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Making the Most of Limited Resources
MICHELLE NICHOLS
You don’t need expensive equipment to enjoy the upcoming solar eclipse; even crackers can be useful.

Party off the Path
VIVIAN WHITE, WITH MIKE REYNOLDS
Not everyone can journey to totality. Here are some suggestions for holding a partial eclipse event.

Practice, Practice, Practice for a Perfect Solar Eclipse Event
LARRY METCALF
Don't try to do too much during a solar eclipse; you might miss out on the experience.

Astronomy in the News
Bladed terrain on Pluto, an astronomer makes a bold prediction, and a fast radio burst is finally identified. These are some of the discoveries that recently made news in the astronomical community.
perspectives

A Far View

The image at right is very cool. Sure, it’s “just” Earth and the Moon. But it’s our planet and its moon as seen from Mars.

This composite view combines the best Earth image with the best Moon image from shots acquired on Nov. 20, 2016, by the HiRISE camera on NASA’s Mars Reconnaissance Orbiter. Each was separately processed so that the Moon is bright enough to see. Since the Moon is much darker than Earth, it would appear very dim at the same brightness scale as Earth. However, the combined view retains the correct sizes and positions of the two bodies relative to each other.

The reddish feature in the middle of the Earth image is Australia, southeast Asia is the reddish area near the top, and Antarctica is the bright blob at bottom left (the other bright areas are clouds).

Why do I think this is such a great shot? First, it has been a mere 50-plus years since we photographed Mars itself, close up, for the first time. Second, it may be less than 50 years hence before we acquire a similar image of an exoplanet, with perhaps the same level of resolution.

Our first close (albeit barely resolved) view of Mars began a revolution in our understanding of the solar system. So, too, will our first far (albeit only vaguely resolved) view of a planet beyond the solar system revolutionize our understanding of exoplanets, exobiology, and our place in the cosmos.

Paul Deans
Editor, Mercury

Earth and Moon from Mars. [NASA/JPL]
Meet Us at the Moonrise

An astronomy meeting at an astronomy-themed hotel — what could be better?

The Moonrise Hotel (right) is a quirky landmark building on the Delmar Loop in St. Louis, Missouri. Famous for a gigantic, rotating Moon on its rooftop, it’s a must-see for astronomy enthusiasts and the ideal place for an astronomer to spend the night. All the guest rooms are decorated with space art and have a 1950s retro feel. The hotel’s meeting rooms are all named for NASA space missions (Apollo 8, Apollo 11, and Gemini) and its Eclipse Restaurant serves seasonal dishes that change — when else — on the solstices and equinoxes. Display cases throughout the common areas hold the owner’s vast and eclectic collection of space memorabilia, and the lobby’s furniture and décor come straight out of George and Jane Jetson’s living room. When you arrive and check in, you fully expect Astro, the Jetson’s dog, to greet you at the reception desk. Since the Moonrise Hotel is famously dog (and cat) friendly, this is a very real possibility.

In early December we held the ASP’s 128th Annual Meeting at the Moonrise Hotel, and it was the perfect venue for our conference focused on making sure every child fully experiences the 2017 North American solar eclipse. This annual meeting was a milestone event for the ASP. We have convened large and successful conferences during the last decade, each focused on sharing successful strategies for bringing the wonder of astronomy to K–12 science classrooms, museums and science centers, state
and national parks, and public events and festivals. But this annual meeting was purposefully small and targeted. We limited the number of attendees to just 100 people, and we made sure that all were actively working to engage diverse and underserved communities for the upcoming 2017 eclipse.

STEM leaders working with diverse audiences and members of the astronomy education community shared their knowledge, materials, resources, and activities. Organizations represented at the meeting included the Boys and Girls Clubs of America, the American Astronomical Society, The Girl Scouts of Northern California, NASA, Astronomers Without Borders, the Challenger Learning Centers, and the SETI Institute, to name just a few. We provided attendees with opportunities to network with one another throughout the meeting. Our goal was to encourage the formation of new and lasting partnerships that will continue to engage underserved communities in astronomy long after the 2017 solar eclipse.

There were amazing presentations by individuals and organizations doing groundbreaking and inspirational work related to engaging audiences in the upcoming eclipse, both on and off the path of totality. There was a workshop on ways to use tactile activities to ensure that the visually impaired can experience the 2017 eclipse, a plenary presentation by Derrick Pitts...
(Chief Astronomer, Franklin Institute, Philadelphia) on successful ways to bring observational astronomy to inner city youth and their families, a presentation on how a mobile “science center on wheels” will bring solar science and other eclipse-related experiences to new and diverse audiences, and a session on how public libraries have become important venues for science education and are now uniquely positioned to bring eclipse resources to various communities across the nation (see page 16).

This issue of Mercury highlights a little of what happened at the meeting. If you missed it, don’t despair. Our attendees expressed overwhelming enthusiasm for holding another conference at the Moonrise Hotel in early December of 2017, focused again on bringing astronomy to diverse and underserved audiences. There is even a great deal of interest in extending the meeting an extra day so that attendees can bring their astronomy activities to the nearby underserved communities of Ferguson and Florissant. Watch for upcoming announcements about returning to the Moonrise Hotel — and plan to join us in St. Louis in late 2017.

LINDA SHORE is the Executive Director of the Astronomical Society of the Pacific.
A Victorian Amateur Astronomer

In a rambling 1874 paper, John Beer updated his readers on various solar system ideas.

The Victorian era was a golden one for amateur scientists, especially in the field of botany, but astronomy was not far behind. One such amateur overlooked in recent studies of the subject is John Thomas Beer, who was born in 1825. He was 12 when Queen Victoria ascended the throne and thus spent his entire adulthood in the age named for her.

By trade he was a tailor in London and in Leeds by 1857. The financial freedom afforded him by his success let him become the quintessential antiquarian. He collected Roman pottery, old china, coins, and rare books. As President of the Students Union in Leeds during the three years of its existence, he gave lectures on several astronomical topics including the transit of Venus, comets and shooting stars, and the Moon. Beer was also President of the Bradford Scientific Association, which gave him the opportunity for further lectures: Motions of the Moon, Past and Present History of the Moon, and Solar Physics.

His greatest achievements were not attained until the 1870s, when he was elected a Fellow of the Royal Society of Literature and of the Society of Antiquaries of Scotland. His 240-page poem Creation, published in 1870, is in the epic genre. Since he was a preacher in the Wesleyan church, it is also very much a religious poem about the origins of Earth, the solar system, and life.

In 1874 he published a rambling paper The Theory of Solar Absorption in the Yorkshire Magazine. In an unintended pun, Beer says that in his day no celestial object “absorbs a greater amount of astronomical attention than the sun.” He reviews the literature, starting with a book published 30 years earlier by T.S. Mackintosh. Beer dismisses it, saying the nature of sunspots, which is a “great question of astronomical science,” is not solved by the author.

He is equally emphatic in refuting Mackintosh’s idea that the Earth is gradually approaching the Sun and will be absorbed into it. “We are not made acquainted with the slightest shadow of what may be taken as proof that the year is shorter...there is not any reason for supposing that we shall, in some indefinite futurity, become a flash-in-the-pan of our burning luminary.”

He then turns to another collision scenario that was believed by some — a distant time when the Moon would collide with Earth. This too he rejects: “The moon taken as an illustration of terrestrial fate, altogether fails in its application.”

Beer updates his readers on an important discovery made just five years earlier. It seems unbelievable now, but in 1869, “it had not then been determined whether the corona and projections [prominences] surrounding the moon during a solar obscuration [eclipse] belonged to the sun or the moon.” The 1869 eclipse proved the corona surrounds the Sun.

Beer further notes that prominences are “not at all likely to be...
connected with the burning up of old worlds,” but rather “are connected with the ordinary and general economy of the central world.” He likens them to “jets of vapour or gas than tongues of flame.”

On the vexed question of what powers the Sun, Beer rejects the notion that planets orbiting close to the Sun sometimes fall into it, thus providing it with fuel. He compares these putative bodies to “a single dew-drop exhibited as sufficient for the magnificent phenomena of an ocean.” Of the sunspots, he also is at a loss for an explanation, poetically terming them “the gourds of yesterday, having no history in the older records of the science.” He dismisses the hypothesis of Robert Holmes that the “opaque spots are burning worlds...a fresh mass of kindling just drawn into the great devouring primary.”

Holmes had written a book in 1871 with a provocative title: Will the Earth become a Sun-spot?

In his conclusion, Beer adopts a suitably humble stance about what was known in 1874. “We, of course, speak from the platform of our present knowledge of the subject, for so rapid and startling are the revelations of scientific truth at some periods, that it would be dangerous to say, with anything approaching to positiveness, what may or may not be demonstrated in the times to come.” On that score, at least, he was absolutely correct, both then and now.

CLIFFORD CUNNINGHAM was recently seen chatting with His Excellency David Johnston, Governor General of Canada.

Detecting Exoplanets on the Cheap

Hundreds of exoplanets have been discovered with expensive CCD arrays. Can we do it with DSLRS?

O

f the five ways to detect exoplanets, the transit method is one of the easiest to implement. Along with the radial velocity method, it is one of the most successful detection techniques. The transit method looks for small variations in the brightness of the parent star as a planet passes between it and an observer. To date, the Kepler space missions have discovered more than 5,000 candidate exoplanets around faint stars by detecting transits.

Searching for exoplanets around bright stars is also done from the ground, and several exoplanet transit surveys are being conducted using CCD camera arrays. SuperWASP, HATNet, and KELT are all wide-angle surveys that measure the light from bright stars via commercially available CCD cameras fitted with wide-angle camera lenses. Collectively, these three surveys have detected nearly 200 exoplanets, most of which are “hot Jupiters”.

The CCD cameras used in these surveys are expensive, costing up to $10,000 each. This makes the cost of expanding the current surveys (or starting a new array) prohibitive. So a group of astronomers from Princeton University decided to investigate the possibility that commercially available DSLRs might be useful for ground-based exoplanet surveys. Their investigation was motivated by previous
studies, which showed that commercial DSLR cameras are well-suited for photometric measurements and can be used to measure light curves of bright variable stars.

DSLRs have a number of disadvantages compared to astronomical CCD cameras. They are not as sensitive as CCDs, because their conversion of photons into electrons is less efficient, and each pixel has a smaller holding capacity for electrons. These factors limit DSLRs to bright stars, but these are the targets of ground-based transit searches anyway. Since DSLRs are not cooled like most CCDs, they have higher noise due to thermal effects. Finally, DSLRs are not monochromatic. They have a Bayer filter (basically a mosaic of red, green, and blue “tiles”) fitted on top of the CMOS chip.

Despite their apparent disadvantages, DSLRs are an appealing alternative to CCD cameras for bright targets. Why? First, and foremost, the average DSLR is about one-tenth the price of the average scientific CCD camera. Next, DSLRs have internal focusing mechanisms that make them lighter and easier to setup. Finally, the Bayer filter, which at first appears to be a disadvantage, actually allows for multi-band photometry to be done with a single observation!

In the summer of 2016, a Princeton University group (M. Zhang et al.) chose an 18-megapixel Canon EOS 60D camera with a street price of about $700. They tested and fully characterized the CMOS chip which, when used in RAW mode, has nearly perfect linearity until it approaches saturation level. The group made simultaneous observations of the same area of sky by piggy-backing a Canon DSLR equipped with a 135mm f/2 lens on a HATNet CCD camera. The DSLR obtained data for one month alongside the HATNet camera, taking simultaneous exposures with the same exposure times. After applying the appropriate image reduction procedures, the team extracted photometry for 6,600 stars and compared stellar light curves obtained by both cameras.

The results were impressive. Individually and combined, the RGB channels on the DSLR provided photometric accuracy on the order of 10 milli-magnitudes, a precision of one percent! To achieve this, the camera settings are important. The images must be obtained in RAW mode, with an optimal ISO setting of 100 and exposure times of about 180 seconds. The precision obtained with this DSLR should permit the detection of transiting hot Jupiters. Interestingly, the group was able to identify KELT-3b, an already discovered transiting hot Jupiter, in their DSLR data! With the continual advancements in commercial DSLRs, the Princeton group posits that new DSLR cameras will likely be even better for exoplanet detection. Given the cost and relative ease of use, it is entirely possible that the next era of exoplanet surveys will consist of DSLR arrays!

JENNIFER BIRRIEL is Professor of Physics at Morehead State University in Morehead, KY. This summer she plans on dusting off her old Canon DSLR to take DSLR variable star measurements.
On September 8, 2016, ORISIS-REx — the Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer — launched from Cape Canaveral and began its seven-year mission to the asteroid Bennu and back.

Bennu was selected as ORISIS-REx’s target from more than a half-million known asteroids. The first requirement was that it be easy to get to, which eliminated all but the approximately 7,000 so-called “Near-Earth Asteroids.” Of those, only 192 have a trajectory that would also be easy to return from — essential for this mission. Bennu’s diameter, about 500 meters, falls into a size “sweet spot” — smaller bodies tend to spin quickly, throwing into space their loose regolith that OSIRIS-Rex wants to collect. Of the 26 remaining targets, five are carbon-rich. The presence of carbon indicates that Bennu is a very primitive body — a time capsule from the solar system’s formation and ideal for fulfilling the “Origins” part of the mission. The final decision was based on “Security.” Bennu is the only one of the five that is a Potentially Hazardous Asteroid, with an orbit that gives it a chance of impacting Earth in the late 22nd century.

The probe will arrive at Bennu in 2018 and spend 505 days orbiting five kilometers above the asteroid, carefully surveying the surface. The sample retrieval is scheduled for July 2020. OSIRIS-REx will not land on the surface. Instead, it’ll give Bennu an extremely gentle “high-five.” The spacecraft will carefully lower itself towards the asteroid, eventually making contact with its 11-foot-long arm. Pressurized nitrogen will be sprayed onto the surface, blowing up to two kilograms of dust and debris into a sample container. Once the collection succeeds, the arm will place the now-full container into its return capsule and seal it for the trip back to Earth.

When ORISIS-REx returns in 2023, the capsule will detach from the probe and re-enter the atmosphere, landing (hopefully) in the Utah desert. Initial cataloging and analysis will occur at NASA’s Johnson Spacecraft Center — the same facility that cares for the Apollo moon rocks. Like the moon rocks, more than half of the samples from Bennu will be stored, held in trust for future generations and better analysis techniques.

OSIRIS-REx is being run out of the University of Arizona, in the
same department where I do my work on the Cassini mission. This afforded me the wonderful opportunity to attend the launch as a guest of NASA. I arrived in Orlando two nights before the scheduled launch. The next day, we received our visitor badges and instructions, as well as a briefing on the mission. During the briefing, we learned the magic words for launch day. If you’ve ever listened to the pre-flight checks from mission control, you’ll have heard what’s known as the “go/no-go” recital, where each department confirms its readiness for launch. The final approvals for this launch come from the rocket, the booster, and the probe controllers: “Go Atlas. Go Centaur. Go OSIRIS-REx.”

On launch day, we were taken to our viewing point — sets of bleachers across the river from the launch complex. We arrived a couple of hours early with plenty of time to explore a little, find a comfortable patch of beach to sit on, and get very, very excited. The audio feed from NASA TV was broadcast over giant speakers. Exactly on time, the final countdown began. The crowd rose to its feet, listening and staring across the water. “Go Atlas. Go Centaur. Go OSIRIS-REx.”

I’ve never seen a launch before. It was amazing. The rocket streaked out of sight, the contrail bending as the rocket curved away. We listened to the audio feed for about 15 minutes after losing sight of the vehicle, until we got confirmation that the probe had safely separated from the rocket and extended its solar panels.

Go OSIRIS-Rex. See you in seven years.

EMILY JOSEPH is a Research Assistant at the Planetary Science Institute and is part-time on the VIMS operations team for the Cassini mission at the University of Arizona Lunar and Planetary Lab.

‘Eclipse’ Reveals Insights to Potentially Habitable Planet

A syzygy loaded with synergy, maybe this transit was an eclipse to some star-struck alien

As you are reading in this issue of Mercury, an eclipse can be very educational. But let’s not limit that to our Earth-Moon-Sun system. An eclipse of sorts in the K2-3 star system — something we earthlings call a planetary transit — has revealed the orbital time of an exoplanet.

Yes, extrasolar planetary transits are a dime a dozen; they occur anytime a little planet crosses its big star while the two objects are in our line of site. But this one is special. This is the first time a modest Earthbound telescope tracked the path of a near-Earth-size exoplanet, and that bodes well for the search for habitable planets and extraterrestrial life.

As reported in the December 2016 issue of The Astronomical Journal, Japanese astronomers used the MuSCAT instrument on the Okayama Astrophysical Observatory’s 1.88-cm telescope to observe K2-3d, a solid planet 1.5-times the size of Earth about 137 light-years away in the constellation of Leo.
Coincidentally, K2-3d is also the third rock from the sun over there, albeit much, much closer to its star than Earth is to the Sun. Indeed, it would fit within the orbit of Mercury. But the star, K2-3, is a red dwarf of about 0.6 solar masses. As a result, the surface temperature of planet K2-3d is only 7°C (44°F), close to Earth’s average of 14°C (57°F). This estimated temperature, along with its likely rocky composition of iron and silicates, places K2-3d among the shortlist of planets possibly suitable for life.

NASA’s Kepler planet-finder first identified the planet in 2015 but couldn’t determine the orbital period, estimated to be about 44 days. A team led by Akihiko Fukui of the National Astronomical Observatory of Japan has now pinned down the period to an accuracy within 18 seconds. Such precision is important, Fukui said, because the transit lasts only four hours. To observe it in that 44-day range, astronomers need to know precisely when to expect it.

“The original uncertainty of nine minutes is too large to capture future transits,” Fukui said. “This error would result in several hours of uncertainties in predicted transit times for 2016, and much larger for upcoming years.”

Fukui said there’s little more that the MuSCAT instrument can glean from observing K2-3d. In theory, during the transit, the starlight would shine through any atmosphere that K2-3d might have. And that would illuminate the chemical composition of the planet, helping discern its suitability for life as well as the presence of life. But the resolution of this 188-cm telescope is not enough to reveal signs of life from a rocky speck around a distant star with an apparent magnitude of 12.17.

For more defining atmospheric studies of K2-3d, astronomers need to wait for next-generation telescopes such as NASA’s James Webb Space Telescope (JWST), NASA’s Transiting Exoplanet Survey Satellite (TESS) and the international Thirty Meter Telescope (TMT).

JWST and TESS may launch in 2018; TMT, alas, could be looking for a new summit now that protests on the planned site, Mauna Kea, may trigger its move to the Canary Islands.

Nevertheless, now that Fukui’s group has determined such a precise orbital period, 44.55612 ± 0.00021 days, astronomers can plan observation time on any of these instruments for years to come.

Fukui said his team hopes to measure the ephemerides and characteristics of other potentially habitable planets with the technique they have established. If nothing else, his group has demonstrated that even a ground-based, 2-meter-class telescope on a 372-meter hill in Japan can play a leading role in refining the transit of small-sized planets.

Any future discovery of a truly habitable planet relying on such orbital information shouldn’t eclipse this initial effort.

CHRISTOPHER WANJEK is a science writer who often transits in Washington, D.C., when the news from there eclipses that from his sleepy home base of Baltimore.
The universe is 13.8 billion years old, while our planet formed just 4.5 billion years ago. Some scientists think this time gap means that life on other planets could be billions of years older than ours. However, new theoretical work suggests that present-day life is actually premature from a cosmic perspective. “If you ask, ‘When is life most likely to emerge?’ you might naively say, ‘Now,’” says lead author Avi Loeb of the Harvard-Smithsonian Center for Astrophysics. “But we find that the chance of life grows much higher in the distant future.”

Life as we know it first became possible about 30 million years after the Big Bang, when the first stars seeded the cosmos with the necessary elements like carbon and oxygen. Life will end 10 trillion years from now when the last stars fade away and die. Loeb and his colleagues considered the relative likelihood of life between those two boundaries.

The dominant factor proved to be the lifetimes of stars. The higher a star’s mass, the shorter its lifetime. Stars larger than about three times the Sun’s mass will expire before life has a chance to evolve. Conversely, the smallest stars weigh less than 10% as much as the Sun. They will glow for 10 trillion years, giving life ample time to emerge on any planets they host. As a result, the probability of life grows over time. In fact, chances of life are 1,000 times higher in the distant future than now.

“So then you may ask, why aren’t we living in the future next to a low-mass star?” says Loeb. “One possibility is we’re premature. Another possibility is that the environment around a low-mass star is hazardous to life.”

Although low-mass, red dwarf stars live for a long time, they also pose unique threats. In their youth, they emit strong flares and ultraviolet radiation that could strip the atmosphere from any rocky world in the habitable zone.

To determine which possibility is correct — our premature existence or the hazard of low-mass stars — Loeb recommends studying nearby red dwarf stars and their planets for signs of habitability. Future space missions such as the Transiting Exoplanet Survey Satellite and James Webb Space Telescope should help to answer these questions.

The paper describing this work is available online. Loeb simultaneously wrote an extended review on the habitability of the universe as a chapter for a forthcoming book.
Creating a Revolution, One Eclipse at a Time

A solar eclipse is the most democratic experience nature has to offer.

Alex Longo is not your typical 16-year-old. As an eighth grader, he submitted a proposal to NASA’s Mars Rover 2020 landing site selection committee. Alex’s suggestion, and his in-person advocacy, has resulted in the inclusion of his proposed site as one of the eight landing-site finalists.

Now a high school junior, Alex is a regular participant in NASA meetings regarding Mars exploration, giving talks and publishing papers. He was a panelist at a recent public talk at the 2016 American Geophysical Union conference in San Francisco, sharing the dais with the lead scientist for Mars exploration. Alex credits his parents taking him to see his first space shuttle launch at the age of five as the spark that put him on the path he is now on.

Although the story of Alex is unusual, mainly due to the publicity surrounding his contribution, it’s common in its demonstration of the importance of experience to spark the interest and ultimately the drive to learn and contribute in a meaningful way. While probably everyone has had their curiosity sparked by something at some point in their life, the vast majority of people remain anonymous.

In an era when science and facts are marginalized, the experience of observing natural phenomena bears increasing importance and relevance to fostering scientific literacy. A phenomenon touches someone emotionally, activating the affective realm and creating a sense of wonder and awe, which may lead to curiosity, and then to appreciation and understanding.

The ASP’s Sky Rangers program was designed to take advantage of this progression by working with park rangers to help foster their interpretive skills about the night sky for park visitors. Interpretation is different from instruction in that it helps people process their personal experience and find relevance to their lives. Often it results in individuals seeking out information as their cognitive realm is activated in the quest to learn more.

For more than 20 years, the ASP’s Project ASTRO has sought to spark imagination and curiosity in young learners by providing a personal connection with someone who takes great joy in experiencing astronomical phenomena. The relationship built between the volunteer astronomer and teacher — and the students they work with — is, in many ways, far more important than just revealing astronomical facts and data. The most effective partnerships are those where the astronomer actively engages learners in some aspect of astronomical phenomena, working with them and mentoring their growth in appreciation and understanding through interpretation rather than exposition.

All of us in the educational community make a great deal about inspiring the next generation of scientists and educators, and fostering a scientifically literate population. We actively work to create change, not only for future generations but for the current one as
well. Some pundits have suggested we have entered a “post-fact” era, one that has an apparent disdain for facts and science and lacks objective truth.

However, this “post-truth” society is still willing to embrace experience and the depth of emotion it can engender, something we can take advantage of this year. A total or even a deep partial solar eclipse has the potential to create a powerful emotional experience. As one of our colleagues said related to the upcoming total solar eclipse on August 21, 2017 — an eclipse is the most democratic experience nature has to offer. Our ability to offer this experience to all, by providing safe viewing opportunities and interpretation not tied to dry facts and statistics, may result in the change we find difficult to create on our own through more formal channels such as curriculum, essays, and press releases.

If we are serious about creating a revolution in the way people consume and apply science, then perhaps those of us who have previously experienced a total eclipse of the Sun should consider including, in our personal agenda for totality on August 21st, the mission of helping those who would benefit from our guidance and interpretation.

As noted, personal connections are a catalyst for sparking the curiosity and interest of learners of all ages. Who knows how many Alex Longos remain uninspired and unknown out there. Perhaps the next child you give a pair of eclipse glasses to — or yield the eyepiece to so they can see the same phenomenon you found inspirational the first time you saw it many years ago — will become another Alex Longo.

Brian Kruse manages the formal education programs at the ASP and is the Director for Region F of the National Science Education Leadership Association.

Public Libraries to Receive Solar Viewing Glasses

The Gordon and Betty Moore Foundation will fund eclipse resources for 1,500 public libraries.

The Space Science Institute was awarded a grant from the Gordon and Betty Moore Foundation that will provide 1.26 million solar viewing glasses and other resources for 1,500 public libraries across the nation. They will serve as centers for eclipse education and viewing for their communities.

The libraries will be selected through a registration process managed by the STAR Library Education Network (STAR_Net) and its NASA @ My Library project. The project team includes staff at SSI’s National Center for Interactive Learning (NCIL).

The Project Director is Dr. Paul Dusenbery (Director of NCIL). Andrew Fraknoi (Chair of the Astronomy Department, Foothill College), Dennis Schatz (Senior Advisor, Pacific Science Center), and Douglas Duncan (Director of the University of Colorado’s Fiske Planetarium) are co-directors.
On August 21, 2017, a spectacular total eclipse of the Sun will be visible across the width of the continental US for the first time since 1918. Every state will see at least 60% of the Sun covered by the Moon, and the lucky people on a narrow path from Oregon to South Carolina will see the stunning beauty of totality. Because the total eclipse is only visible in the US, it is already being called the Great American Eclipse.

“This is a once in a lifetime opportunity for libraries and their communities to work together to participate in a celestial event of this scope,” says Project Director Paul Dusenbery. “Many organizations like NASA, the National Science Foundation, and the American Astronomical Society, are working together to help people understand and view the eclipse safely, and we are delighted to be part of this important educational effort.”

Dr. Robert Kirshner, Chief Program Officer, Science at the Moore Foundation, adds “The Moore Foundation is pleased to help two million eyes enjoy and understand this astronomical spectacle with astronomical spectacles.”

The 2017 Solar Eclipse project is funded by the Gordon and Betty Moore Foundation through Grant GBMF5373 to the Space Science Institute. Libraries can register here.

About the STAR Library Education Network (STAR_Net). Libraries across the country have been reimagining their community role to strengthen community-based learning and foster critical thinking, problem solving, and engagement in science, technology, engineering, and math (STEM). Public libraries serve people of all races, ages, and socio-economic backgrounds. They are becoming “on-ramps” to STEM learning by creating environments that welcome newcomers to the community.

The Moore Foundation project and NASA@ My Library leverage and expand upon STAR_Net, a hands-on learning network for libraries and their communities across the country (www.starnetlibraries.org). STAR_Net focuses on helping library professionals build their STEM skills by providing “science-technology activities and resources” (STAR) and training to use those resources. It includes a STEM Activity Clearinghouse, blogs, a webinar series, workshops at conferences, and a monthly e-newsletter.

About the National Center for Interactive Learning. The Space Science Institute’s National Center for Interactive Learning (NCIL) is dedicated to expanding the understanding and participation of families, youth, teachers, and citizens in science and technology. We foster collaboration between STEM professionals and educators to bring the wonder of science and engineering directly to people.

Our programs span a range of audience needs and delivery methods, including traveling museum and public Library exhibitions; educational films, videos, and websites; hands-on resources and activities; and educator workshops. Our programs are designed to be accessible to all, and to inspire the next generation of STEM innovators. They have a positive impact on rural and urban communities nationwide and reach underserved audiences with inspirational, fun, and innovative STEM activities.
Making the Most of Limited Resources

You don’t need expensive equipment to enjoy the upcoming solar eclipse; even crackers can be useful.

By Michelle Nichols

During the eclipse, look down as well as up. Tree leaves can act as pinhole projectors, projecting eclipsed-Sun crescents onto the ground below them. Courtesy WikiMedia/Nachosan.
During the eclipse of August 21st at the Adler Planetarium (Chicago), we will see about 90% of the Sun hidden by the Moon. We’re planning for several thousand people to head to our Museum Campus area that houses the Adler Planetarium, the Field Museum, and the Shedd Aquarium, and we hope to have satellite viewing locations elsewhere in Chicago. We are also partnering with the Chicago Public Library system to bring viewing experiences to branches all around the city. We’re excited that Chicagoans will get to look up that day!

A Critical Resource
One thing we learned during our 2012 Transit of Venus event is that you can never have enough solar viewing (a.k.a. ‘eclipse’) glasses. As seen from Chicago, the transit lasted about three hours, and we had some 5,000 people attend our event. We ran out of glasses about halfway through the transit. So, my first recommendation is to have solar viewing glasses at your eclipse-viewing event to pass around and share. Have many spare pairs on hand, and have volunteers walk through your audience to let them borrow the glasses so they can see the partial phases of the eclipse safely. You don’t need to supply every visitor with his/her own personal eclipse-viewing glasses, especially if demand outstrips supply.

Do not purchase solar-viewing glasses in bulk from anyone except these reputable suppliers. You can also purchase shade #14 welder’s glass pieces from a welding supply store and pass those pieces from person to person. Only purchase shade #14 welder’s glass; slightly lighter #12 is not good enough.

Photo Fun
You can take pictures of the eclipse with your smartphone. Tape a safe solar viewing filter (use your eclipse glasses if you have a spare pair) over the camera lens of your smartphone and then point it at the Sun, keeping the filter in place at all times. I recommend taping the filter to the camera body with dark-colored tape prior to pointing the camera at the Sun, so that at no time does the Sun ever shine on the unprotected camera lens. If you do an activity like this, be careful not to look at the Sun with unprotected eyes; look at the screen of your phone instead.

The material in your eclipse glasses is fine for this activity, but you can also buy optical quality safety film to make your partial eclipse photos even a little better. Search for ‘BAADAR AstroSolar Safety Film’ — you can get it in 12"x12" sheets. You can also secure a large piece of this filter material to the front of a DSLR camera lens (and your camera’s viewfinder if it’s a point-and-shoot) to safely take photos of the partial eclipse. The American Astronomical Society has recently
posted updated information about how to photograph and video record the eclipse.

**Make a Sundial**

Sundials are a fun way to pass the time before and after an eclipse. You can make a real sundial, but to do it properly, you’ll have to account for your latitude and the different hour-angle sizes of your sundial. If you look at decorative sundials, all the hour angles (the spacing between each hour on the dial) are often the same, so they’re rather useless for telling time! Of course, if you’re just making fun sundials, you don’t need to be so particular!

Here is one sundial hour-angle calculator. Enter your latitude, and the site will calculate the sizes of the different hour angles. If you want to make it more complicated, you can get into the equation of time for a more precise measurement of time (and that’s discussed on the sundial hour-angle calculator website). NASA has a good sundial explanation.

Get out your sidewalk chalk, because you can also make sidewalk sundials. Have a child stand on the sidewalk with their feet together, trace around their feet (make sure you know which child goes with which feet, so write their name next to it), and then trace around their shadow. Do it again every hour. Notice things like shortening and lengthening shadows. Make sure the children strike the same pose each time. You can do it before, during, and after the eclipse, but make sure the kids take time to look at the eclipse, too. Here’s a PDF of an activity called Changing Shadows.

Finally, this is a hint for schools. Warn your administrator ahead of time that you’re going to make shadow sundials. In fact, have him/her come out and make a shadow, too. Otherwise, your administrator might step outside and wonder about all the outlines of bodies on the pavement!

**Making Pinhole Projectors**

A simple pinhole projector can be made with two index cards or two paper plates. Poke a hole straight through one card or plate using a sharp pin. With the Sun behind you, point the hole toward the Sun so that sunlight shines through the hole onto the other card/plate. Pull the two plates apart until you see an image of the Sun. Note that the image will be tiny. The farther apart the plates, the larger the image will be, but also the dimmer it will be. (Don’t look through the pinhole!)

Of course, you don’t have to do it this traditional way. Pick your favorite crunchy cracker with holes in it, and give it a try to see if the holes in the cracker will project images of the Sun. Put a piece of white paper underneath; that’ll help show the little eclipses. Then try
some experiments. Do some crackers work better than others? Does the size of the hole make a difference? Does the distance from the screen make a difference?

More pinhole projector materials include pegboard, colanders, slotted spoons, and tree leaves (see the image on the first page of this article.) The spaces between and the holes in the leaves on the trees act as pinhole projectors, so don’t forget to look down as well as up during the eclipse. And just by interlacing your fingers, you can make a pinhole projector (far right). Try experimenting with other projector materials such as aluminum foil sheets, cardboard boxes, and more. What combination of materials gives you the best image? Leave this activity open-ended to give your audience the maximum opportunity for using their imagination.

Note that a telescope does not necessarily make seeing a partial solar eclipse better. It only makes the view bigger, so seeing an eclipse through a properly filtered telescope is not a vital experience. No significant extra detail will be seen in the telescope (unless there are sunspots), so pinhole projection is an excellent and very inexpensive viewing method to consider for the eclipse experience.

**Earth-Moon Scale and Lunar Phases**

If the Earth was shrunk to the size of a ball or an inflated balloon eight inches across, the Moon at this same scale would be a little more than two inches across, or roughly one-quarter Earth’s diameter. A fun scale-model activity that gets many people involved is to blow up a balloon to about eight inches in diameter — the ‘Earth’ balloon — and distribute ‘Moon’ balloons to audience members. Small water balloons work well as Moon balloons.

First, have each person blow up her/his Moon balloon to the size that s/he thinks is at the same scale as the Earth balloon. After comparisons are done and the right size is shown, have each person walk...
their Moon balloon away from the Earth balloon to what they think is the correct Earth-Moon separation based on this scale. The answer: For an eight-inch-wide Earth, a slightly more than two-inch-wide Moon would be about 240 inches (20 feet) from the Earth balloon.

Then there’s the tried-and-true Moon phases demonstration. The problem with the usual way of demonstrating this — a Styrofoam ball on a stick held by a student with a bright light acting as the Sun — is that your head (as the Earth) gets in the way of the ‘sunlight’ when trying to show a full Moon because your arms aren’t long enough to put the Moon ball far enough away in a scale model.

Here is another way to demonstrate lunar phases. Take a piece of cardboard, maybe four feet square, and cut a hole in the middle for your head. Then take ping pong balls and paint them, so that half of each ball is black, leaving the other half white. Attach them around the edge of the cardboard so that the white halves are all facing in the same direction (toward the ‘Sun’). Make sure the painted balls for new Moon, full Moon, first quarter, and last quarter are properly positioned, and then place the remaining four ping pong balls between the others to create gibbous and crescent Moons. Put your head through the center hole, keep the frame in place, and turn around so you can see the lunar phases, without needing a light bulb or a darkened room. (There is a two-page PDF with a more detailed explanation and a YouTube video showing a variation of this activity.)

Changing Temperatures
Recording the change in air temperature is a great thing to do if you’re on the path of totality, but this works even if you’re experiencing only a partial eclipse. Set a thermometer in the shade and note the air temperature before and after the eclipse, and several times during the eclipse (especially around mid-eclipse). While the drop in air temperature near mid-eclipse is most pronounced within the path of totality, it’s an experiment worth doing whether you are 10 or 100 miles away from the path.

If You’re in the Path of Totality
The 1999 total eclipse was my first; this next one will be my second. I’ve seen an annular eclipse in 1994 — it was great — and I’ve seen lots of partial solar eclipses. But I was not expecting the reaction I had to the 1999 eclipse. When totality hit, I started sobbing.

So, if you’re in the path of totality and want to take pictures of the totally eclipsed Sun, I’d say…don’t. In 1999 I was told, very wisely, “Stare at totality. Burn it into your brain. Don’t take pictures. There will be plenty of professionals taking pictures and you can get their pictures afterward.”

If you really want to attempt photography, do it right as totality starts. Then put your camera down and look with your eyes. If you get a picture, great. If not, you can try again in seven years, or travel to an eclipse in 2019 or 2020. The human eye will capture far more detail than your camera ever will, and you don’t want to miss that.

If you’re planning a totality viewing party, and you have a narrator on a microphone outside narrating the eclipse for a large group, tell that person to be quiet right after totality starts. They can say “Baily’s Beads. Diamond Ring. Take your eclipse viewers and filters off.” And then…silence. Don’t narrate totality. Let everyone enjoy it. Soak it in. Look at the horizon. Look at the color of the sky. Look for stars. Do have the narrator come back at third contact: “Diamond ring. Time to put your eclipse glasses and filters back on.”

Distribute simple notepads and pencils before the eclipse begins. During the eclipse, periodically encourage people to sketch what they see, write down what birds and other animals are doing, and describe what they and others are feeling, doing, and saying. For example, sometime during the partial phase before totality, ask
everyone to stop, grab their notepads, and write down five words to describe what they are feeling at that exact moment.

After totality, ask them to sketch or describe what they saw. This journal has the potential to be a cherished keepsake for years to come. The journal can also be converted to an electronic format such as a webpage, blog post, and more.

Also post-totality, go around with a video camera or your smartphone set to video and ask: What did you feel? What was it like? Get their stories and emotions down right away. Set up a story collection station immediately after the eclipse. Capture stories and experiences through visual arts, audio, and/or video. Put them on display, either in person or electronically. Hold onto them for the 2024 eclipse and share them again.

Finally, do not try to do activities after totality. Your audience will be far too excited about what they’ve just witnessed to pay attention to anything else. Their minds will be too blown to concentrate on astronomical content.

But if you’re not in the path of totality, go wild. Run activities during the entire eclipse. Make it a memorable day, and be sure to mention the next total solar eclipse on American soil: April 8, 2024.

[This article is an adapted transcript of a presentation and discussion that was part of the ASP’s “Engage Every Child in the 2017 Solar Eclipse” conference held in St. Louis in December 2016.]

MICHELLE NICHOLS is Master Educator in the Astronomy Department at the Adler Planetarium, Chicago. She coordinates Adler’s ‘Scopes in the City telescope outreach program and other Adler daytime and evening observing programs.
Party Off the Path

Not everyone can journey to totality. Here are some suggestions for holding a partial eclipse event.

By Vivian White with Mike Reynolds

If you're located somewhere outside the dark band stretching from Oregon to South Carolina, you will see only a partial eclipse of the Sun. Courtesy NASA's Scientific Visualization Studio.
Many people are not going to have the resources to get to the path of totality. A great deal of time and energy is being spent talking about being in the path, but our mission is to get resources to underserved communities who will not be able to reach totality. There will be people and schools, mere miles outside the path of totality, who will miss it — in fact, most of the US will be “left in the light.” We’re not just thinking about folks in Maine and Texas, we’re talking about everywhere outside the path (see the map on the previous page). So here are some ideas and innovative ways to celebrate the partial eclipse.

**Places and Considerations**

Whether you’re inside the path of totality or not, the eclipse is an event that lasts several hours. So you have plenty of time to see the partial phases, take photos, and to do activities. If you’re outside the path, there is absolutely no rush to do anything during the eclipse.

Coming up very soon (if it’s not already available), your school districts will put out their 2017 school schedules. This is very important to know — whether your schools will be in session on Monday, August 21st, or not. If not, then think about where people already naturally congregate. The eclipse occurs (generally) in the middle of the day, and so the Sun is pretty high in the sky. That means you won’t have to worry too much about horizons, though don’t hold an event in a forest or surrounded by highrises!

For a partial eclipse, nobody is likely to travel a great distance to visit your event, but locals will come if it’s advertised. Regardless of where you are, you need to make sure attendees have access to bathrooms and perhaps a food and beverage service. If you feel that you’re not going to have the capacity to deal with large crowds at one particular spot, have many small events going on nearby. Of course, you’ll need staff and volunteers to cover these extra sites. But you don’t require a lot of equipment — a colander or pinhole projectors or tree leaves as a pinhole cameras will let everyone see the eclipsed Sun. You don’t even need a telescope, but of course, you do need eye protection if people want to look directly at the eclipse.

**Partnerships**

We want everyone to think outside the box when it comes to partnerships. There are a lot of people partnering with libraries. Most libraries in the US are going to have resources. NASA is sending informational material to libraries, and many will receive eclipse glasses through StarNet. So if you want to partner with your local library, now is a great time to start the partnership. Don’t forget, many communities have branch libraries, so you don’t need to stick to the main one.
Of course your local science center will have activities, but don’t think of this as a “science only” event. What about the historical aspects of eclipses, or the art of eclipses, or eclipse photography? It really is a multi-faceted affair and is a great opportunity to explore beyond the pure science of the event. So talk to your local art museum or natural history museum and get them involved. Don’t forget Scouts and Guides, summer camps and outdoor schools (if they’re still being offered in August), community centers, and the parks within your town or city. Often the civic leadership of a town is involved in the Elks, Rotary, Kiwanis, and the other big service clubs; a contact through them might help open doors in your community.

Approaching someone in person is often the best way to get a conversation started. And it helps to have something to show. The downloadable page on NASA’s eclipse website has a wide variety of printable fact sheets, posters, and handouts that you can take to meetings with potential partners. Also the Night Sky Network has a downloadable, editable postcard (right) into which you can insert your information, a website link, or even a sponsor’s name. The card also works as a pinhole projector! And there is a 27-slide PowerPoint called An Eclipse to Remember that you can download and adapt — add your own information, use only parts of the presentation, or modify it as you like.

If you think you might have a lot of people at your event, consider contacting organizations that have experience organizing and running large outdoor events such as music festivals and concerts. This isn’t so much about getting them involved as it is about tapping into their knowledge regarding how to handle large crowds, particularly at a somewhat remote location. Potential in-town eclipse-viewing venues that regularly deal with large crowds include football stadiums and baseball parks.

If you’re concerned about the safety element and your site isn’t in town, contact the American Red Cross and request that an aid station be located at your venue. Don’t forget, the eclipse is in August, so you might end up having heat-related issues with your visitors. And of course that means making sure there is water available at your site.

One obvious partner is your local amateur astronomy club, but here’s something to consider. On eclipse day, most of their members will not be available — they’ll all be in the path of totality! Even so, many clubs have loaner telescopes that will likely be left behind. Get in touch with your astronomy club right away, find out if loaner scopes will be available for August 21st, reserve them, and if necessary, be trained on how to use them to look safely at the Sun.
Safe Solar Viewing

There are three ways to safely view the Sun and the partial eclipse. You can either project the image, you can observe it directly with a filter, or you can live-stream it. A projection of the Sun can appear beneath the leaves of trees (see page 25). A really simple pinhole projection system needs nothing but your interlaced fingers.

To view the partial eclipse directly, you must use a safe solar filter. To see the eclipse with your eyes, you need eclipse ‘glasses.’ If you buy them now, there are plenty in stock, but don’t wait! If you delay until just before the eclipse, there may well be none available. They can be purchased from American Paper Optics, Rainbow Symphony, and Thousand Oaks Optical. Their glasses are made in the US, there are standards that the companies adhere to, and the glasses are safe. Just check them before use. If the filters have pinholes, or are damaged in any way, do not attempt to look at the Sun with them — just discard them. And use them by themselves, never in combination with binoculars or a telescope.

Live-streaming the eclipse is a good option, especially if it’s cloudy. NASA’s Eclipse Megacast will carry path-of-totality coverage across multiple platforms, while the Exploratorium’s Live Total Solar

Eclipse 2017 will broadcast the event from two different locations. In addition, the Exploratorium has a total solar eclipse Android app that will let you follow along. If it’s not cloudy, you can still watch the progress of the eclipse and see totality even if you’re not in the path.

Activities

The ASP has developed a wonderful activity, for use in both formal and informal settings, to help answer the question: Why do eclipses happen? It uses simple materials so participants can create 3-D models of the Earth, Moon, and Sun to demonstrate solar and lunar eclipses. [Materials for this Yardstick Eclipse Activity are available in sets of five through the ASP.]

You can use a gnomon to show how the Sun moves during the day. A gnomon is literally just a stick that casts a shadow. A very easy way to do this is with a toilet bowl plunger. Set it on the ground (perhaps on pavement) and watch how the shadow of the stick moves during the course of the day — you can mark its position each hour using chalk.

Think about fun ways to make this a real “event.” Play music that relates to, or at least mentions, the Sun and the Moon. Have snacks with Sun and Moon in their names: Moon pies, Moon cakes, Chinese suncakes, Sun chips, Sun-Maid raisins, sunflower seeds, sundaes (perhaps via an ice cream cart). And for the eclipse after-party for your volunteers — Eclipse gum, Sunkist orange juice, and Corona beer (but lay off the moonshine!). Perhaps a local Sunoco gas station will donate gift cards for a draw or raffle. Finally, don’t forget that the eclipse occurs in August, so make sure people have plenty of “sunscreen” on hand!

Have students or children make eclipse art (you’ll need to bring

Never let anyone do this. Eclipse glasses will not protect your eyes if you look through an unfiltered telescope or pair of binoculars while wearing them — eye damage will result. Eclipse glasses are meant to be used for naked-eye viewing only. [Paul Deans/TravelQuest International]
the necessary supplies). Create a time capsule — have participants write a letter to their 2024 self. Have them describe what they saw, maybe include some photos, and, especially if you are not on the path of totality in 2017, ask them to indicate what they’d like to do and where they’d like to be during the April 2024 total solar eclipse.

Finally, ask yourself how you can leverage this beyond a single event at a single location to get your whole community involved. Just keep in mind that many local experts who might otherwise be available to help could be gone to the path of totality, so make sure you prepare well ahead for the event and the activities.

Selected Eclipse Resources

**How to View the 2017 Solar Eclipse Safely:** NASA and the American Astronomical Society have created this one-page PDF. The document has been endorsed by the National Science Foundation, The American Academy of Ophthalmology, and The American Academy of Optometry. It is available in English and Spanish.

**Solar Eclipse Across America:** The American Astronomical Society’s eclipse website, which includes how to image the eclipse, events and activities, eye safety, and a resources section that contains (among other things) royalty-free images and videos.

**Total Eclipse 2017:** NASA’s eclipse website, which includes an event map, activities, Eclipse 101, and in the Toolkit menu, many ideas for planning and promoting an eclipse party.

**ASP’s 2017 Solar Eclipse Information & Resources:** This site contains an eclipse resource guide (by Andrew Fraknoi), access to *Mercury* and other ASP eclipse articles, eclipse-related educational products, activities, and more.

**Exploratorium Total Solar Eclipse:** The Exploratorium has great videos demonstrating safety and viewing ideas. They’ll also host a live stream of the event.

**NSTA Observer’s Guide:** This is a free, eight-page PDF handout from the NSTA, written by Andrew Fraknoi and Dennis Schatz.

**Great American Eclipse.com:** The site has an eclipse map app, maps of the path across each state where totality falls, and more.

**An Eclipse to Remember:** This 27-slide PowerPoint presentation explains eclipses and how to view them. Feel free to add your own information, use only parts of this presentation, or modify as you like.

[This article is an adapted transcript of a presentation and discussion that was part of the ASP’s “Engage Every Child in the 2017 Solar Eclipse” conference held in St. Louis in December 2016.]

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Practice, Practice, Practice for a Perfect Solar Eclipse Event

Don’t try to do too much during a solar eclipse; you might miss out on the experience.

By Larry Metcalf

On May 20, 2012, the Sun set while in deep partial eclipse as seen from the US Southwest. This scene was captured from the San Juan Mesa Wind Farm off Highway 70 in Elinda, New Mexico. Courtesy Evan Zucker.
It’s important to keep in mind that you don’t want to become so caught up in so many activities during the eclipse that you get distracted and don’t experience the entire event. So let’s consider four aspects that you might want to practice prior to doing an eclipse event: safe viewing, location, still photography, and video. And remember the five “P’s”: Proper Planning Prevents Poor Performance.

**Safe Viewing**

I’d like to share with you what I’ve learned about presenting to young students and the general public. It is incredibly important that no one look at the Sun through an unfiltered optical device (telescope, binoculars, etc.). The easiest action is to not allow any optical devices at your event that are not securely attached to a camera.

The other option is to make sure everyone understands that solar telescopes are modified for safe viewing of the Sun and are not like the typical telescope at home. I always tell my audiences: “Do not try this at home.” Regardless, you are going to need to have a some kind of safety talk, and you need to practice beforehand on how you’re going to talk safety to the people who attend your event.

Eclipse glasses are fascinating, safe and easy to use. They come flat, and believe it or not, a first-grader can’t fold them in the middle, they’ll bend them — even fourth-graders sometimes find it perplexing. And putting the solar glasses on can be equally challenging. My recommendation is that if you’re doing an event with children or students, practice so that you’ll be able to help youngsters put on their solar glasses. Also, get some additional adults involved to help the children avoid a frustrating experience.

One of the things that’s really scary to me about being in the...
path of totality is that when totality strikes, you can take off the solar glasses. But you need to put them back on at the end of totality. I recommend that you have a person announce when it is safe to remove the solar glasses (at second contact) and then announce when it is time to put them back on or look away (at third contact). It is very important that no one accidentally hurt their eyes.

The following is strictly a personal opinion. I never point a telescope at the Sun that has a solar film or glass filter on it. I don't want to risk a pinhole in the film or having someone accidentally remove the filter. I use only a Herschel wedge, also known as a solar wedge. In addition, I don’t recommend using an optical instrument — telescope or binoculars — as a projection device. I am concerned that a naïve person might try to look through the device and do serious damage to their eyes. Personally, I am a huge fan of pinhole projection, because there is no lens magnifying the power of the Sun.

**Location, Location, Location**

Location is a very interesting parameter for your solar event. Xavier Jubier has a phenomenal website with an interactive map (Fred Espenak also has one). You can zoom right into your potential viewing site on a satellite map, and it’ll give you all the numbers for the start and end times of the eclipse (and of totality if the site is in the path) in Universal Time.

Then I use a really cool program called SunCalc. You can plug in the general address of your observing site, plus the date and time, and you can actually see a Google map of the location that shows where the Sun will be at any given time (which you control). On the SunCalc map (right) centered on Lexington County, the yellow line points to where the Sun will rise, and the orange line points to where the Sun will be at 2:40 pm on August 21st — totality time.

Of course, you can move your location on the map and hunt for a spot, but that’s only half of it, because you’re doing it just with the Google satellite image. You need to go to that location. The perfect time to go is sometime in late April — roughly between the 15th and 29th. That’s because you’ll be on the front end of the solstice, and the Sun’s path through the sky will be approximately the same as on August 21st. Visit the US Naval Observatory’s [sunrise/sunset times site](https://aa.usno.navy.mil/computations/horizons/html/horizons.html) and their [Sun/Moon altitude/azimuth site](https://aa.usno.navy.mil/computations/horizons/html/sunmoon.html) where you can enter the location of your eclipse-viewing site and see what April date will match your chosen site.

For Lexington, South Carolina, which is where I’ll be, I’ll go to that location on April 21st or 24th and include some of the teachers as well. We’ll make sure that we have a good, clear view of the Sun between 1pm and 4pm EDT (which is the window of the eclipse in South Carolina). You don’t want to end up with the Sun passing behind trees, power poles or telephone lines, tall buildings, or even a mountain peak — especially during totality. It’s amazing how your brain can ignore things like power poles and power lines…until the
Sun passes right in front of one. (See the image on the first page of this article. It’s pretty, but not what you want during totality.) It’s also a good opportunity to get all your volunteers out, do a little Sun-watching training, make sure your site is good, and practice some more for the big day.

**Still Photography**

I am not a big still photographer. In fact, I’ll direct you to Fred Espenak’s “Mr. Eclipse” site, where you’ll find pages and pages of advice on everything from what size lens to use to image exposures, so I won’t discuss photography particulars. But here are some things to think about if you are planning to take photos.

You don’t want to get so caught up in taking pictures that you miss the experience of totality. Perhaps you can put the camera on an equatorial mount and let it track (you’ll have to practice that ahead of time to ensure your mount is tracking). There are two wonderful pieces of free software that will actually take over your camera and take the pictures for you. They are Solar Eclipse Maestro for MacOS X and Eclipse Orchestrator for Windows.

My other tips include turning off automatic focus. Manually focus on infinity and use a little tape to secure the lens so the focus doesn’t shift. Use a slip-on solar filter on the front of your lens (so you can quickly take it off during totality). Have a written plan with times and action items, and then practice with the camera, focus, solar filter (taking it off and putting it back on in a hurry), mount or tripod, and the controlling software if you have it. And then practice some more.

**Video Photography**

It’s much the same thing with video. If you’re taking a video of the Sun, you need a slip-on solar filter for your camera and have to decide if you’re going to hand hold the camera or put it on a tripod or mount. Develop a written plan, and practice. Consider shooting a video of the crowd before, during, and after totality, perhaps using a wide-angle lens so you can get the sky and what’s going on around you (and make sure your audio is recording). You don’t need a filter on your camera for crowd shots, but you need to determine your tripod location and test your setup.

Again, you must practice. I learned the hard way that the WiFi remote on a GoPro camera will chew up the battery; it lasts only 60 to 90 minutes. So gather together everything you’re going to use, set it up, run it, and make sure the batteries and focus and scenery are good. And sometime between April 15th and 29th will be the perfect time to do your practice.

**Final Thoughts**

Don’t try to organize an event at the last minute. You need to think about your guidelines for safety. You need to find a location with an unobstructed view, facilities, parking, and easy access. Visit the location and determine opportunities to improve your plan. Develop checklists for equipment and volunteer duties. Develop and modify your plans for still and/or video photography — and practice, practice, practice.

But above all, make sure you are able to enjoy the eclipse.

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[This article is an adapted transcript of a presentation and discussion that was part of the ASP’s “Engage Every Child in the 2017 Solar Eclipse” conference held in St. Louis in December 2016.]

**LARRY METCALF** (“Sunspot Larry”) is a retired scientist and teacher who now does science outreach, in the form of solar astronomy, to elementary and middle school students in South Carolina. He is a consultant and guest with the University of South Carolina Astronomy Department and the SC State Museum’s observatory.
Small Impacts Are Reworking the Moon’s Soil Faster than Scientists Thought
Arizona State University

The Moon’s surface is being “gardened” — churned by small impacts — more than 100 times faster than scientists previously thought. This means that surface features believed to be young are perhaps even younger than assumed. It also means that any structures placed on the Moon as part of human expeditions will need better protection.

This new discovery comes from more than seven years of high-resolution lunar images studied by a team of scientists from ASU and Cornell University led by ASU’s Emerson Speyerer,

“Before the Lunar Reconnaissance Orbiter was launched in 2009, we thought that it took hundreds of thousands to millions of years to change the lunar surface layer significantly,” Speyerer said. “But we’ve discovered that the Moon’s uppermost surface materials are completely turned over in something like 80,000 years.”

“We used before-and-after images taken by LROC’s Narrow Angle Camera,” Speyerer said. During the seven years the mission has run so far, he said the team identified 222 new impact craters that formed during the mission. “These range in size from several meters wide up to 43 meters (140 feet) wide.”

The number of new craters found by Speyerer and colleagues is greater than anticipated by standard impact-modeling rates used by lunar scientists. The discovery has the effect of giving lunar surface features younger ages.

Theory says that a lunar geologic unit should accumulate a certain number of craters of a given size in a million years, for example. But if it turns out that impacts are making craters more quickly, then it takes less time to reach the benchmark number, and the geologic unit is in reality younger than theory predicts.

MORE INFORMATION

A new lunar crater appeared between Oct. 25, 2012, and April 21, 2013. At 40-feet wide, the crater is circled and moderately easy to spot, but the starburst pattern of ejected debris is elusive to trace.

[NASA/GSFC/Arizona State University]
Will Earth Still Exist Five Billion Years from Now?

*KU Leuven Institute of Astronomy*

What will happen to Earth when, in a few billion years’ time, the Sun is one hundred times bigger than it is today? Using the most powerful radio telescope in the world, an international team of astronomers has set out to look for answers in the star L2 Puppis. Five billion years ago, this star was very similar to the Sun as it is today.

“Five billion years from now, the Sun will have grown into a red giant star, more than a hundred times larger than its current size,” says Professor Leen Decin from the KU Leuven Institute of Astronomy. “It will also experience an intense mass loss through a very strong stellar wind. The end product of its evolution, seven billion years from now, will be a tiny white dwarf star.” This metamorphosis will have a dramatic impact on the planets of our solar system. Mercury and Venus, for instance, will be engulfed in the giant star and destroyed.

“But the fate of the Earth is still uncertain,” continues Decin. “We already know that our Sun will be bigger and brighter, so that it will probably destroy any form of life on our planet. But will the Earth’s rocky core survive the red giant phase and continue orbiting the white dwarf?”

To answer this question, an international team of astronomers observed the evolved star L2 Puppis using the ALMA radio telescope. This star is 208 light-years away from Earth.

“We discovered that L2 Puppis is about 10 billion years old,” says Ward Homan from the KU Leuven Institute of Astronomy. “Five billion years ago, the star was an almost perfect twin of our Sun as it is today, with the same mass. One third of this mass was lost during the evolution of the star. The same will happen with our Sun in the very distant future.”

300 million kilometers from L2 Puppis — or twice the distance between the Sun and Earth — the researchers detected an object orbiting the giant star. In all likelihood, this is a planet that offers a unique preview of our Earth five billion years from now.

MORE INFORMATION

Composite view of L2 Puppis in visible light. [P. Kervella et al. (CNRS/U. de Chile/Observatoire de Paris/LESIA/ESO/ALMA)]
Sharper Insight into Pluto’s Bladed Terrain

Using a model similar to what meteorologists use to forecast weather, and a computer simulation of the physics of evaporating ices, scientists have found evidence of snow and ice features on Pluto that, until now, had been seen only on Earth.

Formed by erosion, the features, known as “penitentes,” are bowl-shaped depressions with blade-like spires around the edge that rise several hundreds of feet. The research, led by John Moores of York University, Toronto, indicates that these icy features may also exist on other planets where environmental conditions are similar.

The identification of these ridges in Pluto’s informally named Tartarus Dorsa area suggests that the presence of an atmosphere is necessary for the formation of penitentes — which Moores says would explain why they have not previously been seen on other airless icy satellites or dwarf planets. “But exotic differences in the environment give rise to features with very different scales,” he adds. “This test of our terrestrial models for penitentes suggests that we may find these features elsewhere in the solar system, and in other solar systems, where the conditions are right.”

The research team compared its model to ridges on Pluto imaged by NASA’s New Horizons spacecraft in 2015. Pluto’s ridges are much larger — more than 1,600 feet (about 500 meters) tall and separated by two to three miles (about three to five kilometers) — than their Earthly counterparts.

“This gargantuan size is predicted by the same theory that explains the formation of these features on Earth,” says Moores. “In fact, we were able to match the size and separation, the direction of the ridges, as well as their age: three pieces of evidence that support our identification of these ridges as penitentes.” Moores says though Pluto’s environment is very different from Earth’s, the same laws of nature apply.
Hubble Provides Interstellar Road Map for Voyagers’ Galactic Trek

NASA’s two Voyager spacecraft are hurtling through unexplored territory on their road trip beyond our solar system. Along the way, they are measuring the interstellar medium, the mysterious environment between stars. NASA’s Hubble Space Telescope is providing the road map — by measuring the material along the probes’ future trajectories. Even after the Voyagers run out of electrical power and are unable to send back new data, which may happen in about a decade, astronomers can use Hubble observations to characterize the environment through which these silent ambassadors will glide.

A preliminary analysis of the Hubble observations reveals a rich, complex interstellar ecology, containing multiple clouds of hydrogen laced with other elements. Hubble data, combined with the Voyagers, have also provided new insights into how our Sun travels through interstellar space.

“This is a great opportunity to compare data from in situ measurements of the space environment by the Voyager spacecraft and telescopic measurements by Hubble,” said study leader Seth Redfield of Wesleyan University in Middletown, Connecticut. “The Voyagers are sampling tiny regions as they plow through space at roughly 38,000 miles per hour. But we have no idea if these small areas are typical or rare. The Hubble observations give us a broader view because the telescope is looking along a longer and wider path. So Hubble gives context to what each Voyager is passing through.”

The astronomers hope that the Hubble observations will help them characterize the physical properties of the local interstellar medium. “Ideally, synthesizing these insights with in situ measurements from Voyager would provide an unprecedented overview of the local interstellar environment,” said Hubble team member Julia Zachary of Wesleyan University.

In this illustration, oriented along the ecliptic plane, the Hubble Space Telescope looks along the paths of NASA’s Voyager 1 and 2 spacecraft as they journey through the solar system and into interstellar space. Hubble is gazing at sight lines (the twin cone-shaped features) along each spacecraft’s path. (NASA/ESA/Z. Levay (STScI))
Hubble Detects ‘Exocomets’ Taking the Plunge into a Young Star

Interstellar forecast for a nearby star: Raining comets! NASA’s Hubble Space Telescope has discovered comets plunging onto the star HD 172555, which is a youthful 23 million years old and resides 95 light-years from Earth. The exocomets — comets outside our solar system — were not directly seen around the star, but their presence was inferred by detecting gas that is likely the vaporized remnants of their icy nuclei. HD 172555 represents the third extrasolar system where astronomers have detected doomed, wayward comets.

The presence of these doomed comets provides circumstantial evidence for “gravitational stirring” by an unseen Jupiter-size planet, where comets deflected by its gravity are catapulted into the star. These events also provide new insights into the past and present activity of comets in our solar system.

Sun-grazing comets routinely fall into our Sun. “Seeing these sun-grazing comets in our solar system and in three extrasolar systems means that this activity may be common in young star systems,” said study leader Carol Grady of Eureka Scientific Inc. and NASA’s Goddard Spaceflight Center.

A team of French astronomers first discovered exocomets transiting HD 172555 in archival data gathered between 2004 and 2011 by the ESO’s HARPS planet-finding spectrograph. As a follow-up to that discovery, Grady’s team used Hubble to conduct a spectrographic analysis in ultraviolet light.

Hubble detected silicon and carbon gas in the starlight. The gas was moving at about 360,000 miles per hour across the face of the star. The most likely explanation for the speedy gas is that Hubble is seeing material from comet-like objects that broke apart after streaking across the face of the star.
Astronomy Professor Predicts an Explosion that will Change the Night Sky

Calvin College

Calvin College professor Larry Molnar and his students, along with colleagues from Apache Point Observatory and the University of Wyoming, are predicting a change to the night sky that will be visible to the naked eye. “It’s a one-in-a-million chance that you can predict an explosion,” Molnar said of his bold prognostication. “It’s never been done before.”

Molnar’s prediction is that a binary star he is monitoring will merge and explode in 2022, give or take a year, at which time the star will increase its brightness ten-thousand-fold, becoming one of the brighter stars in the heavens for a time. The star will be visible as part of the constellation Cygnus and will add a star to the recognizable Northern Cross star pattern.

Molnar’s exploration into the star known as KIC 9832227 began back in 2013. He was attending an astronomy conference when fellow astronomer Karen Kinemuchi presented her study of the brightness changes of the star, which concluded with a question: Is it pulsing or is it a binary?

Also present at the conference was then Calvin College student Daniel Van Noord, Molnar’s research assistant. He took the question as a personal challenge and made some observations of the star with the Calvin observatory. “He looked at how the color of the star correlated with brightness and determined it was definitely a binary,” said Molnar. “In fact, he discovered it was actually a contact binary, in which the two stars share a common atmosphere, like two peanuts sharing a single shell.

“From there Dan determined a precise orbital period from Kinemuchi’s Kepler satellite data (just under 11 hours) and was surprised to discover that the period was slightly less than that shown by earlier data” Molnar continued.
Hidden Secrets of Orion’s Clouds
European Southern Observatory

A new image from the VISION survey (Vienna Survey In Orion) is a montage of images taken in the near-infrared part of the spectrum by the VISTA survey telescope at ESO’s Paranal Observatory in Chile. It covers the whole of the Orion A molecular cloud, one of the two giant molecular clouds in the Orion molecular cloud complex (OMC). Orion A extends for approximately eight degrees to the south of the familiar part of Orion known as the sword.

The VISION survey has resulted in a catalogue containing almost 800,000 individually identified stars, young stellar objects and distant galaxies. This represents better depth and coverage than any other survey of this region to date.

VISTA can see light that the human eye cannot, allowing astronomers to identify many otherwise hidden objects in the stellar nursery. Very young stars that cannot be seen in visible-light images are revealed when observed at longer infrared wavelengths, where the dust that shrouds them is more transparent.

The new image represents a step towards a complete picture of the star formation processes in Orion A, for both low- and high-mass stars. The most spectacular object is the glorious Orion Nebula, also called Messier 42 seen towards the right of the image. This region forms part of the sword of the famous bright constellation of Orion, the Hunter. The VISTA catalogue covers both familiar objects and new discoveries. These include five new young stellar candidates and ten candidate galaxy clusters.

Elsewhere in the image, we can look into Orion A’s dark molecular clouds and spot many hidden treasures, including discs of material that could give birth to new stars (pre-stellar discs), nebulosity associated with newly-born stars (Herbig-Haro objects), smaller star clusters, and even galaxy clusters lying far beyond the Milky Way.

MORE INFORMATION

This spectacular new image is one of the largest, near-infrared, high-resolution mosaics of the Orion A molecular cloud, and reveals many young stars and other objects normally buried deep inside the dusty clouds. [ESO/VISION survey]
First Look at New, Extremely Rare Galaxy

University of Minnesota, Duluth

Approximately 359 million light-years away from Earth, there is a galaxy with an innocuous name (PGC 1000714) that doesn't look quite like anything astronomers have observed before. New research provides a first description of a well-defined elliptical-like core surrounded by two circular rings — a galaxy that appears to belong to a class of rarely observed, Hoag-type galaxies.

“Less than 0.1% of all observed galaxies are Hoag-type galaxies,” says Burcin Mutlu-Pakdil, a graduate student at the Minnesota Institute for Astrophysics, University of Minnesota Twin Cities and University of Minnesota Duluth. Hoag-type galaxies are round cores surrounded by a circular ring, with nothing visibly connecting them. The majority of observed galaxies are disc-shaped like our own Milky Way. Galaxies with unusual appearances give astronomers unique insights into how galaxies are formed and change.

The researchers collected multi-waveband images of the galaxy, which is only easily observable in the Southern Hemisphere, using a large diameter telescope in the Chilean mountains. These images were used to determine the ages of the two main features of the galaxy, the outer ring and the central body.

While the researchers found a blue and young (0.13 billion years) outer ring, surrounding a red and older (5.5 billion years) central core, they were surprised to uncover evidence for second inner ring around the central body.

“We’ve observed galaxies with a blue ring around a central red body before, the most well-known of these is Hoag’s object. However, the unique feature of this galaxy is what appears to be an older diffuse red inner ring,” says Patrick Treuthardt, an astrophysicist at the North Carolina Museum of Natural Sciences.

MORE INFORMATION

Left: A false-color image of PGC 1000714. Right: A B-I color index map that reveals both the outer ring (blue) and diffuse inner ring (light green). (Ryan Beauchemin)
Exploring a Fast Radio Burst

Gemini Observatory

Fast Radio Bursts (FRBs), sudden rapid explosions of energy from space, have challenged astronomers since their discovery in 2007. Typically lasting only a few milliseconds, many questions remain, including what powers these bursts, their distance beyond our galaxy, and what their host galaxies might look like.

“Now, thanks to deep Gemini observations, we know that at least one of these FRBs originated in a discrete source within a distant dwarf galaxy located some three billion light-years beyond our Milky Way galaxy,” said Shriharsh Tendulkar of McGill University in Montreal, Canada.

The story began with the detection of a burst denoted FRB 121102, which was discovered in November 2012 at the Arecibo Observatory in Puerto Rico. However, unlike the other 17 known FRBs, this one repeated itself and allowed astronomers to watch for it using the Jansky Very Large Array (VLA). The VLA radio telescope has the ability to see the fine detail necessary to precisely determine the object’s location in the sky.

In 83 hours of observing time over six months in 2016, the VLA detected nine bursts from FRB 121102. “For a long time, we came up empty, then got a string of bursts that gave us exactly what we needed,” said Casey Law of the University of California at Berkeley.

“Once we were able to accurately pinpoint the burst’s location in the two-dimensional sky, we enlisted the 8-meter Gemini North telescope on Maunakea in Hawai‘i to characterize the corresponding host galaxy,” said Paul Scholz with the National Research Council of Canada. “The Gemini observations did that, and for the first time with an FRB, left no doubt about its origin.”

MORE INFORMATION

Composite image of the field around FRB 121102. The dwarf host galaxy was imaged, and spectroscopy performed, using the Gemini North telescope on Maunakea in Hawai‘i. [Gemini Observatory/AURA/NSF/NRC]
The Astronomical Society of the Pacific Awards for 2017
Each year the ASP recognizes individual achievements in astronomy research, technology, education, and public outreach. The awards include the Maria and Eric Muhlmann Award (important research results based upon development of groundbreaking instruments and techniques); the Klumpke-Roberts Award (outstanding contributions to the public understanding and appreciation of astronomy); the Richard H. Emmons Award (excellence in college astronomy teaching); the Amateur Achievement Award (significant observational or technical achievements by an amateur astronomer); the Las Cumbres Amateur Outreach Award (outstanding outreach by an amateur astronomer to children and the public); the Robert J. Trumpler Award (a recent PhD thesis considered unusually important to astronomy); the Thomas J. Brennan Award (exceptional achievement related to the teaching of astronomy at the high school level); and the Arthur B.C. Walker II Award presented to an outstanding African-American who works in the areas of astronomy as a recognized leader in efforts to diversify the scientific community.

All nomination documents must be received by the ASP by March 1, 2017. Click an award name for details and a nomination form.

An Updated ASP Membership Portal
We are thrilled to announce the launch of MyASP, a new and vastly improved online membership portal, which is now available for you to use. All of your transactions with the ASP are now in one location making it easier for you to join the ASP, renew your membership, donate to the ASP, and make purchases in the AstroShop. You will also receive your member discounts automatically when making AstroShop purchases. Through this new portal, you will also be able to quickly view your purchase and donation history, as well as manage your credit card payment information and set up recurring donations to the ASP.

To access the MyASP portal, click here. When you log in, you will have to create a new account, even if your membership is current. This will ensure you are registered in our new system and receive all the benefits of membership. We welcome your feedback as we continue to improve the ASP members experience.
NEW MEMBERS — The ASP thanks all those who recently renewed their membership, and welcomes new members who joined between September 15 and December 31, 2016.

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<td>Pia Fiedler Lord, Bloomfield, NJ</td>
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<td>Victoria Walker, Stanford, CA</td>
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The Skies of February

In the west-southwest after sunset, Venus continues to blaze forth. If you were out on January 31st, you’d have seen the 4-day-old crescent Moon to the left of this brilliant world. On the 1st, the Moon is far far to the upper left of Venus. If you look a little more than 10° (the width of your fist held at arm’s length) down and away from the Moon toward Venus, you’ll see a dim red dot in the sky. That’s Mars, still hanging around in the dusk sky. Alternatively, look about 5° to Venus’ upper left to spot it.

If you’re out at the end of the month, you’ll find the crescent Moon again near Venus, about 10° to the planet’s lower left.

In the east, Jupiter rises in the late evening and is high in the south before dawn begins to break. On the 14th the giant planet rises with the Moon hanging above it. During the early morning hours, Saturn rises roughly three hours before the Sun. On the 24th the crescent Moon sits above Saturn as both rise out of the southeast a couple of hours before twilight begins.

As for Mercury, it’s rapidly lost in the glow of dawn, and doesn’t emerge from the solar glare until late March.

There are two eclipses this month. On the 10th (for North America) a penumbral eclipse of the Moon occurs. The eclipse is visible from the Americas, Europe, Africa, and Asia, but this is a very subtle affair, as only near mid-eclipse is there any noticeable difference in the appearance of the full Moon. Mid-eclipse occurs at 00:45 Universal Time on the 11th, which translates to 7:45 pm Eastern/5:45 pm Mountain time on the 10th. On the West Coast, the Moon rises after mid-eclipse. Around this time, does the full Moon look a little dimmer? Is there faint shading on the northern lunar limb? If so, you’ve seen the best that this penumbral lunar eclipse has to offer!

Then on the 26th, portions of the Southern Hemisphere play host...
to an **annular eclipse of the Sun**. Annularity is visible along a narrow path that starts at sunrise in the south Pacific, crosses southern Chile and Argentina, the south Atlantic, and ends at sunset in Angola and the Democratic Republic of the Congo. Maximum annularity (in the mid-Atlantic) is only 44 seconds. Much of southern South America and western Africa will see a partial solar eclipse. More information is available [here](#). About six months later, the great American total eclipse of the Sun takes place.

**The Skies of March**

On the evening of the 4th, the first quarter Moon *occults* (covers) the bright star Aldebaran in Taurus, the Bull, for observers across the continental United States (except in the northeast and Alaska) and southern Ontario (Canada). If you’ve never watched a *lunar occultation*, this is a good one to observe because Aldebaran is bright and the star disappears behind the dark lunar limb. Aldebaran vanishes around 11:00 pm Eastern / 7:00 pm Pacific time, but go outside well beforehand to find the Moon and star. (Here, in Universal Time, are times for the *disappearance and reappearance* of Aldebaran for some 600 North America cities.) You can watch this with the naked eye, but binoculars or a small telescope will give you a better view.

At the beginning of the month, **Venus** is still nicely placed in the early evening sky, setting about 2.5 hours after the Sun. On the 1st, the Moon is to the far, far upper left of the brilliant planet, while **Mars** is a pale red dot some 4° to the right of the Moon as twilight fades. But by the end of the month, Venus is lost in the solar glare.

Around mid-month, **Mercury** rises even as Venus falls, but neither is particularly easy to spot at this time. If you can find Venus between the 16th and 20th, look about 10° to its left for Mercury. (You’ll need a flat, low, western horizon as both planets are very low.) Don’t give up on Mercury, though, because it’s higher as the month ends. On the 29th, a 2-day-old Moon is low in the west after sunset. This could be your best chance to spot Mercury. Look carefully, perhaps with binoculars, for this tiny planet some 10° to the lower right of the Moon — with Mars a little more than 10° above the thin lunar crescent. The next night (the 30th) Mars is a little less than 10° to the lower right of the slightly fatter crescent Moon.

**Jupiter** rises in mid-evening and is nicely placed for viewing high in the south in the pre-dawn sky. On the 14th before midnight the Moon, Jupiter, and the bright star Spica form a triangle as they rise together in the east-southeast — Jupiter to the Moon's upper right, and Spica to Luna’s lower right (and just below Jupiter).

The only dawn planet is **Saturn**, rising four hours before the Sun. The last quarter Moon is to the ringed planet's upper left on the 20th.

**Daylight Saving Time** begins for most of North America on the 12th (and on the 25th throughout much of Europe). The *vernal equinox* occurs on March 20th — 6:29 am Eastern time / 3:29 am Pacific time — marking the astronomical start of spring in the Northern Hemisphere and autumn in the Southern.

**The Skies of April**

**Venus** is gone from the evening sky, and only Mars and Mercury
remain. About 45 minutes after sunset on the 1st, Mercury stands about 10° above the western horizon. But that’s as good as it gets; it’s all downhill (literally) from here. During the next week, it sinks rapidly toward the Sun and simultaneously fades in brightness.

Meanwhile, Mars clings to the sunset sky, barely managing to stay ahead of the solar glare. Its dim and reddish demeanor doesn’t help locate it as dusk fades. On the 20th, try spotting it just to the lower left of the Pleiades star cluster. Then on the 28th the red planet is more than 10° to the lower right of the crescent Moon. But don’t confuse Mars with the red-orange star Aldebaran. The star is much closer to the Moon this evening, while Mars actually lies in between the Pleiades and Aldebaran.

Jupiter is brilliant in the east after sunset and is visible almost all night. On the 7th it’s at opposition — it rises exactly as the Sun sets and so is directly opposite the Sun as seen from Earth. On the 10th, the full Moon sits just to the left of the giant planet; both rise together after sunset. Just below Jupiter is the bright star Spica.

In the east-southeast, Saturn rises around midnight and is well up in the south as dawn begins to break. During the morning hours of the 16th, the ringed world is to the lower left of the Moon.

Venus is now a morning object. It’s very low in the east before sunrise at the start of the month and therefore tough to spot. By month’s end it’s still not very high, but it does rise about 90 minutes before the Sun, making it a little more obvious at dawn. On the 23rd, about 45 minutes before sunrise, Venus and the crescent Moon are low on the western horizon.

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**Star Charts**

If you’d like a star chart to help you explore the naked-eye night sky, you have several options: purchase a star wheel (plansphere) or planetarium software, download a PDF showing the sky this month, find an online star chart, or locate an app for your tablet or smart phone.

**PDF Star Charts.** Skymaps produces a well-done chart that goes beyond a mere monthly star chart. It includes a list of monthly highlights and observable celestial objects. The downside: each month is available only at the very end of the previous month. Another nice star chart is available from Orion Telescopes and Binoculars; you can download it one month in advance. If you’d like simple star charts that don’t show the planets, a set of 12 is available from the Canada Science and Technology Museum.

**Online Star Charts.** Sky View Café gives you control over the chart’s date, time, and location, plus a few other options. But the chart names only a few bright stars, doesn’t identify the constellations, and the printout of the resulting chart is poor. The star chart created on the Tau Astronomy Club website offers fewer options but a better printout. But it lists no star names and the stars are color coded based on their spectral type.

**Apps For Tablets and Smart Phones.** SkySafari 5 ($2.99 for the basic version; available for iPhone, iPad, and iPod touch; also available for Android) is a very well done star chart app and is the one I use consistently. TheSky by Software Bisque is one of the most popular planetarium programs out there, and is now available for the iPad and iPhone. If ASP stargazers have a favorite night sky app, regardless of the device, I’d like to hear about it.

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— P.D.
A Swirl of Filaments

This view of the heart of NGC 4696, the largest galaxy in the Centaurus Cluster, was acquired by the HST's Wide Field Camera 3. It shows the dusty filaments surrounding the center of this huge galaxy in greater detail than ever before. These filaments loop and curl inwards, swirling around a central, supermassive black hole. The image shows a region roughly 45,000 light-years across. Learn more in this *Sky & Telescope* article. [Courtesy NASA/ESA/Hubble/A. Fabián.]