Volume 48 Number 12 December 2022

The Celestial Mechanic

The Official Newsletter of the Astronomy Associates of Lawrence

Coming Events

Monthly Meeting
January 29, 2022, 7:00PM
Baker Wetlands Discovery Center

Public Observing
January 29, 2022, 8:00PM
Baker Wetlands Discovery Center

Club Officers

President
Rick Heschmeyer email

AICOR
William Winkler email

NSN Coordinator
Howard Edin email

Faculty Advisor
Dr. Jennifer Delgado email.

Newsletter Editor
Chuck Wehner email

Inside This Issue

Report From the Officers

By Rick Heschmeyer

As we approach the end of the year, I'd like to express my thanks to all the club members for your time and commitment to the Astronomy Associates of Lawrence throughout the year.

As often happens this time of year, we had to deal with the weather in November. The observing portion of the November Telescope Night at KU was cancelled, but Alex Polanski gave a talk on Exoplanets.

Our PlanetPalooza event with the Lawrence Public Library was also cancelled due to weather. We are looking at future opportunities to partner with LPL for astronomy events. We will keep everyone posted as more details become available.

For our last club meeting of the year on December 4, Dr. Bruce Twarog will be giving a talk titled "Black Hole Discovery: The New Generation". Dr. Twarog is a very entertaining speaker, so we are looking forward to that presentation. The meeting will take place at the Baker Wetlands Discovery Center, and as always, the meeting will be followed by public observing (weather permitting).

December's Telescope Night at KU will take place on Thursday, December 8. Once we receive the flyer we will forward to the club via email and post on our Facebook page.

One other December event worth mentioning, on the evening of December 7 the Moon will occult the planet Mars. See the graphic from the Astronomical League for more details.

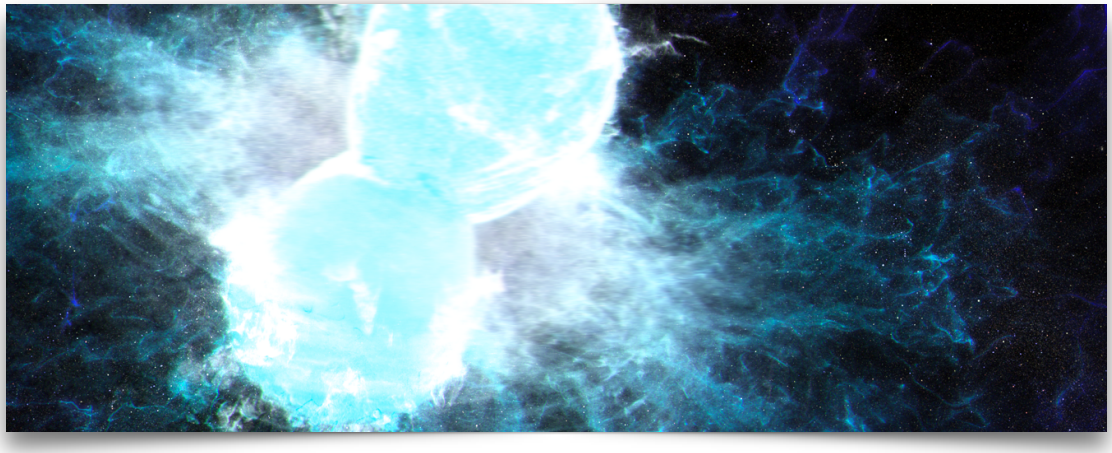
At our January club meeting, we will be viewing the 2022 Critic's Choice Award-Winning documentary film "Good Night Oppy". The film tells the story of Opportunity, a rover that was sent to Mars for a 90-day mission but ended up surviving for 15 years, and the remarkable bond forged between Oppy and her humans millions of miles away.

And don't forget to mark your calendars now for the solar eclipse that will be viewable on October 14, 2023!

Happy a festive holiday season and a Happy New Year! Clear skies to all!

How NASA's RomanTelescope Will Scan For Show-stopping Explosions

HUBBLESITE, NOVEMBER 3, 2022



Summary

ROMAN IS SET TO HELP RESEARCHERS DETECT MORE KILONOVAE, HELPING US LEARN SIGNIFICANTLY MORE ABOUT THESE "ALL-STAR" SMASHUPS.

How do you pinpoint titanic collisions that occur millions or billions of light-years away? First, by surveying large areas of the sky. Second, by teaming up with observatories around the world! Scientists have been searching for kilonovae, when two neutron stars or a neutron star and a black hole collide and set off brief, but fantastic light shows as they merge. Such a collision can cause an enormous eruption that sends out bright cascades of light and ripples in space-time.

How many brilliant eruptions like this occur across the universe? We don't yet know. Only a handful of kilonovae candidates have been detected to date. NASA's upcoming Nancy Grace Roman Space Telescope is set to survey the same areas of the sky every few days, which will help researchers follow up on – or even pinpoint – kilonova detections and ideally set off a "gold rush" of new information.

What happens when the densest, most massive stars – that are also super small – collide? They send out brilliant explosions known as kilonovae. Think of these events as the universe's natural fireworks. Theorists suspect they periodically occur all across the cosmos – both near and far. Scientists will soon have an additional observatory to help follow up on and even scout these remarkable events: NASA's Nancy Grace Roman Space Telescope, which is set to launch by May 2027.

The key actors in kilonovae are neutron stars, the central cores of stars that collapsed under gravity during supernova explosions. They each have a mass similar to the Sun, but are only about 6 miles (10 kilometers) in diameter. And when they collide, they send out debris moving near the speed of light. These explosions are also thought to forge heavy elements, like gold, platinum, and strontium (which gives actual fireworks their stunning reds). Kilonovae shoot those elements across space, potentially allowing them to end up in rocks forming the crust of terrestrial planets like Earth.

The astronomical community captured one of these remarkable kilonova events in 2017. Scientists at the National Science Foundation's Laser Interferometer Gravitational-Wave Observatory (LIGO) detected the collision of two neutron stars first with gravitational waves – ripples in space-time. Almost simultaneously, NASA's Fermi Gamma-ray Space Telescope detected high-energy light. NASA quickly pivoted to observe the event with a broader fleet of telescopes, and captured the fading glow of the blast's expanding debris in a series of images.

But the players in this example collided practically in our "backyard," at least in astronomical terms. They lie only 130 million light-years away. There must be more kilonovae – and many that are farther flung – dotting our ever-active universe.

"We don't yet know the rate of these events," said Daniel M. Scolnic, an assistant professor of physics at Duke University in Durham, North Carolina. Scolnic led a study that estimates the number of kilonovae that could be discovered by past, present, and future observatories including Roman. "Is the single kilonova we identified typical? How bright are these explosions? What types of galaxies do they occur in?"

Existing telescopes can't cover wide enough areas or observe deeply enough to find more distant examples, but that will change with Roman.

Spotting More, and More Distant, Kilonovae

At this stage, LIGO leads the pack in identifying neutron star mergers. It can detect gravitational waves in all areas of the sky, but some of the most distant collisions may be too weak to be identified. Roman is set to join LIGO's search, offering complementary qualities that help "fill out" the team. Roman is a survey telescope that will repeatedly scan the same areas of the sky. Plus, Roman's field of view is 200 times larger than the Hubble Space Telescope's infrared view – not as vast as LIGO's, but huge for a telescope that takes images. Its cadence will allow researchers to spot when objects on the sky brighten or dim, whether nearby or very far away.

Roman will provide researchers a powerful tool for observing extremely distant kilonovae. This is due to the expansion of space. Light that left stars billions of years ago is stretched into longer, redder wavelengths, known as infrared light, over time. Since Roman specializes in capturing near-infrared light, it will detect light from very distant objects. How distant? "Roman will be able to see some kilonovae whose light has traveled about 7 billion years to reach Earth," explained Eve Chase, a postdoctoral researcher at Los Alamos National Laboratory in Los Alamos, New Mexico. Chase led a more recent study that simulated how differences in kilonovae ejecta can vary what we expect to observe from observatories including Roman.

There's a second benefit to near-infrared light: It provides more time to observe these short-lived bursts. Shorter wavelengths of light, like ultraviolet and visible, disappear from view in a day or two. Near-infrared light can be gathered for a week or more. Researchers have been simulating the data to see how this will work. "For a subset of simulated kilonovae, Roman would be able to observe some more than two weeks after the neutron star merger occurred," Chase added. "It will be an excellent tool for looking at kilonovae that are very far away."

Soon, researchers will know far more about where kilonovae occur, and how often these explosions occur in the history of the universe. Were those that occurred earlier different in some way? "Roman will allow the astronomy community to begin conducting population studies along with a slew of new analyses on the physics of these explosions," Scolnic said.

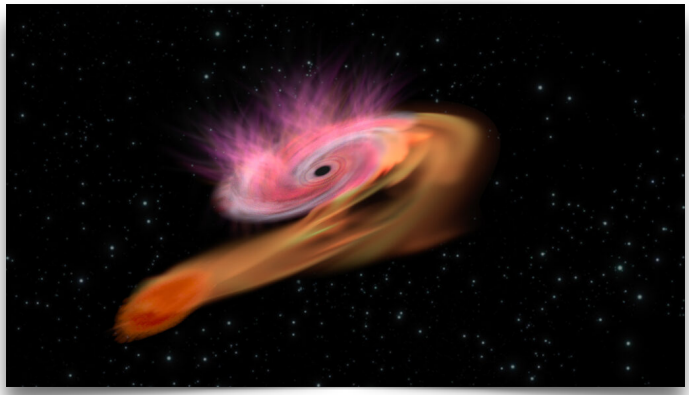
A survey telescope offers enormous possibility – and also a ton of data that will require precise machine learning. Astronomers are meeting this challenge by writing code to automate these searches. Ultimately, Roman's massive data sets will help researchers unravel perhaps the greatest mysteries about kilonovae to date: What happens after two neutron stars collide? Does it produce a single neutron star, a black hole, or something else entirely? With Roman, we will gather the statistics researchers need to make substantial breakthroughs. ☀

High-energy neutrinos may come from black holes ripping apart stars

Evidence builds that tidal disruption events send the subatomic particles zipping through space

By Emily Conover

Sciencenews, May 16, 2022



In a tidal disruption event, a supermassive black hole shreds a star that ventures too close (illustrated). Such events may also spit out high-energy neutrinos.

When a star gets too close to a black hole, sparks fly. And, potentially, so do subatomic particles called neutrinos.

A dramatic light show results when a supermassive black hole rips apart a wayward star. Now, for the second time, a high-energy neutrino has been spotted that may have come from one of these "tidal disruption events," researchers report in a study accepted in *Physical Review Letters*.

These lightweight particles, which have no electric charge, careen across the cosmos and can be detected upon their arrival at Earth. The origins of such zippy neutrinos are a big mystery in physics. To create them, conditions must be just right to drastically accelerate charged particles, which would then produce neutrinos. Scientists have begun lining up likely candidates for cosmic particle accelerators. In 2020, researchers reported the first neutrino linked to a tidal disruption event (*SN: 5/26/20*). Other neutrinos have been tied to active galactic nuclei, bright regions at the centers of some galaxies (*SN: 7/12/18*).

Discovered in 2019, the tidal disruption event reported in the new study stood out. “It was extraordinarily bright; it’s really one of the brightest transients ever seen,” says astroparticle physicist Marek Kowalski of Deutsches Elektronen-Synchrotron, or DESY, in Zeuthen, Germany.

Transients are short-lived flares in the sky, such as tidal disruption events and exploding stars called supernovas. Further observations of the brilliant outburst revealed that it shone in infrared, X-rays and other wavelengths of light.

Roughly a year after the flare’s discovery, the Antarctic neutrino observatory IceCube spotted a high-energy neutrino. By tracing the particle’s path backward, researchers determined that the neutrino came from the flare’s vicinity.

The matchup between the two events could be a coincidence. But when combined with the previous neutrino that was tied to a tidal disruption event, the case gets stronger. The probability of finding two such associations by chance is only about 0.034 percent, the researchers say.

It’s still not clear how tidal disruption events would produce high-energy neutrinos. In one proposed scenario, a jet of particles flung away from the black hole could accelerate protons, which could interact with surrounding radiation to produce the speedy neutrinos.

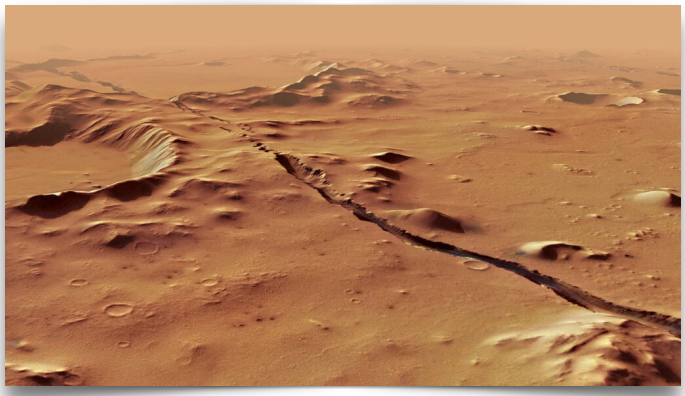
‘We need more data … in order to say that these are real neutrino sources or not,” says astrophysicist Kohta Murase of Penn State University, a coauthor of the new study. If the link between the neutrinos and tidal disruption events is real, he’s optimistic that researchers won’t have to wait too long. “If this is the case, we will see more.”

But scientists don’t all agree that the flare was a tidal disruption event. Instead, it could have been an especially bright type of supernova, astrophysicist Irene Tamborra and colleagues suggest in the April 20 *Astrophysical Journal*.

In such a supernova, it’s clear how energetic neutrinos could be produced, says Tamborra, of the Niels Bohr Institute at the University of Copenhagen. Protons accelerated by the supernova’s shock wave could collide with protons in the medium that surrounds the star, producing other particles that could decay to make neutrinos.

It’s only recently that observations of high-energy neutrinos and transients have improved enough to enable scientists to find potential links between the two. “It’s exciting,” Tamborra says. But as the debate over the newly detected neutrino’s origin shows, “at the same time, it’s uncovering many things that we don’t know.” ☀

Marsquakes hint that the planet might be volcanically active after all



A relatively young fracture cuts through hills and craters in Mars’ heavily faulted Cerberus Fossae region, seen in this 2018 image taken by the Mars Express orbiter.

By Katherine Kornei

Sciencenews, November 3, 2022

Mars might be, geologically speaking, not quite dead.

Researchers have analyzed a slew of recent temblors on the Red Planet and shown that these Marsquakes are probably caused by magma moving deep under the Martian surface. That’s evidence that Mars is still

volcanically active, the researchers report October 27 in *Nature Astronomy*.

Since touching down on Mars four years ago, NASA's InSight lander has detected more than 1,000 Marsquakes (*SN: 11/26/18*). Its seismometer records seismic waves, which reveal information about a temblor's size and location.

Previous studies have determined that several Marsquakes originated from a swath of Martian terrain known as Cerberus Fossae (*SN: 5/13/22*). This region, which is particularly riddled with faults, is more than 1,000 kilometers from the InSight lander.

But most of the Marsquakes linked to Cerberus Fossae so far have been pretty familiar, scientifically speaking, says Anna Mittelholz, a planetary scientist at Harvard University. Their seismic waves, which are low frequency, "are ones that look much more like what we see for an earthquake," she says.

Mittelholz and her colleagues have now analyzed a large sample of Marsquakes, including more than 1,000 high-frequency temblors, which look nothing like their earthly brethren. To better understand the origin of the high-frequency quakes, the researchers added together their relatively weak signals. In that stack of seismic waves, the researchers saw a peak in the amount of seismic energy coming from the direction of Cerberus Fossae. That was an impressive undertaking, says Hrvoje Tkalčić, a geophysicist at the Australian National University in Canberra who was not involved with the research. "No study before this one attempted to locate the high-frequency quakes."

The fact that different types of Marsquakes are all concentrated in one region is a surprise. Previous research has suggested that Marsquakes might be due to Mars' surface cooling and shrinking over time. That process, which occurs on the moon, would produce temblors evenly spread over the planet, Mittelholz says (*SN: 5/13/19*). "The expectation was that Marsquakes would originate from all over the place."

And by comparing the seismic waves that InSight measured with the seismic waves produced in different regions on our own planet, the researchers further showed that the low-frequency Marsquakes are probably produced by magma moving several tens of kilometers below Mars' surface. "Our results are much more consistent with data from volcanic regions on Earth," Mittelholz says.

Rather than being a geologically dead planet, as some have suggested, Mars might be a surprisingly dynamic place, the researchers conclude. This finding rewrites our understanding of Mars, Mittelholz says, and there's still so much more to learn about our celestial neighbor. "We're only scratching the surface."

Liftoff! NASA's Artemis I mega rocket launches Orion to Moon

Sciencenews, November 16, 2022

Following a successful launch of NASA's Space Launch System (SLS), the most powerful rocket in the world, the agency's Orion spacecraft is on its way to the Moon as part of the Artemis program. Carrying an uncrewed Orion, SLS lifted off for its flight test debut at 1:47 a.m. EST Wednesday from Launch Pad 39B at NASA's Kennedy Space Center in Florida.

The launch is the first leg of a mission in which Orion is planned to travel approximately 40,000 miles beyond the Moon and return to Earth over the course of 25.5 days. Known as Artemis I, the mission is a critical part of NASA's Moon to Mars exploration approach, in which the agency explores for the benefit of humanity. It's an important test for the agency before flying astronauts on the Artemis II mission.

"What an incredible sight to see NASA's Space Launch System rocket and Orion spacecraft launch together for the first time. This uncrewed flight test will push Orion to the limits in the rigors of deep space, helping us prepare for human exploration on the Moon and, ultimately, Mars," said NASA Administrator Bill Nelson.

After reaching its initial orbit, Orion deployed its solar arrays and engineers began performing checkouts of the spacecraft's systems. About 1.5 hours into flight, the rocket's upper stage engine successfully fired for approximately 18 minutes to give Orion the big push needed to send it out of Earth orbit and toward the Moon.

Orion has separated from its upper stage and is on its outbound coast to the Moon powered by its service module, which is the propulsive powerhouse provided

by ESA (European Space Agency) through an international collaboration.

"It's taken a lot to get here, but Orion is now on its way to the Moon," said Jim Free, NASA deputy associate administrator for the Exploration Systems Development Mission Directorate. "This successful launch means NASA and our partners are on a path to explore farther in space than ever before for the benefit of humanity."

Over the next several hours, a series of 10 small science investigations and technology demonstrations, called CubeSats, will deploy from a ring that connected the upper stage to the spacecraft. Each CubeSat has its own mission that has the potential to fill gaps in our knowledge of the solar system or demonstrate technologies that may benefit the design of future missions to explore the Moon and beyond.

Orion's service module will also perform the first of a series of burns to keep Orion on course toward the Moon approximately eight hours after launch. In the coming days, mission controllers at NASA's Johnson Space Center in Houston will conduct additional checkouts and course corrections as needed. Orion is expected to fly by the Moon on Nov. 21, performing a close approach of the lunar surface on its way to a distant retrograde orbit, a highly stable orbit thousands of miles beyond the Moon.

"The Space Launch System rocket delivered the power and performance to send Orion on its way to the Moon," said Mike Sarafin, Artemis I mission manager. "With the accomplishment of the first major milestone of the mission, Orion will now embark on the next phase to test its systems and prepare for future missions with astronauts."

The SLS rocket and Orion spacecraft arrived at Kennedy's Launch Pad 39B on Nov. 4 where they rode out Hurricane Nicole. Following the storm, teams conducted thorough assessments of the rocket, spacecraft, and associated ground systems and confirmed there were no significant impacts from the severe weather.

Engineers previously rolled the rocket back to the Vehicle Assembly Building (VAB) Sept. 26 ahead of Hurricane Ian and after waving off two previous launch attempts Aug. 29 due to a faulty temperature sensor, and Sept. 4 due to a liquid hydrogen leak at an interface between the rocket and mobile launcher.

Prior to rolling back to the VAB, teams successfully repaired the leak and demonstrated updated tanking procedures. While in the VAB, teams performed standard maintenance to repair minor damage to the foam and cork on the thermal protection system and recharge or replace batteries throughout the system.

Artemis I is supported by thousands of people around the world, from contractors who built Orion and SLS, and the ground infrastructure needed to launch them, to international and university partners, to small businesses supplying subsystems and components.

Through Artemis missions, NASA will land the first woman and the first person of color on the surface of the Moon, paving the way for a long-term lunar presence and serving as a steppingstone for astronauts on the way to Mars. ☀

Binoculars: A Great First Telescope

By David Prosper

Nightskynetwork, December 2022

Do you want to peer deeper into the night sky? Are you feeling the urge to buy a telescope? There are so many options for budding astronomers that choosing one can be overwhelming. A first telescope should be easy to use and provide good quality views while being affordable. As it turns out, those requirements make the first telescope of choice for many stargazers something unexpected: a good pair of binoculars!

Binoculars are an excellent first instrument because they are generally easy to use and more versatile than most telescopes. Binoculars can be used for activities like stargazing and birdwatching, and work great in the field at a star party, along the hiking trail, and anywhere else where you can see the sky. Binoculars also travel well, since they easily fit into carry-on luggage – a difficult feat for most telescopes! A good pair of binoculars, ranging in specifications from 7x35

to 10x50, will give you great views of the Moon, large open star clusters like the Pleiades (M45), and, from dark skies, larger bright galaxies like the Andromeda Galaxy (M31) and large nebulae like the Orion Nebula (M42). While you likely won't be able to see Saturn's rings, as you practice your observing skills you may be able to spot Jupiter's moons, along with some globular clusters and fainter nebulae from dark sites, too.

What do the numbers on those binocular specs actually mean? The first number is the magnification, while the second number is the size in millimeters (mm) of the lenses. So, a 7x35 pair of binoculars means that they will magnify 7 times using lenses 35 mm in diameter. It can be tempting to get the biggest binoculars you can find, but try not to get anything much more powerful than a 10x50 pair at first. Larger binoculars with more power often have narrower fields of vision and are heavier; while technically more powerful, they are also more difficult to hold steadily in your hands and "jiggle" quite a bit unless you buy much more expensive binoculars with image stabilization, or mount them to a tripod.

Would it surprise you that amazing views of some astronomical objects can be found not just from giant telescopes, but also from seemingly humble binoculars? Binoculars are able to show a much larger field of view of the sky compared to most telescopes. For example, most telescopes are unable to keep the entirety of the Pleiades or Andromeda Galaxy entirely inside the view of most eyepieces. Binoculars are also a great investment for more advanced observing, as later on they are useful for hunting down objects to then observe in more detail with a telescope.

If you are able to do so, real-world advice and experience is still the best for something you will be spending a lot of time with! Going to an in-person star party hosted by a local club is a great way to get familiar with telescopes and binoculars of all kinds – just ask permission before taking a closer look! You can find clubs and star parties near you on the Night Sky Network's Clubs & Events page at bit.ly/nsnclubsandevents, and inspire your binocular stargazing sessions with NASA's latest discoveries at nasa.gov.

The two most popular types of binocular designs are shown here: **roof-prism** binoculars (*left*) and **porro-prism** binoculars (*right*). Roof prisms tend to be more compact, lighter, and a bit more portable, while porro-

prisms tend to be heavier but often offer wider views and greater magnification. What should you choose? Many birders and frequent fliers often choose roof-prism models for their portability. Many observers who prefer to observe fainter deep-sky objects or who use a tripod with their observing choose larger porro-prism designs. There is no right answer, so if you can, try out both designs and see which works better for you.

A pair of good binoculars can show craters on the Moon around 6 miles (10 km) across and larger. How large is that? It would take you about two hours to hike across a similar-sized crater on Earth. The "Can You See the Flag On the Moon?" handout showcases the levels of detail that different instruments can typically observe on the Moon, available at bit.ly/flagmoon. *Moon image courtesy Jay Tanner* ☀

NASA's Webb draws back curtain on universe's early galaxies

Sciencenews, November 17, 2022

A few days after officially starting science operations, NASA's James Webb Space Telescope propelled astronomers into a realm of early galaxies, previously hidden beyond the grasp of all other telescopes until now.

"Everything we see is new. Webb is showing us that there's a very rich universe beyond what we imagined," said Tommaso Treu of the University of California at Los Angeles, principal investigator on one of the Webb programs. "Once again the universe has surprised us. These early galaxies are very unusual in many ways."

Two research papers, led by Marco Castellano of the National Institute for Astrophysics in Rome, Italy, and Rohan Naidu of the Harvard-Smithsonian Center for Astrophysics and the Massachusetts Institute of Technology in Cambridge, Massachusetts, have been published in the Astrophysical Journal Letters.

These initial findings are from a broader Webb research initiative involving two Early Release Science (ERS) programs: the Grism Lens-Amplified Survey from Space (GLASS), and the Cosmic Evolution Early Release Science Survey (CEERS).

With just four days of analysis, researchers found two exceptionally bright galaxies in the GLASS-JWST images. These galaxies existed approximately 450 and 350 million years after the big bang (with a redshift of approximately 10.5 and 12.5, respectively), though future spectroscopic measurements with Webb will help confirm.

"With Webb, we were amazed to find the most distant starlight that anyone had ever seen, just days after Webb released its first data," said Naidu of the more distant GLASS galaxy, referred to as GLASS-z12, which is believed to date back to 350 million years after big bang. The previous record holder is galaxy GN-z11, which existed 400 million years after the big bang (redshift 11.1), and was identified in 2016 by Hubble and Keck Observatory in deep-sky programs.

"Based on all the predictions, we thought we had to search a much bigger volume of space to find such galaxies," said Castellano.

"These observations just make your head explode. This is a whole new chapter in astronomy. It's like an archaeological dig, and suddenly you find a lost city or something you didn't know about. It's just staggering," added Paola Santini, fourth author of the Castellano et al. GLASS-JWST paper.

"While the distances of these early sources still need to be confirmed with spectroscopy, their extreme brightnesses are a real puzzle, challenging our understanding of galaxy formation," noted Pascal Oesch at the University of Geneva in Switzerland, second author of the Naidu et al. paper.

The Webb observations nudge astronomers toward a consensus that an unusual number of galaxies in the early universe were much brighter than expected. This will make it easier for Webb to find even more early galaxies in subsequent deep sky surveys, say researchers.

"We've nailed something that is incredibly fascinating. These galaxies would have had to have started coming together maybe just 100 million years after the big bang. Nobody expected that the dark ages would have ended so early," said Garth Illingworth of the University of California at Santa Cruz, a member of the Naidu/Oesch team. "The primal universe would have been just one hundredth its current age. It's a sliver of time in the 13.8 billion-year-old evolving cosmos."

Erica Nelson of the University of Colorado, a member of the Naidu/Oesch team, noted that "our team was struck by being able to measure the shapes of these first galaxies; their calm, orderly disks question our understanding of how the first galaxies formed in the crowded, chaotic early universe." This remarkable discovery of compact disks at such early times was only possible because of Webb's much sharper images, in infrared light, compared to Hubble.

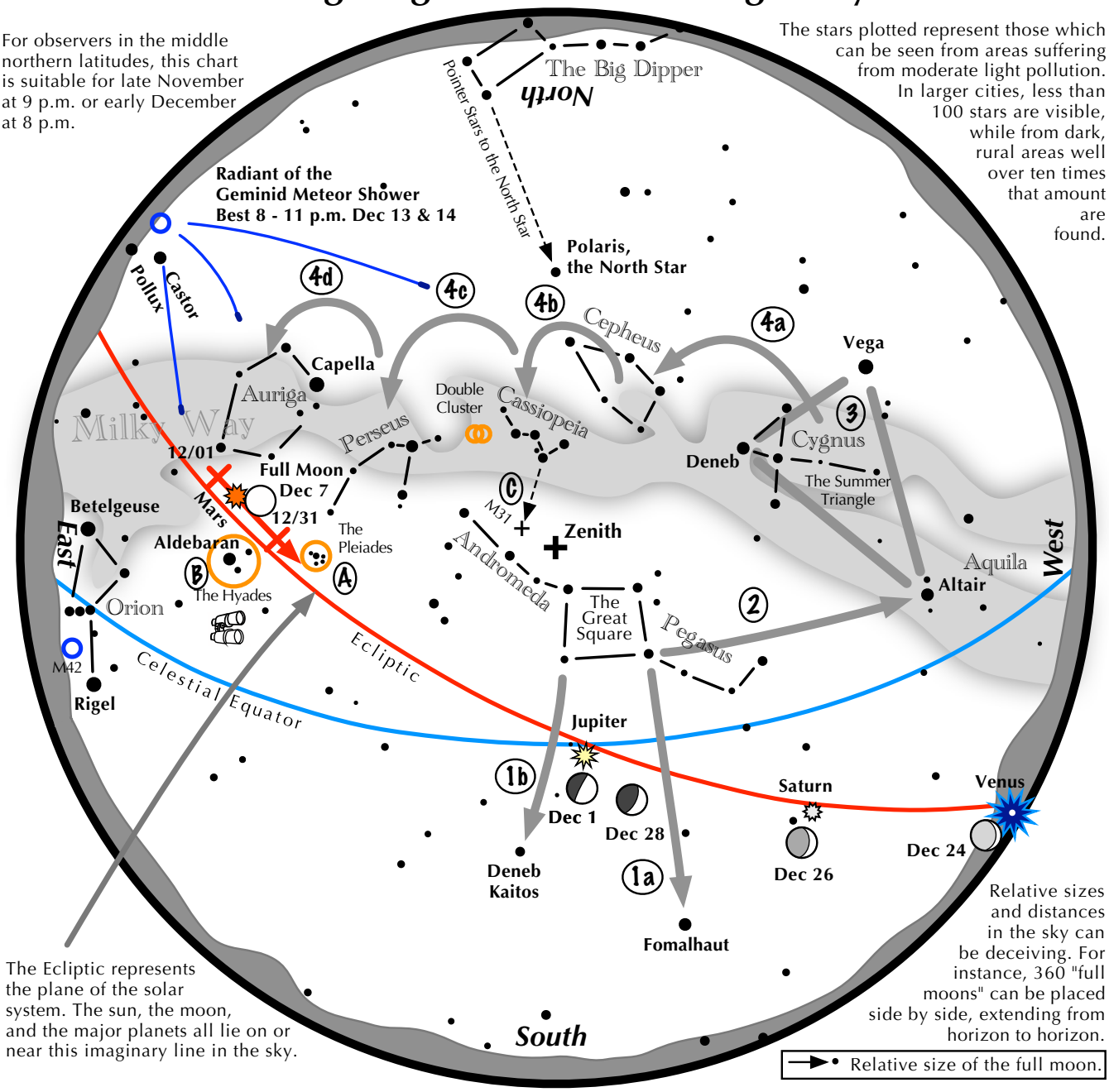
"These galaxies are very different than the Milky Way or other big galaxies we see around us today," said Treu.

Illingworth emphasized the two bright galaxies found by these teams have a lot of light. He said one option is that they could have been very massive, with lots of low-mass stars, like later galaxies. Alternatively, they could be much less massive, consisting of far fewer extraordinarily bright stars, known as Population III stars. Long theorized, they would be the first stars ever born, blazing at blistering temperatures and made up only of primordial hydrogen and helium -- before stars could later cook up heavier elements in their nuclear fusion furnaces. No such extremely hot, primordial stars are seen in the local universe.

"Indeed, the farthest source is very compact, and its colors seem to indicate that its stellar population is particularly devoid of heavy elements and could even contain some Population III stars. Only Webb spectra will tell," said Adriano Fontana, second author of the Castellano *et al*. paper and a member of the GLASS-JWST team.

Present Webb distance estimates to these two galaxies are based on measuring their infrared colors. Eventually, follow-up spectroscopy measurements showing how light has been stretched in the expanding universe will provide independent verification of these cosmic yardstick measurements.

Navigating the December Night Sky



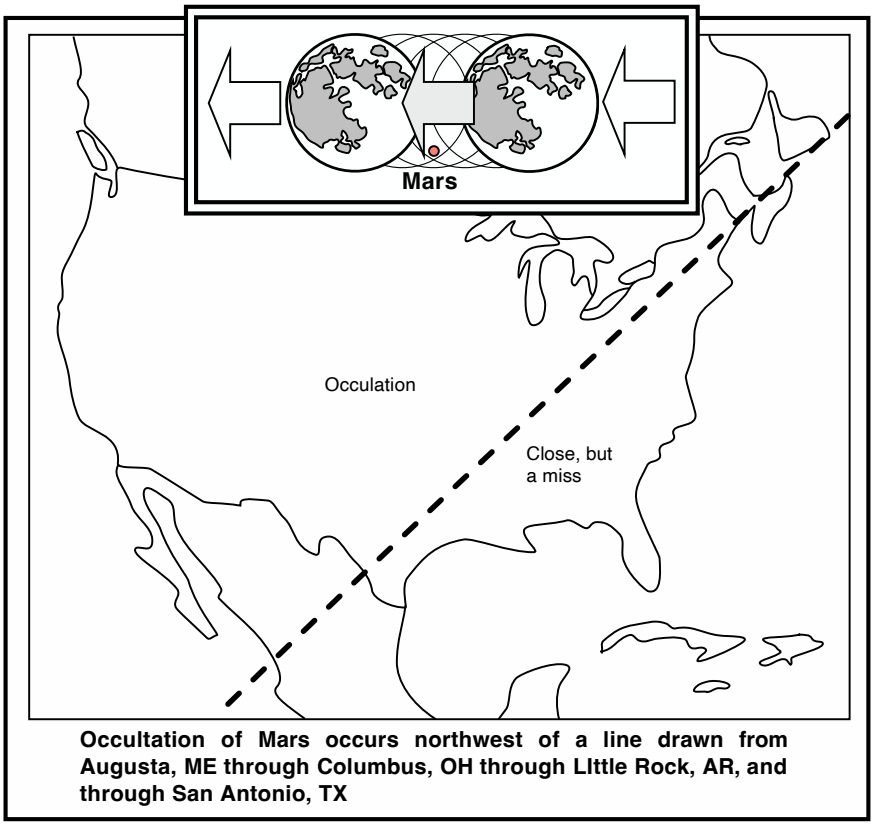
Navigating the December night sky: Simply start with what you know or with what you can easily find.

1. Face south. Almost overhead is the "Great Square" with four stars about the same brightness as those of the Big Dipper. Extend an imaginary line southward following the Square's two westernmost stars. The line strikes Fomalhaut, the brightest star in the southwest. A line extending southward from the two easternmost stars, passes Deneb Kaitos, the second bright star in the south.
2. Draw another line, this time westward following the southern edge of the Square. It strikes Altair, part of the "Summer Triangle."
3. Locate Vega and Deneb, the other two stars of the "Summer Triangle. Vega is its brightest member while Deneb sits in the middle of the Milky Way.
4. Jump along the Milky Way from Deneb to Cepheus, which resembles the outline of a house. Continue jumping to the "W" of Cassiopeia, to Perseus, and finally to Auriga with its bright star Capella.

Binocular Highlights

A and B: Examine the stars of the Pleiades and Hyades, two naked eye star clusters.
C: The three westernmost stars of Cassiopeia's "W" point south to M31, the Andromeda Galaxy, a "fuzzy" oval.
D: Sweep along the Milky Way from Altair, past Deneb, through Cepheus, Cassiopeia and Perseus, then to Auriga for many intriguing star clusters and nebulous areas.

If you can see only one celestial event this December, see this one.



Occultation of Mars occurs northwest of a line drawn from Augusta, ME through Columbus, OH through LIttle Rock, AR, and through San Antonio, TX

Occultations demonstrate the moon's eastward orbital motion as Earth's rotation causes it to move in a westward arc across the night sky.

Full Moon occults Bright Mars

In the evening hours of **Dec. 7**, the brilliant full moon passes in front of bright Mars, which is at opposition, for viewers west of a line drawn from August, ME through San Antonio, TX. It may not be easy to see because of the moon's bright glare!

Approximate local times of disappearance and reappearance. Begin viewing a few minutes before listed disappearance time. Mars' time and position of reappearance is hard to judge since the planet lies concealed behind the moon beforehand.

City	Disappearance	Reappearance
Augusta	10:57	11:25
Austin	8:58	9:12
Buffalo	10:32	11:13
Chicago	9:10	10:04
Columbus	10:26	10:56
Denver	7:45	8:47
Indianapolis	10:16	10:56
Kansas City	8:57	9:51
Little Rock	9:06	9:32
Los Angeles	6:31	7:30
Phoenix	7:32	8:30
Salt Lake City	7:42	8:45
San Antonio	8:59	9:07
San Francisco	6:36	7:35
Seattle	6:53	7:50

About Astronomy Associates

The club is open to all people interested in sharing their love for astronomy. Monthly meetings are typically on the last Sunday of each month and often feature guest speakers, presentations by club members, and a chance to exchange amateur astronomy tips. These meetings and the public observing sessions that follow are scheduled at the Baker Wetlands Discovery Center, south of Lawrence. All events and meetings are free and open to the public. Periodic star parties are scheduled as well.

Because of the flexibility of the schedule due to holidays and alternate events, it is always best to check the Web site for the exact Sundays when events are scheduled.

Copies of the Celestial Mechanic can also be found on the web at newsletter.
Annual Dues for the club are: $12 for regular members; $6 for students Membership forms can be accessed at the club website form.