CORNELL ASTRONOMICAL SOCIETY NEWSLETTER

ISSUE 7 • DECEMBER 2022

LETTER FROM THE OUTREACH COORDINATOR

Happy Holidays! With the fall semester nearly over, it seems like our first year fully open after COVID was a huge success. We returned to our in-person lecture series, celebrating Irv's 100th anniversary with space-themed cupcakes and a talk from our advisor, Prof. Phil Nicholson. We dressed as pirates for Halloween, and in November we celebrated Carl Sagan's birthday with apple pie and Prof. Lisa Kaltenegger's "Alien Earths" lecture. The turnout at these events blew us away—we even had to bring in chairs from the dining hall! Thank you to all our new bright-eyed members, and thank you to all who visited the observatory this semester—waiting in lines out the door, asking big questions, and bringing Fuertes back with a bang.

Sincerely,
Gillis Lowry, Outreach Coordinator

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THE FUTURE OF ARTEMIS

BY CLAIRE CAHILL

After a laundry list of delays and setbacks, Artemis 1 finally launched on November 16. Nearly through its 26-day mission, the un-crewed Orion capsule is performing as expected and has even sent back some pictures, including a recreation of the famous Earthrise photo from Apollo 8. As promising as Artemis 1 has been so far, it only marks the beginning of what will hopefully be a successful program. What lies ahead for Artemis?

Artemis 1 | Credit: NASA

Artemis 1 Prelaunch
Credit: NASA

Artemis 2, the second mission of the launch for the program, is tentatively set for May 2024. Despite the long wait time, Artemis 2 promises a high payoff: if all goes well, it will be the first mission to bring humans near the Moon since the end of Apollo in the 1970s. The mission is expected to last about 10 days, and it will take four astronauts in a loop around the Moon before returning back to Earth.

The iteration of the Space Launch System (SLS) rocket that will launch this crew is already well under development, and has been for over a year. In late September, the four RS-25 engines that will power the rocket's flight arrived at NASA's Michoud Assembly Facility in New Orleans, where they will be installed into the core stage of SLS.

Artemis 2 also marks a beginning for the program. Tentatively scheduled for launch in 2025, Artemis 3 promises to land the first woman and the first person of color onto the surface of the Moon, although quite a few developments back on Earth have to happen first.

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Artemis 3 depends on the successful flights of both Artemis 1 and Artemis 2, and in order for a human landing to be possible, the new spacesuits that NASA has offloaded to Axiom Space have to be flight-ready. Ideally, these spacesuits will be able to fit a wider range of astronauts, and they will have greater flexibility than the ones currently in use.

The end goal of the Artemis program is to build a sustainable human presence on the Moon where science and exploration can take place over an extended period of time. One area of interest involves harvesting lunar resources, including ice, in order to develop safe, Earth-independent operations that could be replicated on a mission to Mars. Scientists also hope that access to the presently unexplored lunar south pole could yield information about the formation of the Moon, the Earth, and the Solar System.

NASA hopes to pair this ground-based presence with an orbital station in an elliptical halo orbit, called the Gateway. Both an international and commercial venture, the Gateway will serve as a waypoint between Earth and the surface of the Moon where spacecraft can dock and science can be performed in microgravity. The first three experiments for the Gateway have already been selected: two of them will be studying space weather and solar radiation, and the third will be investigating radiation shielding and producing improved models of how radiation affects the human body in space.

While these goals may seem quite lofty, the success of the Artemis 1 launch is an important first step, as it provides an essential test of two of the most fundamental building blocks of this long term plan: SLS and Orion.

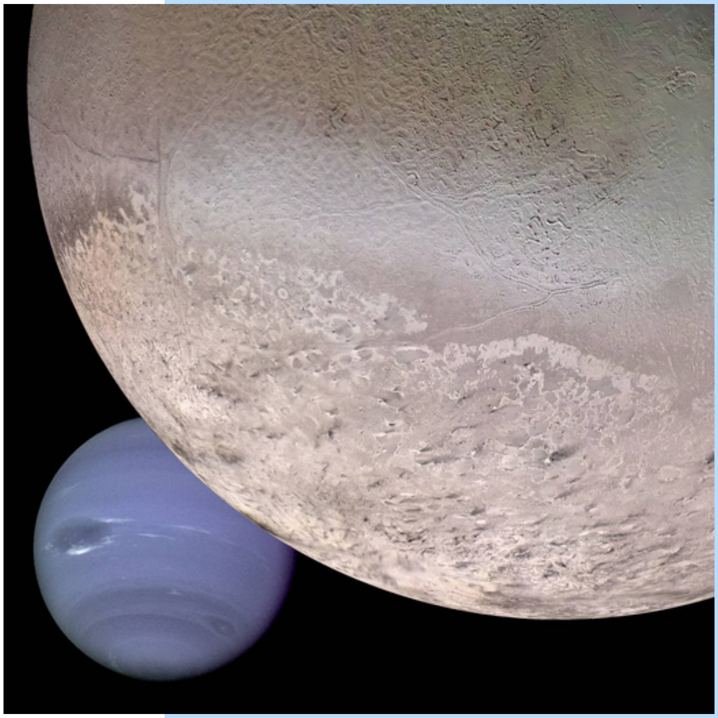
Artemis 1 | Credit: [ESA/NASA]

TRITON

BY JUSTINE SINGLETON

Picture this: It is a very cold morning. Once you manage to convince yourself to crawl out of bed, you stumble to get ready for the day. You pass by a window, then stop. The window is entirely covered in frost.

You remember that frost forms when water vapor in the atmosphere makes contact with the ground or any other surface below freezing, changing from gas to ice through a process called deposition. As you continue with your morning routine, you recall a more extreme version of this. On Neptune's moon Triton, the nitrogen atmosphere seasonally becomes a surface layer of ice. Combined with the fact that its atmosphere also contains methane and carbon monoxide, you feel glad that you do not live there.



Computer-spliced image of Triton and Neptune | Credit: [NASA/JPL/USGS]

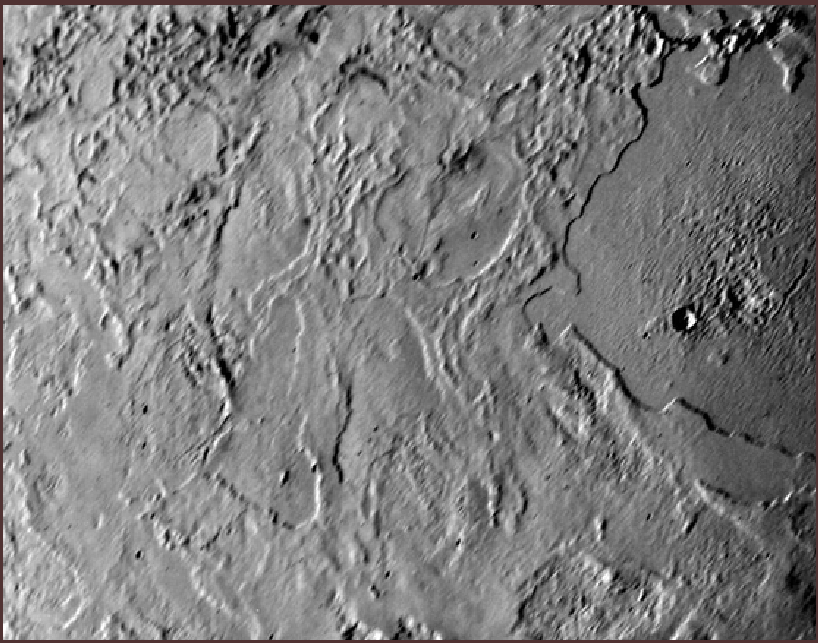


Image of Triton's Northern Hemisphere
Credit: [NASA/JPL]

As you prepare for another day of your life on Earth, the thought of living on Neptune's icy moon returns. You imagine that your building is a space station on Triton. It has less than a tenth of Earth's surface gravity, so you wouldn't be able to move around as usual, but this is only your imagination. If you looked out the window of a Tritonian base, it would be very dark outside. Since Neptune and its moons are so far away from the Sun, it is 900 times dimmer there than on Earth. You wonder if you'd even be able to see the frost on your windowpane.

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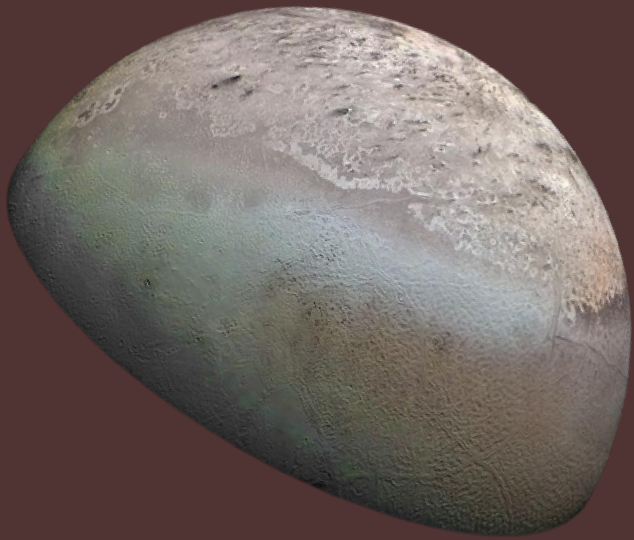
If you put on a spacesuit and went for a walk, either with a flashlight or extremely good night vision, you might notice some interesting features on Triton's surface. Part of the Neptunian moon has a structure called "cantaloupe terrain" due to its resemblance to the melon's rind. It most likely gained this appearance when Triton's icy crust reshaped itself, forming blobs of ice beneath the surface that broke through the top. There are also dark streaks across its surface and wide features known as walled plains, both of which scientists think are signs of volcanic activity.

Plumes were seen coming from Triton when Voyager 2 flew by Neptune in 1989. Its surface features show indications of icy "lava", as opposed to geysers, like those on Saturn's icy moon Enceladus. There are three main hypotheses as to how these cryovolcanoes are powered: solar heating, tidal heating from orbiting Neptune, or a subsurface ocean. An ocean would be especially interesting, since other ocean worlds have been discovered in the Solar System. However, we won't know for certain until another spacecraft passes by Triton. You remember hearing about plans for one a few years ago. Trident. NASA proposed a spacecraft called Trident that was meant to investigate the icy moon's surface and interior, but it was ultimately not chosen by the Decadal Survey, so it is unlikely to launch anytime soon. China, however, has planned a Neptune mission, which would include a satellite designed to penetrate Triton's crust.

You grab your things for the day and pack them into your bag, making sure you don't miss anything. There's another interesting thing about Triton you remember. It was most likely captured into Neptune's orbit. That explains why it is so different from the other moons around it. For one, Triton is the only moon to orbit Neptune in retrograde. It is also significantly larger than the other moons; if Triton were a cantaloupe, the rest of Neptune's moons would be blueberries, or even smaller.

The thought of fruit makes you hungry. You check to see if you have time for breakfast, and thankfully, you do. As the frost on your window slowly dissipates, you return to your relatively warm life on Earth. Then you remember something else. After Triton was captured by Neptune, it destroyed many of its other moons. With a shudder, you feel glad you don't live on any of Neptune's satellites.



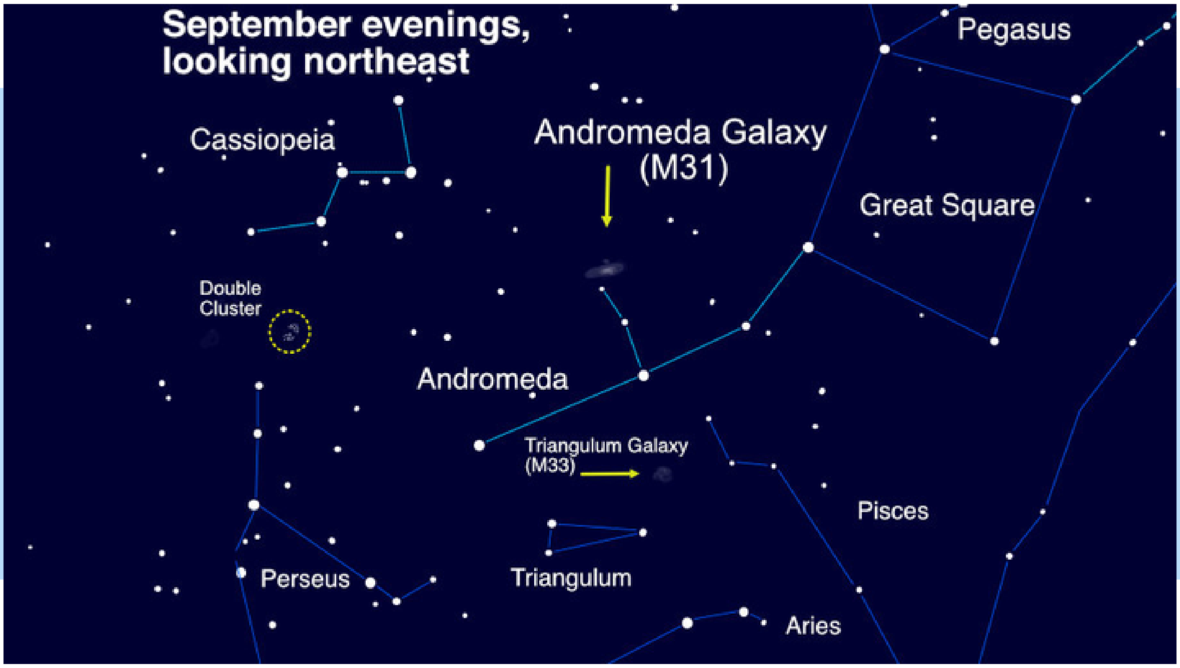
ANDROMEDA

BY LUCAS LAWRENCE

Of all the night sky objects I've seen through a telescope, the one that has stuck with me the most is the Andromeda Galaxy. I still remember the sense of awe I felt when I gazed at this distant cloud containing untold billions of stars, located some 2.5 million lightyears away.

The Andromeda Galaxy is one of the most distant objects that can be seen with the naked eye, and its incredible luminosity allows it to be seen even with moderate light pollution. Unfortunately, the lights here in Ithaca are enough to hide the Andromeda Galaxy from the naked eye, but with a telescope or a pair of binoculars, you too can look upon Andromeda.

Finding the Andromeda Galaxy is a bit of a challenge, but it's made easier with knowledge of the many nearby constellations. To find the Andromeda Galaxy, you must first find the Andromeda constellation. This constellation is to the right of the easy-to-find "W" constellation Cassiopeia. Andromeda is connected to Pegasus. You can locate Pegasus's box-shaped body in the accompanying image.



The northeast sky
Credit: [NASA/JPL]

To find Andromeda, first look at the lower-left corner of the Great Square of Pegasus. Then, make sure you can see the line of three stars to the lower left of that star. This line is the back of Andromeda. Then find the star in the middle of this line, a fairly bright red star called Mirach. Climb up the two "helper stars" just above Mirach. The Andromeda Galaxy is near the second star.

WINTER CONSTELLATIONS

What to Look for in the Night Sky

BY JILLIAN EPSTEIN

If you are a Fuertes regular, you may have noticed the night sky changing over the weeks. Constellations that were easy to spot are now hidden behind the trees, and constellations that didn't rise until after we were closed for the night are now visible! As we move into another chilly Ithaca winter, the night sky changes along with the temperatures.

My personal favorite of the winter constellations is very easy to spot: Orion. This constellation is extremely recognizable due to it being large, bright, and uniquely shaped. It also undeniably looks like a man ready for battle!

Another winter constellation, which rises right after Orion, is also easy to spot, because it contains the brightest star in the night sky. This is Canis Major, a (you guessed it) large dog. The bright star is Sirius, which is not actually one star, but two!

The constellation Orion is framed by two Perseid meteors.
Credit: NASA/Bill Dunford

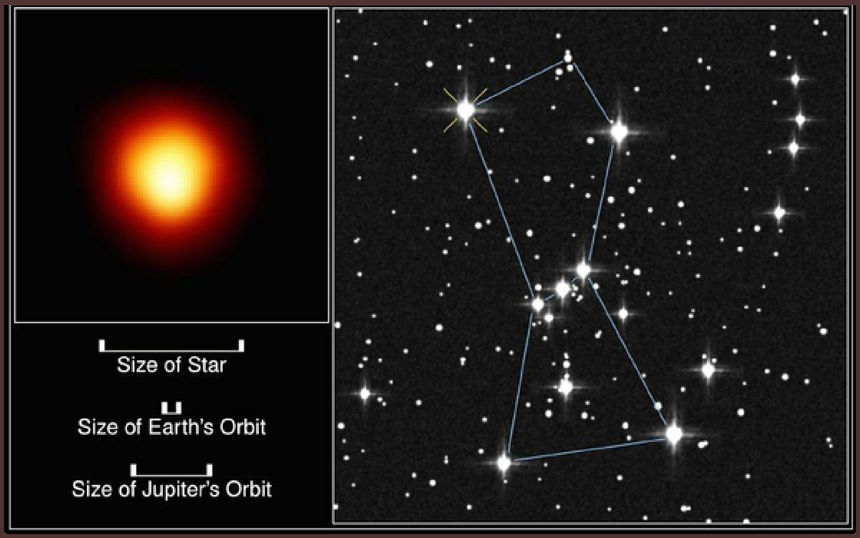


Diagram of the Orion constellation | Credit: NASA

There are also a few new zodiac constellations visible in the night sky in the winter. It is important to note that the zodiac constellations visible in the night sky on a given day do not line up with the zodiac "season" of that given day. Zodiac signs depend on where the Sun is, so we'll never see the current zodiac sign in the night sky!

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Taurus and Gemini are both visible in the winter, getting well above the trees surrounding Fuertes and the lights of campus! Taurus is easy to see if you know how to find one of my favorite astronomical objects: the Pleiades. Whether Taurus includes the Pleiades appears to be (surprisingly) up for debate, but it is at the very least close to the horns of the bull!

Gemini rises about when Orion does. It features two bright stars, Castor and Pollux, as the heads of a pair of twins holding hands. It's not as easy to spot as Orion, because the rest of the stars in the constellation are dimmer, but it's definitely something to look out for if you're a Gemini!

However, if Deep Sky Objects (DSOs) are more your thing, there are a few nebulae that you can point your telescope at.

The Orion Nebula sits below the famous belt of the Orion constellation. It is one of the brightest nebulae in the night sky, and can be seen with the naked eye if it is dark enough (unfortunately, this is unlikely to happen on Cornell's campus). It is a star-forming nebula, which makes it a particularly fascinating object to study for astronomers.

Image of Orion Nebula | Credit: NASA

Image of Crab Nebula
Credit: NASA, ESA, J. Hester and A. Loll)

If you're up for a bit more of a challenge, the Crab Nebula lies within Taurus, and is a bit harder to see than the Orion Nebula. It is a supernova remnant surrounding a pulsar, and you have likely seen the beautiful pictures of this nebula captured by Hubble. The supernova that caused this remnant was recorded by astronomers almost a millennium ago.

Though the night sky is going to look a little different as winter arrives, certain objects and constellations will be visible year-round. If you stay in Ithaca, Ursa Major may be washed out by the lights of North Campus some months, but it will always be above the horizon! The same goes for a constellation that is particularly easy to spot: Cassiopeia. Finally, because Polaris will always be in the same place in the night sky, Ursa Minor will be in the night sky year round.

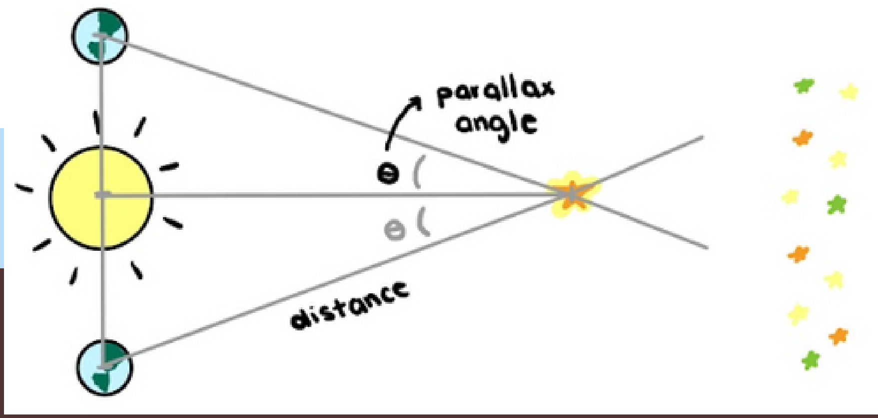
Whether at Fuertes or somewhere else in Ithaca, be sure to look for these constellations and DSOs this winter! Happy stargazing!

ASTEROMETRY

How Do We Measure the Distance to a Star?

BY ABRA GEIGER

How do astronomers measure distances to faraway stars and cosmological objects? After all, we don't have galactic tape measures capable of measuring light years of distance across space. Neither do we have a spacecraft that can fly great distances to various objects in space, measuring the distance traveled along the way. Instead, astronomers cleverly employ a bit of trigonometry when they approximate distances to stars.



As the Earth revolves around the sun, objects in the sky appear to change position with respect to distant background objects. This same phenomenon can be observed when closing one eye at a time while looking at an outstretched finger. The angle of this position change is called parallax.

From the parallax angle and the distance between Earth and the Sun, one can measure the desired distance to an object on the sky. Specifically, the distance to an astronomical object is the distance between Earth and the Sun divided by the object's parallax angle (thanks to the small angle approximation). Conveniently, the distance between the Earth and the Sun is defined to be one astronomical unit (AU), so distance = 1 AU / parallax angle.

Now you may be wondering how we work out the units for this, but fear not! Human unit conventions come in handy. As you may imagine, a star light years away from Earth does not appear to move drastically in the sky over the course of a year. Angular variations for astronomical objects are very small, and they require very precise measurement in order to enable precise distance approximations. Therefore, we split each degree into arcseconds: within one degree (°), there are 60 arcminutes (′), and within one arcminute there are 60 arcseconds (′′).

In concurrence, a common distance unit in astronomy is the parsec (pc), which is defined as the distance to an object with a parallax of one arcsecond. Finally, we can plug this back into the equation from earlier. The relationship used to measure the distance to an object in the sky, including units, is d (pc) = 1 AU / p (′′).

EXOPLANET DETECTION

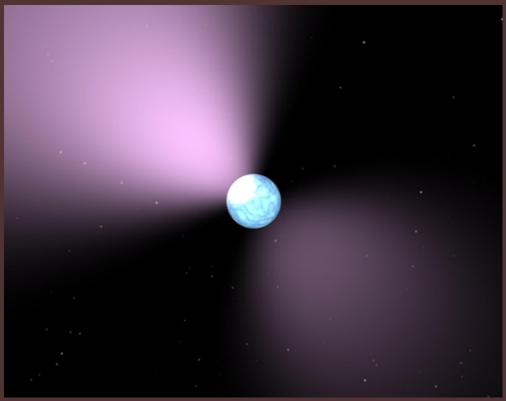
BY DYLAN JACKAWAY

In the late 1500s, an Italian mathematician by the name of Giordano Bruno came to a profound realization. Inspired by the earlier work of Polish astronomer Nicolaus Copernicus, who found that placing the Sun at the center of the Solar System provided a more accurate and satisfying explanation for the motion of the planets, Bruno hypothesized that the distant stars, rather than being fixtures in a celestial firmament, were in fact objects of the same class as our Sun, merely viewed at a great distance.

There was no reason, Bruno argued, that these alien stars could not host their own inhabited worlds; surely the God that the Catholic authorities worshiped would be capable of such a feat. This argument did not placate the Church, however, and he was burned at the stake in 1600 for a laundry list of theological transgressions.

Statue of Copernicus
Credit: NASA/ GSFCA

In the era of modern astronomy, it was long suspected that exoplanets (i.e. planets not orbiting the Sun) were commonplace, and that they would serve to tell us more about the formation of our own Solar System.



Artistic rendition of a pulsar
Credit: NASA/JPL-Caltech

Due to the difficulty of detecting them next to the glare of their parent stars, however, they remained elusive until 1992, when three terrestrial planets were found to be in orbit around pulsar PSR B1257+12, implied by slight inexplicable variations in the pulsar's rotation time. (Pulsars are highly magnetized neutron stars, left over from supernova explosions, many of which rotate dozens of times per second with clockwork precision).

More exciting to astronomers, though, was the discovery in 1995 of a gas giant around a Sun-like star, 51 Pegasi. Coming in at around half the mass of Jupiter and orbiting its star once every four days, it produced a Doppler shift as the star wobbled back and forth under its planet's gravitational influence.

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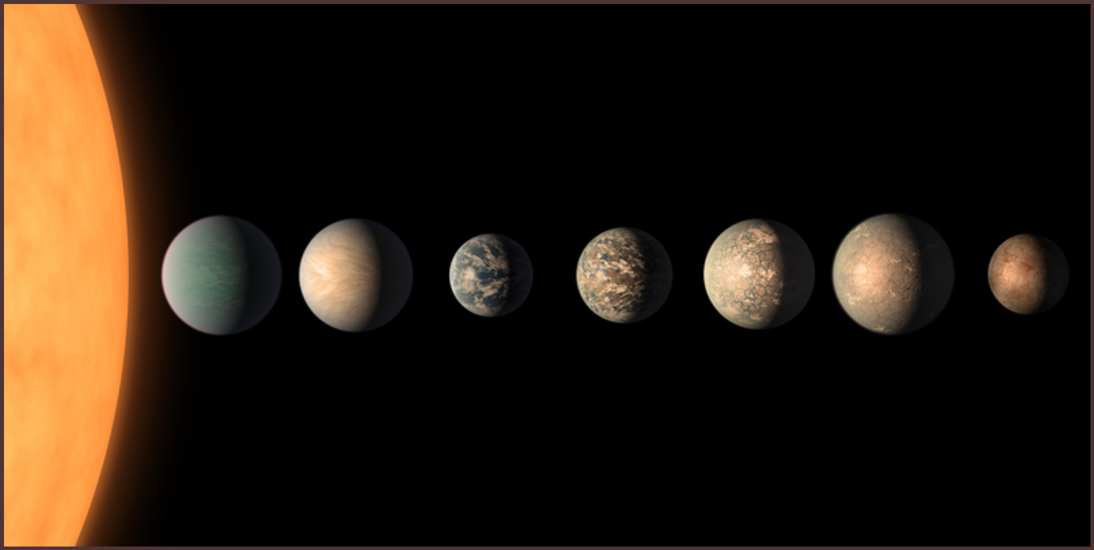
Note that in these cases, it was not actually necessary to obtain an image of the exoplanet; rather, its presence could be shown through careful observation and inference. In the years since, the number of known exoplanets has skyrocketed, and the range of methods used to detect them has broadened. In particular, the Kepler mission, active from 2009 to 2018, found 2,662 planets in a small region of the sky, orbiting stars that briefly dimmed as their planets passed directly in front of them. This is known as the “transit method.”

Although both of these methods favor larger planets with fast orbits (known as “hot Jupiters”), the latter can even be used to find smaller planets, via the variations in the transit times of the larger ones. Additionally, larger planets further away from their stars have been directly imaged, tracing their path around the system in real time. Finally, exoplanets have been spotted passing almost directly in front of distant stars in the background, slightly magnifying their light due to gravitational microlensing.

Exoplanets have also been grouped into various categories, from the aforementioned hot Jupiters to Earth-like planets in their star’s habitable zone (a.k.a. “Goldilocks zone,” the distance where temperatures are right for liquid water), which represent the prime candidates in the search for extraterrestrial life. In 2016, a potentially Earth-like planet was discovered around the red dwarf Proxima Centauri, the closest star to the Solar System at 4.2 lightyears away. Due to the proximity to its star, it is unknown whether the planet, Proxima Centauri b, would be able to retain a biosphere under the frequent solar flares irradiating the surface. (The late Stephen Hawking advocated for the “Breakthrough Starshot” proposal, a plan to explore the system using superlight probes accelerated to 20% the speed of light with lasers.)

In 2017, the red dwarf TRAPPIST-1 was found to have seven terrestrial planets, with as many as three or four of them orbiting in its habitable zone, more than for any other known star system. Although the question of our solitude in the universe remains open, the field of exoplanetology will likely prove instrumental if we are ever to find an answer.



Artistic rendition of the TRAPPIST-1 planetary system | Credit: NASA/JPL-Caltech

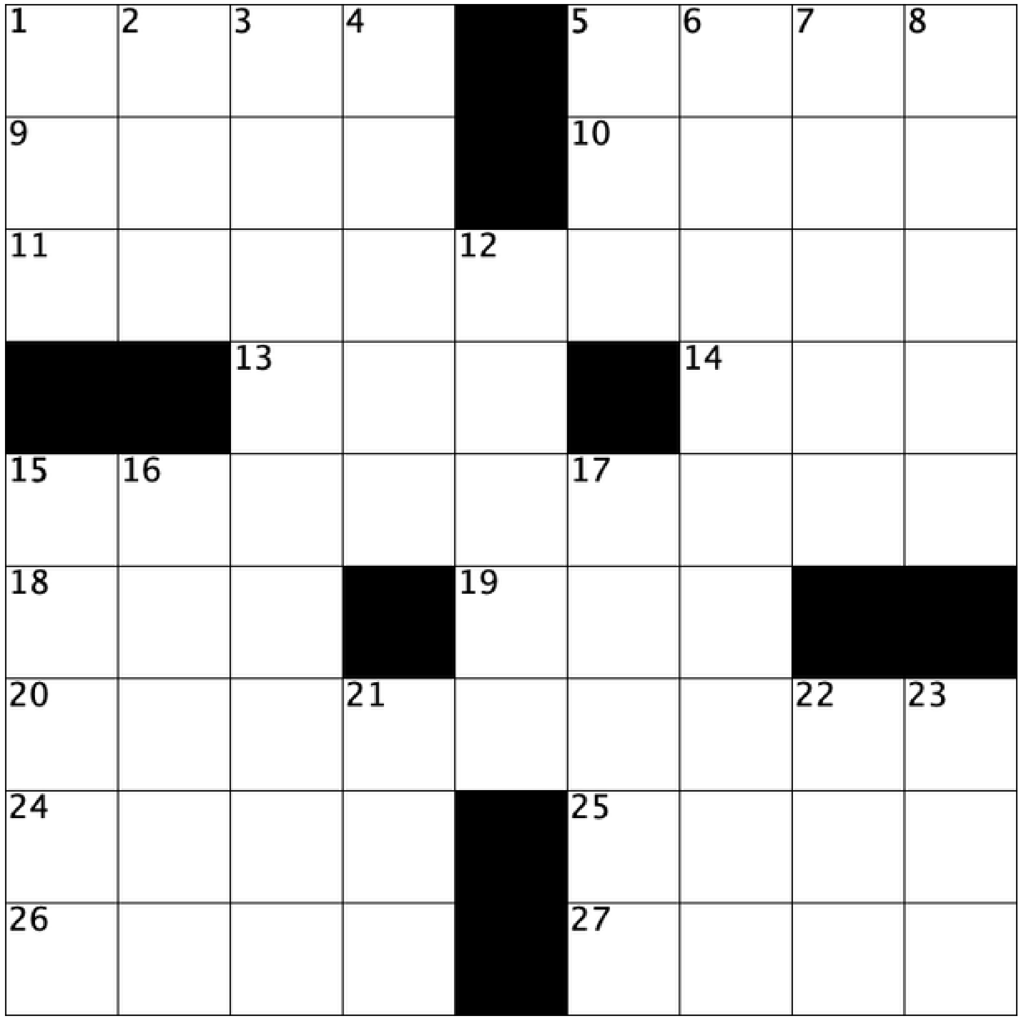
WHAT'S THAT ARTIFACT?

BY ABIGAIL BOHL

IT'S AN ASTRONOMICAL TRANSIT INSTRUMENT!

This bronze and brass instrument was used to determine the current time and relative longitude by measuring the passage of stars across the local meridian. Primarily used in the 19th century, navigators pointed the astronomical transit instrument along the local meridian. The meridian is an imaginary line drawn across the sky that contains the point directly overhead and the north and south celestial poles. The eyepiece was marked with thin parallel lines that allowed the user to precisely target the stars as they passed through the field of view. As the star crossed the meridian, the user would carefully record the time using a clock and chronograph. After averaging multiple measurements, one could find the local time. Differences in longitude could be then found by comparing timings between different observing stations. This method was used to determine the exact longitude of the campus observatory in 1895.

BY BEN JACOBSON-BELL



ACROSS

1. Mötley ___

5. Bad things to tear, in brief

9. Vibe

10. Front of a ship

11. Something one might take a new car for

13. "I love," in Latin

14. Preceder of "Talk" or "x"

15. "___, something incredible is waiting to be known": Sharon Begley

18. Sound of understanding

19. Cochlea location

20. Hyperbolically big number

24. Greek god with a bow

25. Something to watch around one's parents, perhaps

26. Hard to find

27. Common Ithaca winter forecast

DOWN

1. Garfield, for one

2. Regret

3. Big Dipper location

4. Words on a cake in Wonderland

5. Mo. before May

6. Word often pluralized in error

7. "50 Ways to Leave Your ___" (Paul Simon song)

8. One from Stockholm, say

12. Wooden rod

15. Fencing weapon

16. Catherine of "Home Alone"

17. Puts a stop to

21. British "-ize"

22. Musician Yoko

23. Word before Jersey or York

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