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

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Terry Hancock and Tom Masterson (Western Colorado Astronomy Club) captured this fantastic image (shown cropped here) of Comet C/2021 A1 (Leonard), M3, and a meteor, from the Grand Mesa Observatory using a Takahashi E-180 Astrograph with a QHY367C color CMOS camera.
Dave Wickham pointed out to us that the apparent size of NGC 515 in M33 is 30 arcseconds rather than 30 arcminutes (December issue, page 9). In the same issue we inadvertently misspelled the last name of our resident wordplay editor. Dave Tosteson (page 27). We regret both errors, but greatly appreciate that our readers are sufficiently engaged with the magazine to catch them.

Editor’s Note

CALCULATING THE AL in YOUR COMMUNITY OUTREACH

As we (hopefully) see the winding down of the pandemic and the return to in-person public outreach, we at the Reflector want to help clubs recruit new members. We have a limited number of extra copies of the special 75th anniversary issue of the magazine, which we will make available to clubs to hand out at their in-person outreach events. To apply for these valuable giveaways, please email editor Kris Larsen (larsen@ccsu.edu) describing the outreach event and the approximate number of copies you are requesting. Please make your request a month before the event to ensure proper delivery.

To the Editor

Really enjoyed the article “Reaching Out to the Future” by teenager Canol Richards in the June 2021 issue of the Reflector. Our club, the Back Bay Amateur Astronomers (BBA) in southeast Virginia, is big on astronomy outreach. Our motto is “Bringing astronomy to the people of Hampton Roads.”

I am a 74-year-old amateur. These days I engage mainly in visual observation for the sheer joy of it. In the fall and early winter I can spend hours at the eyepiece contemplating the Andromeda Galaxy. Recently I have been astonished by the number of satellites that I see! A satellite in the eyepiece was incredibly rare when I began observing with my homemade 6-inch f/9 reflector back in 1962. Now I see several every night! I had been thinking that this was mainly because my field of view was less than a degree back then, as compared to the 4.7-degree FOV of my 100 mm 1/5.4 f/10. I now realize that a new danger has arisen of satellites interfering with the traditional observatories.

John M. Roberts

CELEBRATING THE AL IN YOUR

population of 900 individuals for this online event. A large number of clubs provided door prizes. The League, as well as many of our member clubs, continued to schedule multiple online meetings. With the pent-up demand from the public to get out under the stars, many societies modified their usual ways of operating to safely allow limited ways of sharing the night sky.

Our members continued to observe. Our observing program coordinators continue to process many submissions, although club outreach activities were slowed dramatically by COVID-19. On December 11, I was honored to be the keynote speaker of the Sugar Creek (Arkansas) Astronomical Society’s annual Christmas party and its 20th anniversary celebration as a society.

The following week, on December 17, I joined the Baton Rouge Astronomical Society to help celebrate its 40th anniversary as a club. The meeting was held at the Highland Park Rod Observatory, where some ALCon 2023 activities are being scheduled by the host club, the Baton Rouge Astronomical Society. The observatory is a joint venture between Louisiana State University and the Baton Rouge Astronomical Society.

May 2022 will be an outstanding year for our members, as we hopefully make positive steps in returning to “normal” after the two years of disruptions caused by COVID-19.

—Carroll Iorg
President

Star Beams 2021 in Review

As we start the new year, it is appropriate to look back and see where we have been. We started 2021 with COVID-19 still a force to be reckoned with. Shortly after the year began, we postponed an in-person ALCon in Albuquerque. ALCon 2021 is still scheduled for July 28–30, 2022. ALCon 2021-Virtual was an outstanding success, with numerous high-quality speakers from around the world and an impressive registration of 900 individuals for this online event.

To the Editor

I really appreciated the article “Reaching Out to the Future” by teenager Canol Richards in the June 2021 issue of the Reflector. Our club, the Back Bay Amateur Astronomers (BBA) in southeast Virginia, is big on astronomy outreach. Our motto is “Bringing astronomy to the people of Hampton Roads.” Having been into amateur astronomy for 21 years myself, I am grateful to have three of my grandchildren also interested. Two of them are members of the BBA, and the third one lives two hours away.

My granddaughter Samantha had to do a science project when she was in sixth grade, so Pop-Pop (that’s me) did some astronomy suggestions, and she took off and ran with them. When I saw her interest, I gave her a small Orion XT 4-inch Dobsonian reflector, and she quickly became adept at it. With two years had outgrown it, so I took it back and gave her an Orion 8-inch Dob.

She is 18 now, and a college freshman, but before she graduated from high school she got her causation in astronomy. I gave 13-year-old Chel that XT scope for Christmas last year, and she loves it! She enjoys attending BBA public observing events, and revels in showing the stars, planets to her friends. Samantha and her 13-year-old cousin Elena, who lives in Goshland, Virginia, interested, and for Christmas I gave each of them an Orion DeepDipper 600 and subscription to Astronomy magazine. Elena is fortunate to live in a semi-rural area, and has a dark sky in her front yard. We live in Virginia Beach have to drive an hour or more to find a dark skies.

I knew Samantha couldn’t fit that 8-inch Dob in her dorm at college, so as a going-away present I gave her an 80 mm refractor on a good, solid Bogen/Manfrotto tripod to take with her to Lynchburg, Virginia, which is farther south. As it was, I was gratifying to see some of my grandchildren following in the steps of their “Pop-Pop.” Our club also has a few other teenagers in the club, and one in particular, Daniel Dan- drade, is a real whiz at finding deep-sky objects in his 10-inch Orion Dob. He treats visitors at our public skywatch to many glorious sights, and seems to have a genuine interest in astronomy. I can attest that there is no lack of interest among young people in astronomy, just an access problem, as Colan said in his article. They need transportation to get to events, and they need guidance and equipment. The BBA receives donated scopes every now and then, which we turn around and give to newbies who show a genuine interest in the stars. We share our knowledge and expertise, patiently mentoring those new to our hobby.

We urge everyone to “keep looking up!”

—George Braid
Back Bay Astronomers (BBA)
енцє was free to anyone who wanted to register and attend whatever sessions piqued their interest. Why am I writing about something after the fact? Because it was so well done and because the entirety of the conference was available on the IDA website (conference.darksky.org). The keynote speaker was Apa Amatnagteretsa, a cosmologist studying the first stars and quasars in the universe. She is a professor in the Department of Physics and Astronomy at the University of San Francisco, and a former National Science Foundation (NSF) Astronomy and Astrophysics Postdoctoral Fellow. Her topic was how to make outreach events accessible to as many people as possible? Making outreach accessible at the conference, but I am sure the presenters as if you attended the conference. It is too late dark sky activists, and satellite proponents can multiple communities worldwide? She gave many do we couple this with responsible space exploration. that dark skies are an inherent human right. How many people wonder about accommodations for folks in wheelchair or limited mobility in general (for example, they can't bend over very far or crouch, or cannot use a step ladder). You can make sure to set up in an area where people can reach you in a wheelchair, either near ramps or places where assistants can help some- one in a wheelchair. Look for a place where you can see the telescope you have almost certainly made some changes to better accommodate them. Do you have a stool or stepladder to help kids of differ- ent heights see through the eyepiece? Maybe you add red lights to help parents and kids see around your telescope just because they couldn’t reach the eyepiece, you want to make sure anyone else who stops by your setup has a chance to see the telescope without making adjustments. If you want to share more accessibility tips and outreach methods from our members as widely as possible, and we look forward to sharing them at tonight’s meeting.

GETTING HANDS ON THE COSMOS
In the last issue of the Reflector, I highlighted season-based activities as examples of how we can double inclusivity and outreach. A prime example is “The Sky in Your Hands” planetarium project, led by Amelia Ordiz-Silin and Lina Canas, who work with the International Astronomical Union’s Office of Astronomy for Development. The objective of “The Sky in Your Hands” is to download the planetarium show and the 3D printer file to generate a half dome constellation sphere. The dome ties into the narration, or for a large crowd, sign language (American Sign Language) interpreters to assist in larger events and conferences even include ASL English speakers are also another option, and some you have someone available who types fast and accurately! Second audio options for non-English speakers are also another option, and some larger events and conferences even include ASL (American Sign Language) interpreters to assist in presentations to their audiences. As you can see, accessibility isn’t a one-and-done sort of thing; it is an ongoing process that you can continually work to better serve your audiences. You may find along the way that in thinking about how to better reach those who are not regularly served by your public events, you end up making improvements for your own public engagement all the more engaging and engaging event for all. How do you make your public engagement more accessible? Do you have any stories or tips to share? Send them to us at nightings@astrosociety.org. We want to share more accessibility tips and outreach

Wanderers in the Neighborhood

IDEA... 

TIPS FOR MORE ACCESSIBLE PUBLIC EVENTS

What do you do to help make your public outreach events accessible to as many people as possible? Making outreach accessible may seem daunting, but there are many things we can do that can help everyone enjoy ast- ronomy. You’ve probably made a few adjustments to help make own setup more accessible already, without even realizing it. As you can see, accessibility isn’t a one-and-
The initial orbit was highly elliptical, ranging from 5,800 miles down to 125 miles. In an elliptical orbit, the spacecraft travels fastest when it is nearest the planet and slowest at its farthest point (apogee). MESSENGER transmits data back to Earth at a fixed frequency, but the frequency of the signal received at Earth varies due to the Doppler shift. The Doppler shift raises the received frequency of the signal from MESSENGER when the spacecraft is moving toward the Earth. The higher the speed, the more the frequency increases. Conversely, when the spacecraft is moving away from us, the frequency drops in proportion to its speed. This is similar to a car horn sounding higher pitched as it approaches and becoming lower as it moves away, as the Doppler effect impacts both sound and light waves. MESSENGER's speed at every transmission was computed and recorded. These measurements, along with data from the Mercury Laser Altimeter, allowed astronomers to determine the shape of Mercury’s gravitational field. This, in turn, exposed Mercury’s internal structure, since the planet’s internal density shapes the gravitational field. The observations showed that Mercury has a large iron core, occupying the central 55 percent by volume of the planet. This is unusual, since Earth’s iron core occupies only 17 percent. Mercury’s core is very dense, implying it is mostly iron. It has a higher percentage of iron than the Earth’s core. In addition, Mercury’s magnetic field indicates that the core is at least in part molten.

It is believed that the central core of Mercury is solid, surrounded by a very thick layer of molten material with a rocky mantle floating on it. The top crust is just 22 miles thick. Many narrow ridges are distinctive features on Mercury’s surface, extending up to several hundred miles long. These most likely formed after the surface solidified but the core and mantle continued to cool and contract.

Four hypotheses provide possible explanations for Mercury's high iron content. One model has Mercury forming with two- to three-quarters its current mass. It was impacted by a planetesimal one-sixth this size, which stripped away most of the rocky material, leaving the enhanced iron content. A second has Mercury forming at twice its current mass, but the early Sun had not stabilized and its heat vaporized much of the surface rock. The vapor was then carried away by the solar wind. A third option has the proto-solar nebula creating a drag on the particles that Mercury was accreting during its formation. This drag caused the lighter particles to fall toward the Sun, leaving the heavier iron-rich particles to form the planet. The final possibility, based on models developed at the University of Maryland, has the Sun’s early magnetic field pulling iron-rich particles nearer the Sun. The particles forming Mercury would then have been iron-rich, giving the planet its high iron content.

The European Space Agency (ESA) and the Japan Space Agency (JAXA) launched the BepiColombo probe toward Mercury on October 20, 2018, to help determine how it got its rich iron content. The spacecraft has already made one flyby of Earth and two of Venus, and then it made the first of six Mercury flybys on October 1, 2021. It will attain orbit around Mercury in 2025. We may learn much how this unique planet formed.
intermediate between a normal and barred spiral galaxy. M65 is slightly fainter and smaller than M66. It is listed at magnitude 9.2 and measures 7.6 by 1.8 arcminutes in size. We see M65 part way between edge-on and face-on, and in small telescopes it appears elongated in the north-south direction. Both M65 and M66 are classified as Sa spiral galaxies. However, M65 appears to be more symmetrical in shape than M66, including its core and spiral arms. Photographs of M65 show a dark dust lane circling the east side of the galaxy, that is, the side closest to us. Typical of spiral galaxies, this dust lane probably surrounds the entire galaxy. Both galaxies are approximately 35 million light-years away.

A magnitude 10.2, NGC 3628 is the northernmost and faintest of the trio of galaxies. It is also the largest, measuring 13 by 3.4 arcminutes in size. Because it is fainter and its light is spread out over a more extended region, NGC 3628 is more difficult to see than M65 or M66. The galaxy is seen edge-on with its brighter galactic disk split in half by a dark dust lane. Since the galaxy resembles a hamburger patty with a bun, astronomers call NGC 3628 the Hamburger Galaxy.

Like its neighbors, NGC 3628 is an Sb spiral galaxy 35 million light-years away. This means the galaxies are actually cosmic neighbors! M65 and M66 may be as little as 200,000 light-years apart with NGC 3628 a mere 300,000 light-years away from the Messier pair. Those distances are comparable to the Milky Way and its satellites, the Large and Small Magellanic Clouds. The big difference is the Magellanic Clouds are much smaller galaxies than the Milky Way while all the galaxies in the Leo Trio are big galaxies like the Milky Way! At those small distances, the views of the other two galaxies from any one are undoubtedly more impressive than the Magellanic Clouds from Earth.

The image (previous page) of M65, M66, and NGC 3628 was taken with a William Optics 132 mm f/7 refractor with a O.8× focal reducer/field flattener to yield f/5.6. The 120-minute exposure was taken with a SBIG ST-4000 color CCD camera. In the image, north is up and east is to the left. The brightest star in the image is magnitude 7.1, whereas the faintest stars are magnitude 16.5. The detail in this image should allow visual observers to test their optics and observing location to see how much detail can be captured with the eye at the telescope!

Women in Astronomy

A GUIDE FOR EDUCATORS AND OUTREACH SPECIALISTS

Just in time for Women’s History Month, this newly expanded and updated guide to resources for teaching about the challenges that face women in astronomy, and the achievements that women have made despite those challenges, is now available. This 200-word article on any astronomical topic of interest. Longer articles are considered on a case-by-case basis. Your article should be submitted as a single text file (MS Word or any rich text format application) to editor Kris Larsen (kris@ccsu.edu). Figures, tables, and photos should NOT be embedded within the text, but instead attached to your submission email as individual files.

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T he Kansas Astronomical Observers are proud to dedicate the telescope won through the Astromo-

nical League to the Douglass Public Library in Douglass, Kansas. The modified telescope was
delivered on November 10, 2021. Their tele-
scope is now registered on the librarianslibrary.telescope-
.org website. They are eager to catalog their new
telescope so their patrons can check it out. Their
new telescope was posted on the library’s Face-
b ook page and was well received with positive
responses that librarian Cina Shirley “is the best
librarian ever. "

Author and famed geodetist Brent Archinal
could not be present, but he sent a wonderful
letter that I read to the audience. After mention-
ing his own remembrances of Bob and noting all
of Bob’s contributions to the preservation of dark
skies, educational outreach, and mentoring, he
channeled a quote from national park plaques
honoring Stephen Mather, first national parks
director: “There will never come an end to the
good that he has done.”

I then spoke of my efforts to find one word
that best described Bob Gent, a good friend
who served as League vice president when I was
president and who helped me in the early days of
the National Young Astronomer Award (NYAA)
program. The word I found was “protector.” As a
retired United States Air Force lieutenant colonel
duty and space systems officer, Bob devoted his career
to the protection of his nation. He fought to
protect the beauty of the night skies though his
work with the International Dark-Sky Association
as both vice president and president, his creation of
International Dark Sky sites, his work with
lighting fixture companies and labs, his contacts
with Congress through the offices of Represent-
ative Gabby Giffords, and his mantra for dealing
with light polluters: “make friends, not enemies.”
He protected our future though his mentoring of
countless young people, and his extensive public
outreach. He protected amateur astronomy in its
key role in educating the public through his work
as the League’s Reflector editor, vice president,
and 30th president, through his service as chair
of League national conventions in 1995, 2001,
and 2010, and through his work with NYAA.
For all of this, he was rightfully recognized with both
the League’s G. R. Wright Award for service and a
President’s Award. Last, but hardly least, he pro-
tected his family. He was the constant companion
of his beloved wife of 48 years, Terrie, who is also
a retired USAF colonel, and later in life, he and
Terrie gave up their home in Arizona to be near
elDERly family members.

Bob Gent Observatory dedication

On October 9, 2021, it was my honor to dedicate the new Bob Gent Observatory at the 2022 Hidden Hollow Astronomy Conference. This dedication was made possible through the kindness and generosity of the Richland Astro-

nical Society, which conducts the conference each October and maintains the William A. Rupp
Observatory and its 31-inch Newtonian reflector in the hills east of Mansfield, Ohio.

Although there was a small chance of rain, the skies cleared to billowy cumulus clouds, bright
sunshine, and 75-degree temperatures for the

LIBRARY TELESCOPE

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and 2010, and through his work with NYAA.
For all of this, he was rightfully recognized with both
the League’s G. R. Wright Award for service and a
President’s Award. Last, but hardly least, he pro-
tected his family. He was the constant companion
of his beloved wife of 48 years, Terrie, who is also
a retired USAF colonel, and later in life, he and
Terrie gave up their home in Arizona to be near
elDERly family members.

Bob Gent Observatory dedication

On October 9, 2021, it was my honor to dedicate the new Bob Gent Observatory at the 2022 Hidden Hollow Astronomy Conference. This dedication was made possible through the kindness and generosity of the Richland Astro-

nical Society, which conducts the conference each October and maintains the William A. Rupp
Observatory and its 31-inch Newtonian reflector in the hills east of Mansfield, Ohio.

Although there was a small chance of rain, the skies cleared to billowy cumulus clouds, bright
sunshine, and 75-degree temperatures for the
...
CALL FOR OFFICER NOMINATIONS

Nominations for league president, vice president, and executive secretary must be received by nominating committee co-chair John Goss at goss.john@gmail.com no later than March 31, 2022.

The president is chief executive officer of the League and has general supervision of the business affairs of the League. The president executes and terminates all legal instruments in the name of the League as authorized by council, presides over League council, business, and executive committee meetings, and appoints persons to all League committees.

The vice president assists the president and assumes the presidency if the president cannot serve. The vice president is responsible for programs not otherwise assigned, is responsible for national convention planning, and chairs (or co-chairs if a candidate) the nominating committee.

The executive secretary oversees the League national office, conducts business as prescribed by the council, and, in cooperation with the national office manager, the League treasurer, and the ALCor from each member society, verifies all change notices. The executive secretary works with the ALCor to ensure current mailing addresses are updated.

The editor-in-chief is responsible for the content of the Reflector and for the official publication of the Astronomical League. The editor-in-chief works closely with the nominating committee to ensure a smooth nominating process.

The treasurer is responsible for the financial affairs of the League, the ALCor, and the ALCor from each member society, verifies all change notices. The treasurer works closely with the nominating committee to ensure a smooth nominating process.

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An Ancient Observatory
With No Telescopes

By Jai Shet

The city of Jaipur, located in the arid region of North India, is home to ancient palaces, forts, and monuments. The city was named after its founder, Maharaja Jai Singh II. He was a king with a particular interest in astronomy and mathematics, and is considered one of the most scientifically educated rulers of the Maghul period. His greatest scientific achievement was Jantar Mantar, a collection of observatories built between 1724 and 1735. Derived from the Indian language Hindi, Jantar Mantar translates to "a calculating instrument." Although five such observatories were built in North India, only four remain to this day.

The observatory in Jaipur is the largest of the remaining four and consists of nineteen fixed astronomical instruments with different functions. It is a common notion that observatories have telescopes; however, in the nearly 300-year-old Jantar Mantar, not a single telescope was ever built. The Europeans had telescope observatories since the 1600s, but such observatories were not used in India for centuries. The ruler of Jaipur at the time presumably knew about European advancements in telescope observatories yet chose to implement older methods of observation. He believed in the importance of preserving the culture of traditional Indian astronomy.

Before Jantar Mantar was built, the older brass instruments they had at the time were worn out. Astronomical charts created using those instruments turned out to be inaccurate when compared with their current observations of the night sky. As a result, Jantar Mantar was constructed with long-lasting materials. They are all static, unmoving constructions of local stone and marble. Their uses included measuring time, tracking the movement of stars and planets, and even predicting eclipses. They all had one thing in common: enabling astronomers to make precise measurements with just naked-eye observations, an impressive feat.

To visitors, the main feature that stands out is the world’s largest sundial. With its remarkable height of 27 m (89 feet), the sundial can measure the time of day with a precision of 2 seconds. The shadow cast by the sundial’s gnomon (the triangular part) moves noticeably at 1 mm per second, which gives the viewer a sense of the Earth’s rotation. The sundial was built on the concept that the larger the structure, the more accurate it would be. This idea of “bigger is better” is apparent in many instruments within the observatory.

Some instruments are said to have been devised by the founder of Jaipur himself. These are two peculiar structures that were some of the most elaborate devices used in 18th-century India: the Rama Yantra and Jaya Yantra (Yantra translates to “device”). Both these instruments were innovative, as they were each split into complementary pairs. Splitting them into two allowed observers to walk inside the structures to more closely inspect the readings on the scale. The Rama Yantra was used to find the altitude of the Sun, and a centered pole cast a shadow on the column’s scale from which a measurement was made. The Jaya Yantra is a pair of hemispherical sundials 5.3 m (17.5 feet) wide that are below ground level. Astronomers could walk down a flight of stairs to observe from underneath. A metal disk at rim level (just visible in the photo, near the top, suspended from crossed wires) casts a shadow during the day on a bowl-like surface that is engraved with equatorial and altitude-azimuth coordinate systems. The disk also serves as a sighting device for nighttime use. In fact, combining the two hemispherical sundials would produce an inverted map of the heavens.

There are many instruments in the observatory that represent architectural and scientific innovations of Jai Singh and Indian scholars of the 18th century. When I visited Jantar Mantar in 2010, I felt as though I had traveled back in time. The ancient structures towered over me in the afternoon sun as I straddled around in wonder. I quenched my curiosity during my visit to learn more about astronomy from the perspective of an ancient culture.

In the present day, Jantar Mantar is recognized as a scientifically and culturally significant collection of astronomical instruments. Many of the Jantar Mantar instruments had precision never before achieved. In 2010, Jantar Mantar in Jaipur was designated a UNESCO World Heritage Site. The observatory is still used for teaching, research, and observation, and serves as a meeting ground for scientific, cultural, and religious communities. More importantly, Jantar Mantar is preserved for future generations to behold as a piece of history and a scientific work of art.
The Artist
And the Eclipse

By Bob Kerr

The astronomy community had long been aware of the historic nature of the June 8, 1937, eclipse. Maximum totality would last 7 minutes and 4 seconds, and total eclipses with durations of 7 minutes or greater don’t come around often. The last totality exceeding 7 minutes had been 7 minutes and 5 seconds, 809 years earlier in 1098.1

Stephens, known as Owen, was 10 years old. His parents moved to Rose Valley, an arts and crafts community in southeastern Pennsylvania. Here, his artistic inclinations were nurtured and his mind was opened to the beauty of the universe. He was fascinated by the possibility of translating scientific knowledge into art forms.

The Hayden Planetarium–Grave Expedition of New York’s American Museum of Natural History (AMNH) was the only significant astronomical expedition to Peru that would stimulate public awareness and provide compelling attractions for Hayden’s public programs. The expedition was led by Dr. George Clymer Fisher, the museum’s curator of astronomy.

Fisher was a renowned astronomer and expert on weather, duration, and accessibility. He evaluated sites based on the climate, topography, and access to the site. He chose Cerro de Pasco, a remote mountain range in the Andes, as the location for the eclipse.

The expedition was funded by the Hayden Planetarium, and D. Owen Stephens was chosen to accompany Fisher on the trip. Stephens was a gifted artist and scientist, and his inclusion was respected by the astronomy community.

The expedition was a significant event in the history of astronomy, as it was the first time a total eclipse of the Sun was observed in the Western Hemisphere. The eclipse was particularly significant because it occurred in the middle of the Little Ice Age, a period of colder than average temperatures.

The eclipse was seen by millions of people around the world, and it was documented in detail by the expedition team. The expedition was a great success, and it paved the way for future eclipse expeditions.

The expedition was a thrill for Stephens, who was able to witness the eclipse from his telescope. He was able to see the moon cover the sun and create a brilliant corona around the sun. He was able to capture the beauty of the eclipse in his paintings, and he was able to document the event in detail.

The eclipse was a momentous event in the history of astronomy, and it was a momentous event in Stephens’s life. He was able to witness a total eclipse of the Sun, and he was able to capture the beauty of the event in his paintings. The eclipse was a moment that he would never forget, and it is a moment that he would always cherish.
Since their arrival, the skies had been mostly overcast, punctuated by episodes of skirt and snow, but there were rare nights when the skies turned magnificently pristine.

At high altitude under skies darker than Stephens had ever seen, the sumptuous southern sky mesmerized him. To his wife, Lucie, he wrote, “The astronomy is queer. The sun in the north and moving apparently backward across the sky, all the familiar constellations are on their backs and new ones we never see....” Stephens memorialized the galaxy’s bounty with “The Milky Way from Sagittarius to Crux,” an expansive canvas of stunning detail.

On the morning of the eclipse, the weary group arose to find heavy frost with dense fog obscuring the mountains. They were incredulous when local residents matter-of-factly informed them this was a good sign. The weather was changing.

As morning progressed, unexpected patch- ed blue deep slope melted the clouds in the northwest. By mid-morning, large swaths of sky were cloud-free, and scientists hurried over the course of the 2 minutes and 38 seconds of totality, numerous exposures were made with each long-focus camera according to a predetermined schedule: 1 second, 4 seconds, 16 seconds, 24 seconds, 16 seconds, 6 seconds, 1 second.

Stephens sketched the shape and extent of the corona, which the astronomers called a “sunspot maximum type,” and then added the locations and sizes of the dozen or so prominences. He was careful to match the colors of the moon, prominences, and sky. In a letter he explained, “I devoted 77 seconds to drawing the corona, 45 seconds to the partially eclipsed Sun, 25 seconds for prominences – 147 in all!” He would later render finished paintings.

The group embarked upon their passage over the mountains. Stephens, to whom little was in- fluential when distant sunrises collapsed into an illusory diamond ring. The bright glint-like solar corona exploded as though at the throw of a switch. Its brilliance appeared, Stephens observed, “Gloriously, misplaced against the blackness of the sky.”

He summed up his satisfaction.

“I painted before totality and after also and lastly the crescent sunnet with grand clouds. A gorgeous eclipse with the weirdness of the light impressing me more than before [earlier eclipses] – and what a setting!”

The coronal display was estimated to have extended a solar diameter and a half, with distinctive streamers running out from the sun’s northeast limb. Later, Dorothy Bennett observed that Stephens’ paintings “Total Eclipse” represents the corona with remarkable transparency and shows the wealth of streamers, arches and brushes that were observed, as well as the prominences.

Afterward, the Hayden parties returned to Lima, but Stephens spent another week at Cerro de Pasco finishing the “big canvases,” as he called them. Reading his commentaries, I wondered what might have run through his mind as he looked upon what were certainly his finest paintings. He couldn’t be faulted for imagining exciting future opportunities. Upon Stephens’ return to Lima on June 15, the staff observed he appeared to be in good spirits. Expedition leader Fisher was gratified all Hayden stations had experienced clear skies and reported excellent results. The group embarked upon their passage home in a celebratory mood, presumably anxious to regale their contemporaries with the activities of the expedition and his death.

The chairman of the Planetarium Advisory Committee charged that the principal eclipse painting “will hang permanently in the Hayden Planetarium....” Having been displayed for decades, most of Stephens’ paintings have been retained to storage. However, “Total Eclipse” hangs there to this day.

In the intervening years, the Hayden has been reimagined as the Rose Center for Earth and Space. Their stylish website states:

“Softly illuminated by deep blue light, the 87-foot Hayden sphere contains the 430-seat Hayden Planetarium Space Theater.... Just west of the giant glass structure, law a terrace where colored lights and jets of water represent the principal stars of the constellation Orion, and inlaid granite suggests the shadow geometry of an eclipse.”

I’d say the center’s inspired architecture is a realization of Stephens’ own grand vision, the appreciation of science expressed through art form. He would approve.

How glorious it would be to see his paintings displayed once again in an exhibit saluting great astronomical works of art, to coincide with the Great American Eclipse of 2024. The sweep of the shadow will grace our nation’s sky, as it did almost 100 years earlier when D. Owen Stephens first painted it there. ♦

must have painted this magnificent scene he called “Sunset Eclipse” with the relish of the landscape artist he was at heart.

In the intervening years, the Hayden has been reimagined as the Rose Center for Earth and Space. Their stylish website states:


“Sunset Eclipse,” Image 2485104284, American Museum of Natural History Library.

“Diamond Ring,” Image 2485123468, American Museum of Natural History Library.

“Sunset Eclipse,” Image 2485814024, American Museum of Natural History Library.

“Diamond Ring,” Image 2485123468, American Museum of Natural History Library.


“Sunset Eclipse,” Image 2485104284, American Museum of Natural History Library.


THE ASTRONOMICAL LEAGUE

ACKNOWLEDGEMENTS


ANS: Eclipse Predictions by Fred Espenak and Jean Meeus (NASA’s GSFC).

2. Clyde Fisher. Summary of Expedition, including quote from a T. Davison letter dated 1937; D. Owen Stephens collection; American Museum of Natural History, Special Collections.


4. Ibid.


7. Ibid.

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T he serene beauty of a spiral galaxy is just a facade. If we could view a time-lapse movie of its history to observe it interacting with the large space around it, we would have a new appreciation for how places like our Milky Way form and constantly change. With the benefit of simulations and a new imager on one of the world’s largest telescopes, that picture is becoming clearer.

A compact, massive merger whose light has been traveling toward us since before our Sun was born is revealing galactic inspiration.

When Galileo modified the new instrument we now call a telescope and pointed it at the sky, a revolution began. Of course, he could see only the visual wavelengths reflected or emitted by objects in our local neighborhood. However, a small fraction of the visible light is produced by gases and dust near us, which we call the Milky Way. In order to see something of what lies beyond our galaxy’s core, we would need to use a device that allowed atomic and molecular emissions and absorptions within it to be identified.

The highest mountain in the world sits not in the snow-capped Himalayas, but forms an island in the middle of our ocean. Mauna Kea has a peak over 4,000 feet above sea level, but its base on the Pacific floor lies 35,000 feet below the dormant top that is one of Earth’s best observing sites. This sacred site of the native Hawaiian people, which they graciously allow astronomers to use, holds the twin 10-meter Keck telescopes. An instrument located in Chile’s Atacama Desert, the Bubble, has recently been used to see, for the first time, details in the outflows of galaxies that are redefining our understanding of how they live.

The visible portions of spiral galaxies belie their true nature. What we see in images is only a small part of the greater structure that surrounds and interacts with them. Dark matter halos hold about ten times the mass of the visible portion and extend far beyond those borders. There is another part called the circumgalactic medium (CGM) that is an integral piece of how they form, grow, evolve, and survive. Until recently the only way to study this glory was through its absorption of light from distant quasars. Galaxies have such a small apparent size on the sky that only one quasar might be seen within its halo. On August 27, 2020, the Bubble site released a landmark study using forty-three background quasars to outline the Andromeda galaxy’s outer halo. Its upgraded apparent size is the diameter of three Big Dippers, extending up to two million light-years away from its center. On more distant galaxies this pointillist and painstaking procedure produced wonderful but limited data about their CGMs, and astronomers wanted a more complete picture.

David Rupke of Rhodes College in Mem-phis, Tennessee, is interested in the outer structures of galaxies, particularly the gas that surrounds them. He wanted to know how it got outside their visible boundaries, and what happened to it when it did. Fortune introduced him to Alison Goll of UC San Di-ego, and they formed a partnership to use Keck’s novel imaging system to study these

A TINY DISTANT GALAXY CAUGHT IN THE ACT OF BREATHING

By Dave Tosteson

Our Milky Way is a dusty star formation machine that is fueled by infalling matter, mostly hydrogen. Stars form from cold molecular gas, recycle through supernovae and stellar winds, and the energetic products of these processes drive galactic winds. The Cosmic Web Imager is a wide-field integral field spectrograph optimized to image low surface brightness phenomena. Rupke’s team used it on a number of galaxy candidates, most of them nearby ones with supermassive black holes at their centers. When fed by infalling matter, these can become active nuclei (AGNs), energetic producers of radiation. Many experts in the study of galactic winds thought AGNs were their source. Instead, a small and very distant object with a broad, known oxygen emission line stood out in the data set. The initial inter- pretation was that the lines were produced within the tidal tails of a galactic merger. It was only two months later, on a second look at his data, that Rupke realized the oxygen emission found by Keck’s CWI was on a much larger scale than the galaxy’s visible light: over a hundred times larger than its core!

This result prompted him to contact a group that was studying molecular outflows from galaxies using ALMA, the millimeter instrument located in Chile’s Atacama Desert. Jim Geach saw that Rupke’s ionized wind corresponded well with their data, and that their stellar formation modeling matched two outflows seen on Keck’s images. In honor of the discovery’s Hawaiian location, Geach offered the name Makani, which means “wind” in the native language. Like my breath on a cold January Minnesota day, Makani was seen exhaling. This galaxy is also known from its Sloan survey coordinates as SDSS J211824.06-001729.4. It is a massive, compact galaxy with one hundred billion solar masses and two tidal tails extending 50,000 light-years. A dense stellar core of only 1.500 light-years diameter contains ten percent of its light, with half its light found within 9,000 light-years of its center. Three ages of star formation were seen: at over a billion years, 400 million years, and less than seven million years. The latter two were likely produced in separate merger events, and correlate with two outflows identified on the Keck imaging. Geach and his team artistically depicted them on a rotateable, color-coded video. The outflow from 400 million years ago was expanding at about 700 kilometers per second, and the recent one had winds three times that fast. The researchers found X-rays illuminating the core suggesting obscured nuclear activity.

Our Milky Way has a leisurely star formation rate of just one solars per year. Makani is furiously making new stars two hundred times faster. Such starburst galaxies are capable of producing fast galactic winds independent of their nuclear activity, as seen in Messier 62, the nearest large starburst galaxy to us at twelve million light-years. The usual winds from compact galaxies are found out thirty thousand light-years or so, but the CGM in some extends ten times farther. Before Rupke’s discovery, the connection between galactic winds and the CGM was suspected but unseen. His composite diagram of Makani’s structure shows the hourglass, bipolar shape that he explains is characteristic of galactic winds. It has limb-brightened, evacuated bubbles with temperatures of 10,000 Kelvin (K) and metal-enriched, ionized gas in an area of 300,000 by 270,000 light-years, the largest O III nebula detected in a single galaxy. One estimate is that this very large structure has reached only a tenth its eventual size.

Astronomers think ninety percent of the Universe’s baryons exist outside the visual bounds of galaxies, within CGMs or the intergalactic medium (IGM). Makani’s nebula contains twelve to thirteen billion solar masses of molecular gas, with six hundred million solar masses of ionized gas, including a large amount of oxygen (O II). Atoms heavier than hydrogen and helium are called “metals” in astronomy, and most of these metals are found outside galaxies, in their CGMs. Unlike their light, metals act as a coolant, so gas nearer a galaxy is usually about 10,000 K. As opposed to the much hotter hydrogen farther out that can be 300,000 to a million K. Jason Fumini-son of the Space Telescope Science Institute has called CGMs “a multiphase medium characterized by rich dynamics and complex ionization states.” He says they are “a source for a galaxy’s star-forming fuel, the venue for galactic feedback and recycling, and perhaps the key regulator of the galactic gas supply.”

There is thus a continuous feedback between a galaxy’s CGM and what occurs within its interstellar medium, where stellar winds, planetary nebulae, kilonovae, and supernovae enrich and mix the gas between the stars. The complex interplay between galaxies, their CGMs, and the IGM has been simulated on the FIRE (Feedback in Realistic Environments) computer program. This multi-team project was led by a core group of four contributors: Phil Hopkins, Claude-André Fauch- er-Giguère, Dušan Kereš, and Eliot Quataert. It uses data representing the universe of 13.6 billion years ago, just the way we see it today, to follow how these three areas interact during and after the formation of galaxies. What was surprising as I watched the animation was how disruptive supernovae explosions were to nascent, forming galaxies in their early
Makani is classified as a compact mass-galaxies may be as much as mass as a spiral like our own, but held within a structure only five to ten percent its area of research. The graduate student--led Astrobites website has a nice explanation of the complex interaction between the GGM, dark matter halos, and IGM, and their roles in galactic evolution.

The Sloan data give a (g) magnitude of 19.78, the answer is yes. But it is faint, very faint. The National Science Foundation's NOIRLab began launching. The astronomy community alerting us to the threat to scientific research may be lost if we are not careful. An overview of the process for estimating satellite brightness is given in the chart representing real-time observing or imaging.

**PREVIOUS STUDIES**
There are many works available that describe the brightness of the Starlink and OneSat payloads, the effect of redesigned spacecraft (VissatStar, Darksat) and orbit manipulation. Many of these are based on a reasonable sample size and present the data with appropriate caveats. The approximate 1,000 km magnitudes (defined in detail later in this article) derived by arguably the best methods are magnitude 6 for the original Starlink and magnitude 7 for OneWeb and the VissatStar. Despite the progress made in quantifying the impact, there are lingering concerns to keep in mind:

1. Much data has been compiled with many measurements at one location, or few measurements at several locations.
2. In most cases, the data was gathered using imaging equipment at sites or by researchers who would be affected by any effect on sky darkness.
3. Satellite brightness is notoriously difficult to measure accurately and consistently, even with imaging equipment.

**STEPS IN MAKING OBSERVATIONS OF BRIGHTNESS**

**MEGASTELLATION SATELLITES**
Practical Ways Amateurs Can Help

**By Brad Young**

The December 2021 issue of the Reflector included an abridged version of an article by Dan Daniels, “The Mega Constellation Threat.” The original article contains additional relevant data.

*Most importantly, there are several new satellite and constellation designs and operators coming soon.*

**Items 1 and 2 are important only in that they provide weaknesses in reliability. However, this is easily managed by adding other sources of data and increasing the sample size. Item 3 is an inherent characteristic: there will always be errors. However, it is reasonable that the accuracy of predicted brightness will increase with more and better data.*

**Item 4 is the real conundrum. Putting aside current concerns, all the prediction models being built now will have to be modified once new assets are launched. Although some equipment parameters will be known, not all will, and this will stymie the operators in their design as well. As more models are flown (and there’s no doubt the existing operators will modify their assets), it will become even more important to understand what is happening before the situation is more alarm.

With research showing how bright comets interact and with our growing understanding of the cosmic web, dark matter, and active nuclei, it is tempting to imagine the Universe as somehow alive with breathing, evolving galaxies.

**From the four winds come O breath**

Makani: 21h 18m 24.06s, +00d 17m 29.4s

**REFERENCES**


**By Brad Young**

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This will provide useful information for improved design, policy, and licensing.

**HAVE WE LOST SCIENCE?**
It is much harder to determine whether scientific data may be lost if we are not careful. The current approach by those upset with the spike in spacecraft numbers is a well-meaning, poorly funded mandate that is competing with a trillion-dollar industry. That industry is crucial infrastructure and is innovating internet access for all. Neither side of this issue is wrong: informed, rational decisions are needed.

**ENGINEERING DECISIONS ABOUT MITIGATION**

The number of active satellite observers who report data is small, and much of that is concentrated on deriving orbit details, called elements, using symbiotic work of observer servers and orbital analysts. There are some observers who report varying brightness such as flaring or flashing (tumbling) but this is an even more niche area.

As with astronomy in general, satellite spotting is not easy and requires time and effort to learn and do. On the bright side, expenses can be kept low; in fact, most of you already have all the necessary equipment.

An overview of the process for estimating satellite brightness is given in the chart below, with blue items indicating preparatory or subsequent indoor activities, and orange representing real-time observing or imaging.
activities. This simplistic view can be expanded as follows.

SELECT TARGET SATELLITES

There are thousands of Starlinks (global cover- age is the key) so, given clear skies, this is not an issue but for one point. The Starlinks do not attain their final orbits and controlled orientations until up to a month after launch. They are wonderful to see in the early days after launch, but data taken at that stage quickly become obsolete. Consequently, until each object attains its final orbit, observation- al metric data are usually not useful.

GET PREDICTIONS FOR YOUR SITE

This also is usually not a problem, with several websites and apps available. At a minimum, you will need to know your loca- tion, expected time of observation, and your equipment’s limiting magnitude. Remember, moving objects may be rendered unseen or the trail dithering with imaging techniques, as the object passing between Taurus and Sexts. I chose to observe and record when the spacecraft was predicted to pass between the comparison stars Epsilon Arietis (magnitude 4.45) and Delta Arietis (4.35). I found an apparent magnitude of 4.4, equivalent to the Delta Arietis. It was steady in brightness and passed at a time of 08:06:20 UT, which means it was on time.

REVIEW AND REPORT DATA

After the observing or imaging is complete, there are several paths to a final, useful report.

• Visual observers that have the comparison star magnitudes are ready to reduce their findings.

• Imagers will need to do the same, using software to process the image to determine the same data.

• Using either the prediction or the actual time and position, the range and phase angle must be determined. This is the distance from object to observer and the Sun-object-observer angle. Both are available using predictions only, but the best data will come when the actual position and time are measured.

AN EXAMPLE

The following is far from a procedure, but will act as a guide. On December 20, 2021, I observed several Starlinks from my home, using 40-80 binoculars and the stopwatch on my Android phone, set using WWV by phone. Following steps outlined above:

Selecting targets

(NORAD catalog number; satellite name)

48571 STARLINK-2221
48583 STARLINK-2237
48595 STARLINK-2252
48556 STARLINK-2251
48604 STARLINK-2275

Getting predictions

(STARLINK-2275 will be used as a single example): Heavensaboveweb gives the pre- diction shown at the bottom of the page, with the object passing between Taurus and Sexts. I chose to observe and record when the spacecraft was predicted to pass between the comparison stars Epsilon Arietis (magnitude 4.45) and Delta Arietis (4.35). I found an apparent magnitude of 4.4, equivalent to the Delta Arietis. It was steady in brightness and passed at a time of 08:06:20 UT, which means it was on time.

Using the predictor app, I found the following:

Range (miles) = 436
Phase Angle = 62.9°

Note that phase angle for satellites is defined as 0 degrees at exactly opposite the sun – this may be unusual if you are used to observing planets or other fields.

Standard magnitude for a satellite is comparable to that of a star, except that both distance and phase angle are used. Many analysts use the 1,000 km magnitude standard, determined at a range of 1,000 km and a phase angle of 0° (fullily). The exam- ple calculation is based on a simplifying but important assumption, that the satellite has a perfectly spherical, lenticular surface. One way to describe this is a diffuse reflector-sur- face. Of course, neither of these things apply for the megacommunication satellites and the art is to determine, from reported apparent magnitudes, the correction factor that models the actual reflectivity of the surface over a range of phase angles.

A FIRST STEP — THE EOSC

The AstroSatellite League’s English Orbiting- Satellite Observing Club, with instructions and activities that may help you take the first step. Doing a few of the observations could inspire you to complete that program, and/or

TOWARDS A REAL SOLUTION

Megaconstellations are a real concern to the public, amateurs, and astronomical research- ers. Currently, there are groups working on this problem, and hopefully they will be able to provide a more effective way of gathering data. Perhaps you would like to contribute as a citizen scientist, monitoring and reporting data on the megacommunications. If so, please contact me and I will try to point you to resources or just have a conversation with you about how you can become involved. As amateur astronomers, we should be highly motivated to do something in this critical area that may impact not only our hobby, but the serious study of the universe.

By George Hripcsak and Klaus Hartkorn

AMATEUR OBSERVATION OF THE SOLAR CORONA OUTSIDE OF A SOLAR ECLIPSE

A

mateur observations of the solar corona outside of a solar eclipse have been an elusive goal. Amateurs view and image solar prominences all the time with modern equipment. However, prominences are about 100 times brighter than the corona and benefit from the fact that they emit their light in narrow bands of wavelengths like hydrogen alpha (656.3 nanometers), combined with the fact that the Sun’s overwhelming brightness makes the corona almost invisible to the naked eye (our Sun is blocked in those same wavelengths). During a total solar eclipse, the corona is revealed to be a beautiful collection of white streamers sometimes several times the Sun’s diameter. Author George Hripcsak first saw the corona during the 1980 total solar eclipse. He had seen photographs of the corona, which used to show little more than a diffuse glow. On his way to the viewing site, he saw a hand-painted report Starlink magnitudes. After this initial step, you may find satellites to be a nice addi- tion to your hobby.

SAFETY FIRST

Amateurs attempting solar viewing or imaging with homemade equipment must exercise extreme caution to make sure their eyes are not impaired. The Sun emits a blinding light that can permanently damage the retina.

The challenge to seeing the corona, which is almost as bright as the full moon, is to block out the million-times-brighter photospheric light right next to it, due to light that is scattered both within the atmosphere and within the telescope. The general approach to viewing the corona, developed by Bernard Lyot in the 1930s, is to build an instrument that produc- es an artificial eclipse, handle all the stray light that is induced, and view from a high mountain to reduce atmospheric scattering.
The advent of narrowband filters also makes the Eclipsion more feasible. Some amateurs have built their own coronagraphs, but until recently, there have been no clearly reported coronal sightings with images. Co-author Klaus Hartkorn started working on seeing the corona about two decades ago. After his first eclipse in 2017, he renewed his efforts, and using a home-built coronagraph and a pair of surplus 532.0 nm filters fitted enough to bring them on board, he saw and imaged the corona in his scope for the first time in November 2020, viewing from Mount Mitchell at 6,684 feet above sea level.

To our knowledge, that is the first documented amateur sighting and image.

Incidentally, Hripcsak set out to detect the corona through advanced image processing based on images through a used Baader prominence viewer. Summer viewing revealed a defective field lens with no chance of coronal detection. Hartkorn’s testing of his accomplishment led to a correspondence and collaboration with over a thousand messages between them and a retooling of the prominence viewer.

Modern amateur H-alpha solar filters, and Hripcsak’s Baader prominence viewer with a Celestron 80 mm /11.4 First-Scope, but the viewer came with cones sized for 919 mm and 1,000 mm. He replaced the Celestron objective with a 50 mm f/2 uncoated laser sight with very low scratch and dig, which minimizes the light scattered by the objective. The lens sits on the First-Scope’s dew shield to accommodate the extra focal length. He removed the baffles from the optical tube to reduce light that is reflected back up from the cone to the baffle and back to the eyepiece.

Hripcsak modified his Baader prominence viewer as follows. His field lens had been damaged and partly replaced by an earlier owner, so that needed replacing. He kept the Baader cones, attaching them with an M3 screw cemented with J-B Weld to a new achromatic doublet field lens. Between the cone and the field lens, he placed a new knife-edge aperture stop made from a thin aluminum sheet with an 18 mm hole, limiting the field to two solar diameters to reduce light scattered from the cone to the instrument wall and then back down toward the eyepiece. He replaced the iris with another knife-edge aperture stop and placed a tiny spot of paint (known as a Lyot spot) on a slip of glass to block light reflected within the objective lens. He kept the Baader relay lenses, although he changed their positioning to make the final rays more telecentric, and he kept the x-y adapter and removed the now-defective H-alpha filter. He blackened all the inside surfaces with Carbon Black 3.0 paint. The instrument was tested with the Sun and also using a very bright LED and collimating lens set in front of a light trap in an upper room at night. The modifications and testing took about a year.

The main filter is a pair of 25 mm single-cavity filters purchased from Andover Corporation centered at 530.3 nm (Fe XIV) when the H-alpha is at 656.3 nm. They were purchased with 42–45 percent transmission. They are sandwiched between a generic ultraviolet–infrared cut filter and an old Meade green CCD filter. The observer uses his homemade optical oven (two thermistors and two strip heaters with two solid-state controllers) to maintain the temperature at 32°C. Full telescope, the modified Baader prominence viewer with the cone removed, and the homemade oven for the 530.3 nm filter.

The first definite sighting and imaging with Hripcsak’s telescope was in October 2021, but the image in the top of figure 1 was taken at 9:34 a.m. EST, November 7, 2021, from Utsayantha Mountain. The corona was seen immediately in the eyepiece. The image was taken with an iPhone 7 with its 12-megapixel color sensor and its f/1.8 lens held by hand aloft a Tele Vue 32 mm Plossl. The image is in its original true green color with only some contrast adjustment and no sharpening. The black disk in the middle is the shadow of the cone, which causes the artificial eclipse, not the image processing. The bright green rim around the disk is due to diffraction. The diffuse green glow around the disk is scattered light in the atmosphere.

At 2 o’clock and 4 o’clock, the image is oriented based on an image of solar prominences of the corona through a solar eclipse in the United States. The image is in its original true green color, with some contrast adjustment and no sharpening. The black disk in the middle is the shadow of the cone, which causes the artificial eclipse, not the image processing. The bright green rim around the disk is due to diffraction. The diffuse green glow around the disk is scattered light in the atmosphere. At 2 o’clock and 4 o’clock, the image shows two large areas of brightening that represent the corona at the Fe XIV line. One can see some lobes in the image. Most other brightenings are artifacts (including the green arc in that area). That is actually the corona is proven in several ways.

1. Hripcsak turned the heater on and off several times to confirm that the two areas disappeared completely and returned when the filter came near 32°C. At 16°C, the filter shifts by about 2.5 angstroms, which pulls it off the Fe XIV line.

2. The images are always compared to a satellite image taken at the same time by the Solar Dynamics Observatory (SDO) at 171 angstroms, which matches the corona well. A download from about the same time is shown in the bottom of figure 1. As can be seen, the two regions at 2 and 4 o’clock match those on the SDO image very well. In the green image, there is something at 11 o’clock but that is an artifact. If one looks closely, there is a slight brightening at 10 o’clock. That also matches the SDO image. Most importantly, the images were not aligned to make the coronal glow match. Instead, the image is oriented based on an image of solar prominences taken at the same time.

3. For previous views, the optical tube was rotated to ensure that the corona does not rotate but stays with the Sun.

4. It so happens that Hartkorn was observing the same day and on the phone that night. The authors both described identical formations, the two big ones 30 degrees apart and a fleeting one across the disk.

Hripcsak subsequently observed the corona from a few yards away from the Peconic Bay, Long Island, so quite close to sea level on an extremely clear fall day. The corona was very subtle, however, Hripcsak also uses the coronagraph to observe prominences in various wavelengths, including H-alpha, H-gamma, and helium D3. He has also seen prominences in their natural color without filtering (other than ultraviolet and infrared blocking and some neutral density for safety). The primary concern is eye safety. It is quite easy to burn the retina on peeking around the cone during a solar eclipse but an accidental burn. The builder needs to consider all the solar wavelengths from 200 nm to 2,500 nm, the size of the objective lens, the degree to which the image is magnified by the series of transmissive lenses, the properties of each filter in the chain, and how to ensure that there is backup so that if one aspect fails or is accidentally forgotten, the eye is saved through another. While Hripcsak started on the coronagraph only a year ago, both authors have been engineer-
RIGHT: Jeff Padell (Skyscrapers, Inc.) captured this image of M83 using Slooh’s 17-inch PlaneWave CDK17 with a FlI ProLine FL16803 monochrome camera. This image combines exposures taken over eight months. Slooh can be a great resource for capturing images of objects you can’t reach from home.

BELOW: Gregg Ruppel (Tucson Amateur Astronomy Association) captured these images of Comet C/2021 A1 (Leonard) from his remote observatory at DSMM in Animas, New Mexico, with an ASA 10N f/3.8 Astrograph with a SBIG STL-11000M CCD camera and from his Tucson-area home with a 200 mm lens. Gregg’s November 24 image was the Astronomy Picture of the Day (APOD) for December 3, 2021.

ABOVE: Dan Crowson (Astronomical Society of Eastern Missouri) took this close up view of NGC 6749 from Dark Sky New Mexico using an Astro-Tech AT12RCT with a SBIG STF-8300M camera on a Paramount MX+ mount.

LEFT: Bernard Miller (East Valley Astronomy Club) captured this deep image of NGC 896 with a PlaneWave 17-inch CDK and an FLI PL16803 CCD camera from his observatory in Animas, New Mexico.
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Since the early 2000s, master astroimager and Team Celestron member Christopher Go has had a love affair with Jupiter. After working all day at his furniture business, he spends most nights pointing his 14” Celestron Schmidt-Cassegrain telescope towards the gas giant. His work has paid off, not just for him, but for the entire scientific community. On February 24, 2006, Go captured an image of Jupiter and noted that a white spot, Oval BA, had turned red. The spot is now known as “Red Spot Junior.” Later, in June 2010, he and co-discoverer Anthony Wesley captured a video of a fireball exploding on Jupiter. It was the first-ever recording of an asteroid impacting a planet.

**The Secrets to Christopher Go’s Stunning Images**

- **The right equipment** – Go has used his trusty C14 since he started imaging seriously more than a decade ago.
- **Impeccable seeing conditions** – Despite being an urban area, his hometown of Cebu City, Philippines, enjoys excellent seeing conditions.
- **Years of passion and hard work**

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<th><strong>Christopher Go’s C14</strong></th>
<th><strong>Hubble Space Telescope</strong></th>
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<tr>
<td>Aperture</td>
<td>14 inches</td>
<td>2.4 meters (7.9 feet)</td>
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<td>Has contributed new scientific knowledge about Jupiter</td>
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<td>Cost</td>
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