PHOTOGRAPHING THE ENTIRE MILKY WAY
BUILDING A PERSONAL OBSERVATORY
EDWIN HUBBLE’S “EUREKA” MOMENT
AMATEUR SLEUTHING FOR EXOPLANETS
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Cover image: Brian Ottum (University of Lowbrow Astronomers) captured IC 2178 (the Witch Head Nebula) from Dark Sky New Mexico using a 10-inch f/5 reflector with a Canon EOS 5D Mark III camera.

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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:

9201 Ward Parkway, Suite 100, Kansas City, MO 64114

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To the Editor

I read with great interest your most informative article published in the June 2020 issue titled “Double Star Observing: Expand Your Toolbag.” What caught the eye of some readers is that the interpretation of this observing program rests with John Wagoner of Dallas, Texas. John is the founding member of the inner-city public observatory “Clyde Tombaugh Astronomical Society for Students” (CLASS). He has been instrumental in too many astronomical initiatives and endeavors to mention in this short write-up. Of note, he still laments the addition of Perseus (Gamma Virginis) to the roster of required double stars. His assertion is that at the time of inception of this observing program he did not consider the fact that Perseus was approaching conjunction and its separation was decreasing. Currently this double star is a challenging observational object.

As with all sciences, we learn from those that go before us, as laid down by Bernard of Chartres in his assertion that we “stand on the shoulders of the giants” that came before us. Those of us who know John have gained invaluable insight and continue to learn from John Wagoner. John has been instrumental in motivating the public to participate in outreach. John is at the forefront of helping the Texas Astronomical Society and CLASS meet that mission goal.

sincerely,

—Henry Stevens
Texas-Astronomical Society of Dallas

Call for Officer Nominations

T he two-year term of the office of the secretary and three-year term of the office of treasurer end on August 31, 2021. If you are interested in using your talents to serve in either one of these two important positions, we would love to hear from you. Please submit your nominations to the Reflector by August 31, 2021.

For specific information regarding the duties and responsibilities of the secretary and treasurer, please refer to the League’s Bylaws, which can be accessed on the League’s website, astronomyleague.org.

Candidates should send Nominating Chair Chuck Allen (vicepresident@astroleague.org) a background statement explaining why they are interested along with a photo of themselves for publication in the Reflector. Please limit your statement to approximately 250 words. All nomination materials must be received by March 15, 2021, so they can be published in the June Reflector.

The ASTRONOMICAL LEAGUE
The two hemispheres of Iapetus, the dark and bright. The dark hemisphere is the leading hemisphere, always facing the direction of motion, since the moon is tidally locked to Saturn. The bright hemisphere is the trailing hemisphere. The brightness difference is linked with, on one side dark ash and charcoal, and the other white ash. The dark one makes up almost 40 percent of the moon’s surface. Both hemispheres are dominated by impact craters, both large and small. The prominent crater on the leading hemisphere is the 145-mile-wide english crater. These images were taken on the September 10, 2007, during a close flyby of Iapetus by the Cassini spacecraft. Image credit: NASA/JPL/Space Science Institute.

Another image from Cassini’s close approach to Iapetus as Saturn’s moon is the Voyager Mountains. The Voyager spacecraft took the first close-up images of Iapetus showing a line of white spots extending from the bright hemisphere onto the dark hemisphere. The images were not very detailed, and it was presumed the bright spots were areas lost 70 feet of ice while the light areas gain back 15 feet and stay white. Over a billion years, the dark material had been mixed in. The bright areas are most likely ice, mixed in. The bright areas are most likely ice, water. This implies that Iapetus is mostly frozen water. However, the dark regions are dark as charcoal, and the other white ash. The dark one makes up almost 40 percent of the moon’s surface. Both hemispheres are dominated by impact craters, both large and small. The bright side shows characteristics of water ice, which reflects more of the Sun’s heat back into space resulting in a colder temperature of ~280°F. The Satumian moons are named after the Titans of Greek mythology, as suggested by John Herschel in 1847. The Titans were siblings of Cnosus and Titanus, Titanus, both Titans, who the Romans called Saturn. The names of geological features on Iapetus are taken from the French epic poem “The Song of Roland.” These include the northern region of the bright hemisphere, Roncevaux Terra, as well as the craters Charlemagne and Balbant. The dark region, Cassini Regio, is an exception to this rule, being named after the moon’s discoverer.

The bright region is split into two sections. Roncevaux Terra is the northern half of the bright region, and Saragossa Terra is the southern half. Saragossa Terra has a very prominent basin 313 miles across named Engelberg. This basin was probably the result of a small asteroid impacting the moon. There are two larger craters on Iapetus, but they are both older and more eroded by more recent impacts. Cassini Regio is 476 miles across, and Tygris, on the equator at the edge of Cassini Regio, is 360 miles across. To learn more about Iapetus, spacecraft need to visit the Saturnian system. Pioneer 11 provided the first glimpse of Iapetus in 1979, but the moon was too far away to get useful images or useful in solving its mystery. In 1980, Voyager 1 was targeted to fly by Saturn’s moon Titan, so it was too far from Iapetus to get close-up images. Voyager 2 in 1981 got better images that clearly showed craters on the surface. Finally, in July 2004, the Cassini spacecraft entered orbit around Saturn and was able to get close-up images of Saturn’s moons, including Iapetus. It made its closest approach to the moon on September 10, 2007. The Cassini spacecraft revealed a surface that was nearly cratered. This indicates that the surface is very old and unaltered by geological processes. They also indicated that the moon’s surface is not spherical. It is an oblate spheroid, a squashed sphere with a polar diameter five percent smaller than its equatorial diameter. This would be normal if Iapetus was making a revolution every 16 hours, instead of every 79 days. This oddity can occur if the crust became frozen in its current shape and the moon continues to slow its rotation until it became tidally locked. The bulging equator has an additional feature, a ridge of individual mountains, mountain ranges, and parallel ridges. Some of these mountains are over 12 miles high, some of the highest mountains in the Solar System. These two features give Iapetus a walnut-shaped appearance. It is the largest object in the Solar System not located in the Hyndell equilibrium. The equatorial ridge is most prominent in the dark hemisphere where it is well defined. In the bright area, the ridge almost completely disappears, but there are single mountain peaks over six miles high scattered along the equator in that hemisphere. The ridge is interrupted by craters, indicating that it is old as the rest of Iapetus’s surface. The source of the ridge is poorly understood, but it may be related to the moon’s non-spherical shape. Voyager 2 imaged a line of white spots near the equator as it enters the dark region. These were initially thought to be mountain peaks towering above the dark material. Dubbed the “Voyager Mountains,” they were not exactly on the equator, but slightly off. Cassini images showed that the bright spots are not on the peaks, but on the sides of mountains, forming one of many examples where bright material exists in the dark region and vice versa.

Dobsonian. Notice the signature Terete altitude bearing design, Russian Baltic birch wood, and beautiful box joints. The last photo shows the pieces that will be boxed specially for ALCon Jr. Rob is an expectant father and cannot confirm his attendance, so Donna Smith from the Sidewalk Astronomers has happily volunteered to help.

The telescope parts kit (not shown) is from e-Scopes and features 6-inch Guider optics, a parabolic primary mirror, matching secondary, 4-vane spider with diagonal holder, 1.25-inch parabolic primary mirror, matching secondary, e-Scopes and features 6-inch Coulter optics, a Dobsonian. Notice the signature Terete altitude bearing design, Russian Baltic birch wood, and beautiful box joints. The last photo shows the pieces that will be boxed specially for ALCon Jr. Rob is an expectant father and cannot confirm his attendance, so Donna Smith from the Sidewalk Astronomers has happily volunteered to help.

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Deep-Sky Objects

One of my favorite classes of deep-space objects to view in telescopes is globular star clusters. Globular clusters contain a hundred thousand to millions of stars in one collection. Unlike galactic or open star clusters that contain many fewer stars, the mass contained in globular clusters is sufficient for the gravitational force to keep all of the stars bound together. The Milky Way Galaxy may contain close to two hundred thousand globular clusters.

Globular clusters form a spherical halo in the outer reaches of the galaxy and circle the galaxy in random orbits. Most globular clusters are very old, dating back to the formation of the galaxy and circle the galaxy in random orbits. Most globular clusters are very old, dating back to the formation of the galaxy.

Ogives of the Milky Way's globular clusters are resolved into hundreds or thousands of stars with an 8-inch telescope. The view is especially exciting in even larger-aperture telescopes.

Near the end of summer and early fall, the constellation Sagittarius rises above the southern horizon as twilight fades to darkness. Most globular clusters are listed in the New General Catalog (NGC). A scan of the NGC list shows there are more globular clusters in Sagittarius (21) than in any other constellation.

The largest and brightest of the globular clusters in Sagittarius is M75 (NGC 6864). M75 is neither the largest nor the brightest of the globular clusters in Sagittarius. But its location along the border of Sagittarius and Capricornus means that it is outside of the glow of the Milky Way. Thus, its stars are not lost among the countless stars in the galactic plane. M75 shines at magnitude 9.1 and is roughly 6.8 arcminutes in diameter. Compare this to Sagittarius's best globular cluster, M22, which is magnitude 5.1 and 32 arcminutes in size.

M75's smaller and dimmer stars are a result of its distance, 67,000 light-years; M22 is only 10,400 light-years away. Were M75 as close as M22, the two clusters would be comparable in brightness and size.

M75 does not lie near any bright stars. It is located roughly eight degrees south-southwest of the third-magnitude star Dabih (Beta Capricorni). To star hop to it, start at Dabih and move 4.5 degrees south to magnitude 5.2 Sigma Capricorni (7 Capricorni). Another 2.7 degrees south and slightly west of 7 Capricorni lies 4 Capricorni (magnitude 5.8). M75 is 2.75 degrees due west of 4 Capricorni.

My image of M75 was taken with a 10-inch f/6 Newtonian with a Paracorr Type-2 corrector and an SBIG ST-2000 XCM CCD camera. The exposure was 40 minutes. The brightest star in the image is on the lower left (southeast) edge shines at magnitude 10.6. The faintest stars are magnitude 18.

M75 is a dense cluster with a relatively bright core and circular appearance. The core may appear east of the center, an artifact of brighter stars on the west side from our vantage point. The best views will be at magnifications between 100x and 200x, which will allow more stars to be resolved.

M75 lies close to the ecliptic and has been doing a dance with the giant planets Jupiter and Saturn since the spring. Outer planets tend eastward along the ecliptic, except when approaching opposition when they begin retrograde (westward) motion. Jupiter made it almost as far as M75 last May before it began moving west. Saturn, on the other hand, passed east of M75 in March, turned around and then passed west of it in July.

After reaching their respective oppositions, Jupiter and Saturn continue their prograde motion along the ecliptic and catch up to M75 in December. For a few days around December 12, both planets will be in the same telescopic field of view with M75 low in the southeast as astronomical twilight ends. The accompanying finder chart for M75 shows the positions of Jupiter and Saturn on December 12, 2020. The circle around M75 and the planets is the field of view through my William Optics 132 mm f/6.5 apo with a 25 mm Tele Vue Nagler eyepiece. All three objects will be visible simultaneously in the 2.3-degree true field of view.

Whether you are in Sagittarius this autumn hunting star clusters or just viewing the gas giant planets, it’s worth making a short hop over to M75. The eyepiece that provides the best detail on Jupiter and Saturn will likely be the best eyepiece to spy this distant globular star cluster.

Dr. James R. Dire Kauai Educational Association for Science and Astronomy
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From Around The League

LEADERSHIP OPPORTUNITIES: PLOT THE FUTURE OF THE AL’S NORTHEAST REGION

A ttention AL members from New England, New York, and northern New Jersey: NERAL has openings in all leadership roles. If you are interested in working with the national officers to revitalize your region, please contact president@astronomyleague.org.

CELEBRATING THE WOMEN OF ASTRONOMY

T he greatest joy in belonging to an astronomy club is bringing new people into astronomy to the people. This necessarily means meeting people where they are, accepting varied levels of interest and varied depths of commitment and participation. Success means being relevant to the people as well as being pertinent to the subject. Participation means being interesting and varied depths of commitment and acceptance. Success means being relevant to the past and the present. We discussed hosting an African-American woman astronomer as a speaker during Black History Month and a Latina Astronomer for Latin History Month.

Our website, vcas.org, has a page dedicated to Women’s Suffrage. What does this have to do with astronomy? The Horkheimer Foundation focuses on astronomical rights and space science. But what to do for 2020? 2020 is the 100th anniversary of women’s voting rights, it unavoidably recognizes that women have continually contributed to the betterment of humanity in all areas, including medicine, politics, science, art, and astronomy. Our astronomy club decided to recognize the women of astronomy by adopting the following theme: In recognition of the 100th Anniversary of Women’s Suffrage, Ventura County Astronomical Society Celebrates the Women of Astronomy.

The theme has been a smashing success. Our website, vcas.org, has a page dedicated to honoring over 100 women who’ve contributed to our hobby, both in the past and the present. We’ve had plans for a women-run-star party in August, nearest the actual anniversary date. We even discussed hosting an African-American woman astronomer as a speaker during Black History Month and a Latina Astronomer for Latin History Month. Then disaster struck: COVID-19.

At present we’re trying to salvage the year. We didn’t get all the speakers we wanted due to their previous commitments, but that has been made up by the pandemic. Now we’re learning how to present our speakers online, which is a challenge for people who only know how to look through a telescope. I joke at that last point, but the challenges of learning how to effectively operate in the current situation are quite real. Yet while our group activities have been put on hold, our group enthusiasm hasn’t. We’re still finding ways to honor the women of astronomy and we are enjoying the journey. There’ve been some major surprises, like learning that a woman is primarily responsible for creating the NGC, or that another woman, still alive today, once held the title of having discovered more comets than any other individual before the dawn of the computer age.

This quote from Mr. Salvisy captures the essence of Vivek’s extraordinary abilities, accomplishments, and willingness to share with others: “This month [March 2020], the Julian Dark Sky Network hosted an event at the Julian Branch of the San Diego County Library, which featured a lively presentation by Vivek on spectroscopy, which has for some time been the area of his science fair projects. The event was advertised in local media and drew over 30 people, which is an excellent turnout in this mountain town of 2500 residents! It was followed by 45 minutes of spirited question and answer, which Vivek handled with both patience and enthusiasm. I heard several people commenting about how impressed they were by Vivek’s ability to break down the science and give people answers they could understand.” In Vivek’s spare time, he has taken college-level physics and related courses at Palomar College. He will be a senior in high school this fall.

Horkheimer/O’Auria Service Award First place: Jai Shet
Jai is an eleventh-grade homeschooled from Houston, Texas. His brother, Neil, a ninth-grader, has been with him every step of the way in his journey in astronomy. See a special joint article written by the brothers elsewhere in this issue.

They are both members of the Fort Bend Astronomy Club. In the Houston area and a homeschooled starting twelfth grade in the fall.

Much of the story of his passion for astrophotography is captured in the Horkheimer/O’Auria Service Award article, above.

As the first-place winner, Jai will receive a plaque and a $1000 check.

Horkheimer/Parker Youth Imaging Award Second place: Vivek Vijayakumar
The title of Vivek’s image is “The Pacman Nebula in SHO.” The image was taken from Julian, California, with a C8-N, ASI1600 pro, CM1000, and Astrozdon 5 mm S-II, H-alpha, and O-III filters. Vivek will receive a plaque and a $500 check for his second-place finish.

Horkheimer/O’Meara Journalism Award Second place: Stephen Castillo
Stephen finished sixth grade this year at Northridge Preparatory School. Like his sister, he lives in Des Plaines, Illinois, with his family, and is also a member of the Northwest Suburban Astronomers.

Stephen will receive a check for $500, compliments of the Horkheimer Foundation. The title of his essay was “SpaceX Falcon 9 Rocket.”

Horkheimer/O’Meara Journalism Award First place: Lucia Castillo
Lucia Castillo will be in ninth grade this fall at Williams Academy in her hometown of Des Plaines, Illinois. She and her family are members of the Northwest Suburban Astronomers.

As the first-place winner of the Horkheimer/O’Meara Journalism Award, she will receive a check for $1000 and a first-place plaque recognizing her splendid achievement, compliments of the Horkheimer Foundation. Her well-written essay is entitled “How Kids can be Interested in Astronomy.”
The title of his essay was "Mars 2020 Rover." Oklahoma. He is a member of the Astronomy Club Legacy Christian Academy in Broken Arrow, respectively presenting much material from members. To above. The newsletter was informative, attracting... 

2020 NATIONAL YOUNG ASTRONOMER AWARD TOP FINISHERS

This award season has been much different, due to the COVID-19 situation. We postponed AlCon 2020 to the first week of August 2021 as AlCon 2021. As a result, top 2020 finishers for the National Young Astronomer Award (NYAA) will be offered the opportunity to attend AlCon 2021 to receive their plaques in person and give their presentations.

Thanks to Explore Scientific for its generous sponsorship of this program for many years. Each year the top two finishers are given a trip to the national AlCon and one of Explore Scientific's subscribing astronomical instruments. We had many excellent submissions this year. Thanks to all who participated.

NYAA Awards first place: Karen Le
Karen is a rising senior at Sarasota High School in Sarasota, California. She became hooked on astronomy while a high school freshman, after looking through her father’s telescope. The next year she started an astronomy club at her school, and she currently serves as president of the group.

Karen recently had the privilege of visiting Mount Wilson’s 100-inch Hooker Telescope. She has studied the field of radio astronomy extensively. Outside of astronomy, she loves math and is a three-time AIME (American Invitational Mathematics Examination) qualifier. She also likes to watch a variety of movies.

NYAA Awards second place: Vivek Vajkakumar
Vivek is a rising senior at San Marcos High School in San Marcos, California. He is a youth Member-at-Large of the Astronomical League. His project is titled “Characterizing the pulsations of Delta Scuti stars using the Mg II triplet.” Vivek’s research objective is “to study the relation between pulsations and changes in the light curves of Delta Scuti variables and the profiles of the Mg II triplet spectral feature, and to correlate its optical depth, Doppler shifts, and broadening. Question: How do the pulsations of Delta Scuti stars correlate to the profiles of the Mg II triplet?”

He found that “the Mg II spectral feature, despite demonstrating no detectable change of appearance in profile, demonstrated peculiarities and activity that shifted the spectral lines and broadened their profile. The strong positive correlations between apparent rotational velocity and broadening demonstrated the effect of fast rotation on the Mg II triplet. Additionally, after accounting for rotational broadening, the strong negative correlation between the residual broadening demonstrated that as the period of the star increases, the detected broadening as caused by chromospheric activity on the star decreases. This is related to non-radial pulsations and activity. There is also possible evidence of the interference of non-radial pulsations in the profiles and their particularly strong shifts as they are not always consistent between spectral lines, and demonstrating no significant correlation with the period.” Vivek further notes that “Delta Scuti stars, as stars along the instability strip and in various evolutionary stages close to the main sequence, are important to understanding and characterizing various different modes of chromospheric activity and the field of asteroseismology. The results also serve to establish the capabilities of amateur astronomers and citizen scientists to contribute to the active observation of stars not only through photometry, but spectroscopically, and in time series.”

Vivek gave special thanks to Curiosity Peak Observing. The observatory gave him access to its observing sites to collect data. Also, his parents were invaluable in driving him to the facility, often on bitterly cold nights.

2020 SKETCHING AWARDS

The purpose of this award is to recognize the special art of amateur astronomy sketching. Thanks to Astronomics for its outstanding generosity in sponsoring this program. The top finishers in the 2020 competition are:

First place: Richard Francini
Richard lives in De Pere, Wisconsin, and is a member of the Neenah Public Astronomical Society. The lunar area he sketched was the fault Rupes Recta (the Straight Wall) and its surroundings. His sketching media were graphite art pencils and black and white charcoal pencils on gray paper. There was no digital manipulation. He plotted all of the six Apollo missions on the Moon in their respective positions and drawing and sketching the details.

No digital manipulation was used. His sketching media were paper, pencils, and a red pen. The task required several observing nights in May to July 2019, during different phases. Seeing conditions ranged from excellent to very good, with transparency rated as 4 and 5.

Second place: Abhi Miland Giudapati
Abhi lives in Sugarland, Texas. He is a member of the Fort Bend Astronoming Club.

Abhi’s project was the NASA observing challenge for the Apollo 50th anniversary. The task was to plot all of the six Apollo missions on the Moon in their respective positions and drawing.

This program was a collaborative effort between NASA and the Astronomical League, and Abhi received a beautiful certificate recognizing this accomplishment signed by a representative of Goddard Space Flight Center and the president of the Astronomical League.

He will receive $250 for his first-place finish, compliments of Astronomics.

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Abhi will receive $250 for his first-place finish, compliments of Astronomics.

Third place: Seth Fenderson
Seth completed fourth grade this year at Mount Wilson’s 100-inch Hooker Telescope. She has studied the field of radio astronomy extensively. Outside of astronomy, she loves math and is a three-time AIME (American Invitational Mathematics Examination) qualifier. She also likes to watch a variety of movies.

Seth will receive $250 for his third-place finish.

350x, with fields of view of 1/3", 1/3", and 1/4", respectively. He will receive $250 for his first-place finish, compliments of Astronomics.

DOING OUTREACH IN A PANDEMIC

A host any astronomy club loves to do outreach and does a great job with it. Then came the pandemic. Clubs had to discontinue in-person outreach for the safety of club members and their guests. But there is still a way to conduct outreach events even in the midst of COVID-19. Some clubs began having online star parties. Zoom and similar platforms make these possible, and such events can count toward the Outreach Award program.

The focus of the Astronomical League’s Outreach Award has always been face-to-face contact so that participants could interact with experienced astronomers. Pre-recorded videos are not acceptable, but we have clarified our Outreach Award webpage to let everyone know that online star parties and other similar online events are acceptable and encouraged. For example, our Reflector editor reports successfully working remotely with girl scouts in Vermont from her home in Connecticut. The key to whether such online events are accepted in Outreach Award submissions is that the events must make it possible for guests or participants to interact with an astronomer.

A 10-inch Dobsonian telescope and 10x50 Vertex Binoculars were used. Telescopic magnification ranged from 4x to 12x.

This program was a collaborative effort between NASA and the Astronomical League, and Abhi received a beautiful certificate recognizing this accomplishment signed by a representative of Goddard Space Flight Center and the president of the Astronomical League.

Abhi will receive $250 to check his outstanding second-place finish. Thanks to Astronomics for its support of this program! We appreciate this very much.

THANK YOU TO ALL!!!
We wrote an article about our tele-
photography experiences and our interest in astrophotography in the June 2020 edition of the Reflector. We would like to further share our interest in astrophotography, our passion for travel, photography, and astronomy. Combining these passions would naturally make us interested in astrophotography in remote dark-sky parks across the country. We have traveled to all the lower 48 United States and to several other countries. Being homeschooled high school students made it easier for us to travel and explore our world—enhancing our learning experience.

During the day we enjoy different types of photography including nature and landscapes, and we eagerly await nightfall to image the night sky. We have captured stunning landscapes from the mountains of Washington to the wetlands of Florida, and from the deserts of California to the rugged coastlines of Maine. We have seen many interesting things, each one more beautiful than the last, making it difficult to differentiate between images. We rely on our knowledge of the night sky, without which we would have been lost like a ship at sea. The only “landmarks,” so to speak, were the intriguing nebulae that confirmed we were heading in the right direction. After several hours of imaging each night, we returned to our hotel exhausted, only to return to the same spot the next night to repeat the process. We did not give up until we had the entire northern portion of the galaxy wrapped up.

The next tedious process was to stitch those individual images to make the panorama. When it all came together, it looked absolutely stunning, like nothing we had ever seen before. However, deep down, we felt the panorama was incomplete without the southern portion of the Milky Way. But we had no easy way to get to the southern hemisphere. We continued with our other travel and astrophotography pursuits over the next few months until one day our parents planned a trip to the South Island of New Zealand. Our eyes immediately lit up at a possible opportunity to capture the southern part of the Milky Way. We desperately convinced our parents to agree to carry the heavy telescope mount with us on this trip. We then got down to the business of studying the night sky of the southern hemisphere.

Our online research of travel in New Zealand indicated that the best way to explore the country was by renting a campervan. Once we got there, we drove around the countryside, marveling at the turquoise blue lakes at the feet of towering snowcapped mountains. We took plenty of pictures during the day and as evening approached, eagerly looked for campgrounds that gave us the best opportunity to photograph the night sky. As we drove on the left side of the road was not challenging enough, finding suitable campgrounds for astrophotography was a beast in its own. Though each campsite was unique, they all had the same weather: heavy cloud cover, fog, and rain. Despite enjoying the daytime experiences, our hopes of making the panorama dried up as the trip progressed. We only got short glimpses of the Large and Small Magellanic Clouds and the Milky Way, for the clouds just kept crashing the party. Our excitement abruptly fizzled out as clouds engulfed the galaxy like a blanket.

We set up our equipment on several occasions and desperately captured however many images we could during periods of respite offered by the thick cloud cover, but the random images were of little use in creating a panorama. We finally gave up and reluctantly went to bed, after unproductively waiting for hours. This happened at every campsite we visited during the trip. We visited Mount Cook National Park, designated an International Dark Sky Reserve by the International Dark-Sky Association. We considered ourselves fortunate to find a camping spot in an otherwise crowded national park campground. However, the good fortune did not follow us into the night as heavy cloud cover forced us to go to bed early with only rain showers forecast for the rest of the night. At one of the campsites, we came across a spectacular view of sheep grazing in the setting sun. Although we saw many such sights that gladdened our hearts, our biggest desire was to complete the panorama. It was a hopeless situation because capturing bits and pieces of the galaxy would not help us merge them with the northern part.

We had almost completely given up hope by the time we were down to the last several days of the trip. We researched remaining interesting places to visit while also keeping an eye on the weather forecast. We decided upon a route back that would offer us the best weather while still providing enough sights to enjoy. The skies at our last campsite seemed to magically hear our calls for help because the clouds simply departed, revealing the galaxy’s mighty face. Recognizing that this was our last chance, we spent the entire night imaging the remaining portions of the galaxy. There was an occasional cloud passing by, but on this night, even those clouds dared not impede our progress. Our goal was to image the southern part of the galaxy all the way to the galactic center, allowing us to connect it to the northern hemisphere. Since the galactic center would not be visible until 3 a.m., we had to wait an incredibly long time just to get a glimpse of it. Our parents and the rest of the folks at the campground were fast asleep—we were the only ones wide awake that night. The Milky Way slowly rose and we took images every ten minutes. We finally captured the last bit of the galactic center that completed the panorama, making it appear as a single image instead of two disjointed pieces. It was 5:30 a.m. by the time we finished, and we hurried to the airport to catch our 8 a.m. flight back home. The rest of the journey was a blur because our tiredness got the best of us. The only memories of the return journey were pleasant dreams of a galaxy far away and yet so close to our hearts.

By the end of the project, we had spent 35 hours taking over 200 images during a six-month period. But as that was not enough, it took an additional 200-plus hours, along with several computer crashes, to process and stitch the images. We even had to borrow our dad’s computer because it was much faster. The final file amassed a whopping 3 gigabytes which we cropped and compressed several times to create a more manageable output. The magnificent panorama of the Milky Way showed all the details we had hoped for. We were happy that we accomplished this seemingly impossible task. The breathtaking final image proved that all our efforts were worth it, and we thoroughly enjoyed the experience. While proudly admiring our work, we wondered if we were the first kids in the world to create such a high-resolution image of the Milky Way.

Jai and Neil Shet are members of the Fort Bend Astronomy Club.

A Journey through Space and Time: the Road to the Milky Way

Here in the Reflector we obviously cannot adequately reproduce Jai and Neil’s full Milky Way composite image, which is over 64, inches long at 300 dpi. You can download a jpg copy at https://tinyurl.com/shet-milkyway.
ninety-seven years ago, nearly to the day, Edwin Hubble imaged a star in the Andromeda Galaxy. He initially thought it was a nova, but after following it for a period of time, realized it was a variable star and crossed out the “N” next to it on his plate and wrote “Var!” This seminal observation would write “Var!” This seminal observation would...
I realized this star was varying. I crossed the Hubble Space Telescope at M31’s point the Hubble Space Telescope at M31’s. Credit: NASA and STScI

AAVSO members to imitate it earlier that year to obtain a light curve, since it had only been studied once since Hubble’s work in the 1920s. Between July and December of 2010, eleven observers made 214 observations during four cycles of variation, and determined a period of 31.384 days and a magnitude range of 18.0–18.7 (r). HST took four images of the star in December 2010 and January 2011. The Cepheid displayed a relatively slow decline for most of its cycle through 25 days, then a more rapid recovery in 6-7 days. They used the following formula for the Julian date of maximum brightness and the cycle length: Jmax = 2455430.5 + 31.4.

Since hearing about this work, I had the idea to observe this Cepheid visually. Its magnitude range is accessible in my 32-inch reflector from my home in Minnesota, but recent fall weather patterns have been unfavorable. Autumn is usually the best season for observing, with clear, crisp, low-humidity nights, but clouds, rain, and higher dew points have ruled for several years. I tried for this star a number of times in the last two years, but could quickly tell that conditions would not allow its observation. The AAVSO has a finder chart for the area, and I plotted stellar magnitudes for its neighbors using data from Megastar. Most nights I could not get within two magnitudes of seeing it. The late evening of September 23, 2019, was different. There was no dew or wind, and I had until just past midnight before a waning crescent Moon entered the sky. I rapidly found the field using Megastar charts and a red image from the POSS 2.

The Cepheid sits within an arrow-shaped asterism of seven stars 1.5 arcminutes across, with the tip pointing west. The three westernmost stars of that group form an equilateral triangle 20 arcseconds on a side, with M31 V1 its southeastern member. The “tip” star to the Cepheid’s west-northwest is magnitude 18.9, in the middle of our target star’s variable range. I hadn’t calculated the cycle for that night, so I did not know what its magnitude should be, but could tell right away that it was quite a bit fainter than the tip star. As chance had it, the Cepheid was at day 23 of its 31-day cycle, just before minimum brightness. I determined the period of seven for about 75 minutes, employing a number of eyepieces that gave from 363x to 650x, in seeing about 75 minutes, employing a number of eyepieces that gave from 363x to 650x, in seeing

A common dream among enthusiasts of the night sky is to have a permanent building, an “astro-house,” if you will. A haven from which to observe, image, commune with friends of the same ilk – and while we’re at it, to have all your stuff in one place, albeit in several rooms. It’s a wonderful feeling to stroll down a gravel path off the back patio and unlock the door to an observatory of your own, something never to be taken for granted.

I’ve been in one of the stars since I was ten years old, and I credit the original Outer Limits television series for starting me down a path I’ve enjoyed traveling for over fifty years. Some creative thinker on the show decided to run the ending credits against a backdrop of images from the 200-inch Hale telescope on Mount Palomar in California, and the beauty and shapes of the portayed galaxies transfixed me, especially M81. I was hooked.

From there, it was an astronomy-passionate fifth-grade science teacher; a steady stream of Lost in Space: The Golden Book of Astronomy, and a 2.5-inch lens &affle refractor. My very first view of Saturn was through this monstor, and a ten-year-old kid was lost to the stars.

The following years, with various telescopes in various locations, I’ve been fortunate to witness, with eye and camera, the marvels of space: our Moon and Sun, planets, beautiful galaxies of all types (and their collisions with Jupiter and the Sun), and planetary nebulae that paint a picture of our star’s eventual destiny. As time advanced, it became desirable to wander less, to forgo the darkest of distant sites, and stay close to home. While I am an enthusiastic observer, imaging is my primary focus (pun intended), and so a permanent facility became a goal.

Building a Personal Observatory in New Mexico

By Steve Solon

I am a dreamer. Years ago, while living just south of Denver, I had a seven-foot Astro-Haven clamshell dome in our yard, an observatory that gave me many inspiring years. While it was a bit of a gymnastic endeavor to maneuver around the Paramount MR and two telescopes inside, I controlled everything from the house. Remote controlling was a wonderful advantage, but I did miss the experience of actually being with the instruments under the stars. Sadly, as with a growing number of suburban locations, encroaching light pollution gradually brightened the skies to an unacceptable level; once-visible deep-sky targets were rendered invisible, and image processing software at the time, could only do so much. My wife and I decided that a move to New Mexico, something we’d planned for retirement years down the road, had become an immediate possibility. I parted ways with the Astro-Haven, donating it to the Boulder astronomy club, and in 2018, we relocated to Rio Rancho, New Mexico, about fifteen miles northeast of Albuquerque.

While we were settling in our new home, I explored the many options for an observatory, and decided that a roll-off structure would meet several criteria, including plenty of open sky, increased interior space, good protection from the elements, and ease of use. Now, I’m a fairly decent DIY kind of person, but there are projects I leave to those who engage in them every day, the experience, reliability, and craftsmanship of professionals are traits I am comfortable
After toe-nailing was removed, the roof was temporarily supported on 2x6 stacks.

Our next step was to literally “raise the roof.” After removing the nails that had temporarily secured the roof to the building, we nailed a 2x4 across two roof joists, and used a Handyman jack and a six-foot plank to lift one side of the roof at a time, placing stacks of three 2x6 blocks underneath at several points for support. With the roof “flying” on these wooden bricks, we then laid sections of inverted groove track on the lightly-greased upper wall headers, eyeballed the straightness down the length of the wall, then loosely secured the track. The shape of the screw holes in the track would permit about 1/4-inch of floating travel; after the roller wheels were attached and the roof lowered, this would allow for self-alignment with the track before tightening the track screws. Once all the track and wheels were attached to the building, we secured the roof with four large eyebolts and turnbuckles; between these and the considerable weight of the roof, Terry and I were confident it wouldn’t go sailing in New Mexico, under some of the darkest heavens in the United States, so the ultimate magic of jet-black skies will always be there. For now, and hopefully for years to come, a “second home” lies just outside the back door; a few welcome steps away.

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**EXOPLANET SLEUTHS in the Era of TESS**

**THE INDISPENSABLE ROLE OF AMATEUR ASTRONOMERS**

**By Dennis M. Conti**

Is there life on other planets? Since we first became aware of the existence of exoplanets, this question has energized our quest to find planets that have the right characteristics to support life. Finding “life,” however, does not necessarily mean finding life “as we know it” – merely finding evidence of current (or past) microbial life on another planet, ideally a rocky one that could sustain liquid water; will be a major milestone in human history. In fact, the discovery of extremophiles that live in extreme environments here on Earth has challenged our common notion of “life as we know it.” A tardigrade – an example of an extremophile that can withstand radiation and extreme pressure and temperature – “Mare Stellarae” – loosely translated to “Sea of Stars” – is an example of an extremophile that can withstand radiation and extreme pressure and temperature.


**CONFIRMING THE EXISTENCE OF EXOPLANETS AND WEEDING OUT SUSPICIOUS “IMPOSTERS” IS A KIN TO A DETECTIVE STORY IN WHICH AMATEUR ASTRONOMERS ARE PLAYING AN ESSENTIAL ROLE ALONGSIDE THEIR PROFESSIONAL COUNTERPARTS AS EXOPLANET “SLEUTHS.” I WILL PROVIDE A COMMENTARY AT THE END OF THIS ARTICLE ON THE GROWING USE OF THE TERM “CITIZEN SCIENTISTS” IN PLACE OF “AMATEUR ASTRONOMER.”**

A light curve showing the effects of orbital alignment. Image credit Image credit: Zhan K., Alper, W., Sturmann, L. Both authors.

**“Dilbert” the observatory mascot waits casually for the night to come.**

**REFLECTOR SEPTEMBER 2020**

**THE ASTRONOMICAL LEAGUE**

**22 23**
telescopes and imaging equipment identical to that used by amateurs doing deepsky imaging.

By observing the depth of the transit and knowing the radius of the host star, we can estimate the radius of the transiting exoplanet. To know "rocky" the planet is (that is, its density), we need one other measurement – its mass.

Our journey to find "habitable" exoplanets began in earnest with the now-decommissioned Kepler space telescope. It continues today with NASA’s latest planet hunter, TESS – the Transiting Exoplanet Survey Satellite. TESS began its first mission in 2018 with some 200,000 relatively bright, nearly stars as its targets. The stated "level 1" science objective of TESS was to find at least 50 exoplanets for which we can estimate size (4 Earth radii or less) and a known mass. The objective of TESS was to find at least 50 objects of interest (TOIs), need further investigation by ground-based observers.

Like a detective following up on a lead, ground-based observers, particularly amateur astronomers, have been essential in following up on TOIs to determine "who really did it." As we shall see, the TOIs are sometimes fingerprints that lead to suspects in the target’s vicinity who are the real culprits. The process of moving a TOI from "candidate" to "confirmed" status consists of a number of subgroups that are part of the TESS Follow-Up Observing Program (TFOP). The first TFOP subgroup in this pipeline consists of ground-based observers who are the real culprits. Differential photometry compares the flux of the star to the flux of an ensemble of presumably non-varying comparison stars to determine the relative magnitude of the target star. A large number of amateur astronomers are part of this TFOP subgroup and are actively conducting such ground-based observations. The American Association of Variable Star Observers (AAVSO) has been a major provider of amateur astronomer talent to TESS through training provided by its own photometric observers, through a qualification program for membership in TESS that it established, and by way of its continuing mentoring and support of amateur astronomer planet-explorer practitioners. In addition to the following clues to help our exoplanet detectives determine which, if any, of the above suspicion might be the actual culprit behind the TESS-detection:

CASE 1: The target is actually a binary eclipsing consisting of a primary star and a secondary star, where the secondary’s transit is mimicking a transiting exoplanet.

CLUE 1: Does the light curve bucket-shaped or "claw-like"? If so, the target star is an eclipsing binary with a different color than the original target.

CASE 2: A variant of case 1 is where the light of the eclipsing binary is blended with a neighbor.

CLUE 2: Are there dips? If so, the target star is an eclipsing secondary grazing primary.

CASE 3: The target is an eclipsing binary where the secondary star "grazes" the primary star.

CLUE 3: Is the light curve different for alternating filters? If so, the secondary star is different from the primary star.

CASE 4: The target is a non-planetary body? For example, if the estimated radius of the transiting object, based on the light-curve depth and radius of the host star, is greater than 2.5 times the radius of Jupiter, then the transiting object is considered too big to be a planet.

Amateur astronomers playing on TESS ground-based observers have proven to be critical in helping TESS achieve its goal. TESS’s cameras have a large image scale of about 1 arcminute to detect transits of planets in front of their host stars. The initial photometry gate through which TOIs pass requires ground-based observations. The American Association of Variable Star Observers (AAVSO) has been a major provider of amateur astronomer talent to TESS through training provided by its own photometric observers, through a qualification program for membership in TESS that it established, and by way of its continuing mentoring and support of amateur astronomer planet-explorer practitioners. In addition to the following clues to help our exoplanet detectives determine which, if any, of the above suspicion might be the actual culprit behind the TESS-detection:

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Amateurs participating on the TFOP team are given access to a very useful tool called the TESS Transit Finder (TFF). The TFF allows an observer to determine which TOIs are observable on a given night at the observer’s location. In addition to predicted transit times and depths, the TFF provides guidance on the goal of the observation, typically to see if any of the above clues exist. Examples of such guidance are:

- If no transit has yet been detected, check for nearby eclipsing binaries in a 2.5-arcminute field around the target. To help both amateur and professional observers perform such a check on sometimes upward of several hundred stars, the author has created an automated tool.

- If a transit has been detected by a ground-based observer using a particular filter, check for any chromaticity difference by observing the TOI with a different filter.

- If a transit has been detected, check if there is a difference in depth between every other predicted transit event. Apart from helping move a TOI from candidate to confirmed status, amateur astronomers are also helping to refine the ephemerides of confirmed exoplanets. For example, because TESS has been able to dwell on most of its targets for only 27 days, further observations are needed to refine the ephemerides of confirmed exoplanets. This is especially important for the exoplanets that will later be observed by JWST in order to precisely know transit times.

As we have seen, the detection of a dip in light of a star by TESS is not proof-positive that it was caused by an exoplanet transiting the face of the star. A rigorous process requires ground-based observations to confirm that an "imposter?" First, let's consider the more common suspects that could result in such false-positive cases. They are:

- "false positive" – one of the more common candidates that could result in a false positive. For example, if the estimated radius of the transiting object, based on the light-curve depth and radius of the host star, is greater than 2.5 times the radius of Jupiter, then the transiting object is considered too big to be a planet.

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MEMBER ASTROPHOTOGRAPHS

All photos © 2020 by their respective creators.

GALLERY

Top this page: Joe Ziha (Astronomical Society of Eastern Missouri) captured this image of M46 and NGC 2438 from Dark Sky New Mexico using a SkyWatcher Esprit 120 refractor with a ZWO ASI1600MM Pro camera.

Just above: Venus captured by Kevin Witman (Astronomy Enthusiasts of Lancaster County) using a Meade LX50 10-inch SCT with a ZWO ASI290MM camera.

Near right: Straight Wall captured by Steve Thornton (Temecula Valley Astronomers) using a Celestron 9.25-inch SCT with a 2x Barlow and a ZWO ASI120MM camera.

Far right this page: Plato and the Alpine Valley captured by Ralph Ford (South Bay Astronomical Society) using a Takahashi Mewlon 210 with a QHY 5-III 290C camera.

Above: Bruce Blair, Jim Cuca, and Jim Shwatal (Chicago Astronomical Society) captured this image of NGC 2264 from Rodeo, New Mexico using a PlaneWave CDK 12-inch with a modified Canon 6D camera.

Below: Kevin Witman (Astronomy Enthusiasts of Lancaster County) captured this image (shown slightly cropped) of NGC 2403 with a Lyrid meteor using a Celestron Edge HD 9.25-inch SCT (1645 mm with 0.7x focal reducer) with a modified Canon 1000D camera.
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Dave Wickholm, No. 1197, Mike Titus, Haleakala Amateur Astronomers
James F. Petruzzi, St. Louis Astronomical Society; No. 1191, Jenny Stein, Houston Astronomical Society;
Binocular Messier Observing Program
Richland Astronomical Society
Rich Krahling, Michael McShan, No. 38, Beyond Polaris Observing Program
Society
No. 30, Dave Wickholm, Back, San-Antonio Astronomical Society
Sky Puppy Observing Program
No. 64, Christopher Tonge, Kamloops Astronomical Society
Solar System Observing Program
Shelior Evolution Observing Program
No. 77, Paul Harp, Evolutionary Astronomers, No. 78, Michael O. Stewart, Astronomical Society of Kansas City, No. 79, Brian Cadick, Houston Astronomical Society, No. 80, Cindy Koch, Haleakala Amateur Astronomers Two in the View Observing Program
No. 35, Stephen Jones, Houston Astronomical Society
Universe Sampler Observing Program
No. 146, Doug Stine, Member-at-Large
Urban Observing Program
No. 201, Mark Collin, Member-at-Large; No. 206, Richard Whelan, Northeast Florida Astronomical Society; No. 207, John Matteliti, Northeast Florida Astronomical Society

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- the classic orange tube C8 of the 1970s,
- the first computerized telescope, CompuStar, in the 1980s,
- Fastar f/2 technology that reinvented astrophotography in the 1990s,
- the SkyScout Personal Planetarium in the 2000s,
- and StarSense self-aligning technology in the 2010s.

Today, our world-class team of optical and electrical engineers at our headquarters in Torrance, California, continues to push the boundaries of technology with our RASA optical systems and our new smartphone app-enabled telescope, StarSense Explorer. Just as our founder did, we’re revolutionizing the hobby of astronomy for beginners and advanced amateurs alike. And we’re just getting started.