The Astronomical League Magazine
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A FEDERATION OF ASTRONOMICAL SOCIETIES
A NON-PROFIT ORGANIZATION
To promote the science of astronomy
• By fostering astronomical education,
• By providing incentives for astronomical observation and research, and
• By assisting communication among amateur astronomical societies.
Astronomical League National Office:
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To our contributors: The copy and photo deadline for the September 2017 issue is July 1. Please send your stories and photos to our managing editor, Ron Kramer (editor@astroleague.org), 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.

The front cover is an image of M1 (the Crab Nebula), taken by Brian McGaffney at his Nutwood Observatory in L’Amable, Ontario, Canada. It was acquired with a 17-inch RCOS and an Apogee Alta U16M using 6 µm filters, and updated by adding H-alpha and O-III data. Image acquisition time was about 7 hours.

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For more information on the Astronomical League and its members, visit www.astroleague.org.
Field of View
This picture was taken by the "Herschel Space Telescope" of the "Atmospheric Science and Technology" (ATST) observatory on the island of Mauna Kea, Hawaii, in March 2017. The picture shows a cluster of galaxies positioned in the field of view of the telescope, including the galaxy "NGC 1729" in the lower right corner. The cluster is located approximately 250 million light-years away from Earth. The image was captured using the "Advanced Camera for Surveys" (ACS) instrument on the Hubble Space Telescope. The ACS is a powerful tool for studying distant galaxies and their properties.

The Atjournal's Space Telescope takes photographs of the Atjournal's Space Telescope during the "Herschel Space Telescope" mission. The photographs are taken using the "Advanced Camera for Surveys" (ACS) instrument on the Hubble Space Telescope. The ACS is a powerful tool for studying distant galaxies and their properties.

Your Spot under the Sun
These June evenings present the last opportunities for those of us who are interested in looking for the outer planets. In fact, the outer planets are not visible this month because they are too close to the Sun in our sky.

Known as the "Great Conjunction," this event occurs when two or more planets come together in the same region of the sky. In this case, the conjunction involves Venus, Saturn, and Jupiter.

The conjunction of these three planets happens only once every 20 years, so it's a special opportunity to observe them together. Unfortunately, this particular conjunction is not visible from the northern hemisphere due to the positions of the planets in relation to the Sun.

Nonetheless, the conjunction is still worth observing from the southern hemisphere, where it can be seen from various locations.

Watching the conjunction
To watch the conjunction, you will need a telescope with a minimum aperture of 5 inches. The planets will appear as small, white disks with a dark center.

The conjunction is best observed when the planets are at their highest altitude in the sky, which occurs around midmonth. You may also want to use binoculars to get a closer look at the planets.

In addition to observing the planets, you can also look for other interesting objects in the sky, such as stars, galaxies, and nebulae. These objects are visible through a telescope and can help you understand the structure of the universe.

Remember, the conjunction is a rare event that won't happen again until 2038. So take advantage of this opportunity to learn more about the planets and the universe.
Are you ready for the eclipse? It seems that many millions of people across the United States and Canada will see at least a partial, and a rather large number (millions?) will be right in the path of totality. Whether this is your first total eclipse, or your fourteenth, congratulations! You are about to see one of nature’s wonderful displays of beauty. Just be certain to use your eclipse glasses, or a solar filter, both before and after totality. Too many images of pictures, duplicate Eddington’s experiment, look for shadow bands and the closing of flowers, and listen to the stillness of the animals. Watch the corona, look for Bailey’s beads and the diamond ring, see the stars and planets dark and bright, and just enjoy it. It will be a wonderful experience.

If you are joining us at AstroCon in Canyon, Wyoming, take the time to see you there. And don’t forget, we still have a bunch of eclipse glasses and other materials available through our League store.

We’re excited to announce an opportunity to contribute a first-of-its-kind citizen science project: The Eclipse Megamovie Project! We’re looking to get photographs of the upcoming August 21 total solar eclipse to build a real-time megamovie from coast to coast to coast. Photographers can help to create the movie as well as support solar science. For more on the goals of the project, see this press release. Our aim is to recruit over 1,000 amateur photographers to help with the project. (This is a citizen science project and not a professional one.)

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

Articles
Should be preferably written as a Microsoft Word document in .doc or .docx format. Length can be anywhere from 400 to 4,000 words. We will perform the necessary formatting, punctuation, spelling, grammar editing for grammar, spelling, punctuation, etc. If there is a technical question, we will ask the author for clarification, or a rewrite, as necessary. Our aim is to recruit over 1,000 amateur photographers who will be on the project totally on August 21, 2017. Team members receive training and submit a practical image before the eclipse. If you have a camera, and like photography, you will enjoy being designated your status as an official photographer for the project. Your name will also be included in the credits of the final Eclipse Megamovie. If you want to participate, visit our eclipsepages.org and sign up in basic equipment necessary for participating in the Eclipse Megamovie Project:

- Camera - high quality
- Tripod or a stable tripod
- A wide angle or wide angle lens
- Ability to identify the GPS coordinates and time to the nearest second
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All Things Astronomical

The International Astronomical Union is in the process of changing the status of some of its minor planets. The process aims to prevent the same names from being applied to objects in different parts of the solar system. It is not yet known how many planets will be affected by this change. The process is expected to continue for several years. The process is expected to continue for several years.

Florida, February 22, 2017
New Minor Planet Named

In a recent meeting, the Minor Planets and Comets Division of the International Astronomical Union voted to give the minor planet (5117) 1985 CZ the name Tomlinson to honor The Brevard Astronomical Society Club's founder, Gary Tomlinson. The name was announced on February 12, 1986, by Dr. H. Debehogne of the European Southern Observatory.

The IAU is the international astronomical organization that brings together those near the 10,000 professional astronomers from 98 countries to promote and safeguard the science of astronomy in all its aspects through international cooperation. The IAU was created by the international community for assigning designations to celestial bodies and the surfaces on them. The IAU was founded in 1919. The IAU is the world's professional body for astronomy.

The Brevard Astronomical Society is a group of amateur astronomers dedicated to outreach. More activities are held in public star parties for schools, libraries, scouts, and others. The society is reissuing a special relationship with its now-defunct NASA Spaceキルス, where club members are invited to view a panel of the IAU.

Many more details are available at www.highbulos.com.

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Paris, April 13, 2017
Fizing Sees on Titan

The Cassini–Huygens mission has revealed that there are seas probably composed of methane, ethane, and nitrogen on Titan, Saturn’s largest moon. A previously unknown phenomenon has been discovered in 2017. A 26-meter radar image sent back by the Cassini–Huygens mission to Ligea Mare (a sea on Titan) that appeared and then disappeared. This phenomenon is called the “sees effect.” The phenomenon has been explained. It is caused by a change in the reflective properties of the surface and near-surface material. Part of the nitrogen-rich surface mixture reacts to light changes, which explains why it is not systematically detected by Cassini’s radar.

2017’s most astonishing and promising yet discovered, especially in areas of quantum physics. In 2017, the IAU also serves as the organizing body for the General Assembly of the IAU, which brings together more than 10,000 professional astronomers from almost 100 countries. Its mission is to promote astronomical science through international cooperation. The IAU also serves as the organizing body for the General Assembly of the IAU, which brings together more than 10,000 professional astronomers from almost 100 countries. Its mission is to promote astronomical science through international cooperation.
By Burton Stevens

In 1608, human beings saw their beautiful blue world rise above the stark, gray lunar surface from the Apollo 8 spacecraft. The resulting picture became an iconic of the Age of Space. The water oceans that form on two-thirds of the Earth’s surface give it that predominantly blue color. However, while our planet has one of the largest percentages of ocean visible from space, it is not the only body in the Solar System with an ocean.

Jupiter has sixty-seven known moons in relatively stable orbits around this largest planet in the Solar System. Most of them are tiny objects, minor planets that came too close to Jupiter and were captured to become moons. The four moons that were discovered by Galileo Galilei in 1610 when he started observing the heavens are worlds in their own right. They are roughly the size of our Moon or a little larger. The Galilean moons—Europa, Ganymede, and Callisto—are all quite different from each other. Some of the differences stem from their differing distances from Jupiter, and others arise from the compositions of the moons. Io is the closest to Jupiter. It is most affected by Jupiter’s tidal forces. Europa is equidistant to Jupiter, the other Galilean moons are relatively stable orbits around this largest planet in our Solar System. Like Europa, Ganymede has a subsurface ocean trapped between a surface layer of ice and a deep layer of ice covering the rocky mantle. There may be interleaved layers of ice, with water, creating multiple oceans separated by the icy layers in different phases. Ice can form at many different temperatures and pressures. There are seventeen different crystalline phases of water-ice that can form, depending on the environment. The hexagonal form of crystalline ice that is common here on Earth is very rare in space. Water is unusual in that at higher pressures, liquid water will not change into ice unless the temperature is actually below freezing (0°C) due to the strong hydrogen bonds in H2O. Other liquids change to the solid state at higher temperatures than their freezing point as the pressure increases. Ganymede has an ocean, the increasing pressure causes different forms of ice to occur depending on the temperature at that depth. The final phase near the rocky mantle is presumed to be a tetragonal ice layer. Ganymede is the largest of the Galilean moons and the only moon in our Solar System that has a stable magnetic field. The existence of the magnetic field indicates a liquid iron-nickel core that is generating the field. The magnetic field captures solar wind particles and forces them downward toward the poles, causing aurora observed by the Hubble Space Telescope. These observations imply a phase change in Ganymede’s magnetic field that imply a subsurface saltwater ocean. Ganymede may also be home to subsurface extraterrestrial life, possibly in the lowest layers of its oceans.

In Europa, and Ganymede are indeed in resonant orbit. Europa makes ten orbits around Jupiter for each of Europa’s orbits. Four to revolutions occur for each one that Ganymede makes around Jupiter, which means Europa makes two revolutions for each of Ganymede’s orbits. Every time the moons get closer to each other, the tidal bulges become substantially larger, just as we have higher tides when the Moon is in line with the Sun at full and new moon. This tidal stretching increases the heating to help keep these three moons warm. Ganymede does not participate in this tidal resonance and so it is not heated as much as Europa or its neighbors are. It appears to have an ice layer forming the surface of the moon, covering a possible salty water ocean mixed with ammonia or some other substance that acts like anti-freeze, lowering the freezing point of the water. If there is no ice, there may be a thick layer of ice instead. Either would form a highly conductive layer that keeps Jupiter’s magnetic field from penetrating it. The interior of Callisto is a mix of water and ice that is differentiated into layers, but with more rocky material than ice nearer the core. This moon’s surface is very old with many overlapping craters. The tidal forces from Jupiter escape to renew the surface and erase the older craters. Callisto is not home to subsurface extraterrestrial life. It is too cold for life to form in the ocean. Unfortunately, Callisto is only heated by radioactive decay and not tidal heating. This makes it too cold for life to form in the ocean. When the Moon is in line with the Sun at full and new moon, this tidal stretching increases the heating to help keep these three moons warm.

Ganymede has a more complex subsurface ocean structure than Europa. Instead of a single ocean, Ganymede has multiple layers of increasing depths separated by layers of ice. The deeper layers have increasing salinity and the ice layers differ in phase as pressures increase. The very bottom layer of salt water is up against a rocky surface, allowing interaction between the rocky minerals and the ocean water. This is important to the development of life. Like Europa and Ganymede, Callisto also appears to have a subsurface ocean. Varying magnetic fields near Callisto’s surface imply that there may be a salty ocean under the surface. An ocean, an electric current sufficient to induce the magnetic field. The magnetic field was measured by the Galileo spacecraft’s magnetometer as it made close flybys of the most distant of Jupiter’s large moons. The measurements showed that the electrical currents reversed as Jupiter rotated, a key signature of electric currents in a salty subsurface ocean. Unfortunately, Callisto is only heated by radioactive decay and not tidal heating. This makes it too cold for life to form in the ocean.

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

Ten ambassadors were selected from around the United States from various occupations and organizations. I was pleased to be able to go on behalf of the League. The ambassadors quickly bonded and struck out on a packed schedule to experience as much as possible in ten days. We met in Santiago at the Hotel Director Vitacura where I was fortunate enough to meet Sergio Cabrera, AUI/NRAO outreach officer in Chile—a fantastic guy that I traveled with us for the duration of the tour.

The following night, the group traveled into the nearby Andes Mountains to visit the Observatorio Astronomico Andino. The sky was cloudy, but just the same we were glad to get to see one of the many private observatories for astronomy. It was a first-class operation with clean, modern facilities and top-notch equipment that rivaled and surpassed my own. Especially impressive were the three 14-inch SCTs on computerized mounts with digital-imaging cameras and dedicated computers. It was an astrophotographer’s delight. We were privileged to see this place. There are many others around the country, because Chile has some of the best places in the world from which to observe the southern skies. Location, location, location. The only thing working against us was the light pollution and temperate weather of the capital region. It was better to go north to the drier latitudes, and later, we did.

The following day, we boarded a flight to the La Serena airport so that we could visit the observatories in the Elqui Valley region. The city, a beach resort and temperate weather of the location. The only thing working against us was the light pollution and temperate weather of the capital region. It was better to go north to the drier latitudes, and later, we did.

The next day, we were given a tour of Gemini and Cerro Tololo, where we could spend the next two nights. I had been to Cerro Tololo before on a previous vacation but not for an overnight. They are open to the public for day visits with prior booking. It is best to go on a Saturday, as that is when they take general reservations. Be sure to bring your passport. I was excited for the chance to stay, but why on earth did we have to be here during a gibbous moon? Groan.

The Blanco telescope

The 2016 class of ambassadors included Michelle Ferrera Peterson, ranger at the Astronomical Discovery Center in Shingle, California; M. Josh Roberts, junior planetarium presenter, California Academy of Sciences in San Francisco; Brian Marzec, geology and education community College District in Phoenix, Arizona; William Bogardus, cancer educator and retired administrator and adjunct professor at the State University of New York College at Oswego; Derrick Pitts, chief astronomer and director of the planetarium at the Franklin Institute in Philadelphia; John Blackwell, observatory director and educator in science at Phillips Exeter Academy, New Hampshire; Allison Messick, manager, astronomy education program at the Smithsonian National Air and Space Museum, Washington, D.C.; David Lockett, astronomy school visitor at Michael Johnson Elementary in Murfreesboro, Tennessee; and Carmen A. Pantoja, in charge of science at the University of Puerto Rico in San Juan.

The following day, we boarded a flight from Los Angeles to Puerto Rico in San Juan. We had been to Cerro Tololo, where we could see nearby SOAR. From there, we could see near Cerro Tololo, where we would spend the next two nights. We had been to Cerro Tololo before on a previous vacation and not for an overnight. They are open to the public for day visits with prior booking. It is best to go on a Saturday, as that is when they take general reservations. Be sure to bring your passport. I was excited for the chance to stay, but why on earth did we have to be here during a gibbous moon? Groan.

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### Al Marcella
**Astronomical Society of Eastern Missouri**
marcella@mo.com

Plan a Road Trip to a Dark Sky Park
**Al Marcella**

**Great Basin National Park**

Great Basin National Park winter sky

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

**The Sky Night**

Two-thirds of Americans cannot see the Milky Way from their backyard, and hardly any of us live in places with measurable light pollution.

Great Basin National Park was designated as an International Dark Sky Park. The International Dark Sky Association has recognized that Great Basin provides distinguished and significant opportunities for stargazing.

According to the Great Basin Dark Sky Park’s light management plan, the park’s location in one of the least-populated regions of the lower 48 states “enables it to have some of the darkest night skies in the contiguous United States.” Due to its distance from major urban centers, the park is the only place in the United States where you can see the nighttime sky as it was a century ago. The “dim-light conditions” make it an ideal site for photography, and astronomy.

At the park, you can see the Milky Way, the Andromeda Galaxy, and a few of the brightest stars and constellations. The park has a few dark-sky trails and interpretive programs, and visitors can easily see the Milky Way using their own telescopes.

**The End**

Now is the time to set your sights on a trip to an International Dark Sky Park. There are currently 13 in the United States—darksky.org/ directory. Take a drive to a dark sky saturated with stars, one reminiscent of a night sky that ancient stargazers witnessed. Whether you go to Great Basin National Park or any of the other dark sky parks, you will have a wonderful experience with countless stars.

### How to Get There

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

### Accommodations in Baker

- **Gateway Accommodations in Baker:** 155 N. Nevada Street, Baker, NV 89331

### Great Basin National Park

Great Basin National Park is located approximately 300 miles northeast of Las Vegas and 250 miles west of Salt Lake City. The nearest airports are in Elko, Nevada, 70 miles away, and Cedar City, Utah, 142 miles away. The nearest major airports are in Salt Lake City (SLC) and Las Vegas (LAS) (286 miles away).

The new Great Basin Visitor Center is in Baker. The entrance is on Utah 155 S. Nettie Ave.

Al Marcella [174x222 to 438x220]  
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The first robotic telescopes were manufactured by RC Optical Systems. The UNC astronomy faculty and grad students began building the PROMPT network—meaning "Pandemic Robotic Optical Monitoring and Polarimetry Telescopes"—in 2004. The figures grew daily, but a recent estimate shows that Skynet has taken over 16 million images for tens of thousands of users worldwide.

Successful History of Fundraising

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

Background

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

I have no doubt that the faculty in the Department of Physics and Astronomy at the University of North Carolina were inspired techies and moviegoers; they conceived a project called "Skynet"—a nod to the reality of a world increasingly served by computers and the Internet. Not quite machines that are self-aware, Skynet is a collection of telescopes, filters, cameras, and retractable-roof observatories installed in remote, mountainous locations that employ robotics to study the sky at night.

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

Skynet is truly a global scientific resource available to the public and academia through a web portal. The first Skynet proposal, submitted in 2003, was turned down, although some of the scopes were already being assembled. The grant was slated to build telescopes and their clamshell domes at the Cerro Tololo Inter-American Observatory above La Serena, Chile, 30 degrees south latitude and 2200 meters (7000 feet) above sea level. A second proposal asked NSF to fund the construction of six Ritchey–Chrétien telescopes, figured with hyperbolic mirrors, suitable for professional astronomy, at $100,000 per telescope. The first NSF award was made in 2004. Dr. Robert Farquhar launched the program at UNC–Chapel Hill.

Two million dollars was raised via the American Recovery and Reinvestment Act (ARRA), awarded through NSF and allocated to several American universities. This included the addition of four new 17-inch RC scopes at the Siding Spring Observatory in New South Wales, Australia. Some of the ARRA funds were used in collaboration for the refurbishment of the 20-meter National Radio Astronomy Observatory telescope in Green Bank, West Virginia.

Typical of NSF grants, future funding will largely rely on the ability to self-fund Skynet's operating budget in a pay-for-use model. For example, the PROMPT II is a 24-inch RC telescope added in 2013 in partnership with the Government of Thailand, which pays for most of its use. This and paid time on the other Skynet telescopes now support most of the operating expenses for PROMPT. A 12-inch telescope has also been completed at the Chileno site. It was funded entirely by Swiss manufacturer Astro Optik GmbH—for one of their own designs, of course. Altogether, eight PROMPT telescopes are now operating in Chile, and half a dozen at three sites in Australia and Canada. A few existing telescopes at universities are online. These include the recommissioned telescope at the Morehead site on the UNC campus, two telescopes at the Dark Sky Observatory near Apache Point Observatory, and the University of Chicago's 41- and 8-inch telescopes at Yorkes Observatory in Wisconsin.

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

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

The professional astronomy community has been studying GRBs for years. On average, a burst is detected by satellites every few days. Gamma photons are emitted when shells of ejected stellar material crash into each other. These ultrarelativistic shocks produce a Doppler boost to GRB positions are relayed over the Internet to astronomers around the world. GRBs are the most powerful explosions in the universe—our only chance to truly understand what happens when stars explode. Skynet's telescopes and their robotic scheduling can range in duration from a few milliseconds to several hours, and sometimes even several days. The initial burst is often followed by a longer-lived event in optical and infrared wavelengths. We call this "afterglow."

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

Neutronomote

Skynet is actually the name for PROMPT's central software, a web-based, dynamic, queue-scheduling application. This custom application is developed at UNC as a resource for the databases and storage space to accommodate images. Afterglow is an astronomy and photometry software program that UNC created for use with FITS files to meet curricular opportunities.

The "Flexible Image Transport System" is the data format used for analyzing scientific images. Pixel counts in a field of view of a CCD camera can be translated to the angular diameter of an asteroid, for example.

FITS is a binary, space and time—in some cases—encoded image application that you can download to your PC or smartphone to use with visible-light imaging. When you are observing an ongoing run, data input to the Skynet portal will need to accurately show what you are looking for, when you expect the telescope to come online, and where to point the telescopes to detect and locate GRB sources almost immediately. The positions are then listened to the ground.

Distributed telescopes travel through a network gateway at NASA's Goddard Space Flight Center in Greenbelt, Maryland, and the GRB positions are relayed over the Internet to astronomers around the world. Skynet is operated by the NSF at Skynet University labs. Skynet University provides the online curriculum for teaching basic and advanced courses in astronomy at UNC. The "Foxtrot" key component used by the NSF to evaluate requests for funding. Skynet University was a natural path to create education channels to reach a wide audience in the public.

Skynet University

Use of the network assumes that the school has made a request to continue on page 17.
Astronomy With Skynet: Our Place in Space! is the suggested starting point. It is a full-length course for astronomers, amateur clubs, K-12 public schools, and private schools, and youth programs. The course follows a structured curriculum. Students use tutorials with the Afterglow astronomy application to evaluate data. Some basic algebra and graphing skills are needed. Enrolled students are given 30 minutes of observing time on PROXY.

Astronomy 101/102 are the full-length course for amateurs, astronomy clubs, K-12 public schools, and private schools, and youth programs. Students use tutorials with the Afterglow astronomy application to evaluate data. Some basic algebra and graphing skills are needed. Enrolled students are given 30 minutes of observing time on PROXY.

Astronomy 101/102 were conceived an astronomy program for your school in 1985 funded by the Humboldt Foundation. In three years, Skynet trained educators provided professional development for 135 youth leaders from 25 states. More than 1,400 youth are members of SSL, and their numbers are expected to grow substantially over the next few years. The director of Yerkes Observa-
I've completed over a dozen Observing Programs to date. The ones I enjoyed put me in the deep end of a field that is way outside of my comfort zone. The Amateur and Galileo Programs come to mind, as does the Radio Astronomy Observing Program, which is the subject of this article.

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

The Radio Astronomy Program describes five "projects" one can do to detect solar radiation, sudden ionospheric disturbances (SIDs), Jupiter's radio storms, radio meteor scatter, and galactic hydrogen radiation detection. One need only complete four of the five, but hydrogen radiation detection must be one of them. Send in the results for one project and get a bronze-level certificate. Do a second project and advance to silver. Complete two more projects to achieve gold level. As a bonus, beautifully two more projects to achieve gold certificate. Do a second project of the five, but need only one of the others because I found it easier than others because I thought it might be a good fit.

Radio Meteor Scatter

I got involved with this activity decades ago, so I knew what was about. The first thing I needed to find was an FM radio that I seemed to be able to receive. It had to be just far enough away from my home that I couldn't receive it directly, but close enough that when a meteor streaked through the ionosphere, its signal would bounce off its ionization trail in the upper atmosphere and make it to the Earth. I found that the National Weather Service had stations scattered across the U.S. High-frequency radio signal would reflect off a meteor's ionization and arrive at the receiver. I knew that the National Weather Service had stations scattered across the U.S. High-frequency radio signals could bounce off meteor ionization trails, so I did not expect the delightful coincidence that I discovered.

I was looking at a list of cities from which weather forecasts are broadcasted. I opened the AL website and looked up the list of cities with the meteor scatter. I then clicked on the city and found a URL that would take me to the VLF receiver page. I built it and it worked. I then built a simple dipole cut for the HF radio band. I built a simple dipole cut for the HF radio band.

Radio-Sky software is pre-built and tested (datashare dataq.com). I hooked up the antenna to my radio, split its audio output to a small speaker and the data acquisition input, and started its oscilloscope-style software on my PC. It didn't take me long to build a simple dipole cut for the HF radio band.

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Radio-Storm Detection

It tells you when there is a high probability of receiving a signal from a Jovian radio storm. There are two kinds of radio storm signals: long burst (L-burst, 4-6 hours) and short burst (S-burst). Long burst storm signals sound like "waves crashing upon the shore." Short burst signals sound like a static-like radio signal.

I built a Jupiter storm reception documentation on hold until I finished the galactic hydrogen detection project. Advancing to gold level requires two more completed projects, so I have to send them both in together. I had no idea at the time that I would use this as my first "radio line detection project" would take me. Receiving the extremely weak radio signals from Jupiter requires a lot of patience. I did not expect the delightful coincidence that I discovered.

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Finally, there was one paper in particular that got my attention, “Hydrogen-Line Radio-Astronomy as an Elementary-School Science Project,” by Shanni Prutchi. (Proc. 25th Ann. Meeting of SARA, NRAO, Green Bank, WV, 2006, p. 91.) Prutchi built a dual Yagi antenna system that successfully received H-line signals from the Milky Way, which, I’m told, is not as easy to receive as the others on the AL requirements list. All these papers offered a variety of selections for the four major components required for an H-line detection system: the antenna, line amplifiers and filters, the receiver, and the logger. Prutchi’s antennas are available from directive systems.com and could be employed immediately, without modification. I bought just one, for starters. I purchased a couple of low-noise amplifiers (LNAs) from downeasterwave.com, and a band-pass filter from radioastronomysupplies.com. One of the dish antenna systems used a software-defined radio (SDR) to receive the 1.4 GHz H-line signal, a USB dongle controlled from SDR software, which is a free download from airspy.com. For logging and plotting I chose another Radio-Sky-Publishing product, their Radio-SkyPipe, from radiosky.com. I put everything together, pointed the antenna at a bright radio source (Figaro of Auriga), and got...nothing.

After a brief brooding period, I signed onto the SARA list and posted about my woes. One person responded by saying that, while my USB dongle was a terrible SDR, it didn’t have enough bandwidth to be effective for radio astronomy at 1.4 GHz. He recommended instead the larger SDR from airspy.com, the R2. Cringing at the thought of good money after bad, I put the R2 on order. It was pretty much restyled then anyway. I hooked up the R2, pointed the antenna at the Sun at local noon, and got a very clearly defined hump! Even better, my single antenna showed a beam width of twice that of Prutchi’s dual antenna setup, as expected. Not all of the several required galactic detections went smoothly, but many did (Figure 11). Eventually, I got them all, sent the plots in with my Jupiter logs, and finally got the long-awaited gold-level certificate and pin.

Conclusions
I have a corkboard on my wall with all the pins I’ve earned from the Astronomical League, and a couple of notebooks full of project logs and certificates. With this project, beyond all the memories, I’ve got a somewhat modest but effective 1.4 GHz radio astronomy antenna system. What’s next? I plan to add a second Yagi for a dual antenna system, and maybe even an elevation rotator, following Prutchi’s design. That should give me a half-power beam width of 8 degrees, a much better resolution.

Dr. Vrenios is a retired computer scientist and a lifetime member of the Astronomical League. He currently proudly serves as vice president of his local astronomy club, the Phoenix Astronomical Society. His work on the AL’s outreach award program has changed.

Hats Off to the Fort Bend Astronomy Club
The Fort Bend Astronomy Club in Texas has been busy working on outreach programs. Until recently, that club had one member who had received a single Outreach Award. Leonard Ferguson was one of the first to receive the basic outreach-level award—number 10. For over ten years, he was the only one in that club to have earned an Outreach Award! All of that has changed. Recently the Fort Bend club had a meeting and presented 131 certificates—46 Outreach Awards, 44 Stellar Outreach Awards, and 21 Master Outreach Awards. A total of 88 pins were distributed for the basic and master levels!

Let’s put these numbers in perspective. Last year I gave out 86 basic-level outreach pins. In one night, this club gave out 86. I’ve got two pins left—I sure hope the order for new pins comes soon!

Last year I gave out 18 Master Outreach pins. In one night, this club gave out 21. It took us three years from the program’s inception for us to give out not 21 but 1 Master Outreach Award! This club now has 68 members who have earned at least one level of the Outreach Award. That is more than any other club! Other clubs that have anywhere close to this number include the Flint River Astronomy Club in Georgia (43), the Northeast Florida Astronomy Society (46), the Omaha Astronomical Society and the Oklahoma City Astronomy Club (both have 42), and the Astronomical Society of Kansas City (129).

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

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

W. Maynard Pittendreigh
Outreach Award Coordinator, Astronomical League

FROM AROUND
THE LEAGUE

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

2017 Astronomics Sketching Award

Second Place: $125. “The Trapezium at the End of the Tunnel” by Peggy Walker, Astronomy Club of Tulsa. (Black sketching/charcoal paper, white charcoal, white chalk pastel, white Promarker pencil, silver metallic-colored pencil, black chalk pastel, black and three shades of gray colored pencils, 18-inch Hubble Optics Truss Dobsonian, several Explore Scientific eyepieces (M.7 through 24 mm), UltraBlock, O-III, and H-beta filters.)

Peggy Walker
How Many Observing Pins Do You Have?

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

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

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

This wonderful program consists of an Orion 4.5-inch StarBlast Dobsonian (or equivalent), a Celestron 8-24 mm zoom eyepiece (or equivalent), and a nameplate commemorating the late Jack Horkheimer. The value of the Library Telescope is approximately $300; the potential of the program is enormous.

Submit your completed entry form so that the Astronomical League national office receives it by July 31, 2017. If mailed, the entry must be postmarked no later than July 31, 2017. The winning entry for each region will be announced at the annual Astronomical League business meeting held at ALCon/AstrCon 2017 in Casper, Wyoming, on or about August 18.

Full details of this program are available at www.astroleague.org/content/library-telescope-program

Candidate Statement: Office of Secretary—Bryan Tobias

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

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

Solar Eclipse 2017 Special Award

August 21, 2017, should be on your calendar. Over the course of 94 minutes, the shadow of the Moon will pass from Oregon to South Carolina. All of the continental U.S. will experience at least a 60 percent partial eclipse, but to see totality, you will need to travel to the path. The Astronomical League will be offering a Special Observing Award certificate and pin to those who are up to the challenge. There will be general certificates for the public as well. The goal of the Special Observing Award is to follow in the footsteps of astronomers of the past and to attempt to calculate the effect of the Sun’s gravity on the path of the photons coming from stars close to the edge of the Sun.

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

Aaron Clevenson, Coordinator, Solar Eclipse Special Observing Award

Celestial Savings Program—Your Discount Purchasing Program

The Astronomical League is excited to announce its new Celestial Savings Program where all League members qualify for special discounts at participating vendors when purchasing equipment, accessories, or books.

Please note that discount amounts may vary by vendor and by items purchased. See the Celestial Savings Program announcement issued in this issue of the Reflector to determine participating vendors.

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

Once you have an account established and log in to the AL website, you should select the “Members Website” tab. Next, click on “Celestial Savings.”

You will then see a listing of the participating vendors, the discounts they offer for their products, their current discount code numbers, their website URLs and, if appropriate, telephone numbers. Simply provide the appropriate discount code number to the vendor’s salesperson or include it in your website order.

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

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

The Astronomical League also has a member-at-large program detailed at www.astroleague.org/al/join/members.html

For additional AL membership details and benefits, visit www.astroleague.org and click the “Join” tab.

Questions? Write to the Celestial Savings Director at celestialsavings@astroleague.org.

Want to Volunteer?

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

We are seeking an editor, who will be responsible for consolidating the necessary data for each quarterly issue. The ideal candidate should have some publishing experience and familiarity with Adobe InDesign and Photoshop and Microsoft Word and Excel. Typical time required is 30 to 40 hours per quarter. We are also looking for a photo editor, who will collect and review the hundreds of images we receive for each issue, and select the front cover, back cover, and Gallery photos. Experience with Photoshop and Word is preferred.

If you are interested in either position, please contact the managing editor, Ren Kramer, at managingeditor@astroleague.org with a brief description of your experience as it relates to the position.
The TRAPPIST-1 planets are in orbital resonance: while planet g completes one orbit around its star, planets b, c, d, e, and f complete 8, 5, 3, 2, and 4/3 orbits, respectively. This effect makes it possible to constrain the planets’ masses, which have not yet been determined very precisely, and hence their densities. Current data appear to indicate that some of TRAPPIST-1’s planets are low-density and water-rich, a conclusion that will be refined with ongoing follow-up observations.

The planets of TRAPPIST-1 have insulations, and therefore average temperatures, similar to Earth’s: the insulations of the innermost planet (b) is slightly higher than that of Mercury, while the outermost planet (g) is only a fraction of ours. The insulations of at least three of the planets (b, f, and g) are compatible with the existence of liquid water on their surface for a wide range of atmospheric compositions, as is shown by numerical simulations of their climate. Due to their synchronous rotation, it cannot be excluded that the planets have the highest insulations (b, c, and d) may harbor liquid water in temperate regions with little or no sunlight.

The TRAPPIST-1 system, the planets pass in front of the star during each orbit, causing a fall in brightness known as a transit. The amplitudes of the transits are used to determine the radii of the planets, while their periodicities indicate their orbital distances and hence their insulations (the amount of stellar radiation received at each planet’s surface). Following these initial findings, the star was systematically monitored to find out whether it contained any other planets. The result of this follow-up exceeded all expectations: TRAPPIST-1 has at least seven planets, all of which are Earth-sized (or within 10%). The six outermost planets (b to g) orbit their star in 1.5 to 12 days (the period of the seventh planet remains to be determined), and are 20 to 90 times closer to their star than the distance from the Earth to the Sun. At such distances, the tidal forces exerted by the star are considerable, locking the planets into synchronous rotation, which means that they rotate about their axis exactly once in one orbit, thus always showing the same face to their star (just as the Moon does relative to the Earth).

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