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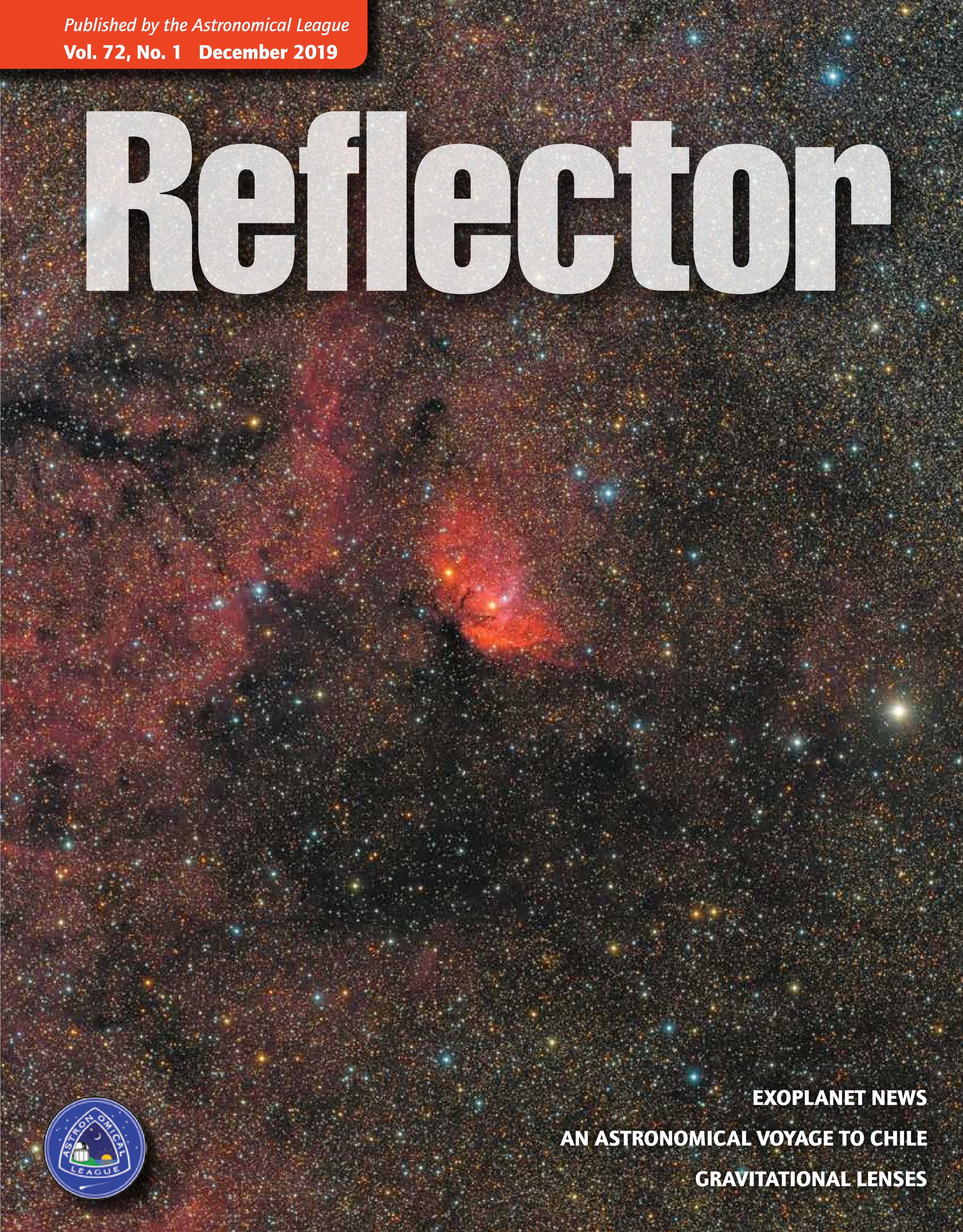
Reflector



EXOPLANET NEWS

AN ASTRONOMICAL VOYAGE TO CHILE

GRAVITATIONAL LENSES

Get Off the Beaten Path

Join a SKY & TELESCOPE Astronomy Tour

African Stargazing Safari

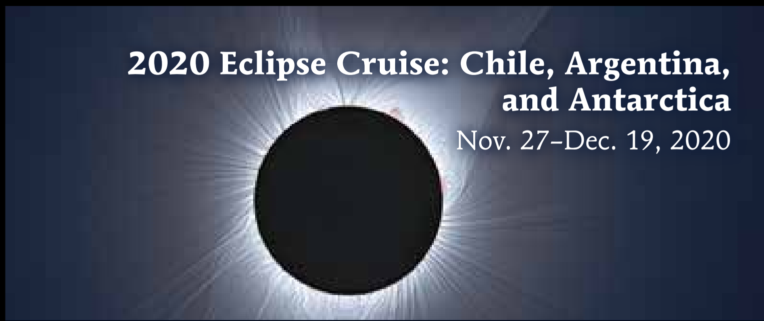
July 17–23, 2020

Join astronomer Stephen James O'Meara in wildlife-rich Botswana for evening stargazing and daytime safari drives at three luxury field camps. Only 16 spaces available! Optional extension to Victoria Falls.

skyandtelescope.com/botswana2020

S&T's 2020 solar eclipse cruise offers 2 minutes, 7 seconds of totality off the coast of Argentina and much more: Chilean fjords and glaciers, the legendary Drake Passage, and four days amid Antarctica's waters and icebergs.

skyandtelescope.com/chile2020



2020 Eclipse Cruise: Chile, Argentina, and Antarctica

Nov. 27–Dec. 19, 2020

Total Solar Eclipse in Patagonia

December 9–18, 2020

Come along with *Sky & Telescope* to view this celestial spectacle in the lakes region of southern Argentina. Experience breathtaking vistas of the lush landscape by day — and the southern sky's incomparable stars by night. Optional visit to the world-famous Iguazú Falls.

skyandtelescope.com/argentina2020

Astronomy Across Italy

May, 2021

As you travel in comfort from Rome to Florence, Pisa, and P ua, visit some of the country's great astronomical sites ican Observatory, the Galileo Museum, Arcetri O and lots more. Enjoy fine food, hotels, and treats. Extensions in Rome and Venic

skyandtelescope.com/italy2020

Moved to May 2021 — new dates coming soon!

See all *S&T* tours at skyandtelescope.com/astronomy-travel

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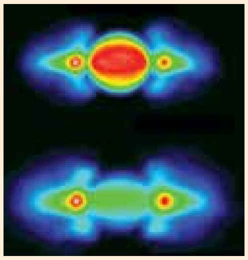
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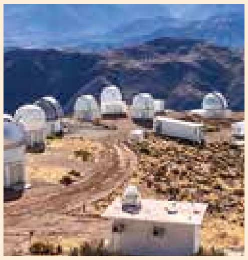
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Cover image: *Bill Neubert (Astronomical Society of Eastern Missouri) captured this this image of Sharpless 101 from the Buford Mountain Conservation Area using a Stellarvue SV80 with reducer (f/4.8 – 384mm) with a QSI 683wsg-8 camera.*

Reflector

The Astronomical League Magazine

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A FEDERATION OF ASTRONOMICAL SOCIETIES
A NON-PROFIT ORGANIZATION
To promote the science of astronomy

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

Astronomical League National Office:
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Reflector

QUARTERLY PUBLICATION OF THE ASTRONOMICAL LEAGUE

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***REFLECTOR* AND CLUB ROSTER DEADLINES**

March issue	January 1
June issue	April 1
September issue	July 1
December issue	October 1

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President's Corner

September and October have been rather busy. First, I spent several days at Okie-Tex, a great star party in western Oklahoma, just across the New Mexico border. Several of the evenings were windy, but the skies were beautiful, the food bountiful, and the people friendly. I even won a pair of Celestron 15x70 binoculars as a door prize.

Next, in October we had the AAVSO 108th annual convention in Las Cruces, where I live. Assistant editor of the *Reflector,* Kristine Larsen, was given the AAVSO Director's Award for her outstanding work in astronomy. Congratulations, Kristine! Very well deserved.

John Martin has accepted the position of League IT manager, and is now responsible for our website, web security, and other important aspects of information technology. He will be building his staff as we move forward. Also, Kristine Larsen has taken on the position of *Reflector* editor, replacing John Martin. Please send all future submissions to Kristine at *editor@astroleague.org.*

Elections for League president and vice president will be held in 2020. If you are interested in either of these important positions, please submit your photo and a 250-word résumé to John Goss at *goss.john@gmail.com.* These will be presented in a future issue of the *Reflector.* Remember, this is *your* League, and we need volunteers to support it.

We are also still looking for someone with successful grant-writing experience to help the League obtain grants to support our activities. If you have the qualifications, or know someone who can do this, please contact me at *president@astroleague.org.*

Plans for ALCon2020, to be held in Albuquerque, New Mexico, from July 16 to 18, are coming together. In addition to the usual meetings and presentations, an ALCon Jr. will be held at the same time, offering students the opportunity to build a 6-inch Newtonian telescope on a Dobsonian mount. The ready-to-use mirrors and pre-cut plywood mount material come from Rob Teeter, who will join us at the event. Peggy Walker is organizing the event in conjunction with the Albuquerque Astronomical Society (TAAS) and it promises to be a major event. More information can be found this this issue.

Finally, consider writing an article or submitting a photo for the *Reflector*. This is *your* magazine, created by hard-working volunteers within the League. We can always use new material, and remember, you get the bragging rights.

—Ron Kramer, AL President

From the New Editor

(CCSU photo)

To start, I'd like to thank John Martin for his hard work in this position. I am very pleased that he is remaining a valued part of the Astronomical League team in the role of IT guru and webmaster. Second, I would like to very publicly thank my partners in this endeavor, assistant editor Kevin Jones, whom I have had the pleasure of working with these past six years, and Michael Patterson, who does the vital role of turning all the disparate pieces of the *Reflector* into a cohesive and attractive whole.

For those of you who don't know me, I am a long-time member of the Springfield Telescope Makers and have completed an 8-inch mirror and telescope. My 12.5-inch mirror is in the figuring stage, and I already have a tube assembly ready to house it once completed. I have served two years on the STM board of trustees, and since 2012 have been the co-coordinator of programming for the annual Stellafane Convention (which I hope you read about in the previous issue of the *Reflector*). My "day" job is astronomy professor at Central Connecticut State University, a position I have held for 30 years. I am also deeply involved with the American Association of Variable Star Observers, having served as its president from 2015 to 2018. I am currently co–section leader of the AAVSO Solar Section and secretary of the board of directors. I have completed several AL Observing

Programs: Messier, Binocular Messier, Binocular Double Star, Binocular Variable Star, Outreach, and Meteor. I therefore consider myself a dedicated pro-am and will be bringing both sides of my brain to my new role as *Reflector* editor.

In an effort to fulfill our commitment to you, our valued members and readers, to produce a high-quality, engaging, and informative magazine in a timely fashion, we are taking the perhaps radical step of streamlining our process and working with a smaller rather than larger team. I will also be making changes behind the scenes that should greatly help us keep to our timeline. The *Reflector* is *your* magazine, and we truly value your input. Please let us know what we are doing well, what we need to do better, and what you would like to see in the future (for example, new columns or topics). If you have ever considered submitting an article to be considered for publication, now is the time! I look forward to hearing from you and continuing the process of making the *Reflector* the very best astronomical magazine it can be.

—Kristine Larsen, *Reflector* Editor

Important Notice

CLUB TREASURERS AND ALCORS:

If your club has not yet paid its 2019–2020 Astronomical League dues, please contact the National Office at *leagueoffice@astroleague.org* as soon as possible. We are concerned that we haven't heard from you, as the dues were payable five months ago. We know you want to continue receiving AL benefits, including the *Reflector*, without interruption – and we certainly don't want to lose your club as an Astronomical League member!

Noted with Sadness

RTMC ASTRONOMY EXPO ENDS

We, the current Board of RTMC, Inc., have made the difficult decision that 2019 was the last year that the Astronomy Expo will be held.

Many contributing factors have led us to this difficult and disappointing decision. We have tried to navigate these challenges while experimenting with many new ideas. However, it has become apparent that hosting further Astronomy Expos is no longer feasible. We are heartened by the fact that both the 50th and 51st years (2018 and 2019) were well received and enjoyed by all those who attended.

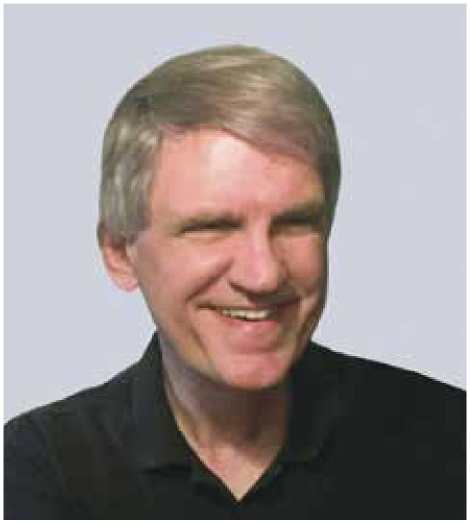
We wish to thank all the past board members and the many volunteers who helped put on this event for 51 amazing years. To the many vendors, who've come to share their products, to the thousands of attendees, and to all our various sponsors, thank you for supporting us through the years. Thank you to all the speakers and presenters we've had through the years for sharing your wonderful knowledge. Thank you to YMCA Camp Oakes for hosting our event for over 40 years in the beautiful San Bernardino Mountains.

We've made many memories, friends, and discoveries along the way. We will cherish them all.

Again, thank you so much for your support and patronage through the years. We wish you all clear, dark skies, and bright futures!

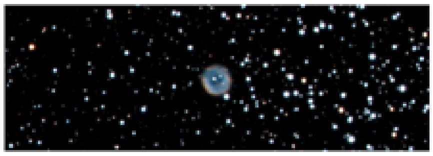
—The Board of RTMC, Inc.

New Astronomical League Secretary



Chuck Allen, a past League president (1998–2002), is now secretary of the Astronomical League. He has served on council for 17 years, is a former Great Lakes chair, and currently serves as Great Lakes treasurer.

Chuck founded the League's 27-year-old National Young Astronomer Award in 1991, chairing the program until 1998. He received the League's G.R. Wright Award for service in 1998, holds the League's Master Outreach Award with over 900



Smart Planning for Imaging

People don't usually plan their imaging beyond finding objects that pass high in the sky. This is because they don't have enough information. Every camera and telescope combination is different. Every object in the sky is different. Basic questions arise that have no clear answers. How long to expose to get a nice image? What sub exposure time to use? What order to observe the filters in? How much moonlight is allowed for a narrow band filter to still get a good result?

Large professional observatories have special purpose software that can answer these questions. Now, you too can have the answers using SkyTools 4 Imaging. Now there is a tool that can search every known object for the ones that are suitable for your imaging system, calculate the optimum filter order, and tell you the right sub exposure times to use. Not only that, but it can create mosaics graphically, organize your projects, track your progress, and create a searchable archive of your images.

What would you do with a tool like that?

SkyTools 4 Imaging
Skyhound.com

2020 Calendar

Enjoy this award-winning, large-format space calendar all year long!

- Over 120 space images
- Sky events, space history, & more!
- **Group discounts available**

See more at **YearInSpace.com**

hours logged, and is also a League Master Observer, completing his Master – Silver level in 2019.

Chuck served as president of the Louisville Astronomical Society from 1991 to 1994 and took over as program director for the Evansville Astronomical Society in 2019. In 1992, he co-founded the 28-year-old Stars-at-the-Beach event at Patoka Lake in Indiana. He is also a past judge and judge leader in Earth and Space Science for the Intel International Science and Engineering Fair, and a past director of the Louisville Regional Science Fair.

Chuck graduated from Duke University (BA) in 1970, served as a United States Air Force officer from 1970 to 1974, and graduated from the University of Kentucky College of Law (JD) in 1977. He practiced law as a partner with Kentucky's largest law firm for 27 years.

An amateur astronomer since age 7, Chuck began giving public programs at age 12, received the League's Advanced Junior Certificate in 1965, and attended his first ALCon in 1965.

Call for Nominations

The two-year terms of the offices of president and vice president end on August 31, 2020. If you are interested in using your talents to serve in either one of these two important positions, we would like to hear from you. Please volunteer!

For specific information regarding the duties and responsibilities of the president and vice president, please refer to the League's bylaws, which can be accessed on the League website at *astroleague.org.*

Candidates should send to Nominating Committee co-chair John Goss, *goss.john@gmail.com,* a background statement explaining why they are interested along with a photo of themselves for publication in the *Reflector*. Please limit all statements to approximately 250 words. All nomination materials must be submitted by March 15, 2020, so they can be announced in the June *Reflector*.

Watch the AL website for a call for new Observing Program Coordinators!

Full STEAM Ahead

"GIVE THE SCOPES TO THE KIDS – THEY'LL KNOW WHAT TO DO"

I had a revelation a couple of months ago: a long-time "outreacher" told me that "STEAM is not a thing anymore. The kids are bored with it all. They are no longer interested."

"I come up with my own activities," I replied, and was told, so did they – "It's on its way out."

The next day I met a man with his junior high school–aged son. The man told me that his wife had made him take their son to a star party. I asked why. He said, "Our son is too addicted to technology and his mom wanted him to go outdoors and do some science." And there it is folks. The reality is that astronomy is competing with technology, iPhones, gaming, virtual reality glasses, robotics, and 3-D printing. Seems STEAM has become TEM. We need to fight for astronomy's "S" – science – and in doing so, it needs to become hands-on and fun at some level. As I continue to conduct outreach, I have kids who want to use our scopes, and some of them just automatically look through the Telrad and point the scope. John Dobson was right – the kids do know what to do.

Telescope making has been around for centuries, and at one time, doing it yourself was the only way to get a telescope. Back in the 1960s, amateur telescope making (ATM) became more popular due to John Dobson (of course), as well as the televised lunar landings and active NASA programs. Amateur telescope making is becoming a dying art; many great folks have passed on, and the relevant skillsets are no longer as popular as they once were. My mission is to bring ATM back into the culture of our hobby and make it relevant to students, families, and all those who love the amateur astronomical adventure.

With this in mind, I continue to encourage you, the Astronomical League's membership, 16,000 to 18,000 strong, to support ALCon Jr.'s amateur telescope making workshop in 2020. By buying calendars or making donations, you can help us be able to purchase the supplies to build 6-inch, f/8 telescopes. Calendars can be purchased in bulk from *store.astroleague.org*. Our goal is to offset the cost of half a scope, in order to include as many students and families as possible. Refer to the "Full STEAM Ahead" article in the September issue of the *Reflector* for more information.

This workshop will be led by a man who designed and built a scope in high school and displayed it at a Stellafane convention. Did I mention he won an award for that back in 1998? This event would later spark the business of Teeter's Telescopes. If anybody follows Rob Teeter's Facebook page, you will see an artist and artisan at work, using beautiful wood stains and finishes with metallic and colorful tubes with etched or laser-cut metal pieces. Rob posts videos of how he uses a software-driven computer numerical control (CNC) machine to cut the bases. By pairing carefully selected stains and finishes to the color of the metal and tubes, we could say Rob was STEAMing it long before it became a thing.

Rob Teeter

Also joining the ATM workshop at ALCon Jr. 2020 is a student from Oklahoma named Abby Bollenbach, AL's 2018 Horkheimer/Smith Award winner. Abby is not only an active astronomer, she also plays the piano, dances ballet, works in a biology lab, and is pursuing an astrophysics career. She has personally supported the ATM workshop by selling an impressive number of calendars in her area. Abby also is an International Mars Generation Ambassador, and an Explore Alliance Ambassador for Explore Scientific. Abby is a co–vice chair for the Mid-States Regional

Abby Bollenbach

Conference to be held June 12–14, 2020 in Oklahoma. She will be staffing the youth conference that will run parallel to the adults' conference. Abby is science to math and all points in between – she fully embodies STEAM.

—Peggy Walker

Night Sky Network

Does your astronomy club membership reflect your community? Does it skew older and whiter and more male? Your club is not alone! But there are clubs that do reflect the diversity of the communities they serve. Find out what they do differently and how your club can become more inclusive and welcoming to all of your community.

Let's start at the beginning. What is inclusivity? Inclusivity means just what it sounds like: the practice of including as many people as possible by being welcoming to people from various backgrounds, ages, races, genders, and abilities. There are no magic buttons that will make your club more inclusive; it's a practice that we get better at over time. As a society, we have a lot of ingrained practices, speech patterns, and learned behaviors that benefit some people and exclude others. These practices are generally not intentional, but they still exist, and can still be harmful regardless of intent.

We can work towards practicing more welcoming outreach, keeping in mind our diverse audiences. Let's look at some concrete examples. Do some younger folks come to your talks and seem absorbed by their phone while the speaker is presenting? What can appear offensive to some might actually be that person sharing details about the event with others. Instead of chastising them, after the lecture say "hi" and ask them what they thought about the talk. You could even find out what topics they're interested in hearing more about. You may have even found your club's new social media manager or publicist!

We know that the world treats girls and boys differently. Try to find a telescope in your local toy store, for example, and you might see who they are targeting. While details like these might seem small, over a lifetime they add up to many girls feeling that science "isn't for them." The great news is that studies show that you can break that narrative in as little as 20 minutes with a positive science experience - and it's simpler than we think.

For example, you can tell more stories of women in astronomy. Looking at Saturn in the telescope? We might want to mention Carolyn Porco, the "Queen of the Rings," who led the imaging team on the Cassini mission! Or when talking about the Juno mission to Jupiter, mention that it was Charlene Valerio who orchestrated its orbit around the gas giant. These are small moments that encourage girls and women to see themselves as part of science.

Be sure to take a look at ways we may unintentionally be biased in our outreach. Are our astronaut examples always men? Do we expect that all children are going to be equally as excited about space or do we assume differences in their interest before you talk to them? A simple way to dispel any preconceived notions is to ask questions of the people approaching your telescope; even something as simple as, "Have you ever looked through a telescope before?" will start a conversation and give you more information about where to meet your visitors. She may turn out to have a telescope at home and help you point out constellations!

If we keep doing the same outreach, we will continue to have clubs that look like they do now. Having conversations, not simply talking *at* our visitors, is the biggest first step. Ask questions and find out their interests. You'll be amazed at how much of a difference even a few small changes can make with your audiences!

Photo: Girl Scouts of Northern California

The Night Sky Network website has a handy list of resources to help learn more about engaging with diverse audiences at *bit.ly/astroall*. This page also includes information about upcoming workshops on working with girls and the new Girl Scout badges from the Astronomical Society of the Pacific. There are new workshops announced every quarter! The IAU has created *inclusive-astronomy.org*, a fantastic resource for those looking to help support underrepresented groups in astronomy. Outreach folks may find the inclusive outreach event planning page especially handy *(bit.ly/eventsforall)*.

We're always learning! Share any techniques that work well for making your club more inclusive by sending your story to *nightskyinfo @astrosociety.org.*

International Dark-Sky Association

JOURNAL OF DARK SKY STUDIES

The University of Utah has just launched the online *Journal of Dark Sky Studies (JDSS)*. The journal is housed at the University of Utah's Consortium for Dark Sky Studies, and is dedicated to light pollution research, important impact stories, and the culture of the night sky. *JDSS* debuted at the 68th United Nations Civil Society Conference in Salt Lake City, Utah, August 26-28, 2019, and coincided with the start of the first class in dark sky studies at the Consortium.

Daniel Mendoza is the editor of the journal. He is the co-director of the Consortium and one of the core faculty members in dark sky studies. He also holds joint appointments in the Department of Atmospheric Sciences and the Division of Pulmonary Medicine. According to Mendoza, "the journal will appeal both to people who have no idea what dark sky studies are and to people who actively research and advocate for dark skies." The *JDDS* boasts a distinguished editorial board, including IDA's John Barentine.

The journal will be published twice a year in the spring around the time of the International Dark Sky Week and in the fall around the time of IDA's general meeting. According to the IDA website, "each issue [of the journal] will consist of three sections regulated by the editorial board. One section is a curated creative space for art and the cultural side of dark skies, such as writing pieces and visual media. A second section will feature conservation efforts around the world to serve as examples for others to use and to help communities who feel isolated in their preservation efforts to feel supported and find useful resources. The final section will include standard, peer-reviewed articles selected by the journal's editorial board on the impacts of artificial lighting on our world from across a range of disciplines, from ecology to human health."

The W.M. Keck Foundation awarded $250,000 in January 2019 to the University of Utah to develop an undergraduate minor in dark sky studies. It is housed in the College of Architecture and Planning, but students from across campus are eligible to take classes in the minor. This mirrors the interdisciplinary philosophy of the Consortium for Dark Sky Studies. To see more details about the new journal, the Consortium for Dark Sky Studies, and the minor in dark sky studies, visit the University of Utah website at *unews.utah.edu/journal-of-dark-sky-studies.*

At my advanced age, I am thrilled that dark sky studies are beginning to get the respect they deserve. This represents the cumulative efforts of those working on dark skies for at least the past 50 years. They are too numerous to mention here, and many are unsung heroes deserving more recognition. Are dark skies now getting the respect they deserve? No, but it is certainly a good start.

—Tim Hunter
Co-founder, IDA

Wanderers in the Neighborhood

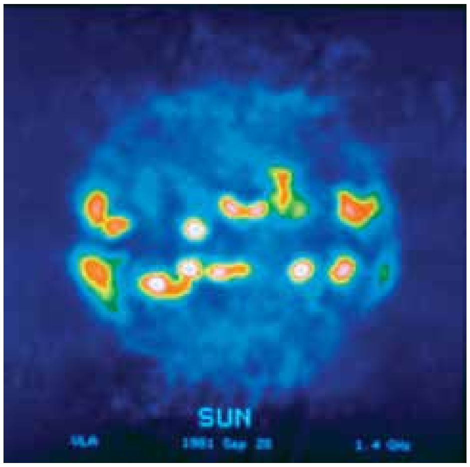
PLANETS ON THE RADIO

We have all seen the planets in visible light, from red Mars, through the belts and zones of Jupiter, and on to Saturn's rings. But our Solar System also teems with electromagnetic waves of a lower frequency: radio signals. They reveal secrets about planets not obvious in visible-light images.

Electromagnetic waves propagate by an electric field inducing a magnetic field, which in turn induces another electric field. The distance between the peaks of these waves is called the wavelength. The shortest waves, gamma rays, have a wavelength of 0.000000000003 inches, smaller than a molecule. The red light we see has a wavelength of around 0.0000257 inches, around the size of a bacterium. As the wavelength gets longer, the radiation moves into the infrared and then into the radio parts of the spectrum.

The radio spectrum starts with microwaves, with a wavelength of around 0.04 inches, about the size of the period at the end of this sentence. As wavelength increases, we pass through hydrogen emissions at a wavelength of 21 centimeters (8.3 inches), television at around 40 inches, AM radio at around one thousand feet, and finally to very low frequency waves like WWVB time signals with a wavelength of over three miles.

The loudest radio source in the Solar System is the Sun. Early attempts to receive medium-wavelength radio signals from the Sun were unsuccessful. On Earth, radio stations in this wavelength band can be heard at a great distance because the ionosphere reflects the radio signals



A radio image of the Sun at a wavelength of 8.4 inches taken on September 26, 1981. The radiation from the bright regions originates in the corona near sunspots. The rapidly varying magnetic field generates the radio-bright areas through synchrotron radiation. Courtesy (NRAO/AUI)

back toward the Earth, which reflects them back toward the ionosphere, and so on. The ionosphere, unfortunately, also reflects astronomical radio signals back into space. Even though the Sun was broadcasting, its radio signals bounced off the ionosphere.

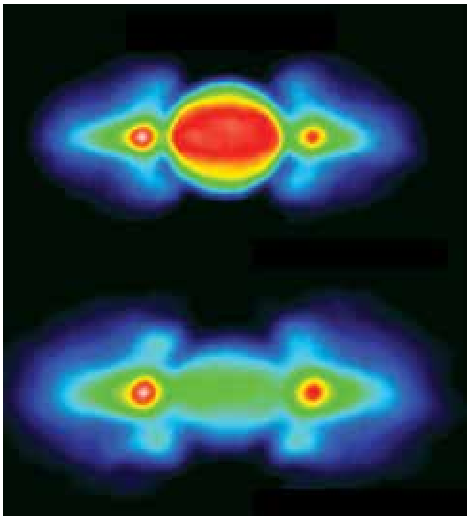
As electronic engineering advanced, shorter and shorter wavelengths could be received, eventually including those short enough to penetrate the ionosphere. The Sun then became visible in radio wavelengths shorter than 33 feet. The Sun, having a surface temperature of 10,000 degrees Fahrenheit, has a peak energy output in the visible part of the spectrum, so little of its energy ends up in the long radio wavelengths. Between three and thirty-three feet, the galactic background radiation is stronger than the Sun's radiation, while at wavelengths shorter than three feet, the Sun dominates.

The Sun is not a constant source of radio waves – its intensity varies with the amount of solar activity. A solar flare not only emits a flash of visible light, but a burst of radio energy as well. Electrons traveling near the speed of light are trapped by the rapidly varying magnetic field around the flare. The electrons are forced to spiral along the lines of force, which requires them to be accelerated continuously by the magnetic field to create the spiral. Accelerating an electron causes it to emit radio energy by a process called synchrotron emission.

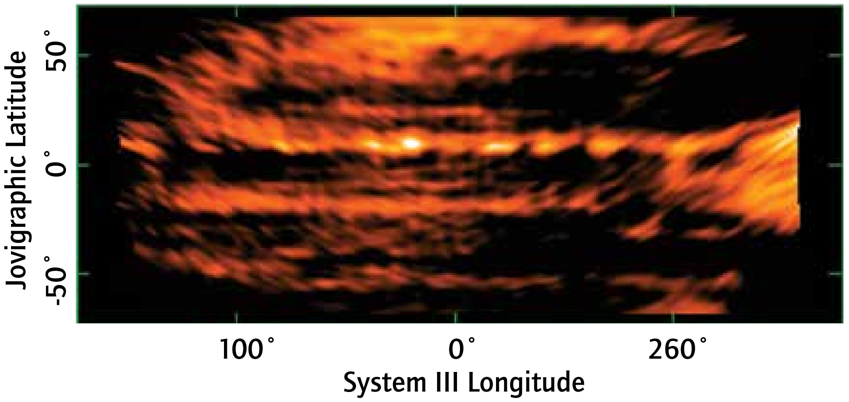
A solar flare will usually emit a radio burst that lasts for seconds, while the wavelength shifts from short to long as the solar plasma oscillates at the beginning of the flare. As the rising plasma from the flare strikes the gas above it, a shock wave forms, emitting even more radio signals. After the flare dies down, there will frequently be a residual signal from the gas above the flare for hours or days.

The second brightest radio source in the Solar System is the planet Jupiter. It emits radio energy across a wide range of wavelengths. The shortest wavelengths, around fifty inches, are thermal radiation from Jupiter's atmosphere. This is similar to the thermal observations of Venus, just at a longer wavelength than the thermal radiation from Venus, since Jupiter is cooler. Using the Very Large Array in New Mexico, it is possible to map the temperatures of the clouds and bands of Jupiter.

For wavelengths between six inches and twenty-five feet, the radio signals come from synchrotron radiation similar to that produced in solar flares. For wavelengths longer than twenty-five feet, the radio signal comes from cyclotron-maser radiation, which is similar to synchrotron radiation, but the electrons are



Two images of Jupiter at wavelengths of 5 and 8.6 inches taken between July 12 and July 26, 1995, with the Australia Telescope Compact Array radio telescope. The upper (5-inch) image has a large contribution from thermal radiation making the disc itself bright. This radiation is greatly diminished at 8.6 inches. The radiation in the two lobes on either side of the disc are due to synchrotron radiation from relativistic electrons trapped in Jupiter's magnetic field. These observations were made by G. A. Dulk, Y. Leblanc, R. Sault, and R. W. Hunstead.



Jupiter imaged in radio at a wavelength of 0.78 inches. This image took six hours of data to produce. The features are smeared in longitude by Jupiter's rapid rotation. The resulting image had the contribution from a 150 Kelvin oblate spheroid with limb darkening of the size and distance of Jupiter subtracted to bring out the hotter features on the cloud tops. Data for this image was taken with the Very Large Array in New Mexico on January 25, 1996, by Imke de Pater (UC Berkeley), and were further reduced and imaged by Chermelle Engel (University of Melbourne) and Bob Sault (ATNF).

travelling much slower than light as they spiral around Jupiter's magnetic lines of force.

Jupiter's radio signals were first discovered in 1955 by astronomers Bernard Burke and Kenneth Franklin, who had set up a 96-acre antenna array in a rural field twenty miles northwest of Washington, D.C. They detected bursts of radio noise that returned four minutes earlier every night. This showed that the bursts were coming from a celestial object, and Burke and Franklin eventually identified Jupiter as the source. This was the first discovery of radio signals from a planet other than Earth.

Similar radio signals come from Saturn and its rings. The signals are fainter and harder to record than Jupiter's. Uranus and its rings can also be observed from Earth with powerful modern radio telescopes like the Atacama Large Millimeter-submillimeter Array. Neptune's radio signal has only been detected by the Voyager spacecraft as it flew past the planet.

Jupiter's cyclotron-maser radiation can be observed by an amateur astronomer with a simple radio telescope. Project Jove is a NASA educational citizen-scientist project to observe the radio emissions from Jupiter, the Sun, and galactic sources.

Project Jove provides plans, kits, and information about putting the amateur radio telescope together. If you are interested in getting involved, you can visit the Project Jove site at *radiojove.gsfc.nasa.gov/index.html*. Other sources for amateur radio telescopes that can observe Jupiter include the Thrush Observatory *(thrushobservatory.org/radio.htm)*, Radio-Sky Publishing *(www.radiosky.com/rjcentral.html)*, the British Astronomical Association *(www.britastro.org/radio/RadioSources/jupiter.html)*, and Jon Wallace and Richard Flagg *(www.radio-astronomy.org/pdf/qex/radio-jove-proof.pdf)*.

While we just see the sky in visible light, our instruments can detect the myriad sources of radio and other electromagnetic radiation reaching us from objects from across the cosmos.

—Berton Stevens

Deep-Sky Objects

A BRIGHT NEBULA IN PERSEUS

The Milky Way galaxy is filled with myriad large clouds of gas. A majority of the gas, perhaps 90 percent, consists of ionized or neutral hydrogen. If a cloud (or nebula) absorbs a lot of ultraviolet light from stars embedded in it or near it, the gases heat up to very high temperature. Collisions among the high-temperature atoms cause them to jump to higher energy states. As the atoms cascade back to their ground state, they emit light at specific wavelengths.

The brightest visible light from hydrogen gas is a red wavelength at 656 nanometers (nm). We call this hydrogen alpha. The next brightest is hydrogen beta, an aqua-colored emission at 486 nm, followed by hydrogen gamma, blue light at 434 nm, and hydrogen delta, violet light at 410 nm. Nebulae that emit mostly hydrogen-alpha light appear red in photographs. Those that also emit large quantities of hydrogen-beta, -gamma and -delta light appear pink. Other gases account for emissions of other colors.

At the eyepiece, the colors are not so apparent. This is due to the human eye not being

capable of detecting colors from faint objects. But that doesn't detract from the thrill of spying great glows such as the Orion Nebula (M42), the Lagoon Nebula (M8), or the Ring Nebula (M57), to name a few!

The constellation Perseus is high overhead during winter evenings in mid-northern latitudes. The Milky Way blazes across Perseus, littering it with splendid star clusters, double stars, and nebulae. Perhaps the best-known nebula in Perseus is the California Nebula. This nebula spans nearly three degrees and has an integrated magnitude of 5. But the nebula is so spread out it cannot be seen with the unaided eye or taken in entirely at the eyepiece. So while panning across this nebula with a telescope, at best, the space between the stars will appear brighter than the dark background between stars elsewhere in Perseus away from the nebula.

A more interesting telescopic nebula in Perseus is NGC 1491 (also called LBN 704). NGC 1491 lies about one degree north-northwest of the 4.3-magnitude star Lambda Persei. It also lies 1.25 degrees northeast of the 5.3-magnitude star 43 Persei. These two stars and the nebula form a right triangle with the nebula at the right-angle corner. There is a 10th-magnitude star nine arcminutes north of the nebula and an 11.2-magnitude star embedded in the center of the nebula. The latter star is responsible for exciting the hydrogen gas within the nebula, giving it the red glow so common in emission nebulae photographs.

NGC 1491 is irregular in shape and roughly three arcminutes in size. The nebula is easily captured in 11- to 14-inch telescopes from dark-sky sites. Those using 8-inch telescopes will more readily see the nebula using an ultra-high contrast (UHC) filter or oxygen (O) III filter. These filters will help bring out the fan shape of the nebula seen in photographs.

The accompanying image of NGC 1491 was taken with a 10-inch Newtonian telescope using an SBIG ST-2000XCM CCD camera (the image is shown here cropped). The exposure was 70 minutes. In the image, north is up and east to the left. The brightest portions of the nebula surround the 11.2-magnitude star and approximate what can be seen in amateur telescopes. The aforementioned 10th-magnitude star lies near the top center of the image. Near the bottom right corner of the image lies an optical double star. The brighter of the pair is magnitude 9.9 and the fainter is magnitude 11.2.

The faint nebulosity trailing off to the south and east of NGC 1491 in the image is part of a much larger nebular region catalogued as LBN 705 and 706. LBN stands for Lynds Bright Nebula, a catalog of nebulae compiled by astronomer Beverly Lynds in the 1960s.

Perseus is not just a constellation in which to explore fabulous star clusters. With the proper equipment, some pretty fascinating nebulae can also be spied.

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

Call for Award Nominations

YOUTH AWARDS

It's time to start thinking about who might be nominated for several youth-based awards: the 2020 National Young Astronomer Award, the Horkheimer/Smith and Horkheimer/D'Auria Youth Service Awards, the Horkheimer/ Parker Youth Imaging Awards, and Horkheimer/O'Meara Journalism Awards.

If you know of a young person who has been involved in an astronomy-related research project or a club service activity or who would like to write about astronomy, now is an excellent opportunity to apply. Or perhaps they have done imaging. There are plenty of programs to nominate that young person for. See our website awards page, *astroleague.org/al/awards/awards.html*, for details.

The deadline for the National Young Astronomer Award and the Horkheimer awards is March 31, 2020. So, encourage your candidates to complete their projects now and find the application on the AL website. Club officers, please nominate these younger members from your club. Remember, they are the future of astronomy.

ASTRONOMY DAY

Astronomy Day presents an opportunity to increase science awareness in your local community. This can be the spark that motivates people both young and older to take a look at the offerings of your society, all simply by personally introducing people to the wonders encountered in amateur astronomy. Look on the AL website, *www.astroleague.org,* for these helpful Astronomy Day materials: the Astronomy Day Handbook and outreach downloads. Astronomy Day will be held on May 2 and September 26, 2020. Showcase your group's special AD activities and apply for the awards by contacting Gary Tomlinson at *gtomlins@sbcglobal.net*.

MABEL STERNS AWARD

The newsletter editor performs the primary function of informing astronomy club members about what is happening in their club. Often the editor is forced to become quite creative in filling the allotted space for each issue when the call for articles does not quite fill up the publication. In acknowledgement of the important role of the newsletter editor, the Astronomical League established the Mabel Sterns Newsletter Award in 1988 to recognize these essential people.

The award is named in honor of the first newsletter editor of the League, Mabel Sterns, who served in that capacity from 1948 to1952. To qualify, club presidents should email a copy of the designated issue of the club's newsletter as a PDF file to *sternsnewsletter@astroleague.org,* along with a cover letter of recommendation (also as a PDF) that includes the postal address of the nominee. In addition, a photo of the newsletter editor, preferably in an astronomical setting, should be sent electronically in JPEG format to the same email address. All items are due by March 31, 2020. The names of both the newsletter editor and the nominating club officer must appear on the general membership roster of the League. The deadline is March 31, 2020.

ASTRONOMICS SKETCHING AWARD

We are happy to say that the art of sketching seems to be creating more interest in astronomy. Sketching the impression of a celestial scene allows an observer to see more detail and to better enjoy our amazing avocation.

The League's Astronomics Sketching Award provides cash awards for first place ($250), second place ($125), and third place ($75). Spectific details can be found at *astroleague.org/al/*

awards/awards.html. This program is made possible by the generosity and vision of Astronomics, *astronomics.com*. The deadline is March 31, 2020.

—Carroll Iorg

All Things Astronomical

REVEALED: EXOPLANET'S "IMPROBABLE" SURVIVAL

Using asteroseismology, a team including an astronomer from the University of Warwick revised the parameters for two red giant stars known to host exoplanets, and discovered that one of these planets simply should not exist in its current location based on our current theories.

Asteroseismology is the study of stellar interiors by measuring seismic oscillations at the star's surface. In seismology, the different vibration modes from an earthquake can be used to study the Earth's interior, in order to get data from the composition and depth of its different layers. In a similar fashion, oscillations at a star's surface can be used to infer the internal structure and composition of a star.

Using asteroseismic data from NASA's Transiting Exoplanet Survey Satellite (TESS), an international team led by the Instituto de Astrofísica e Ciências do Espaço studied the red giant stars HD 212771 and HD 203949. These are the first detections of oscillations in previously known exoplanet-host stars by TESS. The result was published in an article in *The Astrophysical Journal*, available at *dx.doi.org/10.3847/1538-4357/ab44a8.*

Lead author Tiago Campante (Universidade do Porto) explains that detecting these oscillations was only possible because "TESS observations are precise enough to allow measuring the gentle pulsations at the surfaces of stars. These two fairly evolved stars also host planets, providing the ideal testbed for studies of the evolution of planetary systems."

Having determined the physical properties of both stars (such as their mass, size, and age) through asteroseismology, the authors then focused their attention on the evolutionary state of HD 203949. Their aim was to understand how its planet could have avoided being engulfed, since the outer atmosphere of the star would have expanded well beyond the current planetary orbit during the red-giant phase of evolution.

Based upon extensive numerical simulations performed by Dr. Dimitri Veras from the University of Warwick's Department of Physics, the team thinks that star–planet tides might have migrated the planet inward from its original, larger orbit, placing it where we see it today.

Dr. Veras said, "We determined how this planet could have reached its current location, and to do so whether or not the planet had to survive engulfment within the stellar envelope of the red giant star. The work sheds new light on the survivability of planets when their parent stars begin to die, and might even reveal new aspects of tidal physics."

Co-author Vardan Adibekyan (Universidade do Porto) comments, "This study is a perfect demonstration of how stellar and exoplanetary astrophysics are linked together. Stellar analysis seems to suggest that the star is too evolved to still host a planet at such a 'short' orbital distance, while from the exoplanet analysis we know that the planet is there!"

Adibekyan adds "The solution to this scientific dilemma is hidden in the 'simple fact' that

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stars and their planets not only form but also evolve together. In this particular case, the planet managed to avoid engulfment."

In the past decade, asteroseismology has had a significant impact on the study of solar-type and red giant stars, which exhibit convection-driven, solar-like oscillations. These studies have advanced considerably thanks to space-based observatories like CoRoT (CNES/ESA) and Kepler (NASA), and are set to continue in the next decade with TESS and PLATO (ESA).

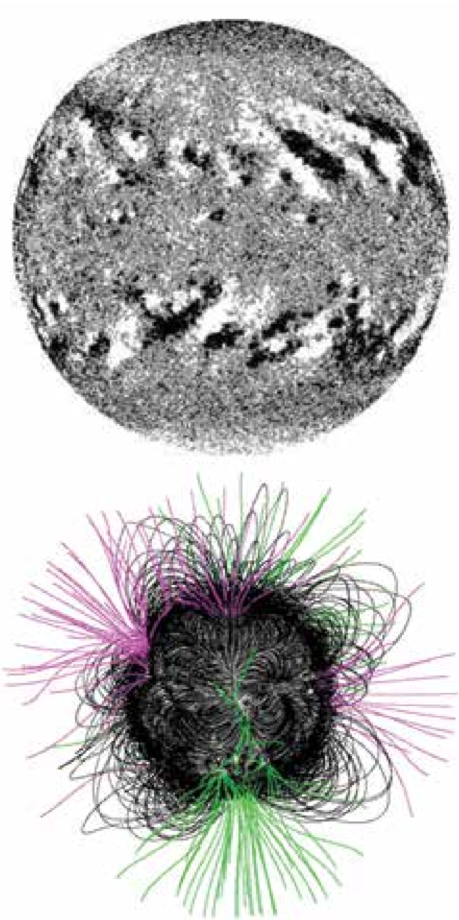
—University of Warwick Press Release

EVEN 'GOLDILOCKS' EXOPLANETS NEED A WELL-BEHAVED STAR

An exoplanet may seem like the perfect spot to set up housekeeping, but before you go there, take a closer look at its star. Rice University astrophysicists are doing just that, building a computer model to help judge how a star's own atmosphere impacts its planets, for better or worse. By narrowing the conditions for habitability, they hope to refine the search for potentially habitable planets. Astronomers now suspect that most of the billions of stars in the sky have at least one planet. To date, Earth-bound observers have spotted nearly 4,000 of them.

Lead author and Rice graduate student Alison Farrish and her research adviser, solar physicist David Alexander, led their group's first study to characterize the "space weather" environment of stars other than our own to see how it would affect the magnetic activity around an exoplanet. It's the first step in a National Science Foundation-funded project to explore the magnetic fields around the planets themselves.

"It's impossible with current technology to determine whether an exoplanet has a protective magnetic field or not, so this paper focuses on what is known as the asterospheric magnetic field," Farrish said. "This is the interplanetary



A stellar flux transport simulation, top, shows positive (white) and negative (black) magnetic polarity on the surface of a star. At bottom, associated coronal magnetic field lines show outward (magenta) and inward (green) lines that extend into interplanetary space, forming the magnetic field of the inner asterosphere, while those in black represent closed lines with ends rooted in the stellar photosphere. Researchers at Rice University used the models to help determine that some exoplanets may not be habitable despite having orbits in the so-called "Goldilocks" zones around their stars. (Credit: Alexander Group/ Rice University)

extension of the stellar magnetic field with which the exoplanet would interact."

In the study published in *The Astrophysical Journal,* the researchers expand a magnetic field model that combines what is known about solar magnetic flux transport – the movement of magnetic fields around, through and emanating from the surface of the Sun – to a wide range of stars with different levels of magnetic activity. The model is then used to create a simulation of the interplanetary magnetic field surrounding these simulated stars. In this way they were able to hypothesize the potential environment experienced by such "popular" exoplanet systems as Ross 128, Proxima Centauri and TRAPPIST 1, all dwarf stars with known exoplanets.

No star is ever still. The plasma at its surface is constantly churning, creating disturbances that send strong magnetic fields (like those embedded in the Sun's solar wind) far into space. Earth's own magnetosphere helps make it a safe harbor for life, but whether that is the case for any exoplanet remains to be determined.

"To most people, a 'habitable zone' planet traditionally means it has just the right temperature for liquid water," Farrish said. "But in these specific systems, the planets are so close to their stars that there are other considerations. In particular, the magnetic interaction becomes very important."

These "Goldilocks" planets may enjoy temperatures and atmospheric pressures that allow life-giving water to exist, but likely orbit too close to their stars to escape the effects of the star's strong magnetic fields and the associated radiation.

"Depending on where it is within the extended magnetic field of the star, it is estimated that some of these habitable zone exoplanets could lose their atmospheres in as little as 100 million years," Alexander said. "That is a really short time in astronomical terms. The planet may have the right temperature and pressure conditions for habitability, and some simple lifeforms might form, but that's as far as they're going to go. The atmosphere would be stripped and the radiation on the surface would be pretty intense.

"When you don't have an atmosphere, you now have all the ultraviolet and X-ray emission from the star on top of the particle emission," he said. "We want to understand this interaction better and be able to compare it with observations in the future. And the ability to direct and define the nature of these future observations will be really helpful."

Read the abstract at *iopscience.iop.org/article/10.3847/1538-4357/ab4652.*

—Rice University Press Release

ALCon 2020

ALCon 2020 will be hosted by the Albuquerque Astronomical Society, July 16-18, 2020. Accommodations will be at the Embassy Suites Hotel, $129/night, single or double. All rooms are two-room suites with complimentary Wi-Fi, a complimentary cook-to-order breakfast, and a complimentary evening reception. The AL council will meet July 15, conference days will be July 16 and 17, and a tour of the Very Large Array is scheduled for July 19.

GALLERY

MEMBER ASTROPHOTOGRAPHS

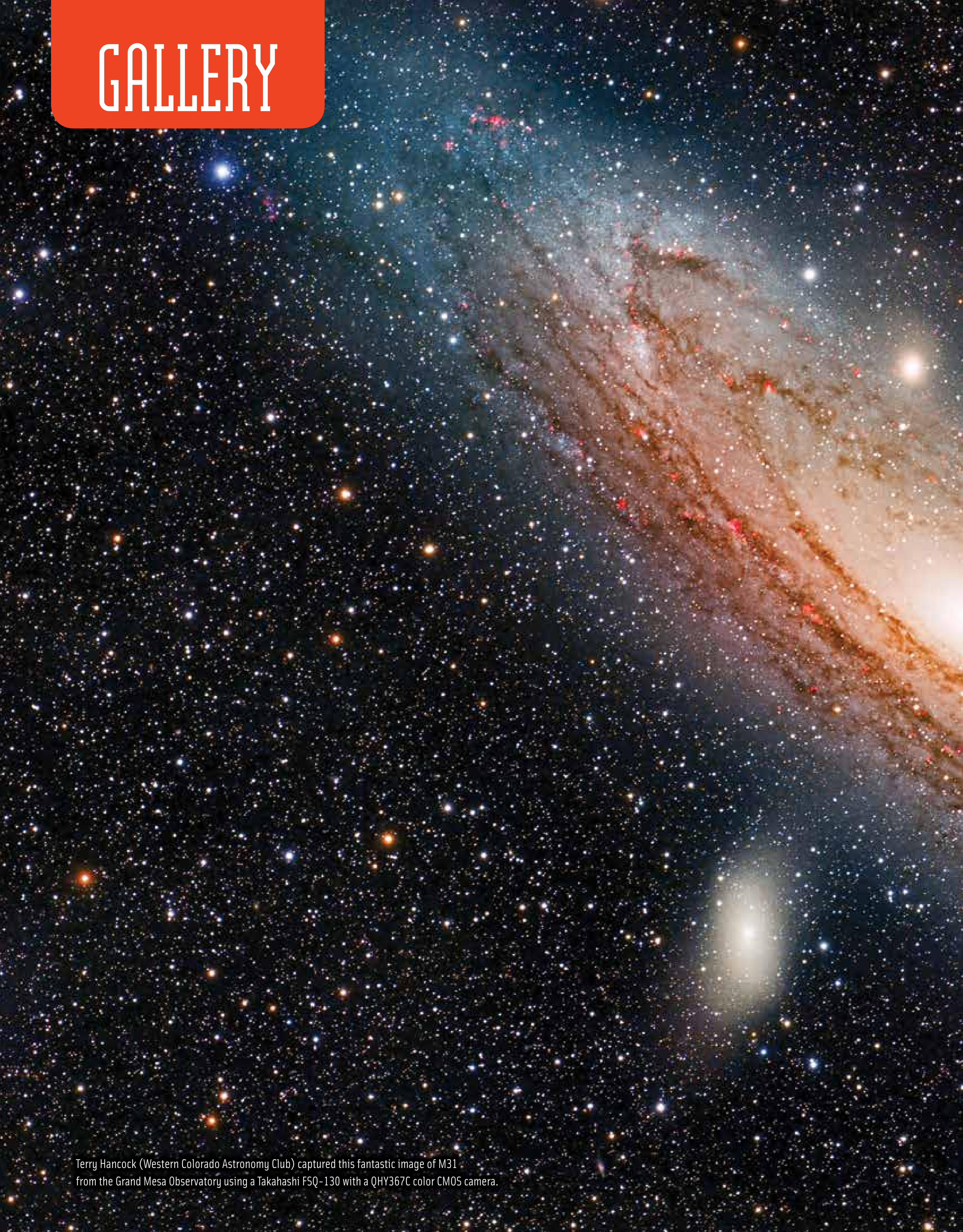
All photos © 2019 by their respective creators.

(Left) **Frederick Steiling** (Astronomical Society of Eastern Missouri) captured this lunar ISS transit on September 11, 2019, from Broemmelsiek Park using ASEM's Celestron C14 (f/11 at 3910 mm) with a ZWO ASI174MM camera.

(Below) **Gregg Ruppel** (Tucson Amateur Astronomy Association) captured this image of vdB 107 from his remote observatory at DSNM in Animas, New Mexico, with an ASA 10N f/3.8 Astrograph with a SBIG STL-11000M CCD camera.

(Opposite Page) **Jim Thommes** (San Diego Astronomy Association) captured this image of the Main Serpens Cloud star-forming region (LBN 583) from his DAA Observatory using a Takahashi FSQ-106N at f/5 with an ATIK 383L camera.

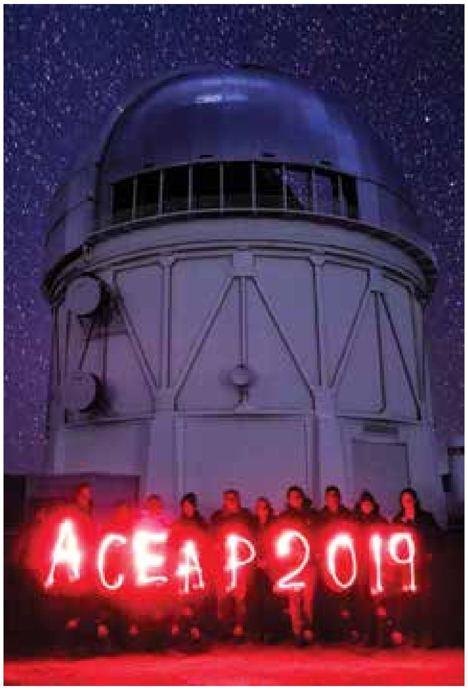
GALLERY



Terry Hancock (Western Colorado Astronomy Club) captured this fantastic image of M31 from the Grand Mesa Observatory using a Takahashi FSQ-130 with a QHY367C color CMOS camera.

Chile: Connecting to the Cosmos

by Carla Johns



The 2019 ACEAP cohort stands in awe in front of the Victor Blanco Observatory, Cerro Tololo. Photo by L. Sparks (ACEAP/NSF)

Northern Hemisphere amateur astronomers dream of experiencing the skies in the Southern Hemisphere. The Southern Cross, Omega Centauri, Alpha Centauri, Eta Carinae, the Jewel Box cluster – the observing list is vast and virtually endless. The eclipse chasers amongst us flock to South America in droves to see the Moon block the Sun for a precious few minutes. Chile was especially lucky to fall in the path of totality in 2019 and again on December 14, 2020. As Chile continues to roll out its red carpet to the world, many people are unaware of the significant commitment the Chilean government, research community, and science educators have made to increase everyone's chance to connect with the universe.

Chile's geography has made it one of the most attractive places in the world in which to build observatories. A long, narrow country, Chile would stretch from California to the Atlantic seaboard if tilted horizontally. Chile is bordered on the west by the vast Pacific Ocean and on the east by the Andes, the longest mountain range on Earth. To understand the climatic diversity of Chile, envision flipping the state of California on its head. In the central region, the temperate Mediterranean climate prevails. The southern areas of Chile are moist, forested coastal landscapes – much like northern California – with mountains and glaciers that give way to tundra and to the grassy plains of Patagonia. Northern Chile mirrors southeastern California's dry desert landscapes; however, the extreme elevations in this region produce the highest, driest desert plateau in the world, the Atacama Desert. Sandwiched between the Chilean Coastal Range to the west and the Andes to the east, this exceptionally arid region is host to a virtually constant temperature inversion. Average rainfall is typically less than half an inch per year, and some areas have never recorded any rain.

Traveling throughout Chile as a part of the Astronomy in Chile Educator Ambassadors Program (ACEAP) was a gift beyond measure. Supported by the National Science Foundation (NSF), Associated Universities (AUI) collaborates with the National Radio Astronomy Observatory, Association of Universities for Research in Astronomy (AURA), National Optical Astronomy Observatory, and Gemini South Observatory to give amateur astronomers, observatory and planetarium professionals, K–16 teachers, and informal astronomy educators an opportunity to visit U.S.-funded facilities in Chile. Members of our cohort received a firsthand look at the extensive astronomy infrastructure in place, as well as the new facilities under construction.

As one would expect, the skies of the dry climate of the northern Andes are exquisite. As a result, many *observatorios turisticos* (tourist observatories) welcome people from across the globe and serve as educational hubs for local schools and communities. Observatorio Astronómico Andino (OAA), a short drive from Santiago, offers tourists the opportunity to view the night sky. They also provide businesses with a unique setting to hold workshops. Local graduate students share their research and expand public outreach in the area. With multiple telescopes and inviting decor, OAA reminded me of the Colorado Plateau and southwestern United States.

The "mushroom farm," dormitory, and casino cafeteria at CTIO. Photo by C. Johns (ACEAP/NSF)

The exquisite southern sky above Cerro Tololo. Photo by R. Pettengill (ACEAP/NSF)

Alfa Aldea Centro Astronómico sits in the Elqui Valley of the Coquimbo Region, not far from La Serena. Astrotourism rises to the next level here with a vineyard, brewery, lodging, dining facilities, telescopes, and a spectacular view of the mountains where Cerro Pachón majestically rises with the Gemini South Observatory, SOAR telescope, and the Large Synoptic Survey Telescope in view.

Alfa Aldea welcomes tourists and provides educational opportunities to the local community and schools. In an effort to expand their reach and streamline their programs, they partnered with the talented team from AURA. Leonor Opazo, AURA's outreach manager, provides guidance on implementing new educational initiatives and activities to enhance public outreach efforts and educational development across the region.

Within the Coquimbo Region and just an hour south of Alfa Aldea, the mountains of Cerro Pachón and Cerro Tololo rise above the valley. Both were identified as prime spots to build observatories in the early 1960s. *Cerro* means hill in Spanish, but these sites are so much more. The flora is sparse and the fauna far between. Except for an inquisitive Andean fox, rare puma sighting, and difficult-to-identify birds in the one blossoming cherry tree, geology dominates the landscape. Resourceful engineers crushed the light-colored volcanic rock and placed it around the bases of the observatories to regulate their temperatures.

Working in these remote locations and harsh environments requires a resilient spirit and passionate soul. Oftentimes, the UV radiation index used to forecast the strength of the Sun's ultraviolet radiation hits 11+, indicating an extreme risk of harm from unprotected exposure. Further to the north in the Atacama Desert, readings as high as 25 are not uncommon due to the towering elevation, high altitude of the Sun in tropical regions, and low ozone levels.

The extreme nature of this region is exactly why astronomy flourishes. The summit of Cerro Pachón has some truly exquisite astronomical facilities. AURA's Gemini South Observatory has an 8.1-meter telescope, with its northern twin on Mauna Kea in Hawaii. These telescopes watch the sky in the optical and infrared wavelengths, and have produced tremendous amounts of data over twenty years of operation. Additionally, they have the capacity to observe time-critical events with only a few minutes of warning. One of the newer instruments on Gemini South is the Gemini Planet Imager, which uses extreme adaptive optics to find exoplanets and protoplanetary disks around stars. Both twin telescopes can be remotely operated from base facilities in La Serena, Chile, and Hilo, Hawaii, thus reducing the environmental impact of these remote facilities.

Not far from the silver dome of Gemini South sits the NOAO's Southern Astrophysical Research Telescope, known as SOAR. This 4.1-meter scope works from 320 nm to the near infrared. Upon entering the observatory, the flags of SOAR's international partners are proudly displayed around the pier. When SOAR utilizes its adaptive optics module, it can achieve images of 0.25-arcsecond resolution, rivaling the image quality of the orbiting Hubble Space Telescope.

Also perched on the mountain is the NSF-funded Large Synoptic Survey Telescope (LSST), soon to see first light. This telescope will produce the deepest, widest images of our universe with an 8.4-meter mirror and a 3,200-megapixel camera – the world's largest digital camera. They anticipate collecting 15 to 30 terabytes of data every night! The tele-

The Large Synoptic Survey Telescope takes shape to the right on Cerro Pachón as the Gemini South Observatory, to the left, watches its soon-to-be neighbor. Photo by C. Johns (ACEAP/NSF)

Nothing but Andes as far as the eye can see from Cerro Tololo at sunset. Photo by C. Johns (ACEAP/NSF)

scope mount assembly, which will support the mirrors, cameras, and subsystems, arrived in September 2019. When the telescope comes online in fall 2022, the most pressing questions of our time will be addressed, including a deeper understanding of dark matter and dark energy, identifying potentially hazardous asteroids in our neighborhood, and an extensive investigation into the structure and formation of the Milky Way. Plus, the powerhouse imaging capability will reveal answers to questions now unknown by imaging "the entire visible sky every few nights" according to *lsst.org*. Truly amazing!

About five miles as the crow flies from Cerro Pachón is the Cerro Tololo Inter-American Observatory (CTIO), a huge complex of telescopes that made me swoon every time I gazed upon the mountaintop adorned with domes. Our cohort was thrilled to spend almost three days at CTIO and live with the dedicated team of hyper-focused staff members and visiting researchers.

The largest telescope at CTIO is the famous 4-meter Víctor M. Blanco Telescope, completed in 1976 and managed by NOAO; it was the largest optical telescope in the southern hemisphere until 1998. Now equipped with the Dark Energy Camera (DECam), the Blanco continues to be a workhorse, investigating large-scale structures and the expansion of the universe. Dr. Kathy Vivas, an associate astronomer at CTIO, is studying the Sagittarius stream and the Milky Way's interaction with small and large galaxies with DECam. By studying RR Lyrae stars and dwarf Cepheid stars, she investigates the halo surrounding our galaxy. Pulling back the curtain to our galaxy's formation, her work is giving us new insights into the universe.

The 4-meter Blanco is one of almost twenty observatories on the mountain. One area is affectionately known as the "mushroom farm" due to the many domes clustered together. These include the Small and Moderate Aperture Research Telescope System (SMARTS) consortium, which operates the 1.5-meter, 1.3-meter, 1-meter, and 0.9-meter telescopes. In addition, the Las Cumbres Observatory Telescope Network, 2MASS, S-MAPS, and additional research projects are all located at Cerro Tololo.

In addition to the in-depth tours of the observatories of CTIO, we were treated to two nights of observing with Juan Seguel from the outreach team. He generously showed us the wonders of the southern sky with his telescope. After being completely gobsmacked, I finally lied down on the concrete between the large domes and stared into the night. The view of the Milky Way overhead with Jupiter and Saturn at the zenith, the LMC and SMC circling the southern pole, Crux to the south, and the False Cross on the horizon were all burned into my retinas and reappear whenever I close my eyes. To awaken after a night of observing atop Cerro Tololo is to truly be alive.

At this point during the expedition, one would think it couldn't get better, but it did! Our cohort visited the highly acclaimed ALMA, the Atacama Large Millimeter/sub-

The Atacama Large Millimeter/submillimeter Array (ALMA) at 16,500 feet above sea level with penitentes

millimeter Array. The 16-kilometer array sits on the Chanjnantor Plateau – which means “place of flight” in the Kunza language – at an elevation of almost 16,500 feet above sea level. This spectacular Mars-like region is surrounded by volcanoes and is home to vicuñas (small camelids), donkeys, vizcachas (small rabbits) and Milu the dog, the official greeter at the first checkpoint below the plateau.

As we drove towards the high-altitude site to see the array in action, Valeria Foncea, education and public outreach officer for ALMA, shared her love of the land and excitement about the research being conducted. As we climbed higher onto the plateau, the ever-deepening blue sky was the only reminder that we were still on Earth and not Mars. At the top, the plateau is surrounded by peaks and volcanoes (some of which are dormant), and the UV radiation is off the charts.

The array consists of sixty-six antennas, fifty-four 12-meter dishes and twelve 7-meter antennas, which all work in unison and collect radio waves from the cold, distant universe. ALMA is a partnership between the Republic of Chile, the European Southern Observatory, the (U.S.) National Science Foundation, and the National Institutes of Natural Sciences of Japan, with additional partners in Canada, Taiwan, and South Korea. Despite four different antenna designs from North America, Europe, and East Asia, all met the required specifications and work together perfectly. Each antenna was crafted with such precision that its parabolic surface remains uniform over its entire surface to better than 12 microns (a fraction of the width of a human hair). Each antenna’s receiver is chilled to a few degrees above absolute zero, which suppresses unwanted noise. These 100-ton antennas are moved into different configurations by two transporters named Otto and Lore, weighing 130 tons each. To observe large-scale features, the antennas are moved close together, and the highest resolution is achieved when they are arranged far apart. When an antenna needs to be repaired, it slowly descends the plateau to the Operations Support Facility aboard a transporter moving less than 7 miles per hour.

Dr. Paulo Cortes searches for our cosmic origins with ALMA by investigating pre-biotic molecules in solar-type protostars. Additionally, he has an insatiable curiosity about the formation of molecular clouds, interacting galaxies, and galactic evolution. Originally, Paulo had planned on a career as a truck driver, but a physics teacher mentored him after school and he became a software engineer. He now studies the universe and shares his findings with unrivaled excitement. Everyone has an unusual path to ALMA, which acts very much like a magnet, drawing talented minds together and propelling research forward in leaps and bounds.

There is much more to see in Chile, including the La Silla Observatory, Paranal Observatory, Las Campanas Observatory, and many more *observatorios turisticos*. Astronomy is thriving in Chile through the government’s continued commitment to the research community. Recently, Chilean president Sebastián Piñera signed a decree to limit light pollution across the entire country. The International Dark Sky Association had previously (in 2015) designated the AURA site, which includes Cerro Tololo and Cerro Pachón, as the first International Dark Sky Sanctuary in the world. It was officially named the Gabriela Mistral Dark Sky Sanctuary, honoring the famous Chilean poet and first Latin American author to receive a Nobel Prize in Literature.

Dr. Luis Chavarría, director of the Astronomy Program at the National Commission for Scientific and Technological Research within Chile’s Science, Technology, Knowledge, and Innovation Ministry, was excited to share with us that by 2022, seventy percent of the optical and infrared telescopic collecting power in the world will be located in Chile. Ten percent of the time on the observatories will continue to be allotted to Chilean astronomers.

Interest in science, technology, engineering, and math (STEM) careers, and astronomy in particular, continues to grow. Currently, fifteen universities have astronomy programs and countless more offer STEM-related degree programs that are critical to Chile’s research effort and infrastructure. Astronomy and physics are taught at an early age at private, subsidized, and municipal schools. Students also have many informal learning opportunities through which to discover the world and the cosmos around them during the national Día de las Ciencias. Chile has a clear picture of its future, and astronomy is a key component to its continued economic growth.

Until the universe affords me another trip to Chile and a double-dip into my bucket list, my reminisces of the people, landscapes, observatories, and magnificent skies of Chile will be eternally intertwined with the lyrics of “Southern Cross” by Crosby, Stills & Nash. *“When you see the Southern Cross for the first time, you understand now why you came this way.”* Have you added Chile to your bucket list yet? ★

in the foreground and the Atacama Compact Array to the right. Photo by C. Johns (ACEAP/NSF)

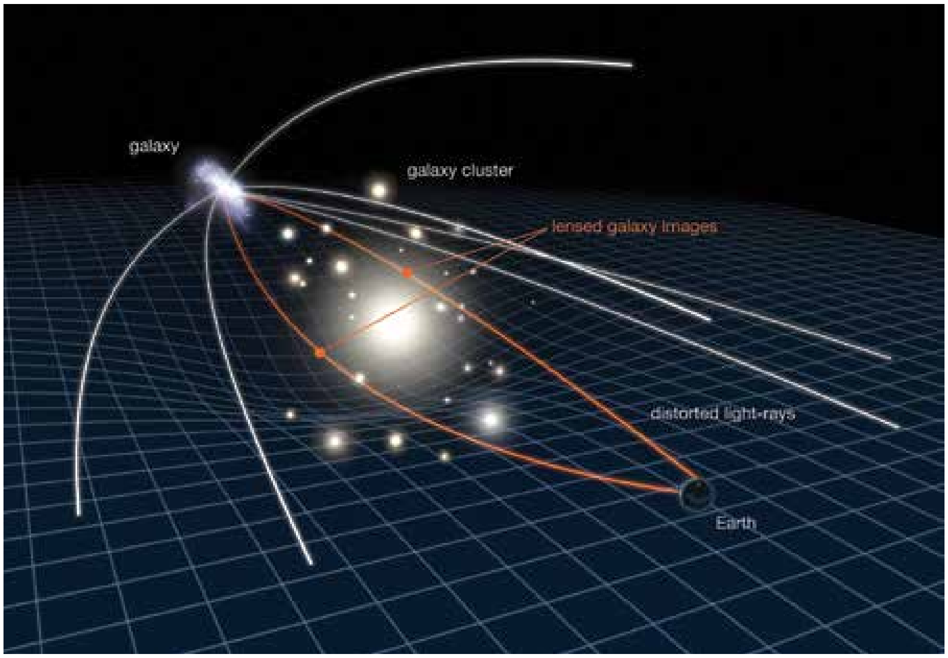
Gravitational Lenses

By Dave Tosteson

I have a bent for bent light.

Light can be redirected in several ways after it leaves its source and before it reaches us. Diffusion, reflection, refraction and reradiation are a few. Rainbows, Earthshine, haloes, sun pillars, and the green flash display the variety of forms light can take toward our eyes. At night, if we look very carefully, we can glimpse a unique type of redirection: light whose path has been altered by the very fabric of spacetime.

Einstein was the first to imagine, recognize, and formalize how matter affects light. The gravity of massive objects like stars and galaxies alters the path of light rays skimming their edges in an amount measurable from Earth under the right conditions. He attained overnight fame after his 1915 general theory of relativity's prediction about this alteration was confirmed by Sir Arthur Eddington's research at the total solar eclipse of 1919. According to Jürgen Renn of the Max Planck Institute for the History of Science, some of Einstein's notes suggest he was considering the separate lensing effect of gravity as early as 1912, but it was not until 1936 that he published an article in *Science* outlining his thoughts. Tilman Sauer, senior editor of the *Collected Papers of Albert Einstein,* provides a concise history of the events surrounding these ideas. A geometric lens, where an intervening mass diverts light onto a different path, creates the effect of a distant point source apparently being split into two or more components. Einstein seems to have considered such an effect unobservable given the limited understanding at that time of potential light sources and their distances, which may explain his reluctance to publish it. Recall that the discovery of quasars was half a century away, and that a mature understanding would take decades. Several other physicists and astronomers, including Eddington, published papers about gravitational lensing in the years after the general theory was out but, according to Sauer, "all authors agreed that the phenomena would not be observable – that there was no chance for a terrestrial astronomer to find a gravitational lens in the sky."



Gravitational Lensing. Illustration credit: NASA, ESA & L. Calçada

Since quasars figure so prominently in the history of gravitational lenses, the discovery of the first one bears repeating. Radio sources had been published since the early 1950s, but in 1959 Maarten Schmidt of Caltech pondered one particular object in Virgo with unrecognizable spectral features. 3C 273 was apparently unlike anything he or his colleagues had seen, and it took a feat of remarkable insight, a spectral paradigm shift if you will, to interpret its lines as normal features moved far into the red end of the spectrum. Such a redshift for what appeared as but now could not have been a star had not been understood before Schmidt's eureka moment, and his *Nature* article landed him on the cover of *Time* magazine. This redshift of 0.158 meant the object was 2.4 *billion* light-years away and had to be producing light and energy at an unprecedented level to be 13th magnitude. The idea of a central black hole accumulating material into an accretion disk and emitting tremendous amounts of energy as an active galactic nucleus evolved from this research.

English astronomer Dennis Walsh's PhD work at the University of Manchester's Jodrell Bank Observatory would become an important part of the history of discovery in gravitational lensing. His early association with that group in the mid-1950s would help him, two decades later, to follow up the Jodrell

Bank 966 Mhz radio survey by using optical telescopes to identify and study their sources. With images and data from the 2.1-meter telescope at Kitt Peak, he and his team noted two quasars in Ursa Major that were not only very close in position, but whose spectra and redshifts were nearly identical. In their 1979 *Nature* article they offered "the possibility that they are two images of the same object formed by a gravitational lens." What they called B0957+561 A and B would later be christened the Twin Quasar. A surrounding galaxy cluster was found on deeper optical images, whose gravity caused the lensing.

In 1992 I attended the Texas Star Party, and significant excitement among some observers attracted my attention. Stephen O'Meara had brought a finding chart and information about the Twin Quasar, and he and Ed Boutwell had just visually split the object in Ed's 25-inch reflector. Though I had been observing for several years, this category of astrophysical significance eclipsed anything I had previously seen, and it sparked both aperture fever and an enduring interest in pursuing arcane targets. Looking back, that single observation likely bent my observing path more than any other. For amateurs, this 16.7-magnitude object with a separation just under 6 arcseconds should be visible in excellent conditions using 15-inch scopes at higher power. In 2009 I was able to split a similar lens called HE 1104-1805 only half as wide (3 arcseconds) using my 32-inch scope at 363x in fair conditions. The difference in brightness between the magnitude 16.7 and 18.6 components increased the challenge.

Scientists distinguish two main types of lensing of light: strong and weak. Strong lensing produces split images, as in the Twin Quasar or the arcs seen within Abell galaxy clusters. Weak lensing is more subtle. The mysterious dark matter that dominates the mass of the Universe changes the shape and observed projection angles of background galaxies, as the galaxies' light passes through a galaxy cluster's density variations. Once astronomers knew what to look for, the door was open to finding more examples of lensing, and amateurs were beneficiaries of this research. One of the most famous lensing examples visible in amateur telescopes is the object called Einstein's Cross, or Q2237+030. This quasar is situated eight billion light-years away and sits directly behind the 15th-magnitude galaxy CGCG 378-15. Located 400 million light-years away in southern Pegasus, the lensing spiral is nicknamed Huchra's Lens after the late John Huchra of the Harvard-Smithsonian Center for Astrophysics. The quasar's four components of 17th to 18th magnitude at the very core of the tilted galaxy are in a nearly square arrangement only 1.6 arcseconds across. I have observed it multiple times in my 32-inch reflector, and excellent seeing is needed to split the images. I have seen two of the images several times, and likely saw three once. I have never done what my friend Jimi Lowrey accomplished with his 48-inch reflector: see all four components simultaneously. PG 1115+080 near Leo's back foot is similar to Einstein's Cross, but in a tighter and less symmetric configuration, reflecting the differences in geometry and gravitational power between the systems. I have observed it once each in my 25- and 32-inch reflectors, but I have not split the components.

"Einstein's Cross." Credit: NASA /Hubble

If the 1990s offered a trickle at what lay hidden in the Universe of gravitational guises, then the first decade of the new millennium would deliver a deluge of new lenses. Many of these came from a single source called the Sloan Digital Sky Survey, or SDSS. Its relatively small 2.4-meter reflector at Apache Point, New Mexico, scanned a quarter of the sky away from the plane of our galaxy in five wavelengths, and produced an order of magnitude improvement in data over the best previous survey (Palomar in the 1950s, updated during the 1990s). One of its new lenses was found by Håkon Dahle and colleagues in 2012: SDSS J2222+2745, a *sextuply* imaged quasar with a redshift of 2.82 and a maximum image separation of 15.1 arcseconds. Found in the Sloan's Giant Arcs Survey, this was only the third case found where a quasar was apparently split by the gravity of a galaxy cluster. I was able to see its six quasar components and lensing galaxies (magnitudes 21 to 22) as only one unsplit, nonstellar, and slightly irregularly shaped group in my 32-inch in 2014 and 2016.

In the mid-2000s, Sloan produced two discoveries of objects in rapid succession that eclipsed the lensing separation record held by the Twin Quasar for a quarter century. Reported by Naohisa Inada and colleagues in 2003, SDSS J1004+4112 is a multiply lensed quasar with a split of 14.62 arcseconds between its widest components, more than twice the previous record of separation. Hubble's tremendous color rendering quickly became my favorite deep-sky image. The four stellar, slightly asymmetrically patterned quasar images (redshift of 1.734), with a fifth later discovered hovering just outside the lensing galaxy's core, framed the elongated elliptical and its faint, stringy jet. They sat within a dense and richly varied galaxy cluster at redshift 0.68. Infrared arcs circumferentially extending from the outer quasar images confirm the source quasar is part of a galaxy. Presumably, a "naked" quasar such as HE 0450-2958, the jettisoned core of an interacting galaxy pair, would lack such arcs. At the 2005 Texas Star Party, I used my 25-inch f/5 reflector to spot the A and C components, magnitudes 18.5 and 19.4 respectively, though I saw none of the cluster's galaxies. In the future I hope to spy all four quasar components together in my 32-inch, though the central cD galaxy's 6.3-billion-year-old light is likely too faint.

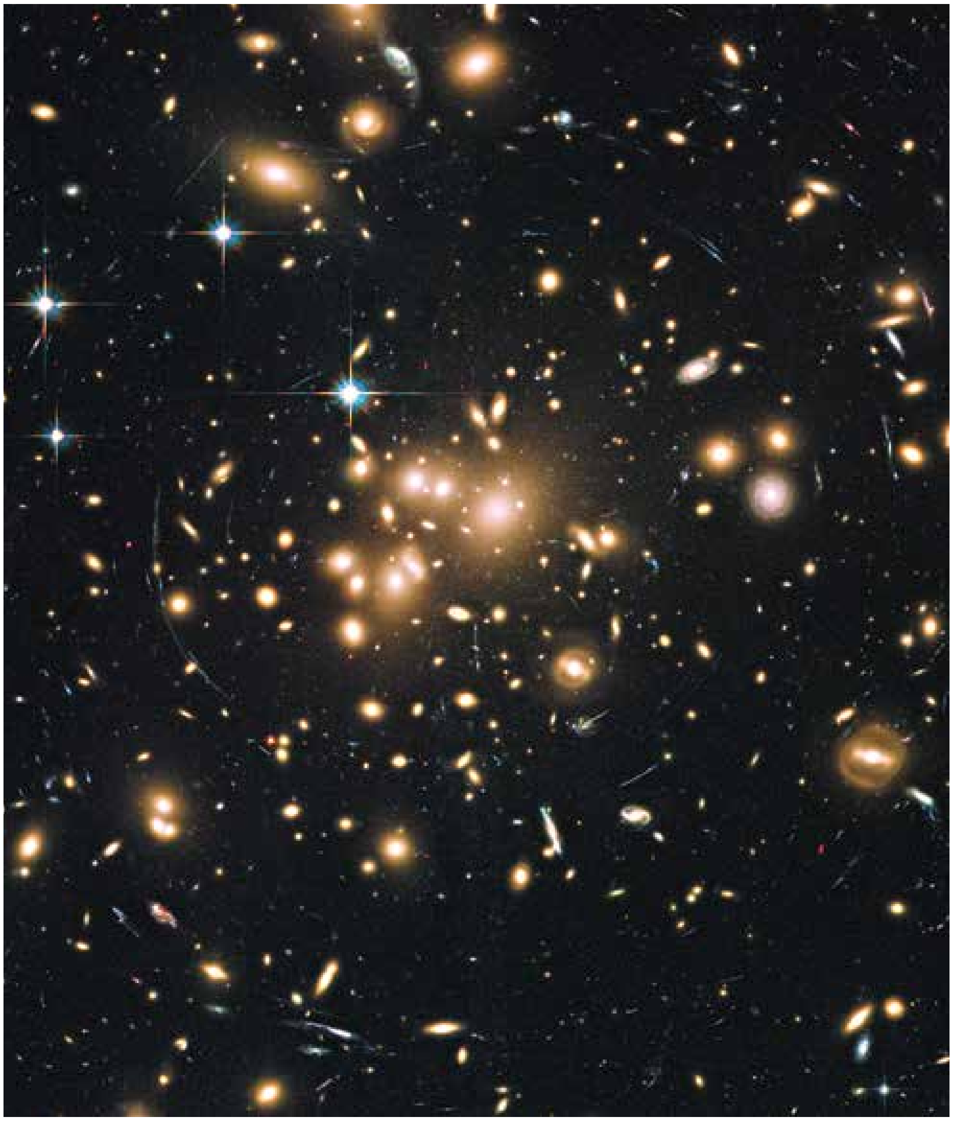
In late 2006, Inada and colleagues reported the discovery of another lensed quasar with a separation of 22.5 arcseconds. This was the widest known at the time, and is a record maintained in over 130 lensed quasars catalogued as of 2015. It was named SDSS J1029+2623 after its Sloan coordinates in northern Leo, and carried a redshift of 2.197, implying about 10 billion years of light travel time. The lensing galaxy cluster showed multiple areas of substructure and was at a redshift of 0.55, or about half the distance of the quasar. Its two main components, A and B, have similar magnitudes of about 18.75 in the red, and show a time delay separation of 744 days. In May 2015, I brought SDSS J1029+2623 as one of my offerings to attempt in Jimi Lowrey's 48-inch telescope. I was reasonably certain I could see the quasar components in my 32-inch, so my ulterior reason to offer this to Jimi was to spot the intervening lensing galaxy cluster. I had been unable to see similar lensing galaxies for SDSS J1004+4112 in my 25-inch scope in 2005, but I felt the larger light grasp of the 48-inch may spy the cluster of SDSS J1029+2623. The night of the 16th was far from optimum, with seeing only a 3 or 4 out of 10, and transparency waxing and waning around 5 out of 10. Visual conditions were changing every few minutes.

We started with a 10 mm eyepiece giving 488x magnification. Both components of the quasar were seen with some effort and could be held with direct vision. At the increased power of 697x using a 7 mm Takahashi eyepiece, the seeing prevented more detail from being extracted. Though it was moderately windy, we decided to push to a 6 mm Zeiss Abbe Ortho. It had a narrower field of view, but compensated with increased clarity and light transmission. The slight, occasional shaking from the wind acted as a scope jiggler, a technique that an observer can use to move an object around the field of view of the observer's retina, searching for the retina's most sensitive area and taking advantage of the brain–eye motion detection capability. Our diligence was rewarded when we were able to spot the cluster's two brightest galaxies, G1 and G2, as one mass at the higher power of 813x in the Zeiss, just a few arcseconds west of the quasar images. Unlike the quasar components, the lensing galaxies were not point sources, and their extended size gave them a lower surface brightness. As we were driving home through Oklahoma the next night, Jimi texted that that sky's clarity and stability improved and views of individual galaxies in the lensing cluster were better defined.

The search for widely lensed quasars was fueled in part from a desire to determine if galactic cluster halo masses, and not just those from individual galaxies, could act as lenses. The hope was that the larger mass concentrations within clusters would produce more widely separated lenses. What was found with the two largest radio surveys (Jodrell Bank's JVAS and the Cosmic Lens All-Sky Survey, CLASS) consisting of about 15,000 sources studied by the VLA, were 22 objects with separations between 0.3 and 6 arcseconds. On follow up research, none of their 13 potential lenses with 6- to 15-arcsecond separations were confirmed. The conclusions were that groups and clusters have flatter mass distribution profiles than individual massive galaxies, and that the critical limit needed for lensing is not attained in most of them. The largest separation they found was 4.56 arcseconds in B2108+213, and though it was within a galaxy group, the inner mass profile was dominated by a single, very massive galaxy.

The bending of light has been extensively modeled to help researchers understand and predict astronomical phenomena. Objects that act as point sources, mainly quasars, can be split into multiple images, usually two or four. The relative placement and geometry of the lensing body, usually a galaxy, will determine how the images are arranged. For a perfect alignment between a point source, lens, and observer, a ring could be produced, but that is rarely seen. Since quasars are almost always associated with a host galaxy, it is their extended surrounding body that can be lensed into longer, drawn out arcs and rings, as seen in many of the Hubble Space Telescope's (HST) galaxy cluster images. PG 1115+080 was the second lensed quasar discovered, with a source split into four bright, point-like components, along with a much fainter ring from the host galaxy that connects these dots into a circle. This combination of points and dim arcs can be seen in a number of split quasars on very deep images, most notably SDSS J1004+4112.

The strongly lensed arcs that grace so many of Hubble's galaxy cluster images were called "the Holy Grail of visual observing" by Barbara Wilson. She and Larry Mitchell have been an integral part of the Texas Star Party since the mid-1980s, and their pursuit of arcane and obscure targets fueled my imagination early in my observing career. Once the HST was repaired, observers quickly started to use it to find thin, curved, and drawn-out arcs within many galaxy clus-



A portion of the Hubble image of AGC 1689 showing many strongly lensed arcs. We have applied unsharp masking to the image to help ensure that the delicate arcs make it through our printing process. To see the full image at much higher resolution, download it at hubblesite.org/image/3238/gallery. *Photo credit: NASA, ESA, B. Siana, and A. Alavi* ters, particularly those of George Abell. His eponymic, acronymic AGCs such as 1689 in central Virgo or 2218 halfway between the Little Dipper's bowl and the head of Draco displayed tantalizingly beautiful offerings for an amateur interested in spotting such wraiths. Hundreds of narrow, blue arcs can be seen in Hubble's updated 2013 image of AGC 1689. I use the Palomar Sky Survey (POSS) images as a guide to determining visibility in my 32-inch, and careful inspection in the last half of the 1990s and first half of the 2000s of all its galaxy clusters I could find with arcs did not reveal any visible candidates for observing. Exotic names such as the Lynx arc and the 8 o'clock arc caught my attention, but these gravitational mirages could not be seen. The arcs were just too faint. Sloan found complete and mostly complete rings of background light, shaped by the near perfect alignment of each observational syzygy. The object called a perfect Einstein ring, SDSS J1627-0053, was discovered in 2005, and four years later I saw its central lensing galaxy, but not the outer ring. In 2007, Raphaël Gavazzi and his team released a study of a double Einstein ring, SDSS J0946+1006, where a 3 billion light-year distant galaxy lensed two more distant galaxies 6 and 11 billion light-years away. As in the other cases, the brighter central galaxy (magnitude 17.1) could be seen, but its lensed outer arcs/rings at radii of 1.4 and 2.0 arcseconds could not.

In 2005, I found a Hubble image of AGC 370 located at a reasonable declination in northern Cetus, just 1.7 degrees south-southeast of M77. This excited me because its brightest arc was not deep blue, as almost all the others had been. The arc that is south of the central pair of cD ellipticals can be seen to show the nucleus of the lensed galaxy as a bluer portion on its western end, but the center of the extended arc was reddish, derived from the center of the background galaxy. The bluer outer layers of the arc represent the distorted image of its galaxy's distal portions. Its red and blue components offered a chance its peak luminosity would be closer to the middle, or most sensitive part, of our visual spectrum. The next year I took my charts to the 2006 Okie-Tex Star Party, where the cluster would rise to a greater height in the sky and increase my chance of observing its arc. I spent several 30- to 60-minute sessions carefully inspecting this field as it reached culmination but, though the two 19th-magnitude cD ellipticals and six to eight other galaxies within the cluster were all seen, the arc itself remained elusive. I had had a very good view in excellent conditions at a southerly site and came up empty. The two peaks of the arc's visual intensity at the ends of my retinal sensitivity did not cross the threshold of perception. I was beginning to think there would be no arc found to be visible in amateur equipment, an opinion shared by Wilson and others who had all tried for over a decade.

So sat the situation in the spring of 2007 when NASA released an HST image of a dense galaxy cluster in northern Sculptor, 1.5 degrees southeast of the point where that constellation border meets that between the Cetacean and Water Bearer. The website drew attention not to the arc of my interest, but to what they called the Comet Galaxy. The motion of this starbursting spiral was carrying it through the dense intracluster medium, compressing and igniting its gas into new star-forming regions. The ram pressure of this journey produced a tail of debris following the galaxy, reminiscent of a comet and bestowing its nickname. When I saw the image, I was immediately drawn to its thick multicolored arc on the western side that curved around its central elliptical, itself interesting for its similarity to NGC 1275 in Perseus. When I checked the POSS, that brightest portion was clearly visible on the blue plate for the northwestern part of this cluster's arc! This was the first such arc I had studied to be so, and I put this on my observing list to view from Okie-Tex, as its –26-degree declination would not allow adequate observing from Minnesota. In September 2008, I had my first chance to observe Abell 2667 at that southern star party, and I spent three nights for 30 minutes each atop my ladder using the 32-inch reflector, hand guiding at 929x. I can tell I am close to seeing something if I can successfully observe stars and objects in the field that are a magnitude or so brighter. After that amount of prolonged viewing I was certain I saw the arc several times, and felt a great sense of joy and relief. Interestingly, I have tried for it several times since then from the same site with the same equipment and have not seen it again.

Albert Einstein first imagined a Universe where light could be bent by the gravity of massive objects. He considered but never formalized strong lensing of background objects, partly because he thought it impractical. If there were no way to test a theory, he felt it had little use. His theories far outpaced the observational capabilities of his time, so it is ironic that this *relative* lack of imagination led him to predict the phenomenon was not observable, in the face of the great variety of ways we can see it today. Amateurs are fortunate to ride the curved coattails of these noble, insightful pursuits to view for ourselves the bows of gravity's reign. ★

Data:

AGC 370:
02h 39m 48s, –01d 45m 35s.

AGC 2667:
23h 51m 48s, –26d 00m 00s.

Einstein's Cross (Q2237+030):
22h 40m 30.3s, +03d 21m 31s.

HE 1104-1805:
11h 06m 33.4s, –18d 21m 23.8s.

PG 1115+080:
11h 18m 16.9s, +07d 45m 58.2s.

SDSS J0946+1006:
09h 46m 56.7s, +10d 06m 52.8s.

SDSS J1004+4112: 1
0h 04m 34.8s, +41d 12m 39.0s.

SDSS J1029+2623 (Component A):
10h 29m 13.94s, +26d 23m 17.9s.

SDSS J2222+2745:
22h 22m 08.70s, +27d 45m 33s.

Twin Quasar (Q0957+561):
10h 01m 20.9s, +55d 53m 56.5s.

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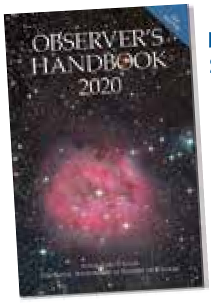

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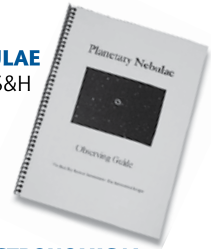

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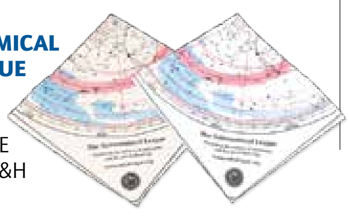

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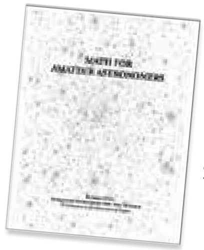

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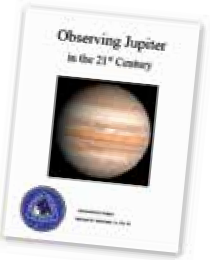

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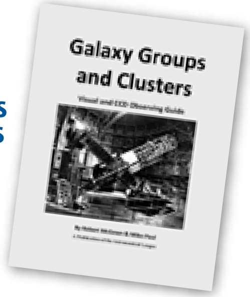

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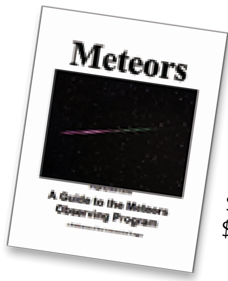

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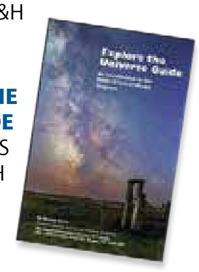

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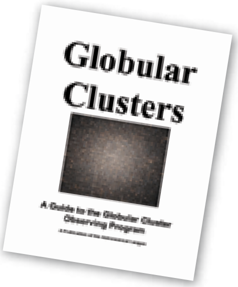

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Catawba Science Center, Hickory, North Carolina *www.catawbasky.org*

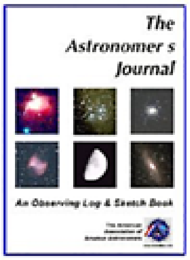
FEBRUARY 17–23
Winter Star Party
Camp Wesumkee, Florida Keys
scas.org/winter-star-party

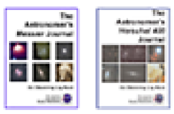
FEBRUARY 19–23
Orange Blossom Special International Star Party
Withlacoochee River Park, Dade City, Florida
www.stpeteastronomyclub.org

MARCH 21–28
The 2020 OzSky Star Safari (a.k.a. Deepest South Texas Star Safari)
Coonabarabran, New South Wales, Australia
ww.ozsky.org

APRIL 22–25
Mid-South Star Gaze and Astronomy Conference
French Camp, Mississippi
rainwaterobservatory.org/events

APRIL 24–25
North Carolina Statewide Star Party
50 public skywatching events from the North Carolina mountains to the coast
www.ncsciencefestival.org/starparty

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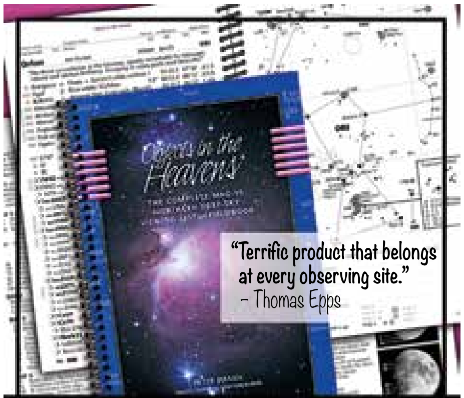

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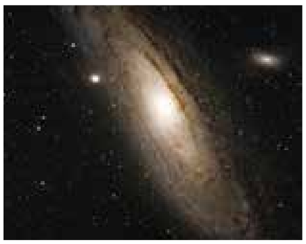
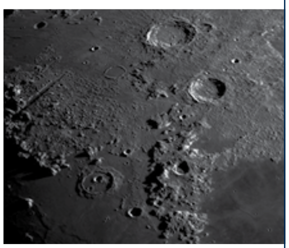
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Observing Awards

ALCon Binocular Observing Challenge

Jeffrey Moorhouse, Gold, La Crosse Area Astronomical Society; **Jason Cousins,** Silver, Amateur Observers' Society of New York; **Dawn Davies,** Silver, Austin Astronomical Society; **Derek Demeter,** Silver, Central Florida Astronomical Society; **James Dire,** Silver, Kaua'i Educational Association for Science and Astronomy; **James Ketchum,** Silver, Astronomical Society of Kansas City; **Brian Lippincott,** Silver, Austin Astronomical Society; **Kathleen Machin,** Silver, Astronomical Society of Kansas City; **David Prosper,** Silver, Member-at-Large; **George J. Robinson,** Silver, Member-at-Large; **James Small,** Silver, St. Louis Astronomical Society; **Gary Trapuzzano,** Silver, Delaware Valley Amateur Astronomers; **David Whalen,** Silver, Atlanta Astronomy Club; **Albert Ansorge,** Member-at-Large; **Laurie Ansorge,** Member-at-Large; **John Bajtelsmit,** Delaware Valley Amateur Astronomers; **Jacqueline Beucher,** Astronomical Society of Kansas City; **Isaac Broudy,** Member-at-Large; **Thomas Broudy,** Member-at-Large; **Debra Chapman,** Astronomy Club of Tulsa; **Steven Chapman,** Astronomy Club of Tulsa; **Aaron Clevenson,** North Houston Astronomy Club; **Elizabeth Davidson,** Rochester Astronomy Club; **William Davidson,** Rochester Astronomy Club; **Andy Flowers,** Tallahassee Astronomical Society; **David Godman,** Greensboro Astronomy Club; **Diane Godman,** Greensboro Astronomy Club; **John Holtz,** Amateur Astronomers Association of Pittsburgh; **Katherine Holtz,** Amateur Astronomers Association of Pittsburgh; **Angie Hutchison,** Richmond Astronomical Society; **Tyler Hutchison,** Richmond Astronomical Society; **Betty Iorg,** Astronomical Society of Kansas City; **Carroll Iorg,** Astronomical Society of Kansas City; **Charles Jagow,** Back Bay Amateur Astronomers; **Amy Lynn Johns,** Amateur Astronomers Association of Pittsburgh; **Frances Kaplan,** Brevard Astronomical Society; **James Knoll,** Tucson Amateur Astronomy Association; **Susan Knoll,** Tucson Amateur Astronomy Association; **Ron Kramer,** Astronomical Society of Las Cruces; **Albert Lamperti,** Delaware Valley Amateur Astronomers; **Marie Lott,** Atlanta Astronomy Club; **Cynthia Lynch,** Member-at-Large; **Barbara Madera,** North Houston Astronomy Club; **Ashini Modi,** Shreveport-Bossier Astronomical Society; **Ashish Modi,** Shreveport-Bossier Astronomical Society; **Kalgi Modi,** Shreveport-Bossier Astronomical Society; **Morni Modi,** Shreveport-Bossier Astronomical Society; **Jean Moorhouse,** La Crosse Area Astronomical Society; **Kevin O'Neill,** Asheville Astronomy Club; **Vadim Paley,** Amateur Observers' Society of New York; **W. Maynard Pittendreigh,** Brevard Astronomical Society; **Judith Riley,** Astronomical Society of Kansas City; **Ryan Riley,** Astronomical Society of Kansas City; **Rhodora Robinson,** Member-at-Large; **Susan Rose,** Amateur Observers' Society of New York; **James Smith,** Barnard Astronomical Society; **Shirley Smith,** Barnard Astronomical Society; **Steven Tilley,** Baton Rouge Astronomical Society; **Tracy Berlin Trapuzzano,** Delaware Valley Amateur Astronomers; **Dena Vettor,** Astronomical Society of Las Cruces; **Cynthia Wagner,** Brevard Astronomical Society; **Gary Wood,** Richland Astronomical Society; **Patricia Wood,** Richland Astronomical Society; **Susan Whitehead,** Miami Valley Astronomical Society; **Dennis Wilde,** Amateur Observers' Society of New York; **Edward Zapadka,** Amateur Astronomers Association of Pittsburgh

Arp Peculiar Galaxies Northern Observing Program

No. 93-V, **Michael Overacker,** Star City Astronomy Network; No. 94-V, **Stephen L. Snider,** Albuquerque Astronomical Society

Arp Peculiar Galaxies Southern Observing Program

No. 18-I, **Marie Lott,** Atlanta Astronomy Club

Asterism Observing Program

No. 51, **Russell F. Pinizzotto,** Southern Maine Astronomers Club

Asteroid Observing Program

No. 62, **Mark Bailey,** Gold, Member-at-Large

Beyond Polaris

No. 32, **Sharon Rigsby,** Astronomical Society of Southeast Texas; No. 33, **Laurie Ansorge,** Member-at-Large; No. 34, **Michael Grabner,** Rose City Astronomers

Binocular Double Star Observing Program

No. 36, **Charles E. Allen,** Evansville Astronomical Society; No. 37, **W. Maynard Pittendreigh,** Brevard Astronomical Society

Binocular Messier Observing Program

No. 1166, **Michael Nameika,** Colorado Springs Astronomical Society; No. 1167, **Bruce Scodova,** Richland Astronomical Society; No. 1168, **David Wickholm,** San Antonio Astronomical Association; No. 1169, **Michael Phelps,** Atlanta Astronomy Club; No. 1170, **Jim McLaughlin,** Auburn Astronomical Society; No. 1171, **Jeffrey Moorhouse,** La Crosse Area Astronomical Society; No. 1172, **Michael Keefe,** Raleigh Astronomy Club; No. 1173, **John Zimitsch,** Minnesota Astronomical Society; No. 1174, **Stephen Hildenbrandt,** Miami Valley Astronomical Society; No. 1175, **Keith Lawrence,** Vermont Astronomical Society; No. 1176, **Jason Brant Dodson,** NASA Langley Exchange Skywatchers; No. 1177, **John McLaren,** Seattle Astronomical Society; No. 1178, **Raymond David Whatley,** Northeast Florida Astronomical Society

Caldwell Observing Program

SILVER AWARDS

No. 261, **Bernard Venasse,** Member-at-Large; No. 262, **Bill Hennessy,** Neville Public Museum Astronomical Society

Citizen Science Program

No. 1, **Steve Boerner,** Member-at-Large, Variable Stars, Silver; No. 1, **Michael Hotka,** Longmont Astronomical Society, Meteors; No. 1, **Michael Hotka,** Meteors, Longmont Astronomical Society, Variable Stars, Silver; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Milky Way, Gold Class 13; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Moon Zoo, Gold Class 32; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Ice Hunters, Gold Class 101; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Andromeda Project, Gold Class 4; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Space Warps, Gold Class 138; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Sunspotter, Gold Class 2; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Planet Four Ridges, Gold Class 53; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Planet Four Terrains, Gold Class 10; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Local Group Cluster Search, Gold Class 12; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Radio Galaxy Zoo, Gold Class 6; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Galaxy Zoo, Gold Class 2; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Galaxy Zoo 3D, Gold Class 16; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Galaxy Zoo, Clump Scout, Gold Class 1; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Variable Star Zoo, Silver; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Galaxy Bars, Silver; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Supernova Sighting, Silver; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Radio Galaxy Zoo Gems, Bronze; No. 1, **Al Lamperti,** Delaware Valley Amateur Astronomers, Galaxy Zoo Mergers, Bronze; No. 1, **Aaron Clevenson,** Northern Houston Astronomy Club, Galaxy Zoo, Bronze; No. 1, **Aaron Clevenson,** Northern Houston Astronomy Club, Radio Meteor Zoo, Bronze; No. 1, **Aaron Clevenson,** Northern Houston Astronomy Club, Muon Hunters, Bronze; No. 1, **Aaron Clevenson,** Northern Houston Astronomy Club, Gravity Spy, Bronze; No. 1, **Aaron Clevenson,** Northern Houston Astronomy Club, Zwicky's Quirky Transits, Bronze; No. 1, **Aaron Clevenson,** Northern Houston Astronomy Club, Protect Our Planet From Solar Storms, Bronze; No. 1, **Aaron Clevenson,** Northern Houston Astronomy Club, Variable Star Zoo, Bronze; No. 1, **Aaron Clevenson,** Northern Houston Astronomy Club, SuperWASP Variable Stars, Bronze; No. 1, **Aaron Clevenson,** Northern Houston Astronomy Club, Planet Hunters TESS, Bronze; No. 1, **Aaron Clevenson,** Northern Houston Astronomy Club, Local Group Cluster Search, Bronze; No. 1, **Aaron Clevenson,** Northern Houston Astronomy Club, Astronomy Rewind, Bronze; No. 1, **Aaron Clevenson,** Northern Houston Astronomy Club, Backyard Worlds, Bronze; No. 1, **Aaron Clevenson,** Northern Houston Astronomy Club, Planet Hunters TESS, Silver; No. 1, **Douglas Smith,** Tucson Amateur Astronomy Association, Variable Stars, Gold Class 1; No. 1, **W. Maynard Pittendreigh,** Brevard Astronomical Society; Variable Stars, Silver

Comet Observing Program

No. 44, **Paul Harrington,** Gold, Member-at-Large; No. 45, **Tim Tomljanovich,** Gold, Northwest Suburban Astronomers; No. 110, **Glenn Wolford,** Silver, Member-at-Large

Constellation Hunter Observing Program (Northern Skies)

No. 228, **Peter Detterline,** Member-at-Large; No. 229, **Edgar G. Fischer,** Albuquerque Astronomical Society; No. 230, **Jeffrey S. Moorehouse,** LaCrosse Area Astronomical Society; No. 231, **Jenny Stein,** Houston Astronomical Society

Dark Sky Advocate Program

No. 15, **David Whalen,** Atlanta Astronomy Club

Deep Sky Binocular Observing Program

No. 408, **Janean L. Shane,** Omaha Astronomical Society; No. 409, **Rich Krahling,** Richland Astronomical Society

Double Star Observing Program

No. 632, **Jonathan Cross,** Seattle Astronomical Society; No. 633, **Bob Nolen,** Shreveport-Bossier Astronomical Society; No. 634, **Keith Lawrence,** Vermont Astronomical Society; No. 635, **Steven Powell,** Houston Astronomical Society; No. 636, **Jeffrey S. Moorhouse,** La Crosse Area Astronomical Society; No. 637, **Mike Reitmajer,** Rose City Astronomers

Earth Orbiting Satellite Observing Program

No. 37, **Rob Ratkowski,** Haleakala Amateur Astronomers

Flat Galaxy Observing Program

No. 28, **Kevin Mayock,** Honorary, Rose City Astronomers

Herschel 400 Observing Program

No. 609, **Bernard Venasse,** Member-at-Large; No. 610, **Rakhal Kincaid,** Haleakala Amateur Astronomers; No. 611, **Keith Lawrence,** Vermont Astronomical Society; No. 612, **Larry Farrington,** Mt. Shasta Stargazers; No. 613, **Mike Reitmajer,** Rose City Astronomers

Herschel Society

No. 8, **Jim Ketchum,** Silver, Astronomical Society of Kansas

Local Galaxy Group & Galactic Neighborhood Observing Program

No. 40-DA, **Rodney R. Rynearson,** St. Louis Astronomical Society; No. 41-DA, **Roy Troxel,** Member-at-Large; No. 42, **Charles E. Allen,** Evansville Astronomical Society

Lunar Observing Program

No. 911B, **Walter Jablonski,** New Hampshire Astronomical Society; No. 1063, **Jeff Willson,** Rose City Astronomers; No. 1064, **Eddie Trevino,** Astronomical Society of Southeast Texas; No. 1065, **Cat Trevino,** Astronomical Society of Southeast Texas; No. 1066, **Tom Gazzillo,** Chesmont Astronomical Association; No. 1067, **Robert A. Mayer,** Magic Valley Astronomical Society; No. 1068, **Mark L. Mitchell,** Delaware Astronomical Society; No. 1069, **Don Martin,** Von Braun Astronomical Society; No. 1070, **David Wickholm,** San Antonio Astronomical Association; No. 1071, **Jeffrey Moorhouse,** La Crosse Area Astronomical Society; No. 1072, **Bradley**

Nasset, Minnesota Astronomical Society; No. 1072B, **Bradley Nasset**, Minnesota Astronomical Society; No., 1073, **Raymond L. Bradley,** Roanoke Valley Astronomical Association; No. 1074, **David Decker,** San Diego Astronomy Association; No. 1075, **Lonnie Mosley,** Astronomical Society of Southeast Texas; No. 1076, **Jim Michnowicz,** Raleigh Astronomical Association

Lunar II Observing Program

No. 100, **Terry Trees,** Amateur Astronomers Association of Pittsburgh; No. 101, **Roger D. Joyner,** Greensboro Astronomy Club

Observer Award

Michael Blase, Olympic Astronomical Society; **Peter K. Detterline,** Member-at-Large; **Edgar G. Fischer,** Albuquerque Astronomical Society; **Rob Ratkowski,** Haleakala Amateur Astronomers; **Robert J. Olsen,** Member-at-Large; **Jonathan Poppele,** Minnesota Astronomical Society

Master Observer Award

No. 226, **Rakhal Kincaid,** Haleakala Amateur Astronomers

Advanced Observer Award

Rob Ratkowski, Haleakala Amateur Astronomers

Master Observer Award – Gold

Mark Simonson, Everett Astronomical Society; **David Whalen,** Atlanta Astronomy Club

Messier Observing Program

No. 2811, **Tom Nelson,** Honorary, Tucson Amateur Astronomy Association; No. 2814, **Aaron Roman,** Honorary, Kalamazoo Astronomical Society; No. 2815, **Kevin Hartnett,** Honorary, Goddard Astronomy Club; No. 2816, **Michael Nameika,** Honorary, Colorado Springs Astronomical Society; No. 2817, **Jonathan Cross,** Honorary, Seattle Astronomical Society; No. 2818, **Brad Bird,** Regular, Astronomical Society of Kansas City; No. 2819, **Sharon Flemings,** Regular, Ancient City Astronomy Club; No. 2820, **David Wickholm,** Regular, San Antonio Astronomical Association; No. 2821, **Jeffrey S. Moorhouse,** Honorary, La Crosse Area Astronomical Society

Meteor Observing Program

No. 76, **Steven Sauerwein,** 18 hours, Member-at-Large; No. 112, **Debra Wagner,** Honorary, Member-at-Large; No. 189, **David Whalen,** 18 hours, Atlanta Astronomy Club; No. 193, **Kiefer Iacaruso,** 12 hours, Youth Member-at-Large; No. 194, **Paul Jones,** Honorary, Ancient City Astronomy Club; No. 195, **Andrea L McCann,** 24 hours, Member-at-Large; No. 196, **Glenn Wolford,** 6 hours, Member-at-Large

NASA Observing Challenge – Apollo 50th Anniversary

Jim Barbasso, North Houston Astronomy Club; **Jeff Barney,** North Houston Astronomy Club; **Mary Barteau,** St. Louis Astronomical Society; **Steve Boerner,** Member-at-Large; **Dwain R. Bostick,** San Antonio Astronomical Association; **Scott Cadwallader,** Baton Rouge Astronomical Society; **Aaron Clevenson,** North Houston Astronomy Club; **Heather Martha Cook,** Member-at-Large; **Dan Crowson,** Astronomical Society of Eastern Missouri; **Tom Doyle,** Member-at-Large; **Franke Dunne,** Member-at-Large; **Tony Edwards,** Island County Astronomical Society; **Charles R. Ferguson,** Astronomical Society of Southeast Texas; **Vincent Giovannone,** Member-at-Large; **Amelia Goldberg,** Houston Astronomical Society; **Carlos Gramajo,** North Houston Astronomy Club; **Abhi Milind Gudipati,** Fort Bend Astronomy Club; **David Haviland,** Fort Bend Astronomy Club; **Blake S. Hurlburt,** San Antonio Astronomical Association; **Joe Khalaf,** Houston Astronomical Society; **Mike Keefe,** Raleigh Astronomy Club; **Brian Kelly,** Member-at-Large; **Lorna Kelly,** Member-at-Large; **Craig W. Lamison,** Houston Astronomical Society; **Al Lamperti,** Delaware Valley Amateur Astronomers; **Doug Lively,** Raleigh Astronomy Club; **Grant Martin,** Astronomical Society of Eastern Missouri; **Renee Mettle,** St. Louis Astronomical Society; **Jim Michmowicz,** Raleigh Astronomy Club; **Jeff Moorhouse,** La Crosse Area Astronomical Society; **Faith Newsome,** Raleigh Astronomy Club; **Bonnie Orlando,** Member-at-Large; **Loyd Overcash,** North Houston Astronomy Club; **W. Maynard Pittendreigh,** Brevard Astronomical Society; **Bruce Pollard,** North Houston Astronomy Club; **Susan Pollard,** North Houston Astronomy Club; **Krista Reed,** Baton Rouge Astronomical Society; **Greg Rigelman,** St. Louis Astronomical Society; **Ramiro Rodriguez,** Raleigh Astronomy Club; **Mark Simonson,** Everett Astronomical Society; **John Strebeck,** St. Louis Astronomical Society; **Kathleen Strebeck,** St. Louis Astronomical Society; **Jo Ellen Sutter,** Fort Bend Astronomy Club; **Joana Tan,** North Houston Astronomy Club; **Robert Togni,** Central Arkansas Astronomical Society; **Benjamin Toman,** Baton Rouge Astronomical Society; **Anastasia Vail,** Raleigh Astronomy Club; **Bernard Venasse,** Member-at -Large; **Willem Weber,** Member-at-Large; **Willow Weber,** Member-at-Large; **Nick Wightman,** Member-at-Large; **Brad Young,** Astronomy Club of Tulsa

Open Cluster Observing Program

No. 88, **David Whalen,** Advanced, Atlanta Astronomy Club

Outreach Observing Award

No. 113-M, **Jim Dixon,** Central Arkansas Astronomical Society; No. 822-M, **Terzah Horton,** Fort Bend Astronomy Club; No. 828-M, **James Wooten,** Fort Bend Astronomy Club; No. 918-M, **Marilyn Perry,** Member-at-Large; No. 926-M, **Aneesa Haq,** Fort Bend Astronomy Club; No. 963-S, **John Carter,** Prescott Astronomy Club; No. 1017-M, **Stephen L. Snider,** Albuquerque Astronomical Society; No. 1027-S, **Teresa Bippert-Plymate,** Big Bear Valley Astronomical Society; No.1028-S, **Claude Plymate,** Big Bear Valley Astronomical Society; No. 1060-S, **Peter K. Detterline,** Member-at-Large; No. 1110-S, **Jeffrey Padell,** Skyscrapers; No. 1119-S, **Christopher Leake,** Astronomical Society of Kansas City; No. 1124-O, **Gisela Esteva,** Fort Bend Astronomy Club; No. 1131-S, **Sam Pitts,** Temecula Valley Astronomers; No. 1135-O, **Pat Bledsoe,** Prescott Astronomy Club; No. 1136-S, **Catherine S. Anderson,** Tucson Amateur Astronomy Association; No. 1136-M, **Catherine S. Anderson,** Tucson Amateur Astronomy Association; No. 1137-M, **Paul W. Anderson,** Tucson Amateur Astronomy Association; No. 1138-O, **Chelsea Neckel,** Flint River Astronomy Club; No. 1139-M, **Pranvera Hyseni,** Member-at-Large; No. 1140-S, **J. Lopez-Incandela,** Northeast Florida Astronomical Society; No. 1141-O, **John Zimitsch,** Minnesota Astronomical Society; No. 1142-O, **Jim Michnowicz,** Raleigh Astronomy Club; No. 1143-O, **David Prosper,** Eastbay Astronomical Society; No. 960-S, **Moises Ramirez,** Fort Bend Astronomy Club; No. 1144-O, **Prakash Shet,** Fort Bend Astronomy Club; No. 1145-O, **Jai Shet,** Fort Bend Astronomy Club; No. 1146-O, **Neil Shet,** Fort Bend Astronomy Club; No. 1147-O, **Preeti Shet,** Fort Bend Astronomy Club; No. 1148-O, **Howard Persky,** Fort Bend Astronomy Club; No. 1149-O, **Zachary Leutwyler,** Fort Bend Astronomy Club; No. 1150-O, **Srinivas Gudipati,** Fort Bend Astronomy Club; No. 1151-O, **Durgamba Gudipati,** Fort Bend Astronomy Club; No. 1152-O, **Abhi Gudipati,** Fort Bend Astronomy Club; No. 1153-O, **Debra Wagner,** Member-at-Large; No. 1154-S, **Kenneth R. Magar,** Indiana Astronomical Society; No. 1155-O, **Dave Eberle,** Spokane Astronomical Society; No. 1156-O, **Kia Hurtley,** Prescott Astronomy Club; No. 1157-S, **John McLaren,** Seattle Astronomical Society; No. 1158-O, **Alex Holt,** Popular Astronomy Club; No. 1159-O, **Mary Holt,** Popular Astronomy Club; No. 1160-O, **Mike Danielson,** Pontchartain Astronomy Society; No. 1161-O, **Mark Pershing,** Popular Astronomy Club; No. 1162-O, **Michael R. Martin,** Roanoke Valley Astronomical Society; No. 1163-O, **Rick Gering,** Naperville Astronomical Association

Planetary Nebula Observing Program

No. 77, **Doug McCormick,** Advanced Manual, Houston Astronomical Society; No. 78, **David Cooper,** Advanced, The Astronomy Connection; No. 79, **Bill Hennessey,** Neville Public Museum Astronomical Society

Sketching Observing Program

No. 37, **Vincent Giovannone,** Member-at-Large

Solar System Observing Program

No. 143, **Jonathan Poppele,** Minnesota Astronomical Society; No. 144, **Russell F. Pinizzotto,** Southern Maine Astronomers; No. 145-B, **Russell F. Pinizzotto,** Southern Maine Astronomers; No. 146-B, **Aaron Clevenson,** North Houston Astronomy Club

Two in the View Observing Program

No. 37, **Charles E. Allen III,** Evansville Astronomical Society; No. 38, **W. Maynard Pittendreigh,** Brevard Astronomical Society

Urban Observing Program

No. 197, **Jonathan Cross,** Seattle Astronomical Society; No. 198, **Jeffrey Moorhouse,** La Crosse Area Astronomical Society

Variable Star Observing Program

No. 34, **Marilyn Perry,** Member-at-Large; No. 35, **James Pryal,** Seattle Astronomical Society

2019 Astronomy Day Winners

Once again in 2019, we received tremendous submissions for the Astronomy Day Awards. Thanks to *Sky & Telescope* and the American Astronomical Society for their longtime support of this most valuable outreach program. This year, the winner in the Large Metropolitan Area category was the **Girl Scout Council of the Nation's Capital.** This was the first submission we've received from a Girl Scout Council.

The Children's Museum at the Travelers Science Dome in West Hartford, Connecticut, was the winner in 2019's Small Metropolitan Area category. This group is a repeat winner from previous years.

The Roanoke Valley (Virginia) Astronomical Society was a return winner in the 2019 competition. The society won the Medium Metropolitan Area category award and the Best New Idea award for a virtual reality planetarium.

May 2, 2020, is the date for Astronomy Day next year. It is not too early to start making your plans to participate in this nationwide event and submit an entry for the Astronomy Day program.

For more information, contact Astronomy Day Headquarters: Gary Tomlinson, Astronomy Day coordinator, can be reached at *gtomlins@sbcglobal.net.*

Sketching Award

Gerry Kocken was presented with his first-place Sketching Award at the October 3, 2019, meeting of the Neville Public Museum Astronomical Society.

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#22115 $650

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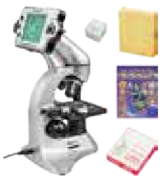
Orion® StarBlast™ AutoTracker Mount & Wi-Fi Adapter
#21189 $280

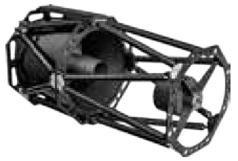

Orion® 10x50 Binocular Stargazing Kit
#10314 $60


Orion® Classical Cassegrain Telescopes
CC6 6" #52138 $500
CC8 8" #52139 $950


Orion® StarBlast™ 90mm Altaz Travel Refractor Telescope Kit
#20185 $230


MicroXplore 5mp LCD Digital Microscope Kit
#22054 $250


Orion® GoScope™ 80mm Backpack Refractor Telescope Kit
#21191 $200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Orion® 8x25 ED Waterproof Monocular
#8279 $100


Orion® StarBlast™ 102mm Altaz Travel Refractor Telescope
#10283 $300


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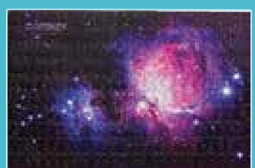
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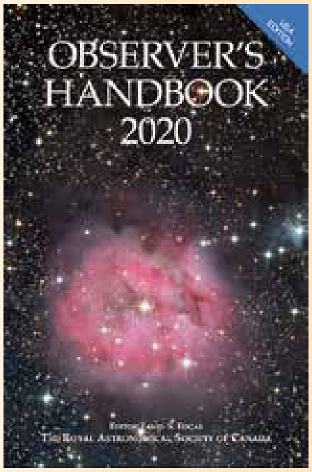

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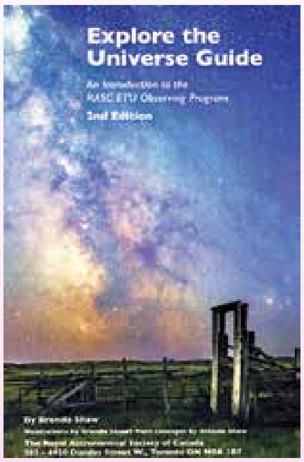

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