Picasso's approach to art as a model, you learn the sky and how objects appear visually, and then change the medium, deconstructing the sky, as it were. But, with wisdom and discipline, you can choose to stay true to your interpretation of what's there.

Or, with a more modern outlook, you may spend thousands on equipment you

don't know how to use (in a modern extrapolation of the old problem of buying too much aperture first) and try to make realistic images of things you've never seen (except in other images). If the batteries die, you are completely out of luck. You aren't as well equipped mentally to understand the sky, and the subject becomes less important than the method.

What is the driving force in the marginalization of visual astronomy anyway? Is it economic—a struggling industry finds a new twist that is more marketable to a tech-savvy younger generation? Is it because the graying population of amateurs can no longer see anything through their yellowed corneas and the glow from yellow streetlights? Or is it the natural progression of our civilization, just like the eponymous fable of a man swinging a hammer versus a machine driven by steam?

Whatever the reason may be, I hear more and more from other observers that there is true value in visual astronomy that should not be overlooked or lost. Additionally, people should not be excluded for not using the newest technology. Instead, they should be celebrated for their harder-won achievements.

I can remember when CCDs first came out and film was still the medium of choice for imaging. Those who used film looked down their noses at the new technology and the people who were using it. Only a few years later, film has become a nearly impossible option: it's hard to get, and even harder to process, unless you do it yourself. Fortunately, the reasons that drove film to extinction don't carry over to visual astronomy. We, as a hobby and community, can elect to give visual astronomers the respect that they are due. Although I am not adept at it, I have seen sketches made at the eyepiece that rival digital images for their beauty and detail. And there are certain aspects of observing that are simply more enjoyable and useful when done visually.

If you share my concerns over this important issue, I would appreciate your feedback. I can be reached at [allenb\\_young@yahoo.com](mailto:allenb_young@yahoo.com). ☼

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# David Levy's Gift to Linda Hall Library of Science, Engineering and Technology

**By Carroll Iorg, Astronomical League Media Officer and Convention Coordinator; Photos compliments of Linda Hall Library**

**What more can** be said about David Levy that hasn't already been? I pondered this question before interviewing him last fall at the Linda Hall Library of Science, Engineering and Technology in Kansas City, Missouri.

Dr. Levy is a longtime friend of the Astronomical League and received the League's 1988 Leslie C. Peltier Award for his outstanding contributions to observational astronomy. Dr. Levy received his PhD in 2010 from Hebrew University, where, he noted, Nobel Prize-winner Albert Einstein served on its first board of governors. Most of us in the astronomical community know that Levy's passion has been searching for comets most of his adult life, but I also learned many things I didn't know.

For example, how does one persevere for 19 years before making a major discovery in his

scientific field? This is how long it took for Dr. Levy to discover his first comet! How did he continue his quest without giving up and thinking he would never discover a comet?

Before beginning the journey to become a comet hunter, he told me, he had trouble focusing his attention. This was different than any other goal he'd had, and it became a real passion that far surpassed anything else he had set a goal for. This burning passion kept him motivated during the long journey.

Let's back up a bit and discuss the reason for Dr. Levy's visit to the Linda Hall Library. Over ten years ago, Levy first visited this library, and was impressed with being able to view much of its vast collection of rare works from such astronomers as Galileo Galilei, Isaac Newton, Tycho Brahe, and Sir William Herschel. This experience encouraged him to make his documentation of observing the sky for nearly 60 years available for future generations.

When Dr. Levy became aware that Herschel's observing logs and other works were housed in a library, he decided he would like to choose a library such as the Linda Hall Library, with its strong reputation and mission for preserving scientific works for future scholars and the public.

While visiting the Kansas City area last fall, Levy was the featured speaker for the Linda Hall Library lecture series with

his presentation, "Sixty Years of Skywatching: A Gift of My Observing Records to the Linda Hall Library." He also spoke at the Heart of America Star Party, sponsored by the Astronomical Society of Kansas City. The special Linda Hall Library lecture coincided with the announcement that he was giving his observing logs to the library. The first volumes were on display at the lecture, and the remainder will be transferred later. He told me that having such an outstanding depository for his collection ranks right up there with his comet discoveries as far as personal satisfaction.

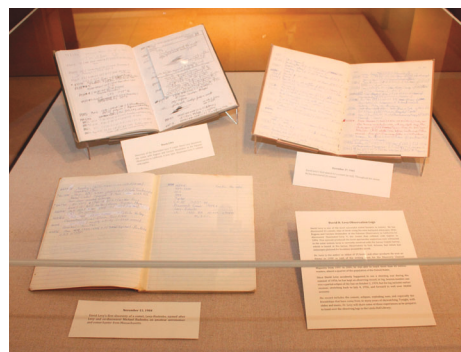
The November 13, 1984, entry in Dr. Levy's observing logbook recorded his first comet discovery! Since then, independently and with Gene and Carolyn Shoemaker, he has discovered over 20 additional comets.

When I asked him what his favorite comet was, he answered without hesitation that it had to be Comet Shoemaker-Levy 9, because it "rewrote the book on how comets behave."

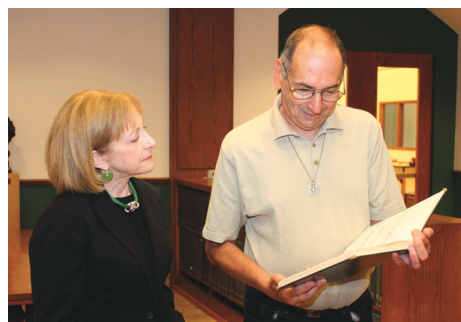
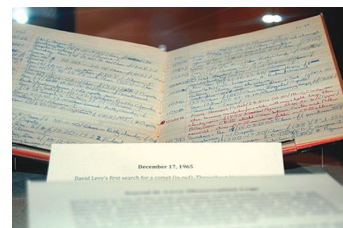
That comet, which was discovered in 1993 and crashed into the planet Jupiter in 1994, became famous because it was the first one in modern history known to crash into a planet. Levy stated that scientists calculated the comet's collision course with Jupiter about 16 months before the crash was to occur. Suddenly, Levy was at the center of the media coverage for the comet. He gave over 150 interviews with the media during this time, which



David Levy shared his story of 60 years as a skywatcher to a packed house at Linda Hall Library.



Levy's observation logs were on exhibition at the library this winter, including one from his early comet discoveries (below).



Linda Hall Library president Lisa Browar and Levy look over his observation logs shortly before his lecture.

increased his visibility in the astronomical community.

ALCon and regional conference attendees have previously had the opportunity to visit the special rare books collection at the Linda Hall Library. Now there is another outstanding reason to visit this library and appreciate Dr. David Levy's tremendous collection of observing materials. ☼



David Levy presents his observation logs to the Linda Hall Library. From left, board of trustees members Nick Powell, Charles Sosland, Marilyn Hebenstreit; Levy; Linda Hall Library president Lisa Browar; and trustees John MacDonald and Tuck Spaulding.

## The Fort Worth Astronomical

Society's members were looking forward to the Geminid meteor shower at the club's dark site near Ranger, Texas. It is a great site, although not completely dark, as the lights of Ranger do affect part of the sky. However, it is dark enough to see the splendor of the Milky Way, with the Andromeda Galaxy clearly visible to the naked eye.

With sunset at 5:23 p.m. on December 13, and sunrise at 7:23 the next morning, there was a potential of over 12 hours of dark viewing time with the moonless night. Si Simonson was hoping to get in about ten good hours of observing during a long, clear night. He arrived at the dark site at about 4:30 p.m. to set up and be prepared for any meteors that might appear shortly after sunset. It was cool—about 48 degrees—with a strong breeze. Si had a digital voice recorder to log all of his observations and maximize his viewing experience,

recording his sightings to submit to the Meteor Observing Program.

Bruce and Laura Cowles arrived just prior to sunset, bringing heaters and a coffee pot, which came in handy. Clouds moved in at about dark, so Bruce heated up coffee in our club's building on the site and we discussed the plans for the night's viewing.

About 8:15 the clouds broke, and we all settled in our reclining lawn chairs, facing east. The number of meteors per hour increased steadily as the night went on, with many long ones overhead early. We were observing about 30 meteors an hour until our first break to warm up, at 11:30 p.m. When we returned at midnight, the

rate had increased, and we were each viewing about 80 an hour, many at the same time. We were seeing most of the meteors from about 45 degrees in altitude, falling toward the

horizon. Many times Laura and Bruce commented on ones that Si did not see, and they were not seeing the ones that Si was recording—so the rate was well over 100 per hour. At about this time we were joined by another club member, Don Vick.

Unfortunately, we took another break during prime viewing time, about 1:45 a.m., to warm up again. At 2:15 we resumed viewing, now facing north-northwest. We continued to focus at about 45 degrees in altitude, again

capturing many meteors streaking straight down toward the horizon. Don had left at about 2 o'clock, and Laura retired to warm up at about 2:30. Despite the cold (now about 42 degrees), Bruce lasted until about 3:45 a.m., and Si persisted until 4:45, when he was still seeing about 80 an hour.

Overall, we had a great night, seeing many multiple meteors, some side-by-side, some that skipped in and out of the atmosphere, and some brighter than Venus. Don saw quite a few, Laura and Bruce viewed over 300 meteors each, and Si logged 443 meteors. Unfortunately, we only got a maximum of about six and a half hours of viewing in due to the clouds and the breaks from the cold. As we prepare for the Quadrantid meteor shower, we will definitely bring more hand warmers, sleeping bags, and more blankets to brave the projected 35-degree weather. ☼

## The Rewards of Having a Truly Dark Site and a Moonless, Clear Night to Observe a Winter Meteor Shower

By Si Simonson, Fort Worth Astronomical Society

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# FORBIDDEN RADIATION IN PLANETARY NEBULAE

If you have observed a planetary nebula through a telescope, you can appreciate not only the ethereal appearance of these objects, but also their distinct bluish-green color. We can enhance our views of these celestial objects by attaching a filter to our eyepieces that selectively blocks out nearly all light except that most strongly emitted from the object we're observing. The filter used on planetary nebulae is the O III filter, in the arsenal of wide- and narrowband filters that we use to eliminate sky glow and increase the contrast of the objects we are observing. The O III



X-ray/optical composite image of NGC 6543, the Cat's Eye Nebula (X-ray: NASA/UIUC/Y.Chu et al., Optical: NASA/HST). Optical image: Wide Field Planetary Camera-2, composite image of three images taken at different wavelengths: red, hydrogen-alpha (656.28 nm); green, ionized nitrogen (658.4 nm); and blue, neutral oxygen (630 nm).

filter blocks most light except the prominent blue-green light produced by planetary nebulae. A seasoned amateur astronomer will tell you that the blue-green light you see emanating from the planetary nebulae is the forbidden radiation of doubly ionized oxygen—O III.

So what exactly are doubly ionized oxygen and forbidden radiation, and why is this the

By Scott P. Donnell, Vice President  
Colorado Springs Astronomical Society

most prominent visible radiation from these objects? If it's forbidden, does that mean you shouldn't look at it, or that if you do, you will wish you hadn't? Not at all; it simply means that the blue-green light you are seeing in a planetary nebula originates in an atomic process that is unique to the conditions in which these objects exist.

A planetary nebula is formed when an aging star depletes its hydrogen fuel and enters a period of instability in which its outer layers are blown off into

space. The shell of luminous gas surrounding the dying star is what we observe and call a planetary nebula. The stars that go through this process are those with masses

ranging from about that of our sun to a few times that of our sun. For most of their lives, these stars steadily produce energy through the conversion of hydrogen into helium in their cores via nuclear fusion. As these stars consume their hydrogen fuel, a core of helium builds up and, as it does so, steadily contracts under the influence of gravity. As the core contracts, it heats up and, at some point, the temperature in

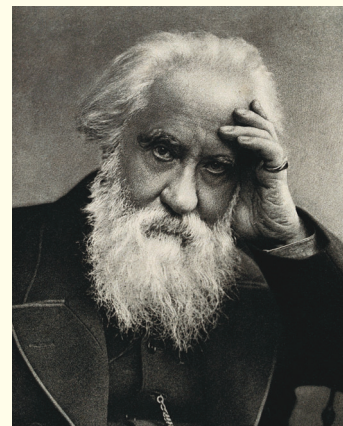
the core will be high enough for the helium to undergo fusion, creating carbon and oxygen in the process.

Now, helium fusion is extremely sensitive to small changes in temperature—more so than hydrogen fusion is. Consequently, small temperature variations in the helium-fusing star results in dynamical instabilities and these instabilities give rise to physical pulsations of the star. These pulsations can build up and eventually produce enough kinetic energy to eject the outer layers of the star into space, forming a planetary nebula. At the center of the nebula remains the core of the star, now transformed into a small, dense white dwarf. A helium-fusing star can do this multiple times, producing successive layers, or shells, of the planetary nebula.

The first planetary nebula discovered was the Dumbbell Nebula in the constellation of Vulpecula. It was observed by Charles Messier in 1764 and listed as M27 in his catalog of nebulous objects. To early observers with low-resolution telescopes, M27 and subsequently discovered planetary nebulae somewhat resembled the giant planets like Uranus, and William Herschel, discoverer of this planet, coined the term “planetary nebula” still used today.

It was in the mid-1800s that astronomers first applied the technique of spectroscopy—

spreading light into its component colors—to the study of stars and other astronomical objects. And it was in 1864 that English astronomer Sir William Huggins first examined the spectrum of a planetary nebula—NGC 6543, the Cat's Eye Nebula in Draco.



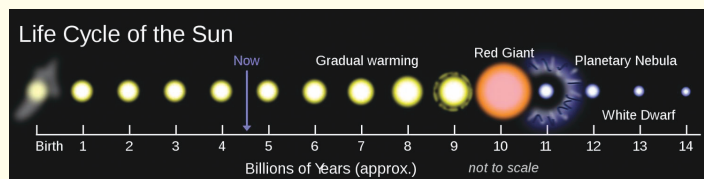
Sir William Huggins, 1824–1910

When Huggins observed the spectrum of this nebula he noted something very peculiar.

*On the evening of the 29th of August, 1864, I directed the telescope for the first time to a planetary nebula in Draco (NGC 6543). The reader may now be able to picture to himself to some extent the feeling of excited suspense, mingled with a degree of awe, with which, after a few moments of hesitation, I put my eye to the spectroscope. Was I not about to look into a secret place of creation? I looked into the spectroscope. No spectrum such as I expected! A single bright line only!*

What Huggins observed in his crude spectrum was the strong emission line of doubly ionized oxygen—the forbidden radiation I mentioned earlier—although he did not know it at the time.

Subsequent observations by other observers at better resolution showed that the bright line that Huggins observed was actually two



Formation of a planetary nebula



Low-resolution spectrum of a planetary nebula (S. Donnell, Kiwa Creek Observatory, using RSpec v1.8.0)

closely spaced lines, and other emission lines were present as well. Huggins' observations showed that planetary nebulae had bright emission lines, unlike the broad continuous spectra produced by myriad unresolved stars, which, at that time, were believed to comprise planetary nebulae. Huggins concluded that planetary nebulae are enormous masses of hot, luminous gas or vapor, since their spectra resembled the emission-line spectra produced by hot gases in the laboratory.

Through careful analysis of the spectral features of planetary nebulae, it was determined that the prominent blue-green color is due to a pair of emission lines produced by atoms of oxygen that have had two of their outer electrons stripped away (that is, the atoms are doubly ionized). The radiation from these two emission lines at 495.9 and 500.7 nanometers can account for one-half or more of the total radiative emissions in these objects, even though oxygen accounts for less than 0.1 percent of their total mass. The human eye's peak sensitivity at about 550 nanometers is near this region of the spectrum and accounts for the distinct blue-green hue noted by visual observers.

When these lines were first observed in the mid-1800s, the element responsible for these emissions could not be identified based on a comparison with laboratory spectra of the known elements. Consequently, these emission lines were attributed to a new element believed to be found only in nebulae and called "nebulium" (analogous to the element helium being first found in the spectrum of the Sun—*Helios*—in 1868). When the atomic weight of nebulium was determined in 1914, it was thought that nebulium might not be a new element after all, since there were no gaps in the periodic table of elements that would accommodate a new element of low atomic weight.

These considerations led **Henry Norris Russell** in 1927 to the conclusion that "it is now practically certain that they [the emission lines] must be due not to atoms of unknown kind, but to atoms of known kinds shining under unfamiliar conditions."

In his paper titled "The Origin of the Chief Nebular Lines," published in 1927, **Ira S. Bowen** of the California Institute of Technology provided a detailed description of the mechanism by which these

emission lines are produced. Bowen suggested that nebulium emission lines are created by electron transitions from atomic metastable states, which are possible only at very low density—the "forbidden" transitions.

Bowen computed spectral line wavelengths for transitions between several metastable states known in oxygen, and many of the resulting wavelengths matched the nebulium lines exactly. A few years later, in 1931, two nebulium lines (oxygen at 630.0 and 636.4

nanometers) were reproduced in the laboratory. It took a two-hour photographic exposure to record the faint emission lines from a quartz discharge tube operating at a pressure less than 0.003 atmospheres. It was now certain, as Russell suggested, that the mysterious "nebulium" was actually a known element, oxygen in this case, shining under conditions not typically encountered on Earth.

To understand how these "forbidden" transitions occur, we need to understand a few basic facts about atomic transitions in general. First, electrons that are bound to atoms can exist only in discrete energy levels, or states. Electrons absorb energy when transitioning from a lower energy level to a higher one, and emit energy when transitioning from a higher energy level to a lower one. The energy absorbed or emitted can be in the form of either electromagnetic radiation or kinetic energy. In the case of electromagnetic radiation, the wavelength of the absorbed or emitted radiation corresponds to the energy difference between the two states, with larger energy differences corresponding to shorter wavelengths of radiation. If the transition between states is due to a collision with another atom or electron, then the energy absorbed or released is in the form of the kinetic energy of the colliding particle.

Transitions of electrons between states in an atom are governed by a set of selection or transition rules, which ensure that certain properties of the atom, such as total angular momentum, are conserved in the transition. Transitions that obey these rules are termed

normal, or electric dipole, transitions. Transitions that violate the selection rules can nevertheless occur as magnetic dipole or electric quadrupole radiation, but with much lower transition probability.

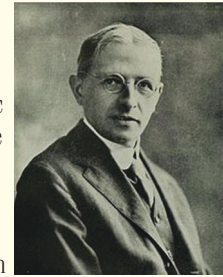
These are the so-called "forbidden" transitions. Being forbidden does not mean that these transitions cannot occur, only that they are electric dipole forbidden, and if they occur as electric quadrupole or magnetic

dipole transitions they do so at a much lower rate. The blue-green light we see from a planetary nebula is forbidden radiation, meaning that it results from downward transitions of electrons that

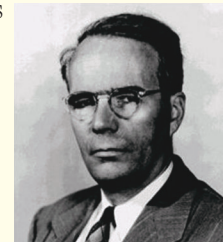
violate the normal transition rules and have a much lower probability of occurring. Yet they are the dominant emission from these objects.

So why is this forbidden radiation so dominant in planetary nebulae if these transitions are so highly unlikely and due to an atom—oxygen—that constitutes less than 0.1 percent of the nebular mass? The answer lies in the rarified conditions in which planetary nebulae exist and in the ways in which electrons in an atom can transition between states.

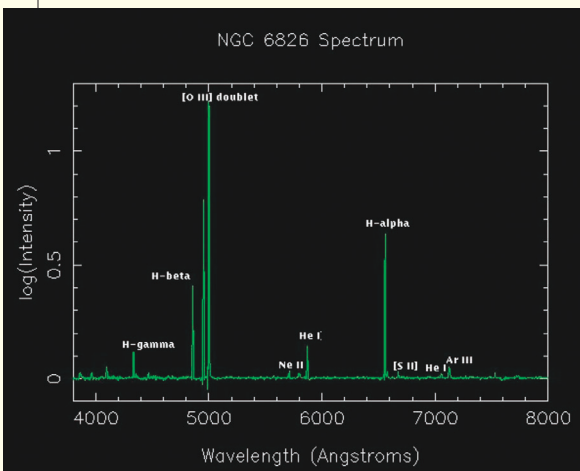
Again, an electron in an atom can be placed into a higher energy state, or excited, in one of two ways. In the first way, the atom absorbs a passing photon of electromagnetic energy and one of its electrons is boosted



Henry Norris Russell (1877–1957)



Ira Sprague Bowen (1898–1973)



Detailed spectrum of NGC 6826, the Blinking Planetary Nebula

into a higher energy state. This is termed radiative excitation. The other way is through a collision with another atom or electron. In this case, the other atom gives up some of its kinetic energy, allowing an electron to move to a higher energy state. This is termed collisional excitation. In both cases, the energy state into which the electron is boosted depends on the energy of the passing photon (for radiative excitation) or the kinetic energy released in the collision (for collisional excitation). Sometimes this energy is just the right amount to place the electron into a metastable state

where there is no downward transition that doesn't violate the normal electric dipole transition rules.

Once an atom's electron is in an excited state, it can

generally transition back to a lower energy state either by the emission of a photon of radiation or by a collision with another atom. If there is a downward transition that doesn't violate the normal transition rules, then the atom will immediately (less than a microsecond) and spontaneously emit a photon of radiation, and the electron will transition to a lower energy state. In a dense gas, collisions between atoms occur frequently enough that collisional deexcitations can occur. This is just the opposite of collisional excitation, except that the electron transitions from a higher to a lower energy state and the released energy is added to the kinetic energy of the particles in the gas.

The balance between radiative deexcitations and collisional deexcitations depends on the density and temperature of the gas. In a hot, dense gas, the atoms of the gas

are moving fast in tight quarters, so the number of collisional excitations and deexcitations is high. We measure this by the mean time between collisions. When the mean time between collisions is less than the time an electron spends in an excited state, then it is more likely that atoms will collide with other particles before the electron can radiatively deexcite, and the electron will transition to a lower energy state through collisional deexcitation. On the other hand, if the mean time between collisions of the atoms in the gas is longer than the time an electron spends in an

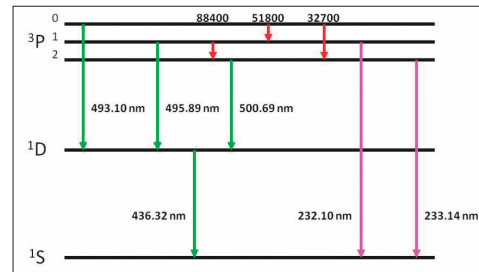
excited state, then it is more likely that the electron will radiatively deexcite.

In the case of forbidden radiation, an electron is excited to a

higher state (typically by collision with a free electron in the gas) in which it becomes "trapped." That is, there is no downward transition that doesn't violate the normal electric dipole selection rules. In this metastable state the electron can linger for long periods of time (10 seconds to 10,000 seconds or more) before spontaneously transitioning to a lower state and emitting radiation. It is also possible for electrons to be trapped in a metastable state as a result of a permitted transition of an electron from a higher energy state.

In a dense gas, any electrons in a metastable state will typically be knocked out of that state by collisions with other atoms or electrons in the gas well before they can radiatively deexcite from the metastable state. In this case, no forbidden radiation is emitted—the transition energy goes into the kinetic energy of the colliding

particle instead. But if the gas density is low enough that the mean time between collisions is longer than the amount of time an electron lingers in the metastable state, then there is a chance for the electron to radiatively deexcite from the metastable state before a collision occurs. If this happens, then radiation is emitted even though the electric dipole



*Forbidden and permitted electron transitions in the oxygen atom (Wikipedia user Cepheiden, en.wikipedia.org/wiki/Doubly\_ionized\_oxygen#/media/File:Oiii-linesp.svg)*

selection rules for the transition are violated, producing the forbidden radiation we've been discussing. This is exactly the condition that prevails in the low-density environment of interstellar space. Electrons that find themselves in a metastable state would normally transition out of that state through a collision with another atom or electron, but in the rarified environment of a planetary nebula, where electrons are left undisturbed in metastable states for long periods of time—long enough for them to spontaneously deexcite and emit photons—we observe the emission from these forbidden transitions.

In the case of O III, the observed emission lines at 495.9 and 500.7 nanometers are due to the downward transition from the 3P1 to 1D2 and 3P2 to 1D2 states, respectively. Normal transitions are shown in magenta (ultraviolet) and red (infrared). Forbidden transitions are shown in green (visible).

So how is it that oxygen is such a small part of the mass of a planetary nebula, yet it

accounts for half or more of the observed light from these objects? The answer is twofold. First, the energy required to excite O III electrons into a metastable state is on the same order as the kinetic energy of free electrons and atoms at the temperatures typical of a planetary nebula (about 10,000 K), whereas most other

states require significantly more energy. So the temperature of the gas is just right to favor the excitation of electrons into these metastable states. Second,

transitions from the O III metastable states correspond to photon energies in the visible range. Other allowed transitions are either in the ultraviolet or infrared and are invisible to the human eye. Forbidden radiation from other elements also contributes in weaker amounts to the total nebular emission. Elements with observable forbidden lines in the visible range include carbon, nitrogen, neon, sulfur, argon, chlorine, potassium, and magnesium, although their contribution to the total nebular emission is much less than that of O III.

To sum up, in planetary nebulae, we have the low-density conditions that allow electrons trapped in metastable energy states to spontaneously transition downward, before collisions with other atoms or electrons would knock them down in collisional deexcitations. Also, even though oxygen comprises less than 0.1 percent of the total mass of the nebula, its forbidden emissions account for a majority of the visible light we see in these objects. So the next time you turn your telescope to a planetary nebula and gaze upon its bluish-green hue, remember that what you are seeing is "forbidden" radiation. ☼

Element	Percent of Total Mass
Hydrogen	87.9%
Helium	12.0%
Carbon	0.03%
Nitrogen	0.03%
Oxygen	0.07%

*Elemental abundances in planetary nebulae*

# Wanderers in the Neighborhood

## Orbital Oddities

By Berton Stevens

**We normally think** of orbits as a mundane part of astronomy. The Earth makes an almost circular orbit around the Sun, much like the other major planets in our Solar System. Sometimes, gravity can play games with orbits and unusual results can occur.

Our Earth occasionally picks up a new moon. These tiny minor planets come into the Earth–Moon system traveling slowly enough to be captured by the Earth’s gravity, at least temporarily. Most near-Earth asteroids pass the Earth with enough speed to keep from being captured. Those traveling slowly enough are in rather unusual orbits.

The first object that we know was captured by Earth was dubbed J002E3. This object was discovered on September 3, 2002, by Canadian amateur astronomer Bill Yeung, observing from Benson, Arizona, with an eighteen-inch telescope. Further observations by amateur and professional astronomers around the world showed that J002E3 was in a distant Earth orbit. However, the orbit was chaotic, moving from near Earth, to near the Moon, and then far from either of them.

When they ran the orbit backward, they discovered that it had come through the L1 (Lagrange 1) point between the Earth and Sun, where the Earth’s gravity is balanced by the gravity of the Sun. With the assistance of the Moon’s gravity, the scale is tipped, and it is easy to capture an object that passes through this point. After floating

around in the Earth–Moon system for fourteen months, a second close pass by the

Moon allowed the object to exit through the L1 point in June 2003.

While this object initially appeared to be an asteroid, spectroscopic observations showed that J002E3 had the spectral characteristics of titanium oxide paint and aluminum, typical of a rocket body. Tracing the

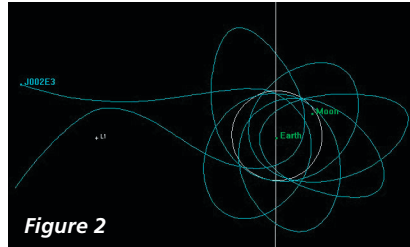


Figure 2

J002E3’s fourteen-month journey around the Earth–Moon system. The original capture was mediated by a close pass of the Moon, bringing it from a solar to a terrestrial orbit. It orbited the Earth five times until it made another close pass of the Moon, returning it to solar orbit. (NASA/Jet Propulsion Laboratory/California Institute of Technology)

orbit backward, J002E3 originally left the Earth–Moon system in March 1971 and is probably the S-IVB (third) stage of the Saturn V rocket that put Apollo 12 on course to the Moon. The identification of a new near-Earth “asteroid” as flight hardware happens on a regular basis. J002E3 is not gone for good; it will probably be back in the mid-2040s.

Another minor planet with an interesting orbit is 2002 AA<sub>29</sub>, discovered by LINEAR (Lincoln Near-Earth Asteroid Research) in White Sands, New Mexico, on January 9, 2002. This object is in an orbit that takes one sidereal year, just like the Earth. 2002 AA<sub>29</sub> is very close to Earth’s orbit, and the Earth’s gravity has an effect on it. If this asteroid were traveling alone in its orbit, it would round the Sun just like any other planet. However, the Earth alters the asteroid’s orbit when the asteroid gets near our planet. As the asteroid comes up on Earth from behind, Earth’s gravity speeds the asteroid up, and the asteroid goes into a slightly more distant orbit.

The asteroid takes longer to circle the Sun on its new orbit, so 2002 AA<sub>29</sub> now starts to lag behind Earth, moving farther away. Over the next century or more, both Earth and the asteroid continue to orbit the Sun, with the asteroid falling further behind. Eventually, it will drift all the way

around its orbit, approaching the Earth from the forward side. Now Earth’s gravity pulls on the asteroid, slowing it down. This moves the asteroid into a closer, faster-than-Earth orbit. 2002 AA<sub>29</sub> now starts to move away from the Earth again, but this time it is moving forward away from us, spending another century moving back around to Earth’s backside, where the process repeats.

From Earth’s point of view, 2002 AA<sub>29</sub> follows a horseshoe orbit, always coming near the Earth, then turning around, and drifting backward around the far side of the Sun all the way back to the opposite side of the Earth along their mutual orbit. This appears as a horseshoe to us, a horseshoe that takes over a century to traverse and just as long to return. Because this asteroid shares the same orbit as the Earth over many years, it is called co-orbital.

A recently discovered minor planet is in what amounts to a reverse-horseshoe orbit. Minor planet 2016 HO<sub>3</sub> was discovered on April 27, 2016, by the Pan-STARRS 1 asteroid survey telescope on Haleakala, Hawaii. It appears to be orbiting the Earth–Moon system. However, it is not gravitationally bound to the Earth, but is independently orbiting the Sun. Earth’s gravity does tug on the object,

pulling it back toward the Earth when it gets too far away.

This asteroid’s orbit is a little more eccentric than the Earth’s orbit, and is tilted 7.77 degrees to the ecliptic. This takes 2016 HO<sub>3</sub> north and outside our orbit where it slows down, allowing the Earth to

*Continued on page 27*

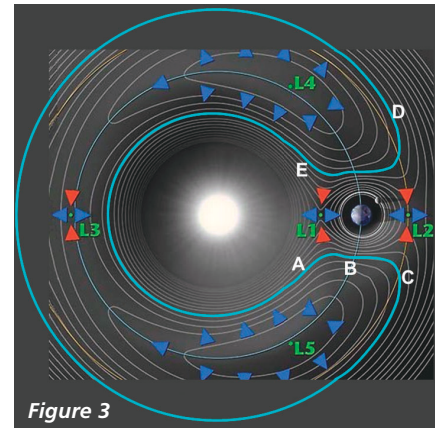


Figure 3

A minor planet in a horseshoe orbit is trapped by Earth’s gravity. This view shows the object’s motion relative to the Earth over an extended period (for 2002 AA<sub>29</sub> over two centuries). At point A, the object is in an orbit closer to the Sun than the Earth’s orbit, so it is moving faster than the Earth. Between L5 (Lagrange 5) and the Earth, the object is pulled by the Earth’s gravity, speeding it up. This moves it toward a higher orbit through point B to point C. The object is now in a more distant, slower orbit, so it starts to fall behind the Earth. It moves all the way around the Sun to the leading side of the Earth (point D) where the process reverses. Earth’s gravity slows the object and it drops into a closer, faster orbit (point E) and starts to outrun the Earth again. (NASA/Jet Propulsion Laboratory/California Institute of Technology)

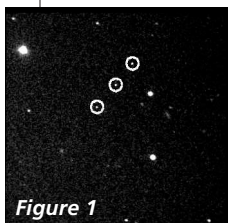


Figure 1

J002E3 was discovered in this composite of three images showing the motion of the object toward the upper right. This object, first thought to be a minor planet, turned out to be the S-IVB (third) stage of the Apollo 12’s Saturn V rocket. These images were taken by Bill Yeung on September 3, 2002. (NASA/Jet Propulsion Laboratory/California Institute of Technology)

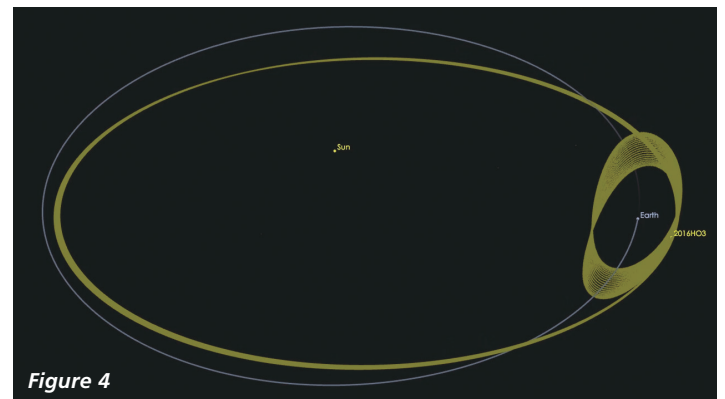


Figure 4

(469219) 2016 HO<sub>3</sub> is in a solar orbit very close to ours. Initially trailing the Earth, it moves sunward where it travels faster than the Earth, passing it. Its orbit now takes it ahead of the Earth, crossing the Earth’s orbit and becoming more distant from the Sun. The more distant orbit means the asteroid slows down and the Earth now passes it. Finally, the asteroid’s orbit takes it back through the Earth’s orbit, but this time behind the Earth to almost the same point where it started. The combination of movements makes it appear from our point of view as if it is orbiting the Earth. However, it is not gravitationally bound to us and will eventually move back into a horseshoe orbit. (NASA/Jet Propulsion Laboratory/California Institute of Technology)

# The Music of

By Dave Falkner, Minnes

**The Minnesota Astronomical Society (MAS)** does a great job performing public outreach and introducing people to the wonders of the heavens—usually through presentations or observing through telescopes. But once in a while, we get the opportunity to do something truly extraordinary to engage the public in space and astronomy.

In November 2014, **Sergey Bogza**, artistic director for the **Mesabi Symphony Orchestra (MSO)**, contacted me about a potential collaborative project between the MSO and MAS. The MSO is a community symphony orchestra on Minnesota's Iron Range. They have about 80 mostly-volunteer members and perform six times a year in the cities of Virginia and Hibbing, northwest of Duluth.

Sergey wanted to collaborate with the MAS in performing Gustav Holst's *The Planets*. The symphony has seven movements, one for each planet other than Earth. The



movements, in order, are "Mars, the Bringer of War," "Venus, the Bringer of Peace," "Mercury, the Winged Messenger," "Jupiter, the Bringer of Jollity," "Saturn, the Bringer of Old Age," "Uranus, the Magician," and "Neptune, the Mystic." The music reflects the personality of each astrological character. Sergey wanted to show images of the planets during each of the movements, and to have displays about the planets to provide some scientific context. He wanted it to be both an educational and a musical experience.

The symphony was scheduled to perform *The Planets* one year later, on November 21 and 22, 2015. While I realized this would be a considerable undertaking, I felt that a year would be enough time to put together a display and presentation worthy of the MAS. I assembled a team of seven MAS members to create a great presentation and

display. Two were educators and the rest were members who thought the whole idea of accompanying an orchestra with NASA images was a cool idea.

Our main contribution would be a visual presentation to accompany the orchestra in their performance. We also decided to create static displays, one for each planet, each with a poster containing three images, ten facts, and three or four bits of trivia. In addition, we would set up a scale model Solar System walk to provide a sense of how far apart things are in space and provide some sort of fun take-away items for children.

We decided to create a slide show that would run automatically during the performance of each movement, and then pause between movements to allow the next section to be manually started when the orchestra began the next movement. I purchased a copy of *The Planets* performed by the St.

Louis Symphony Orchestra, and three of us created separate presentations set to the score of each movement, using public domain images from NASA, ESA, and other

space agencies. The work was time-consuming, but by mid-September, things were really coming together and the final presentation was looking great. The St. Louis Symphony Orchestra's recording was indispensable in setting the timing of transitions in the presentations.

We designed the posters for each planet and they looked great, with wonderful images and text. Although *The Planets* only highlights seven planets, we also included a poster for Earth, and one for Pluto, although it hadn't yet been discovered when Holst composed *The Planets*. The recent New Horizons flyby of Pluto provided spectacular images for this poster.

Trivia boxes were designed and built out of wood. Each box had three questions about its planet with flaps that revealed each answer when you flipped them up. I also

ordered 3-D glasses with images from Mad Science Minnesota that we could use as take-away items for children. The glasses were inexpensive, and some of their pictures were of planets.

In late October, I contacted Sergey to make sure we were on the same page regarding the performance. There was one more element he wanted to do. He wanted to talk about each movement and how Holst composed the music to evoke each planet's astrological personality. Then he wanted me to say a few words about the planet itself. I put together some facts about each planet and another presentation with a full image of each planet. We combined our two scripts so we knew how this part of the concert would proceed.

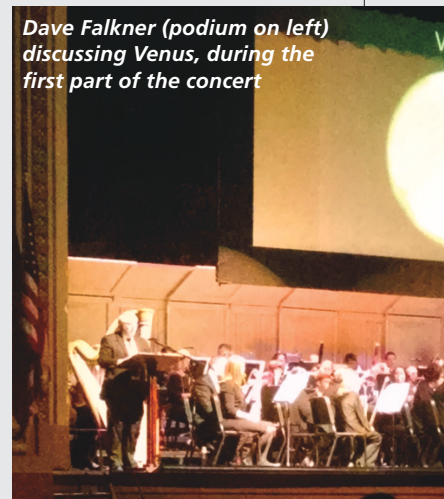
By November, the stage was set. Four of us would travel to the Iron Range on Friday afternoon, November 20, 2015. Arrangements were made for us to stay at the Giants Ridge Ski Lodge in Biwabik, Minnesota. Dress rehearsal would be Friday night, November 20, in the Virginia High School auditorium. The first performance was Saturday evening in the Hibbing High School auditorium and the second performance was Sunday afternoon in the Virginia High School auditorium. We would return home after Sunday's performance.

I loaded my Honda Odyssey with my duffel bag, the handouts, the 3-D glasses, the Solar System model, the posters, my computer with the presentation, the trivia boxes, and the other three volunteers and we headed for the Iron Range. We arrived at Giants Ridge on Friday afternoon and checked in.

After dinner in Virginia, we proceeded to the Virginia High School to set up the computer and prepare for dress rehearsal. I wasn't sure what I expected the high school auditorium to look like, but I certainly didn't expect what we saw. The high schools were

built when iron ore companies ruled the range and were trying to attract workers. They spared no expense and the auditoriums were built as beautiful, acoustically perfect theatres, with main level and balcony seating. The stages were fully equipped with lights, multiple curtains and a large projection screen. The dress rehearsal went well, and our strategy of manually

**Dave Falkner (podium on left) discussing Venus, during the first part of the concert**



**Orchestra and presentation during the movement on Jupiter**



**Dave Falkner (left) talking about Mercury**





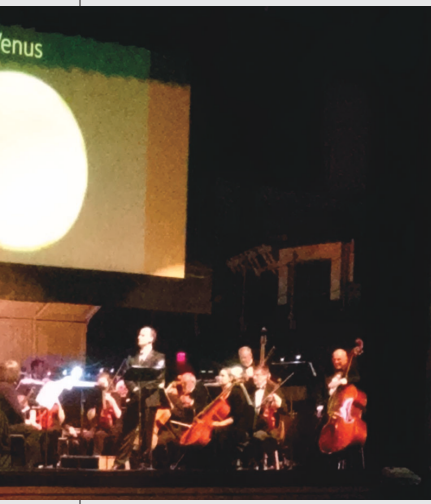
# the Spheres

ota Astronomical Society

starting each section of the presentation with the orchestral movement worked.

The snow machines were hard at work when we arrived back our Giants Ridge room around midnight. They were trying to build up the ski runs after a very warm fall. After a celebratory beer and some snacks, we called it a night.

We arrived at Hibbing High



School after supper on Saturday and unloaded all of our props (after driving by the house where Bob Dylan grew up, just a few blocks from the high school). While the other three MAS members set up the displays in the hallway outside the auditorium, I connected my computer to the projector and verified it displayed on the huge screen above the orchestra. We received a nice surprise when eight large, professional banners arrived, each featuring one of the eight planets. They were donated by the Paulucci Space Theatre of Hibbing, and we hung them on the wall behind our displays. We set up the Solar System walk along the hallway leading to the auditorium. I made placards for each planet, giving the actual size of the planet and its distance from the Sun, as well as the scaled planet size and distance from the Sun. We were able to fit from the Sun (a yellow Styrofoam sphere) to Mars in the hallway and then clustered the remaining planets just beyond that.

Like the one in the Virginia High School, the Hibbing High School auditorium was more like a theatre, with main floor and balcony seating, and it could seat 1800 people. The acoustics were wonderful. When the doors to the building were opened before the concert, the audience began filtering in, and they wandered from one display to another and were genuinely interested.

By 7 p.m., an audience of about 155 people had gathered in the theatre. I was disappointed there weren't more people, but that didn't deter our enthusiasm. The lead violinist crossed the stage to applause and tuned up the orchestra. Then Maestro Sergey Bogza and I entered the stage to applause. He introduced me and set the stage for the performance.

Each concert consisted of two parts. The first part was an explanation of how Holst depicted each of the planets in the composi-

tion. Sergey introduced each planet while I showed the planet on the screen. Sergey explained how the music reflected each planet's astrological personality. He had the orchestra play small segments of each movement to demonstrate. At the end of his explanation for each planet, I discussed our scientific understanding of the planet through history to the present day. Sergey insisted I say a few words about Pluto, even though it was not a part of the orchestral piece. (We seem to have a hard time letting go of Pluto as a planet.)

After a brief intermission, the lead violinist tuned the orchestra, Sergey assumed his position in front, and the orchestra played the entire symphony. I sat near the computer and projector, so I could start each section of the slide show with the orchestra.

At the intermission and at the end of the concert the audience flooded

out into the hallway. The posters and explanations there stirred their imaginations. Everyone we talked to loved the performance and the displays. After the performance, we packed up our displays,

including the newly added banners, and made the hour drive back to Giants Ridge. It was a late night, but it was opening night and it went very well!

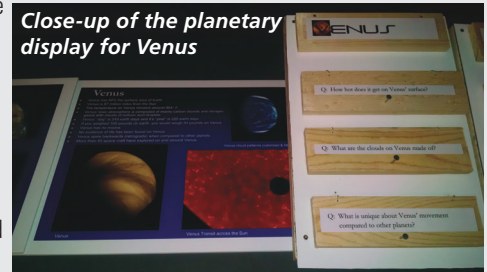
Things moved more quickly on Sunday. We packed our things, left Giants Ridge for the last time, and drove to Virginia, Minnesota, half an hour away. We set up in plenty of time, and the local cable station set up a couple of cameras to record the concert.

The performance went the same as at Hibbing, with just one hitch; at one point, my wireless microphone stopped working for about 10 seconds. I just raised my voice a bit and I was told that I could be heard easily even in the back of the theatre—that's how acoustically perfect the theatre was.

After the concert ended and the crowd dispersed, we began breaking down our displays. As I packed up, the videographers told

me that their cameras had been unable to capture both the orchestra and the screen where the images were displayed, so they just focused on the orchestra! Well, I hope their viewers enjoyed the orchestral performance.

Sergey invited us to join him and a couple of the other folks we had collaborated with for supper. We loaded the van and proceeded to the Whistling Bird restaurant in Gilbert, about half way between Virginia and Biwabik. Walking into the restaurant from the accumulating snow outside was a transition from snowy Minnesota into tropical Jamaica—the decor, music, and cuisine were all Caribbean. We had a wonderful time with great food, drink, and conversation and stayed longer than we should have. We finally got on the road back to the Twin Cities around 7:45. The snow stopped just south of Cloquet, and we had dry roads the rest of the



way back. I dropped everyone off at their houses and arrived home just after midnight.

I'd like to thank the MAS board for supporting this event. I would also like to thank the MAS members who made up the team: Suresh Srinivasan, Larry Gray, Steve Baranski, and Roxanne Kuerschner. Finally, I want to thank team members Heather Birch, Stu Chastain, and Jake Hairrell for giving up the weekend before Thanksgiving to travel to the Iron Range and make this such a successful event.

There were 155 people at the Hibbing performance and 178 at the Virginia performance. Although this may not have been the largest outreach event the MAS has been a part of in terms of the number of people attending, it was certainly the most complex, requiring coordination with a geographically

*Continued on page 27*

**This is the story** of the process of creating an astronomical observatory for public access in Manchester, a small town in northern Maryland. The process of developing a public-access observatory is quite different from that of developing an observatory for private use. Among other differences is the fact that you are able to beg for publicity, support, and donated stuff. Hopefully, readers will find ideas in this article that they can adapt to their local situations.

To create a small public observatory, you need: 1) a suitable telescope, 2) a suitable location, 3) suitable housing for the telescope, and 4) enthusiastic initial clients.

What follows is the story of how one club got access to those items. The process was quite simple. Opportunities and resources came along naturally and decisions were uncomplicated. Any club with the motivation should be able to emulate what we have done and create a "satellite" observatory.

### The Environs

Manchester is a small town in northern Maryland, near the Pennsylvania state line. As of 2010, the population was 4,815. Manchester is about 10 miles north of Westminster, which has a population of 18,645 and is the county seat for Carroll County, Maryland. The Westminster Astronomical Society has access to a planetarium and has a domed

# How to Hustle Up an Observatory

**Robert L. Clark**  
*Westminster Astronomical Society*

observatory on the grounds of the Bear Branch Nature Center in Westminster. The nature center is governed by the county parks organization. Both the planetarium and the observatory host monthly public events, which are fairly well attended by residents of Westminster.

The Manchester site is at a nature center named Charlotte's Quest, operated by the Manchester Parks Foundation, not the county. This distinction is important in that the smaller, more local management can be more responsive.

### Background Leading to an Observatory

In the past, the Westminster Astronomical Society had run astronomical events on the occasion of "Spring Fest" at Charlotte's Quest for the benefit of the residents of Manchester. Otherwise there had been little

interaction between Charlotte's Quest and the Westminster club.

A little over a year ago, the author and several other members of the club attended a meeting of the Charlotte's Quest board at which the board expressed interest in gaining access to a telescope and establishing some kind of astronomical site. Westminster Astronomical Society officers expressed their willingness to cooperate, with no specifics. Separately, the

author set up an analemma at the Charlotte's Quest site as a sign of

interest, and because an analemma can be built with little support—enough money to buy some lumber and some labor to plant the pole is about it! I contributed the bit of money; a couple of club members and a member of the Charlotte's Quest board of directors contributed the digging labor. A club member contributed a

rather elegant brass sundial that was mounted on the south side of the analemma. In the meantime, I contacted the local paper and got a nice article written with a picture of the installation that landed on the front page. It is important to note that the Charlotte's Quest effort was undertaken as part of the activities of the Westminster Astronomical Society. Technical support, advice, and assistance with events were available and welcomed. But much of the Charlotte's Quest activity took place at the same time as the development of the club's domed observatory at Bear Branch, so whatever needed to be done at Charlotte's Quest had to be accomplished with an absolute minimum of financial or management load on the club.

### The Telescope

At about the same time, the chairman of the Westminster Astronomical Society's board mentioned that he had, in his basement, a 15-inch Newtonian donated to the club by the estate of a deceased member. Things were beginning to come together. We collected the telescope from the basement, found it to be in good condition and even in decent collimation, and covered and stored it at a Charlotte's Quest building. A 15-inch telescope was more telescope than I had been looking for, but that was just fine. The next issue was finding a way to house

the thing and arrange for its convenient use.

The telescope was on a Dobsonian mount with an unusual arrangement for transportation. Two 6-foot handles can be connected to its rocker box. Each handle has a wheel at one end, so when they are attached, the whole thing becomes a

wheelbarrow. Once the telescope is moved into place, the handles can be removed.

### Telescope Housing

The fact that the instrument is amenable to rather easy, short distance, movement allowed us to consider arrangements that require that it be rolled out for use. We settled on using a shed with a patio. An 8- by 12-foot shed, prefabricated and set up on site, was available for a little more than \$2,500. The City of Manchester was willing to contribute the labor, excavation, bedding stone, and concrete to build a concrete slab sufficient for the building and a large patio outside the shed doors. The specific site was selected to be a reasonable distance from other structures and from trees. Once the



*Analemma and sundial at Charlotte's Quest Nature Center*



*North Carroll High School field trip to the Pine Observatory (Charlotte's Quest)*

concrete was in place, low retaining walls were built on three sides to prevent any incursion of mud during heavy rains. The same member of the board of Charlotte's Quest who helped with the analemma contributed the labor for the retaining walls.

The \$2,500 came from an unusual source, but, in general, the challenge of finding a donor of only that amount should not be a serious problem. In our case, the donor is an organization that runs an annual bocce tournament at the nature center. Over several years, they built a fund from entrance fees that was sufficient to cover our needs. The organizer of the bocce ball tournament is also a member of the board of directors of Charlotte's Quest.

### Developing a Clientele

In terms of the four initial requirements, we were almost there. The physical parts of the installation were taken care of. Still, we needed an enthusiastic initial clientele. The local high school is located only about half a mile from our site. We contacted the principal and explained our situation, stressing that we could operate events specifically oriented to the curricula of their courses. We suggested that they could consider our observatory as an extension to, or laboratory for, their courses, and they might consider developing curricula based on its availability.

The high school's science department has an enthusiastic and energetic chairperson, who has developed a real interest in using our equipment and developing projects and educational experiences for the students. So far we have done a field trip centered around observations of the Solar System, daytime views of the Moon, and observation of some sunspots. In addition, a scale model of the Solar System was established on the grounds of the nature center. We had help with this effort from two members of the Westminster club.

Several students have joined the Westminster club, partly to gain membership in the Astronomical League so that they can work on

the various League certificates. We planned a combination star party and meteor party for the Geminids to provide three hours of observation for the Astronomical League Meteor Club certificate. Unfortunately, it got clouded out. I think that the interest will persist and we can try again.

There is also a nearby middle school and some faculty interest is developing there.

At this point I am a little anxious about nighttime public events during the winter. The final couple hundred yards of road is in pretty bad shape and, so far, I have been unable to arrange free paving or plowing. We will plan some solar parties for the public. For solar events, the "Sunspotters" Club of the Astronomical League can serve as motivation.

I think that extending the clientele beyond the local high school is important. We have started a "Constellation Hunter" program that meets about once a month. We locate and discuss three to five constellations and their lore. Attendees interested in the Astronomical League Constellation Hunter activity are encouraged to make their sketches. In some constellations, we observe one or two "deep-sky" objects. That gets the telescope into the picture without allowing it to steal attention from the constellations. It also helps to set the idea of using constellations as celestial locators. For example, when we observe the constellation of Lyra, we can establish its name as "the Ring Nebula in Lyra."

We recently drew significant publicity and participation with the transit of Mercury, which we helped the public observe from numerous county locations. We are also planning a "Learn Your Way Around the Moon" project that will lead to the Astronomical League's lunar program. The development of our programs has been made significantly easier by drawing on the established programs of the Astronomical League. We hope other clubs will follow our lead, and partner with local nature centers and schools in this way. ☼

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

By Mike Stewart, Astronomical League Historian

### August 1966 New! Observe Manual

*OBSERVE* is a new manual published and sold by the Astronomical League. It contains the complete Messier catalog of deep-sky objects, arranged by seasons. The descriptions of each item were written by an amateur astronomer from personal observation using a Skyscope 3 reflector and a homemade 6-inch reflector. Your personal record of Messier observations may be entered on a score sheet contained in the manual.

*It has a goodly number of amateur photographs of the brighter objects. The manual continues to be one of the League's more popular publications. The Messier Observing Program continues to be the League's most popular observing program. By the summer of 2016, over 2700 astronomers had completed either the regular or honorary level.*



### August 1991 The Big One—Total Solar Eclipse, July 11, 1991

A total solar eclipse is a rare event for any spot on earth, and when it does happen, it is over some barely accessible area, such as the Sahara Desert, or Northern Siberia during the winter. The eclipse of July 11, 1991, however, not only passed over Mexico's Baja California Sur, but also Hawaii, and a large part of central Mexico, including Mexico City. Mexico City had only a 20 per cent chance of viewing the eclipse, and unfortunately was actually clouded out along with the rest of mainland Mexico; Hawaii, too, was mostly clouded during totality, and there was rain in Central and South America. But on the southern cape of the Baja peninsula, one of the clearest, sunniest spots on the entire North American continent, conditions were textbook perfect for viewing the longest eclipse of the century.

*The August 1991 Reflector reported more details of the joint Houston Astronomical Society-Texas Astronomical Society trip to Baja. A quarter century later, North America is fortunate to have a coast-to-coast total eclipse. Where will you be on August 21, 2017?*



### September 2006 Stardust Returns Home

How many times have we given any thought to astronomy in the United States that took place some 1,200 years ago, or 3,000 years ago? What may be a hobby today was a matter of life and death in the ancient past and even a part of one's religion. Knowing the seasons was vital to survival. Boring subject? Think again! While many people think of Stonehenge when it comes to archaeoastronomy, North America has many ancient astronomical sites to be seen and studied.

Ancient pre-Columbian native Americans left us an incredible amount of astrological data in ancient archaeological records called petroglyphs (carvings or inscriptions on rocks) and pictographs (prehistoric drawings or painting on rock walls)—commonly grouped together under the simple name rock art. The ancients built cities, mounds and temples that were dedicated to astronomy and astrology. Entire priesthoods or shamans were skilled in the science of astronomy. They recorded supernovas, comets, shooting stars, solar and lunar eclipses and many more astronomical events. Imagine a night sky 1,500 years ago without any light pollution. The stars, planets, and other celestial objects must have been far brighter, more visible and breathtaking than most of us have ever experienced. The ancients used the night sky and the Sun as calendars, navigational beacons, telling of stories or events, symbols of deities and religious cosmic-totemism.

*Dr. Clinton D. Willis's richly illustrated article described the astronomical achievements and depictions left in the Arkansas-Missouri region by Native Americans. His story reminds us that astronomers of today are descendants of a long line of people interested in the heavens.*

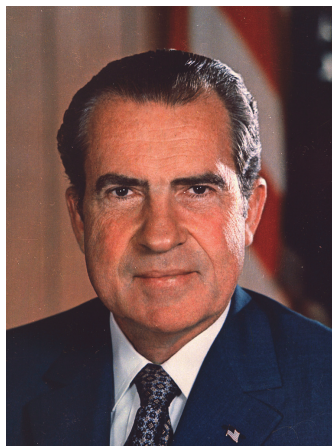


**On June 17, 1972**, a group of supporters of U.S. President Richard M. Nixon broke into the Democratic National Committee headquarters at the Watergate office complex in Washington, D.C., leading to President Nixon's resignation almost two years later, on August 9, 1974.

Between those two dates, in 1973, a new idea was born: Astronomy Day. Every year since that first Astronomy Day, hundreds of locations across the nation (and now the world) have prepared and executed special events celebrating astronomy.

Doug Berger of the Astronomical Association of Northern California, the originator of Astronomy Day, first came up with Astronomy Day's theme, "Bringing Astronomy to the People," by transporting telescopes and setting up astronomy related exhibits at locations where people were *already* congregated, especially indoor shopping malls. The idea was (and still is) to engage people who had no thought or intent of interacting with anything astronomical. But when astronomy was staring them in the face, not only did they partake, they enjoyed it. But how is this related to Watergate?

While President Nixon was embroiled in the Watergate scandal, the United States was fast approaching its Bicentennial, but the Nixon administration was far too busy to devote much attention to the nation's birthday. As the scandal escalated,



President Richard M. Nixon

Astronomy Day hosts were trying to decide how to take this grassroots movement national. While Astronomy Day was slowly spreading across the U.S. and beyond, discussions ensued

# How Watergate Influenced Astronomy Day

**Gary Tomlinson**  
**Astronomy Day Coordinator**

about a strong national directive versus local planning and execution.

One prominent player in this decision process was *Sky & Telescope* assistant editor Norm Sperling. At that time, *Sky & Telescope* was the de facto coordinator of the event.

Enter the Nixon resignation and the succession of Gerald R. Ford to the presidency. For several months after taking office, Ford was still dealing with Watergate (hence the Nixon pardon). His administration did not have enough time to plan and execute a national celebration for the Bicentennial, so it was decided to let each locality

plan and execute whatever celebration they could muster. It was this American model that served as a basis for Astronomy Day celebrations all around the world then and today.

Today each locality plans and executes Astronomy Day events with minimal guidance from the national Astronomy Day coordinator. Currently that basic guidance consists of:

- Determining the dates for the spring and fall Astronomy Days;
- Providing a 76-page handbook of procedures, ideas and suggestions for hosting Astronomy Day events (sponsored by *Sky & Telescope*, accessible via the League's website: [astroleague.org/al/astroday/astrobook.html](http://astroleague.org/al/astroday/astrobook.html));
- Providing a listing of Astronomy Day events;
- and Judging the Astronomy Day Awards (given for the Best Celebration by Population, Best New Idea, and Quality Events Year after Year), currently sponsored by *Sky & Telescope*, the American Astronomical Society, and the Astronomical League.

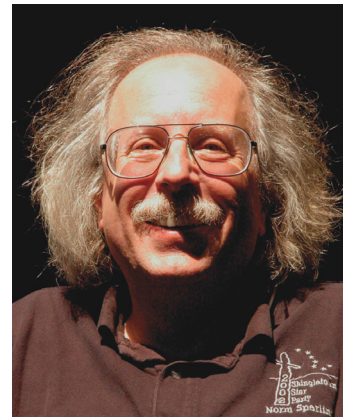
Information for all the above may be found on the Astronomy Day web page at [www.astroleague.org](http://www.astroleague.org). While Astronomy Day itself is

co-sponsored by 14 astronomy and astronomy education organizations and endorsed by the International Astronomical Union, the Astronomical League coordinates the celebration.

So without Watergate, Astronomy Day might have been quite a different animal. If you



Doug Berger, now retired and living in Bend, Oregon (photo by Gary Tomlinson)



Norm Sperling teaches part-time in Oakland, California but travels extensively in an RV the rest of the time.

want to plan something (or just see what's happening in your neighborhood), go to the League's Astronomy Day page to either list your event or see other events taking place. The next two events are October 8, 2016, and April 29, 2017. These are also great opportunities to promote the August 2017 solar eclipse that takes place in the United States and to educate people on eclipse safety. All of North America, Central America, and the northern part of South America will experience at least a partial solar eclipse, visible by more than a billion people. ☀



## Give the Night Sky to Your Young Observers

Does your club have young observers 8 through 10 years old? Why not encourage their celestial explorations by presenting them with the Astronomical League's *Sky Puppies* guide? This great introduction to the wonders in the heavens is available for purchase through League Sales. Go to [store.astroleague.org/index.php](http://store.astroleague.org/index.php), then click on "Observing Manuals."

## A radio meteor is a meteor

that is heard on a radio receiver only because radio waves from a transmitter some 75 to 200 miles distant are reflected by the meteor's resulting ionization. The primary advantage of observing meteors using radio methods is that one can observe during daytime and inclement weather.

**Meteor showers:** The 1995 *American Radio and Relay League Antenna Handbook* lists the five best meteor showers that contribute to ham radio skip communication—where distant radio signals “skip” on an ionized area of the atmosphere, such as that produced by a meteor, and can be heard much farther away than normal. These are the Quadrantids (January 3), Arietids (June 7–8), Perseids (August 11–13), Orionids (October 20–22), and Geminids (December 12–13). I like to listen to all showers, and listen at random times with a portable FM radio. In 2014 and 2015, I heard a moderate daytime shower on July 3.

**Physics:** Meteors typically vaporize from 100 to 70 km altitude, producing visible and ionizing ultraviolet light and a 10 to 15 km long trail of free electrons, ionized air, and debris. If the trail of electrons is sufficiently dense, it reflects radio waves as if it were a metal cylinder. I like to think of the ionization trail as having the properties of both a radio antenna (a “wire”) and a narrow illuminated slit. The “wire” can produce a sound like the original radio signal, while the “slit” creates a Fresnel diffraction pattern. The latter is a varying volume level that is co-added to the “wire” component (figs. 1 and 2).

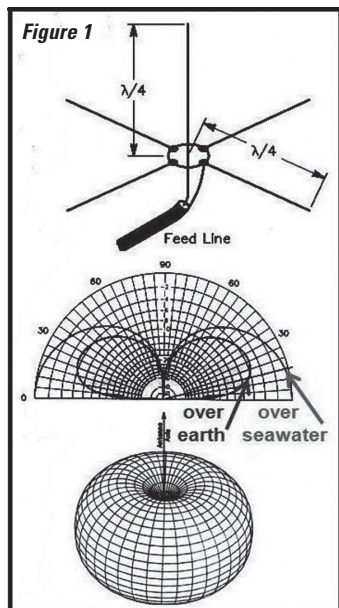


Figure 1

## Meteor (and other) signals:

Radio meteors are observed at frequencies from 28 to 432 MHz, with the best region between 30 and 100 MHz. The FM band, from about 88 to 107 MHz, is well suited. A typical meteor signal usually lasts only as long as the meteor is visible—about half a

second—but large meteors leave a persistent ionized cloud reflecting for many seconds or even minutes (fig. 3). However, large meteors are rare. Signals lasting longer than five or ten seconds are probably not meteors. If you ignore *all* these longer signals, your hourly counts will still be quite accurate.

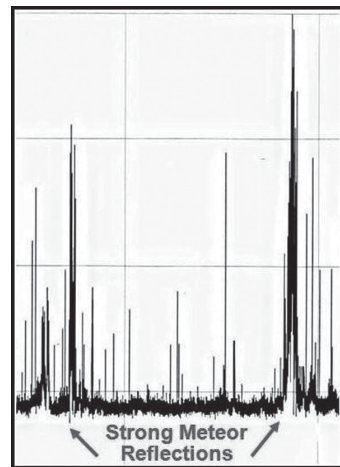


Figure 3

**Interference:** The vast majority of radio interference is from man-made sources such as lights, all electrical appliances, distant aircraft, and nearby cars. Cars produce a distinct, repetitive popping noise. I rarely hear interference from the Sun or other natural sources such as auroras, tropospheric ducting (when radio signals can propagate farther than normal because of a temperature inversion in the atmosphere), and lightning. Each type of interference also has unique characteristics that allow it to be identified. The first three last for many minutes to hours—not typical of a meteor. Lightning has a brief but very distinct frying sound. Aircraft are more difficult to discern, but they are only heard if they are flying both near the

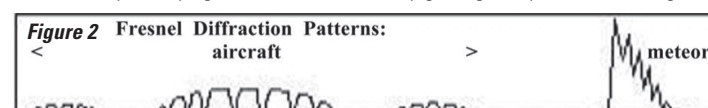


Figure 2 Fresnel Diffraction Patterns:

# Radio Meteors

By R. B. Minton  
Southern Colorado  
Astronomical Society

ground and near a transmitter. Their signal can last from a second to a minute. Unless you live close to a major airport, you will probably never record aircraft.

**Hardware:** A good FM radio and antenna are vital tools for detecting radio meteors. Modern AM/FM car radios are ideal. They

have large-scale integrated circuitry, are sensitive, reject noise, have digital tuning, and are fairly inexpensive. They also use 50-ohm coaxial cable, which matches a ground plane (GP) antenna (fig. 1, top). Other antenna designs, such as Yagi, have more gain in a preferred direction, but nowhere else. The GP is better because of its omnidirectional reception pattern in azimuth. A vertical whip car antenna works okay, but not as well. You can build a GP antenna from five 29-inch lengths of 40-gauge (or heavier) copper wire, soldered and connected as shown in figure 1. Tape a paper wad on each tip for eye protection. A 29-inch wire is the correct length for the middle of the FM band.

If the radio and antenna pull in distant stations, you're ready to

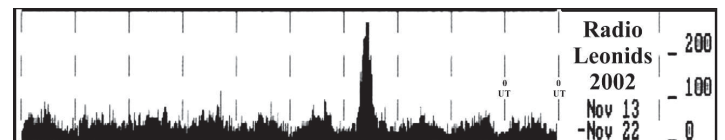


Figure 4

search for blank FM frequencies where meteors can be heard. The best time to search is early morning, because sporadic meteors are more numerous. Start at the low end of the FM band (88.1 MHz), listening for 30 seconds. If you hear nothing, go up to the next odd frequency (88.3 MHz—the even decimals are not used for FM radio stations in the United States). When you hear a brief signal (music, voice, etc.) write it down under “good”—you just heard a meteor reflecting the signal from a distant station. If you hear a constant radio station, write it down under “bad”—and also include the two frequencies below and above this one. These adjacent channels may get signal splatter imitating a

meteor. In an hour or so you should have been able to search all frequencies. Do this again from time to time until you have a list of all good meteor frequencies. Some frequencies will reveal more meteors than others, either because the station is closer, or there are multiple stations on the same frequency. A frequency with two stations will detect twice as many meteors. The higher count from such a frequency will produce smoother data and can help determine when a radiant rises and sets.

**Data records:** You should also record your observations on a computer. In 2002, I wrote a computer program in BASIC to sense a speaker's volume and write the time to a floppy disk using the game port. It was crude, but good enough to reveal a large peak in the Leonid meteors (fig. 4). Later, I used a PC-compatible multimeter to sense voltages. Today, I suggest using Radio-SkyPipe II software. It uses the computer's audio input line. It will capture data for 24 hours per record, and the display's scale can be compressed or expanded an immense amount. I like it, and the program and installation instructions are free. Note that the sound card information for a PC-compatible computer under “Options, Sound, Choose sound

format” should be: Name = untitled, Format = PCM, Attributes = 11.025 kHz, 16-bit mono, 21 kb/sec.

**Contacts:** The International Meteor Organization has been (and probably still is) interested in radio observations, many of which are very different from the simple method I describe here (some types require a radio license). I can be reached at [astro.old.geezer@gmail.com](mailto:astro.old.geezer@gmail.com), and I recently opened a website, [astrooldgeezer.wix.com/photography-studio](http://astrooldgeezer.wix.com/photography-studio). Other references I suggest are “Listen in on a Meteor Shower,” Dave Prochnow, *Popular Science*, November 2014 (also available at [www.popsoci.com/article/diy/how-repurpose-your-old-radio-listen-meteor-showers](http://www.popsoci.com/article/diy/how-repurpose-your-old-radio-listen-meteor-showers)) and “Meteor Phenomena and Bodies,” Zdenek Cepelcha and others, 1998, *Space Science Reviews*, v. 84, no. 3, p. 327–471. ☼

Radio meteor observing satisfies requirements of the AL Radio Astronomy Observing Program.

# FROM AROUND THE LEAGUE

## Astronomy Day 2016

Gary Tomlinson, Astronomy Day Coordinator

For 44 years, astronomy enthusiasts and organizations have hosted special events to celebrate the grassroots movement that turned into **Astronomy Day**. This year was no different. Some places have hosted events for years while others have done only a few. Regardless, we all benefit.

In 1980, an award was established to provide recognition to those organizations that best emphasized the concept of Astronomy Day. That award was discontinued after two years, however. In 1989, the Astronomical League resurrected the award. Over the years, the award has changed and is currently sponsored by the League, *Sky & Telescope*, and the American Astronomical Society.

This year, the weather cooperated in some locations and not in others. Either way, most locations had a multitude of indoor activities, such as lectures, planetarium shows, kids activities, Solar System models, and even rocks from outer space (meteorites and Moon rocks). Host locations included public libraries, state parks, botanical gardens, nature centers, and museums.

The winners of the 2016 Astronomy Day Awards are:

- Northern Virginia Astronomy Club (NOVAC), Large Metro Area, Oakton, Virginia
- Oglethorpe Astronomical Association, Medium Metro Area, Savannah, Georgia
- Popular Astronomy Club, Small Metro Area, Moline, Illinois
- Kalamazoo Astronomical Society, Quality Events Year After Year, Kalamazoo, Michigan
- The Children's Museum, Travelers Science Dome at the Gengras Planetarium, Best New Idea, West Hartford, Connecticut

This is the first award for NOVAC, whose members did an impressive set of special events (unfortunately they had cloudy skies at night). The

other awardees are previous winners of one sort or another, so this goes to show you that organizations that have never entered the competition before can walk away with the top award. And to the other winners, we thank them for their current and continued efforts to promote astronomy. The Children's Museum has a sanctuary for confiscated illegal animals, and matched appropriate animals to

the constellations, targeting preschool children, garnering the museum the Best New Idea Award (this idea would also work well for zoos).

Next year will be the 45th Astronomy Day, so now is the time to start planning events. To assist, a newly revised Astronomy Day handbook is available for a free download (see the League's website). This 85-page handbook is chock full of ideas, suggestions, advice, and resources to assist local organizations in providing a variety of educational, interesting, and safe displays and events. So as Dr. Leonard McCoy (from *Star Trek*) would say, "Get crackin'!"



Astronomy Day 2016: Popular Astronomy Club's portable observatory

## Some Thoughts on Hosting Outreach Events

By W. Maynard Pittendreich

### The Events

**School visits:** Offer to bring properly equipped telescopes to the school for a look at the Sun. Don't forget to stress safety.

**Boy Scouts:** Scouts often want to earn their merit badge in astronomy. Offer to be with them one night for a look through the telescopes and to provide some help with their badge.

**Trick or treat:** Set up your telescope outside your house and, with a bowl of candy, invite folks to look through the telescope and see the Moon, Jupiter, or Saturn. Along with the candy, put a flyer in their bag about the next outreach event or about your astronomy club.

**Sidewalk astronomy:** Take the telescopes to the people. This may literally be on a sidewalk, or in a park where people tend to gather. Have signs that welcome people to look through the telescope "free of charge."

**Barstronomy:** A man calling himself Duke Skygawker hosts sidewalk astronomy outreach events just outside his favorite bars.

**Sun day at church:** It is especially helpful if the pastor is an astronomer, but setting up a properly equipped telescope to view the Sun is a good way to encourage people of faith to feel comfortable as people of science. As before, stress safety!

**Civic organizations:** Kiwanis, Rotary, and other organizations are often seeking speakers for their clubs. Deliver a presentation at one of their meetings, followed by telescope time outside.

**Introduction to your new telescope:** This is especially good after Christmas. Encourage people to attend an event at which people bring their own scopes and you help set up and use them. This is not a time to "put down" any telescope. This is a time to encourage and teach.

### The Publicity

- Use social media to announce the event.
- Public service announcements on radio or television are free for many nonprofit or educational institutions.
- Use flyers and posters at schools and clubs.

### Give the night sky to your young observers

Does your club have young observers 8 through 10 years old? Why not encourage their celestial explorations by presenting them with the Astronomical League's Sky Puppies guide? This great introduction to the wonders in the heavens is available for purchase through League Sales. Go to [store.astroleague.org](http://store.astroleague.org), then click on "Observing Manuals."

### Top Ten Things to Consider

1. Binoculars on a tripod: You can't just point and say, "look there." The binoculars need a mount. Most people have a pair of binoculars, and many visitors will think, "I can do this at home without buying a telescope."
2. Use a telescope you don't mind being handled and mishandled. Allow viewers to move and guide the scope.
3. Use low-power, wide-field eyepieces that can take a fingerprint where fingers ought not touch.
4. A small star atlas and a planisphere: Attendees may ask questions that require these tools, and they may value seeing that these tools are available.
5. An adjustable stool or telescope chair: People come in all sizes. Some viewers will be children needing a stable step up. Others will be adults needing to sit at the eyepiece. Some will need something to lean against as they bend down to look.

6. Have a plan. Don't just show double stars, but also don't just show a dim nebula that is only seen with averted vision. Hopefully the "star" players will be out: the Moon, Jupiter, Saturn, a good globular or open cluster, the Orion Nebula, etc.
7. There are no stupid questions. Actually, there are, but the important thing is to always give good answers that inspire and not deflate. If someone asks, "Will Mars really appear as large as the Moon in August?," a good response is, "I am so glad you asked that. It won't (and here is why)."
8. Appropriate attire: You will need to be comfortable.
9. Red lights: And, yes, white lights as well. People will need to find you and feel safe as they walk. Limited light will be needed, and the red lights you use will be more for the educational moment to introduce them to night vision than for preserving your night eyes.
10. Ushers: Every good theater has them. Someone to greet people at the parking area and walk the visitors to the first telescope will be appreciated.

## Youth Awards 2016

Compiled by William Bogardus

### National Young Astronomer Award

The 2016 National Young Astronomer Award first place winners are a team, **Jayasuriya Senthilvelan** and **Swagat Bhattacharyya**, who will share the award for their work, titled "Detection of Interstellar Molecule OH in W3, W49, Cassiopeia A, K350 W75s and NGC 7538 Using the 40 ft. Telescope and the GBT."

Jayasuriya is a 10th-grade student at Buchanan High School in Clovis, California, and Swagat is a 10th-grader at Morgantown

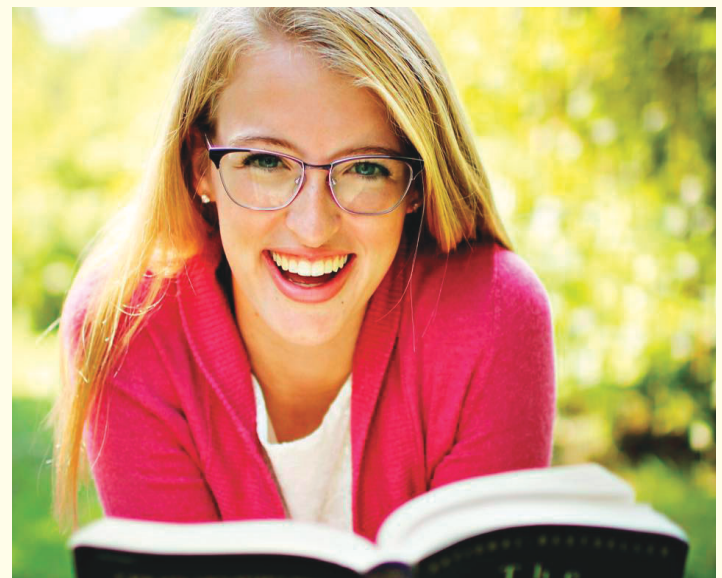
Young Astronomer Award competition goes to **Megan T. Gialluca** for her work, titled "Radiation-Hydrodynamic Outflows and Magnetar Glitches and Anti-Glitches." She is a member of the **New Hampshire Astronomical Society** and a guide at their **Skywatches**. She is an 11th-grade student at the Hollis Brookline High School, New Hampshire, where her work was presented to an audience of students, parents, and school board members, and published in the *Nashua Telegraph*.

### Horkheimer/Smith Youth Service Award

The 2016 Horkheimer/Smith Youth Service Award goes to **Katie Melbourne** of the **Popular Astronomy Club** in Illinois, which she first joined in 2013. Her interest in astronomy goes back to grade school, when she attended a summer science camp and became hooked on astronomy. While in high school, she went to **Kitt Peak National Observatory**, where she used telescopes to collect data as part of a program for high school students. She also spent six weeks at **Boston University** doing research on M dwarf stars and took a class at **Northwestern University** on astrophysics. Katie is now a freshman at **Yale University** studying astrophysics.



Megan T. Gialluca



Katie Melbourne



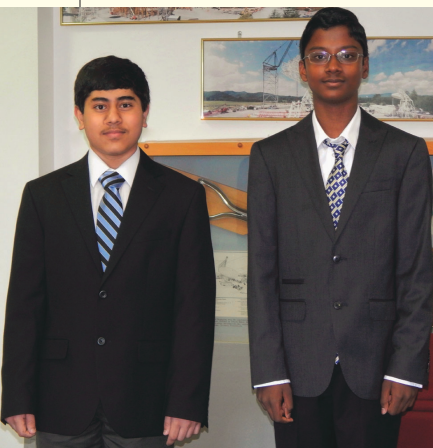
Virginia Mellott

Katie volunteered at many public star parties that the **Popular Astronomy Club** holds each month at the **Niabi Zoo**. She has gone out to the club's observatory for observing and contributed an article to the club newsletter detailing her observations. She also presented a program at a monthly meeting about her work on stellar evolution and neutrinos.

### Horkheimer/D'Auria Youth Service Award

The 2016 Horkheimer/D'Auria Youth Service Award goes to **Virginia Mellott** of the **Charlottesville (Virginia) Astronomical Society** for her service to the astronomical community, writing letters and articles in her school's newspaper and the local newspaper, the *Daily Progress*. Her

*Continued on next page*



Swagat Bhattacharyya and Jayasuriya Senthilvelan

High School, West Virginia. They attended the **2014 West Virginia Governor's School for Math and Science** at the **Robert C. Byrd Green Bank Science Center** to work on their project. They also presented their work at the 2015 Society of Amateur Radio Astronomers conference.

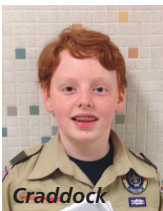
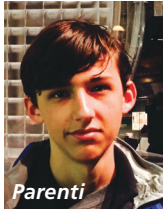
**Second Place** in the National

writings have been informative and encouraged people to get interested in the club's activities.

### Horkheimer/O'Meara Journalism Award

The 2016 Horkheimer/O'Meara Journalism Award goes to Clay Parenti of the Houston Astronomical Society, an 8th-grade student at Westchester

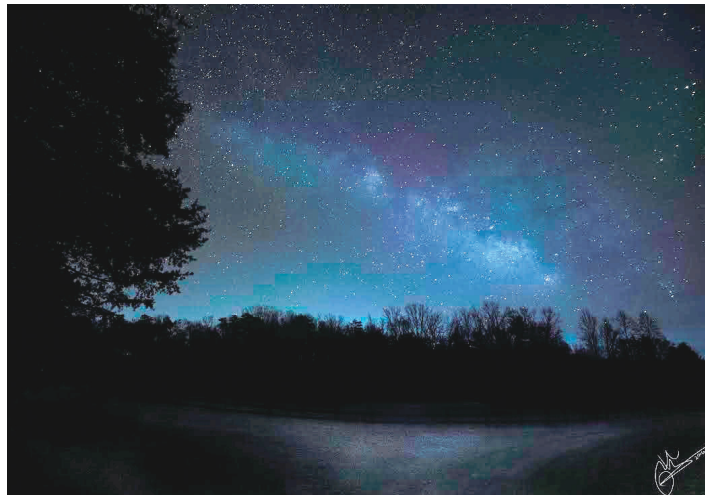
Academy for International Studies in Houston, Texas, for his writing on "Kepler's Laws." Second place goes to Ephraim Craddock of the Baton Rouge Astronomical Society, a 5th-



grade student at Galvez Primary School in Prairieville, Louisiana, who wrote on "Examining the Mystery of Tabby's Star." Note: due to space limitations, the essays will be printed in the December issue.

### Horkheimer/Parker Youth Imaging Award

The 2016 Horkheimer/Parker Youth Imaging Awards resulted in first, second, and third place winners. First place was awarded to Ginger Mellott of the Charlottesville Astronomical Society for her work, titled "Milky Blue." The second-place winner was Clay Parenti of the Houston Astronomical Society for his photo of daylight lunar craters. Third place went to Benjamin S. Dutschmann, sponsored by the North Houston Astronomy Club, for his image of M42. ☀



Milky Blue by Ginger Mellott, 1st place



M42 by Benjamin S. Dutschmann, 3rd place

## League Regional Chairs

- GLRAL** (Great Lakes Region): Ron Whitehead, [executivesecretary@astroleague.org](mailto:executivesecretary@astroleague.org)
- MARS** (Mountain Astronomical Research Section): Wayne Green, [dxwayne@gmail.com](mailto:dxwayne@gmail.com)
- MERAL** (Mid-East Region): Terry Trees, [treest@comcast.net](mailto:treest@comcast.net)
- MSRAL** (Mid-States Region): James Small, [webmaster@slasonline.org](mailto:webmaster@slasonline.org)
- NCRAL** (North-Central Region): Gerry Kocken, [gerryk@kockenwi.com](mailto:gerryk@kockenwi.com)
- NERAL** (Northeast Region): Maryann Arrien, [Arrien@optonline.net](mailto:Arrien@optonline.net)
- NWRAL** (Northwest Region): Gene Dietzen, [gene.dietzen@gmail.com](mailto:gene.dietzen@gmail.com)
- SERAL** (Southeast Region): Richard Schmude, [schmude@gordonstate.edu](mailto:schmude@gordonstate.edu)
- SWRAL** (Southwest Region): David Moody, [bicparker@mac.com](mailto:bicparker@mac.com)
- WRAL** (Western Region): Wayne Johnson, [mrgalaxy@juno.com](mailto:mrgalaxy@juno.com)

## Astronomical League Observing Programs

- |  |  |
|--|--|
| <ul style="list-style-type: none"> <li>Active Galactic Nuclei Program</li> <li>Advanced Binocular Double Star Observing Program</li> <li>Analemma Observing Program</li> <li>Arp Peculiar Galaxies Northern Observing Program</li> <li>Arp Peculiar Galaxies Southern Observing Program</li> <li>Asterism Observing Program</li> <li>Asteroid Observing Program</li> <li>Binocular Double Star Observing Program</li> <li>Binocular Messier Observing Program</li> <li>Binocular Variable Star Observing Program</li> <li>Bright Nebula Observing Program</li> <li>Caldwell Observing Program</li> <li>Carbon Star Observing Program</li> <li>Comet Observing Program</li> <li>Constellation Hunter Observing Program (Northern Skies)</li> <li>Constellation Hunter Observing Program (Southern Skies)</li> <li>Dark Nebulae Observing Program</li> <li>Dark Sky Advocate Observing Award</li> <li>Deep Sky Binocular Observing Program</li> <li>Double Star Observing Program</li> <li>Earth Orbiting Satellite Observing Program (EOSOC)</li> <li>Flat Galaxy Observing Program</li> <li>Galaxy Groups &amp; Clusters Observing Program</li> <li>Galileo Observing Program</li> </ul> | <ul style="list-style-type: none"> <li>Globular Cluster Observing Program</li> <li>Herschel 400 Observing Program</li> <li>Herschel II Observing Program</li> <li>Hydrogen Alpha Solar Observing Program</li> <li>Local Galaxy Group &amp; Galactic Neighborhood Observing Program</li> <li>Lunar Observing Program</li> <li>Lunar II Observing Program</li> <li>Master Observer Award</li> <li>Messier Observing Program</li> <li>Meteor Observing Program</li> <li>NEO Observing Program</li> <li>Occultation Observing Program</li> <li>Open Cluster Observing Program</li> <li>Outreach Observing Award</li> <li>Planetary Nebula Observing Program</li> <li>Planetary Transit Special Observing Award</li> <li>Radio Astronomy Observing Program</li> <li>Sketching Observing Award</li> <li>Sky Puppy Observing Program</li> <li>Solar System Observing Program</li> <li>Southern Skies Binocular Observing Program</li> <li>Southern Sky Telescopic Observing Program</li> <li>Stellar Evolution Observing Program</li> <li>Sunspotters Observing Program</li> <li>Two in the View Observing Program</li> <li>Universe Sampler Observing Program</li> <li>Urban Observing Program</li> <li>Variable Star Observing Program</li> </ul> |
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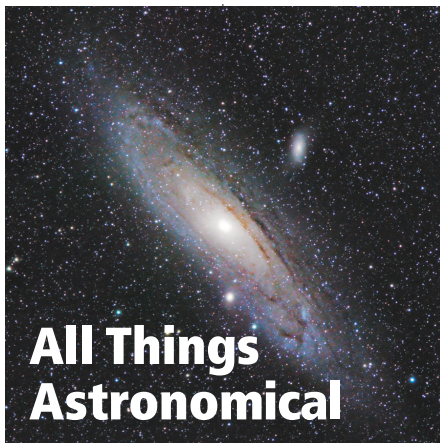


Daylight lunar craters by Clay Parenti, 2nd place



**Late-breaking news from the world of astronomy**

**Los Altos Hills, California, July 7, 2016:** The Silicon Valley Astronomy Lectures at Foothill College, in Los Altos, California, just passed the milestone of one million views on its YouTube channel at [www.youtube.com/svastronomylectures](http://www.youtube.com/svastronomylectures).



**All Things Astronomical**

**Tokyo, July 5, 2016:** An international team of researchers from Royal Observatory of Belgium, Institut de Physique du Globe de Paris, Université de Rennes 1, Kobe University, and the Earth-Life Science Institute of Tokyo Institute of Technology investigated the formation process of a disk produced by a potential giant impact on Mars, and the process of satellites' formation from this disk. Their model suggests that a huge satellite quickly forms from this disk, and it enhances the accretion of Phobos and Deimos in the outer region. After their formation, the huge satellite falls into Mars due to the strong tidal interaction with Mars, and disappears. Only two tiny satellites—Phobos and Deimos—are left behind. Researchers also found that about half of the disk produced by a giant impact originally came from Mars, so Phobos and Deimos should contain Martian materials. Recently, Japan Aerospace Exploration Agency (JAXA) has started to plan a sample return mission from the Martian satellites.

**New York, July 6, 2016:** The Smithsonian Channel will celebrate the 50th anniversary of *Star Trek* with a two-hour special that will take a look at the lasting influence the original *Star Trek* series has had on the world. "Building *Star Trek*" will premiere Sunday, September 4, at 8 p.m. ET/PT on the

Smithsonian Channel.  
**Towson, Maryland, June 15, 2016:** Scientists at Towson University and the Johns Hopkins University are reporting a new way to peer through the event horizons around black holes and visualize what lies beneath. Their results could rewrite conventional ideas about the internal structure of spinning black holes. Current approaches use special coordinate systems in which this structure appears quite simple, but quantities that depend on an observer's choice of coordinates can give a distorted view of reality, as anyone who has compared the apparent sizes of Greenland and the United States on a map knows. The new approach focuses exclusively on mathematical quantities known as invariants, which have the same value for any choice of coordinates. Expressed in terms of these quantities, black hole interiors reveal a much more intricate and complicated structure than usually thought, with wild variations in curvature from place to place. ☼

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**A MEMBER BENEFIT FROM McDONALD OBSERVATORY**

*StarDate*, the bi-monthly publication of the nonprofit McDonald Observatory, is offering our members a 25% discount. Their magazine provides easy-to-read articles on the latest astronomy research, skywatching, the history of astronomy, and many other topics. *StarDate* also offers starcharts for each month, a sky calendar, and Merlin's answers to reader questions. The discounted rate is \$19.50 for members in the continental USA, \$22 for Canada, and \$30 to other foreign countries. Members-at-Large should send their check (payable to the Astro League) to Astronomical League Office, 9201 Ward Parkway, Suite 100, Kansas City, MO 64114. For members' societies, the appointed person in each club should gather the subscriptions, and send the appropriate amount to *StarDate* Magazine, c/o Paul Previte, 1 University Station A2100, Austin, TX 78712. You can read more about *StarDate* at [www.stardate.org](http://www.stardate.org). If you have any questions, please contact the League's National Office at [leagueoffice@astroleague.org](mailto:leagueoffice@astroleague.org)



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Okie-Tex Star Party  
 September 30, 2008  
 Howard Edin

TITLE PHOTOGRAPH: M31; COMPLIMENTS OF TOM S. MARTINEZ, ASKC

# Gallery



Ptolemy's Cluster (also known as M7 and NGC 6475) is an open cluster consisting of around 80 stars, located approximately 980 light-years from Earth in the constellation Scorpius. It is the southernmost Messier object, at  $-34.8$  degrees declination. When Dan Crowson took this image, it was only 12 degrees above the horizon. At the 2 o'clock position is NGC 6453, a Type IV globular cluster. Crowson imaged from the Danville Conservation area in New Florence, Missouri, on April 8, April 12, and May 5, 2016, using an Astro-Tech AT90EDT telescope at  $f/6.7$  and 630 mm. Total imaging time was 240 minutes.



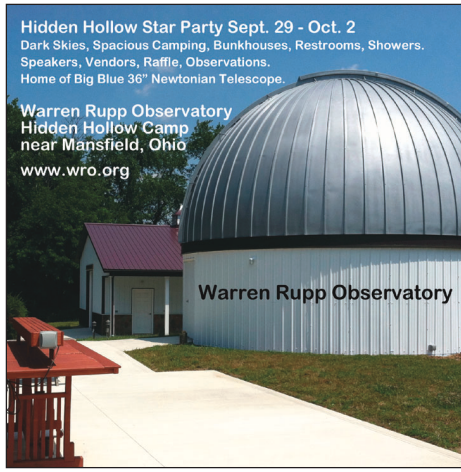
Astronomical Society of Eastern Missouri member Frederick Steiling submitted this image of LBN 552, LDN 1228, and the orange reflection nebula Cohen 129. Lying just 11 degrees from Polaris, the dark nebula LDN 1228, on the left, and the bright(er) nebula LBN 552, on the right, sit near Cohen 129 (also cataloged as GN 21.00.4). Below it and to the right is an interesting cascade of stars, streaming from left to right. He used an Orion 8-inch Newtonian Astrograph (800 mm focal length at  $f/3.9$ ) and a MoonLite CR Newtonian focuser on a Celestron CGEM mount. Imaging was done over four nights between June 5 and June 10, 2016 (total integration time was 11 hours, 52.5 minutes), using an SBIG STF-8300M with an FW5-8300 5-position filter wheel and an OAG-8300 off-axis guider. Guiding was done with PHD2, acquisition with Sequence Generator Pro, and integration/processing with PixInsight 1.8.



Using an ES 127 mm APO refractor on an iOptron IEQ45 mount and an Atik 314L+ camera, Jack Mogren, a member of the Rochester (Minnesota) Astronomy Club, took this image of M51 (the Whirlpool Galaxy), located some 23 million light-years from Earth in the constellation Canes Venatici, on June 7, 2016. A total of 32 images were taken (8 each of LRGB), 300 seconds each. Jack tells us, "I work out of a 6 x 10 trailer and drive at least 25 miles out of town to find a dark spot. Everything has to be portable and must be set up and torn down each night. All this on top of the normal issues like light pollution, Moon glow, wind, seeing, etc. I humbly marvel at being able to collect any photons at all. What an amazing and rewarding hobby."



Larry Hubble, of the Harford County (Maryland) Astronomical Society, imaged M8 and M20 on June 29, 2016, from the Broad Creek Memorial Scout Reservation. He used a William Optics 102 mm APO refractor and Canon 70D. Processing software included DeepSkyStacker, ImagesPlus and Photoshop.



### Wanderers/ from page 15

pass it. It then moves southward and closer to the Sun. This speeds it up so it passes south and sunward of the Earth. Its orbit then takes it back away from the Sun, moving northward, returning almost to the initial position.

From Earth's vantage point, 2016 HO<sub>3</sub> appears to go around the Earth. However, since it is not gravitationally bound to us, it is called a quasi-satellite of Earth. Following its motion backward, it had been in a horseshoe orbit until the 1920s, when it was captured by Earth's gravity. It will continue to circle around us until 2322 or 2323 when it will drift back into a horseshoe orbit.

This object appears to be a rock between 120 feet and 300 feet across, probably knocked off the Moon in an asteroid impact. A few older observations have been found, starting in 2004. This has confirmed the object's orbit well enough for this object to be numbered as minor planet 469219. Its orbit never brings it closer than nine million miles from Earth.

Other minor planets that are co-orbital with Earth include the above-mentioned 2002 AA<sub>29</sub>, 2003 YN<sub>107</sub>, 2004 GU<sub>9</sub>, and (3753) Cruithne. Some of these alternate between horseshoe-shaped orbits and quasi-satellite orbits. These two orbits are not very different; both take a year to travel around the Sun and are not too inclined to the ecliptic and not too eccentric. Only the Earth's gravity alters their motion to keep them near the Earth or forces them to stay away. ☼

Berton Stevens is co-director of the Desert Moon Observatory (Minor Planet Center 3448, www.morning-twilight.com/dm448).

### Music of the Spheres/ from page 17

remote partner and hours of work by the MAS team. It was a huge success, and the MAS made a big impression on the Iron Range. I hope we are able to partner with the Mesabi Symphony Orchestra in the future for another performance that combines music and astronomy. It's a match made in heaven! ☼

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.

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On August 21, 2017, at 10:16 a.m., PDT, the moon's shadow comes ashore just south of Astoria, Oregon, races across the United States and moves out to sea near Charleston, South Carolina at 2:47 p.m. Do you have the equipment to safely view the eclipse and the Sun? These glasses are ideal for viewing large sunspots on the Sun's face and partial, annual, and partial phases of total solar eclipses.

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

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League office: 816-DEEP-SKY; [leaguesales@astroleague.org](mailto:leaguesales@astroleague.org).

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

**Analemma Observing Program**

No. 13, Theo Ramakers, Regular, Atlanta Astronomy Club

**Arp Peculiar Galaxies Southern Observing Program**

No. 10-I, Stephen A. Tzikas, Northern Virginia Astronomy Club

**Asterism Observing Program**

No. 34, Lloyd Lashbrook, Texas Astronomical Society

**Binocular Double Star Observing Program**

No. 107, Russell F. Pinizzotto, Member-at-Large; No. 108, Antone G. Gregory, Minnesota Astronomical Society; No. 109, John H. McCammon, Member-at-Large

**Binocular Variable Star Observing Program**

No. 9, Frank Dempsey, Member-at-Large; No. 10, Rich Glassner, Member-at-Large; No. 11, Jeff Oaster, Delaware Valley Amateur Astronomers

**Bright Nebula Observing Program**

No. 11, Nora Jean Chetnik, Member-at-Large

**Caldwell Observing Program**

No. 26, Michael A. Hotka, Gold, Longmont Astronomical Society; No. 225, Joe Castor, Silver, Kansas Astronomical Observers; No. 226, Nora Jean Chetnik, Silver, Member-at-Large; No. 227, Mark Bailey, Silver, Member-at-Large; No. 228, Melinda Hopper, Silver, Astronomical Society of Kansas City; No. 229, Jerry Jones, Silver, Minnesota Astronomical Society; No. 230, Fred Gassert, Silver, Kansas Astronomical Observers

**Carbon Star Observing Program**

No. 67, Anthony J. Kroes, Member-at-Large; No. 68, Marilyn Perry, Member-at-Large; No. 69, Fred Gassert, Kansas Astronomical Observers; No. 70, Becky Ramotowski, Albuquerque Astronomical Society

**Comet Observing Program**

No. 32, Mike Lanska, Gold, Ventura County Astronomical Society; No. 85, Steven Sauerwein, Silver, Member-at-Large; No. 86, Marilyn Sameh, Silver, Wabash Valley Astronomical Society; No. 33, James L. Twellman, Gold, Astronomical Society of Eastern Missouri

**Constellation Hunter Observing Program (Northern Skies)**

No. 172, Mike Blasé, Tulare Astronomical Society; No. 173, Kathy Machin, Astronomical Society of Kansas; No. 174, Mark Bailey, Member-at-Large; No. 175, Paul Harrington, Member-at-Large

**Constellation Hunter Observing Program (Southern Skies)**

No. 7, Steven A. Tzikas, Northern Virginia Astronomy Club



# Observing Awards

**Deep Sky Binocular Observing Program**

No. 379, Ken Boquist, Popular Astronomy Club; No. 380, Johnny Scarborough, Central Texas Astronomical Society; No. 381, Mike Blase, Tulare Astronomical Association; No. 382, Rakhil Kincaid, Haleakala Amateur Astronomers; No. 383, J. Stephen Vincent, Cumberland Astronomical Society

**Double Star Observing Program**

No. 582, Danny Lineberger, Greensboro Astronomy Club; No. 583, John Neumann, Richland Astronomical Society; No. 584, John E. Hill, Minnesota Astronomical Society; No. 585,



Antone Gregory, Minnesota Astronomical Society, No. 586; Alex McConahay, Pomona Valley Amateur Astronomers; No. 587, Bruce P. Bookout, Colorado Springs Astronomical Society

**Galileo Observing Program**

No. 32, John C. Zellner, Member-at-Large; No. 33, Bill Sanders, Central Arkansas Astronomical Society; No. 34, Vincent Michael Bournique, Lifetime Member; No. 35, W. Maynard Pittendreigh, Lifetime Member; No. 36, Mark McCarthy, The Astronomy Connection; No. 37, Dick Francini, Neville Public Museum Astronomical Society

**Global Cluster Observing Program**

No. 285-V, Rakhil Kincaid, Haleakala Amateur Astronomers; No. 286-V, Philip Sacco, Flint River Astronomy Club

**Herschel 400 Observing Program**

No. 557, Jeffrey Corder, Ancient City Astronomy Club; No. 558, Coy Wagoner, Shreveport-Bossier Astronomical Society; No. 559 Jim Kvasnicka, Prairie Astronomy Club; No. 560, Will Young, Astronomical Society of Southeast Texas; No. 561, Marie Lott, Atlanta Astronomy Club

**Herschel II Observing Program**

No. 99, Vincent Michael Bournique, Lifetime Member; No. 100, Jeff Hoffmeister, Olympic Astronomical Society

**Hydrogen Alpha Solar Observing Program**

No. 31, Jim Ketchum, Astronomical Society of Kansas City.

**Lunar Observing Program**

No. 948, Fred Schumacher, Member-at-Large; No. 949, Henry G. Stratmann, Ozarks Amateur Astronomers Club; No. 950, Johnny Scarborough, Central Texas Astronomical Society; No. 951, Ralph DeCew, Warren Astronomical Society; No. 952, Jim Zappa, Member-at-Large; No. 953, Dan Chrisman, Jr., Roanoke Valley Astronomical Society; No. 954, Joe Castor, Kansas Astronomical Observers; No. 955, Tim Hunter, Lifetime Member, Tucson Amateur Astronomy Association; No. 956, Devin Booth, Minnesota Astronomical Society; No. 957, Alex McConahay, Pomona Valley Amateur Astronomers; No. 958, Ethan M. Karn, Member-at-Large

**Lunar II Observing Program**

No. 71, John Goss, Roanoke Valley Astronomical Society; No. 72, Dan Posey, Hill Country Astronomers; No. 73, John McCammon, Member-at-Large

**Messier Observing Program**

No. 2089, Russell F. Pinizzotto, Honorary, Member-at-Large; No. 2687, Cindy Bahl, Honorary, Astronomical Society of Kansas City;

No. 2710, Mike C. Neal, Honorary, Echo Ridge Astronomical Society; No. 2724, Steve Coltrin, Honorary, Rio Rancho Astronomical Society; No. 2727, Zack Stockbridge, Regular, Member-at-Large; No. 2728, Bob Fini, Honorary, Northern Virginia Astronomy Club; No. 2729, Gordon Schaefering, Honorary, Albuquerque Astronomical Society; No. 2730, Dan Posey, Honorary, Hill Country Astronomers; No. 2731, Randall DiGiuseppe, Honorary, Milwaukee Astronomical Society; No. 2732, Antone G. Gregory, Regular, Minnesota Astronomical Society; No. 2733, Michael Blasé, Regular, Tulare Astronomical Association; No. 2734, Devin Booth, Regular,

Minnesota Astronomical Society; No. 2735, Rene Gedaly, Honorary, Houston Astronomical Society; No. 2736, Jim Fordice, Honorary, Albuquerque Astronomical Society; No. 2737, Darin Templet, Regular, Rio Rancho Astronomical Society; No. 2738, Jarret Lingle, Honorary, Mason Star Gazers

**NEO Observing Program**

No. 6, Scott Donnell, Advanced, Colorado Springs Astronomical Society; No. 7, Brad Young, Intermediate, Astronomy Club of Tulsa; No. 8, Brad Young, Advanced, Astronomy Club of Tulsa

**Open Cluster Observing Program**

No. 75, Mark Simonson, Advanced, Everett Astronomical Society; No. 76, Nora Jean Chetnik, Advanced, Member-at-Large

**Outreach Observing Award**

No. 168-S, Dr. Alex Vrenios, Lifetime Member; No. 282-S, Don Knabb, Chester County Astronomical Society; No. 564-M, Douglas D. Hoople, Seattle Astronomical Society; No. 575-M, Mark V. Baker, Temecula Valley Astronomers; No. 583-S, Rusty Case, Popular Astronomy Club; No. 588-S, Andrew Edelen, Astronomical Society of Southern Illinois; No. 721-O, Edwin T. Luccott,

TITLE PHOTOGRAPH: M64, THE BLACK EYE GALAXY; NASA AND THE HUBBLE HERITAGE TEAM (AURAWSTC)

Chester County Astronomical Society; No. 722-S, Chuck Nejedly, Omaha Astronomical Society; No. 723-O, Jerry Don "J. D." Powell, Cumberland Astronomical Society; No. 724-O, Diane Bagley, Boise Astronomical Society; No. 725-O, Kristopher Flory, Kansas Astronomical Observers; No. 726-O, Robert Fish, Boise Astronomical Society; No. 727-O, Rebecca Robinson, Minnesota Astronomical Society; No. 728-O, Rich Kraehling, Richland Astronomical Society and Charter Lifetime Member; No. 729-O, Cheryl Ernst, Astronomical Society of Southern Illinois; No. 730-O, Fred Isberner, Astronomical Society of Southern Illinois; No. 731-O, Julie Wittenborn-Sikorski, Astronomical Society of Southern Illinois; No. 732-O, Mary Giangregorio, Back Bay Amateur Astronomers; No. 733-O, Steve Rogers, Astronomical Society of Southern Illinois; No. 734-O, David Novotny, Rose City Astronomers; No. 735-O, Kenneth Olson, Flint River Astronomy Club; No. 736-O, Sarah Milligan, Flint River Astronomy Club; No. 737-O, Victoria Walters, Flint River Astronomy Club; No. 738-O, Bryan Raser, Popular Astronomy Club

**Planetary Nebula Observing Program**

No. 9, Dan Crowson, Imaging, Astronomical Society of Eastern Missouri; No. 66, David Whalen, Advanced, Atlanta Astronomy Club

**Radio Astronomy Observing Program**

No. 16-B, Stephen Tzikas, Northern Virginia Astronomy Club; No. 17-B, Mike Stewart, Astronomical Society of Kansas City; No. 18-B, Louis Dorland, Omaha Astronomical Society; No. 19-B, Fred Schumacher, Member-at-Large; No. 20-B, Ron Mosher, Everett Astronomical Society; No. 21-B, Russell F. Pinizzoto, Member-at-Large; No. 13-S, Mark Simonson, Everett Astronomical Society; No. 14-S, Stephen Tzikas, Northern Virginia Astronomy Club; No. 15-S, Brad Young, Astronomy Club of Tulsa; No. 16-S, Russell F. Pinizzoto, Member-at-Large; No. 5-G, Stephen Tzikas, Northern Virginia Astronomy Club; No. 6-G, Brad Young, Astronomy Club of Tulsa

**Sketching Observing Award**

No. 8, John Eaccarino, Amateur Observers' Society of New York

**Solar System Observing Program**

No. 94, Adam Yore, Member-at-Large; No. 95, Marie Lott, Atlanta Astronomy Club

**Southern Skies Binocular Observing Program**

No. 94, Michael A. Hotka, Longmont Astronomical Society

**Southern Sky Telescopic Observing Program**

No. 50, Kevin Shackleton, Member-at-Large; No. 51, Michael A. Hotka, Longmont Astronomical Society

**Sunspotters Observing Program**

No. 184, Walter Jablonski, New Hampshire Astronomical Society; No. 185, Kristin Hendershot, Shenandoah Astronomical Society; No. 186, Kevin Carr, Minnesota Astronomical Society

**Two in the View Observing Program**

No. 12, Bob Kacvinsky, Prairie Astronomy Club; No. 13, Margaret McCrea, Rose City Astronomers; No. 14, Jonathan Schuchardt, Rio Rancho Astronomical Society

**Universe Sampler Observing Program**

No. 124, David Whalen, Naked-Eye, Atlanta Astronomy Club; No. 125, Marie Lott, Naked-Eye, Atlanta Astronomy Club

**Urban Observing Program**

No. 166, Brad Payne, Northern Virginia Astronomical Club; No. 167, John Neumann, Richland Astronomical Society; No. 168, Christopher Hardy, Texas Astronomical Society; No. 169, Jim Tallman, Back Bay Amateur Astronomers; No. 170, Gerard Jones, Minnesota Astronomical Society

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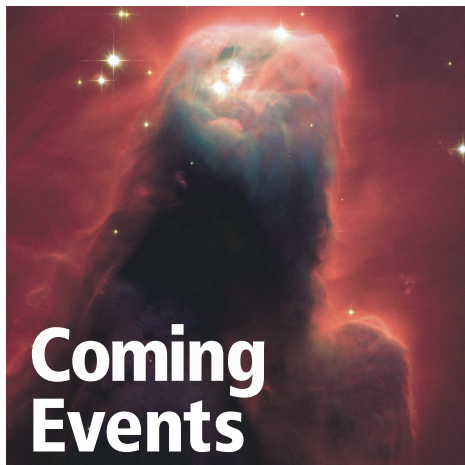
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# Coming Events

To have your star party or event listed, please send the details, including dates, sponsors and website, to [astrowagon@verizon.net](mailto:astrowagon@verizon.net). Confirm dates and locations with event organizers. — John Wagoner

## August 31–Sept. 5

### Brothers Star Party

Brothers, Oregon

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

## September 1–5

### Iowa Star Party

Whiterock Conservancy, Coon Rapids, Iowa

[www.iowastarparty.com](http://www.iowastarparty.com)

## September 2–4

### Craters of the Moon Star Party

Craters of the Moon National Monument, Idaho

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

## September 2–4

### Black Forest Star Party

Cherry Springs State Park, Pennsylvania

[bfsp.org](http://bfsp.org)

## September 2–6

### Almost Heaven Star Party

Circleville, West Virginia

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

## September 9–10

### Astronomy at the Beach

Kensington Metropark, Brighton, Michigan

<https://www.glaac.org/kensington-astronomy-at-the-beach>

## September 22–25

### Acadia Night Sky Festival

Bar Harbor, Maine

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

## September 24–Oct. 2

### Okie–Tex Star Party

Kenton, Oklahoma

Oklahoma City Astronomy Club

[www.okie-tex.com](http://www.okie-tex.com)

## September 25–Oct. 2

### Peach State Star Gaze

Deerlick Astronomy Village, Georgia

[www.atlantaastronomy.org/PSSG](http://www.atlantaastronomy.org/PSSG)

## September 29–Oct. 1

### Great Basin National Park Astronomy Festival

Baker, Nevada

[www.nps.gov/grba/planyourvisit/greatbasinastronomyfestival.htm](http://www.nps.gov/grba/planyourvisit/greatbasinastronomyfestival.htm)

## September 29–Oct. 1

### Illinois Dark Skies Star Party

Jim Edgar Panther Creek State Fish and Wildlife Area, Illinois

[www.sas-sky.org](http://www.sas-sky.org)

## September 29–Oct. 2

### Heart of America Star Party

Butler, Missouri

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

## September 29–Oct. 2

### Great Lakes Star Gaze

Gladwin, Michigan

[www.greatlakesstargaze.com](http://www.greatlakesstargaze.com)

## September 29–Oct. 2

### SJAC Fall Star Party

Belleplain State Forest, New Jersey

[www.sjac.us](http://www.sjac.us)

## September 29–Oct. 7

### Astroblast

Oil City, Pennsylvania

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

## September 30–Oct. 1

### Idaho Star Party

Bruneau State Park, Idaho

[www.isp.boiseastro.org](http://www.isp.boiseastro.org)

## September 30–Oct. 2

### Tennessee Fall Star Gaze

Pikeville, Tennessee

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

## September 30–Oct. 2

### The Connecticut Star Party

June Norcross Webster Scout Camp, Connecticut

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

## September 30–Oct. 2

### Hidden Hollow Star Party

Hidden Hollow Camp, Ohio

[wro.org/?page\\_id=7](http://wro.org/?page_id=7)

## October 7–8

### Kopernik AstroFest

Vestal, New York

[kopernikastro.org/astrofest](http://kopernikastro.org/astrofest)

## October 8

### Gateway to Space 2016

Saint Louis, Missouri

[www.eventbrite.com/e/gateway-to-space-2016-tickets-21973368938](http://www.eventbrite.com/e/gateway-to-space-2016-tickets-21973368938)

## October 21–23

### Bays Mountain Starfest

Bays Mountain Park, Kingsport, Tennessee

[www.baysmountain.com/astronomy/astronomy-club/?GTTabs=4](http://www.baysmountain.com/astronomy/astronomy-club/?GTTabs=4)

## October 23–30

### Chiefland Star Party

Chiefland, Florida

[www.chieflandastronomy.com/#!information/mf4vn](http://www.chieflandastronomy.com/#!information/mf4vn)

## October 24–29

### Eldorado Star Party

X-Bar Ranch, Eldorado, Texas

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

## October 24–30

### Staunton River Star Party

Scottsburg, Virginia

[www.stauntonriver-starparty.org](http://www.stauntonriver-starparty.org)

## October 25–30

### Deep South Regional Star Gaze

Norwood, Louisiana

[www.stargazing.net/dsrsg](http://www.stargazing.net/dsrsg)

## October 26–29

### Enchanted Skies Star Party

Socorro, New Mexico

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

## October 27–30

### Nightfall

Borrego Springs, California

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

## October 28–Nov. 4

### The OzSky Star Safari, a.k.a. The Deepest South Texas Star Safari

Coonabarabran, New South Wales, Australia

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

Attendance is extremely limited.

## October 29

### Virginia Association of Astronomical Societies

Roanoke College, Salem, VA

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

## November 4–6

### Custer Jamboree

Custer Institute, Southold, New York

[custerobservatory.org/jamboree](http://custerobservatory.org/jamboree)

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**.

## ADVERTISING RATES for the REFLECTOR

The following is a listing of the advertising rates for the *Reflector*. If you are interested in promoting your products, consider placing an ad with us. We offer a highly targeted market with a circulation of 16,000 astronomers.

Rates for the inside front cover, inside back cover, and back cover are negotiable.

Deadlines: March issue – January 1 June issue – April 1 September issue – July 1 December issue – October 1

Number of Issues	Full Page	1/2 Page	1/3 Page	1/6 Page	Mini Ad
H = Horizontal V = Vertical	7½" H x 10" V	7½" H x 5" V	5" H x 4½" V or 2⅔" H x 10" V	2⅞" H x 5" V or 4½" H x 2⅞" V	2⅞" H x 2⅞" V
1	\$1,000 B/W \$1,100 Color	\$500 B/W \$550 Color	\$400 B/W \$440 Color	\$200 B/W \$220 Color	\$150 B/W \$165 Color
2	\$900 B/W (each) \$990 Color (each)	\$450 B/W (each) \$495 Color (each)	\$350 B/W (each) \$385 Color (each)	\$175 B/W (each) \$192.50 Color (each)	\$125 B/W (each) \$137.50 Color (each)
4	\$800 B/W (each) \$880 Color (each)	\$400 B/W (each) \$440 Color (each)	\$300 B/W (each) \$330 Color (each)	\$150 B/W (each) \$165 Color (each)	\$100 B/W (each) \$110 Color (each)

Note: Advertising pricing is subject to change without notice.

To submit advertisements or for further information, please contact: Carla Johns, Advertising Representative, at [c.johns@icloud.com](mailto:c.johns@icloud.com) or 1-970-567-8878.

## Astronomical League Membership-at-Large Program



### What does the League offer you as Members-at-Large?

- Full voting privileges at AL meetings.
- A subscription to the *Reflector*.
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RASC *Observer's Handbook* \$27.00 • *StarDate* \$19.50

(Foreign rates are higher; see website)

- Free Astronomical League Observing guide with membership.

To join the Astronomical League as a Member-at-Large, send a check for \$40.00,

\$50.00 foreign, made payable to the Astronomical League, to:

Astronomical League National Office, 9201 Ward Parkway, #100, Kansas City, MO 64114

Phone: 816-333-7759; Email: [leagueoffice@astroleague.org](mailto:leagueoffice@astroleague.org)

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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9201 Ward Parkway, Suite 100  
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If you have questions about the merchandise, or discounts on bulk orders, please call the League office, 816-DEEP-SKY, or email: [leaguesales@astroleague.org](mailto:leaguesales@astroleague.org).



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

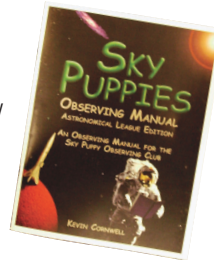
Available at <http://store.astroleague.org/>. Shipping rates will be added at checkout. Or call or email for shipping rates and options.

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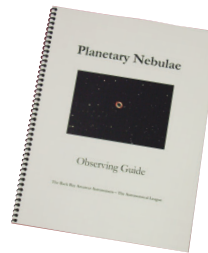
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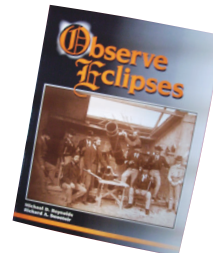
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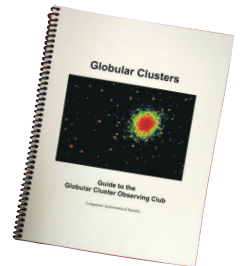
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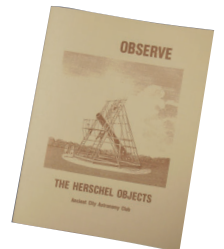
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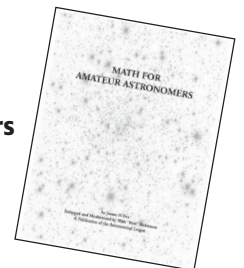
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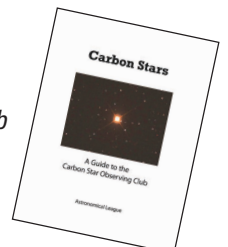
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