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CORNELL ASTRONOMICAL SOCIETY NEWSLETTER

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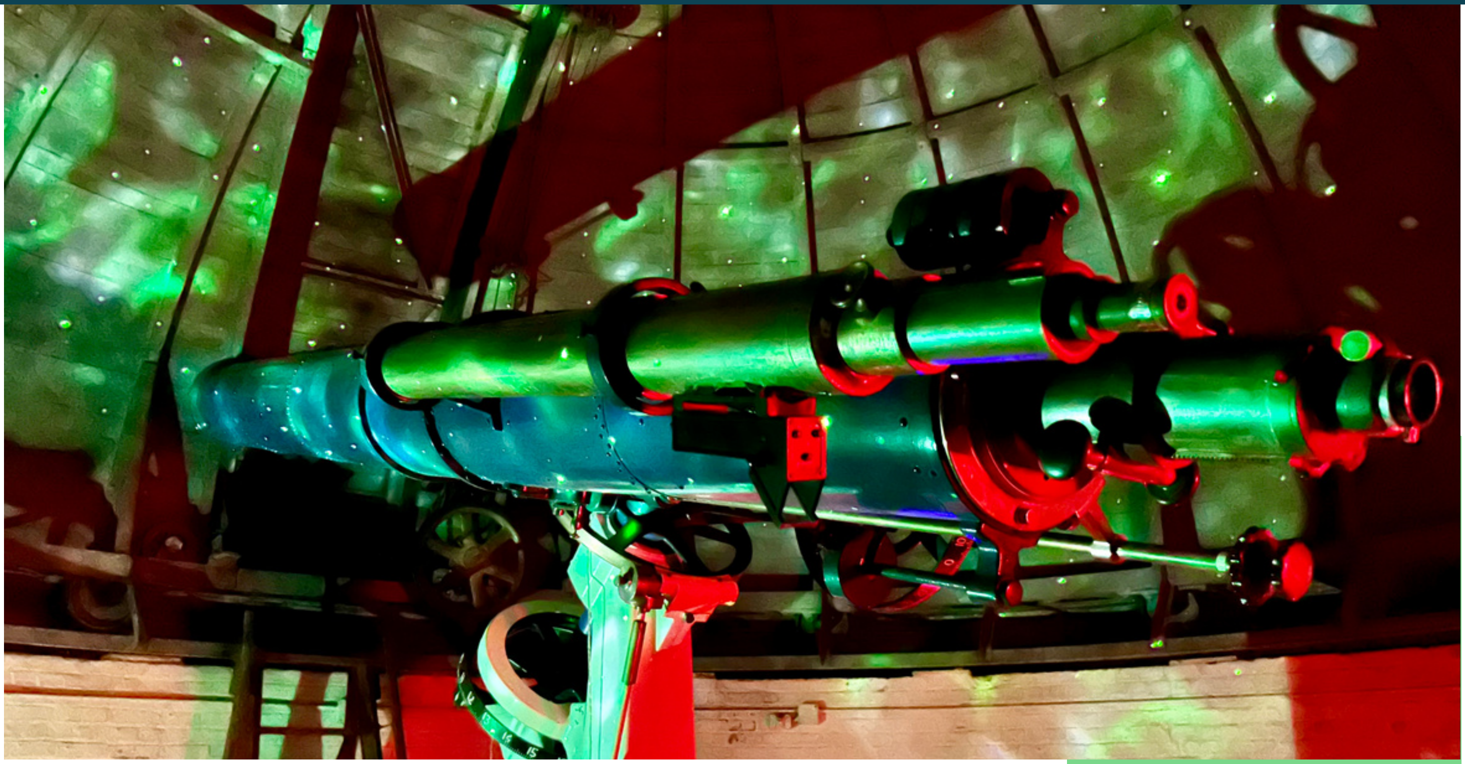

LETTER FROM THE EDITOR

Hello everyone and welcome to the final newsletter of 2023! The past semester was filled with exciting events, from the first of two solar eclipses this academic year to dressing as space-cowboys for Halloween. The sun puzzle was finally completed, and when the notorious Ithaca weather blocked our view of the sky, we brought the stars indoors by projecting them onto the dome. Finally, our lecture series reached its conclusion with a stellar talk on the life of Carl Sagan by our president Gillis (which you can read about on the next page)!

This semester was an exciting blend of CAS tradition and new ideas, none of which would have been possible without our dedicated members—both old and new—and our enthusiastic visitors. Thank you all for stopping by and making this year such a joy.

Happy holidays, and we hope to see you again next year!

Sincerely,
Abigail Bohl, Editor in Chief

TABLE OF CONTENTS

LECTURE RECAP:
CARL SAGAN’S BIRTHDAY

BY GILLIS LOWRY

On November 7th, I gave a lecture on Carl Sagan’s life and work, featuring apple pie, golden record stickers, and dozens of guests!

I discussed his early life, his scientific papers, and his status as a trailblazer for science communication. The recording of my talk is available here.

Unfortunately, the event was besieged with technical difficulties. There's more I wished to say in the talk, but my nerves and the disruptions got the better of me. I was upset at first, but I've made peace with the fact that I'm just starting out in all this, and it's a wonderful thing that there's always room for each of us to improve ourselves!

It reminds me of a quote from one of the biographies I read (*Carl Sagan: A Life* by Keay Davidson). Ann Druyan, Carl Sagan’s widow, got the sense that he "wanted to keep on growing for the rest of his life," learning new things and learning how best to treat people kindly.

It wasn’t me alone honoring Carl Sagan’s legacy. Among the attendees of my talk were Prof. Don Greenberg (a friend of Carl Sagan who still teaches computer graphics at Cornell) and a person who drove multiple hours to Ithaca just for this event. Later, when I gathered fellow members of the Cornell Astronomical Society to write a letter to place on Carl Sagan's grave, we left a pencil next to the paper—on the next day, November 9th, I returned to find that two visitors to his grave had added on. All these little instances continue to blow me away—so many people are passionate about Carl Sagan's legacy, and work so hard to take his words to heart.

For icons like Carl Sagan, it often feels as though our work and our writing will never do their legacy justice. I've tried to write about him so many times, exhausted every word I have, and still, it never feels enough. But even when our own writing seems to fail us, we add to the aggregate of all these little tributes, from talks to articles to letters to kindness. Each of us helps fill the space together. *The vastness is bearable only through love*, after all.

Thank you for helping fill that space with me, and for shaping a future he’d be proud to see.

Love from Gillis, CAS President

LECTURE RECAP: PROFESSOR ANNA HO

BY JACK QUALKENBUSH & NICHOLAS VASILESCU

Our fall 2023 lecture series has come to an end, with Professor Anna Ho and CAS President Gillis Lowry giving our final two lectures. If you missed either lecture, they can be found on our YouTube channel.

Professor Ho's lecture was an introduction to her research in time-domain astronomy, specifically supernovae and other high-energy transients. Her lecture served as a great introduction to the stellar life cycle, focusing on the stars whose deaths result in high-energy transients. Her lecture also touched on her current research on a unique high-energy transient nicknamed "The Tasmanian Devil." She recently published a paper about her research, which garnered national attention and was covered by the Cornell Chronicle and news agencies such as CNN and Nature. An overview of Professor Ho's research on "The Tasmanian Devil" and what makes it so unique is provided below.

PROFESSOR ANNA HO AIDS IN DISCOVERY OF RARE EXPLOSION DUBBED "THE TASMANIAN DEVIL"

A rare explosion of light, dubbed "The Tasmanian Devil", has confused astronomers as it continued to emit bright light months longer than similar events would. The "Tasmanian Devil" is an example of a luminous fast blue optical transient (LFBOT), an incredibly rare explosion event that is highly luminous (like gamma ray bursts), but rises and decays faster. Unlike gamma ray bursts or supernovae, other highly luminous explosions, LFBOTs have their light concentrated in the blue range, indicating they are much hotter and brighter. "The Tasmanian Devil", officially known as AT2022tsd, is only the sixth LFBOT ever detected. While typical LFBOTs can be only observed for a matter of days, AT2022tsd's sudden pulses in luminosity began on December 15, 2022, more than three months after the initial explosion occurred, and lasted for about four months.

These shocking findings were recently published on November 15, 2023 in a Nature paper titled *Minutes-duration optical flares with supernova luminosities*, led by Professor Ho.

Artist's concept of a LFBOT
Credit: NASA ,ESA, NSF's NOIRLab, Mark Garlick , Mahdi Zamani

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“We had never seen anything like that before—something so fast, and the brightness as strong as the original explosion months later—in any supernova or FBOT (fast blue optical transient),” she told CNN. Previously, astronomers theorized that LFBOT explosions are possibly failed supernovae that collapsed into black holes or neutron stars before they were able to explode.

However, AT2022tsd flares seem to arise from a relativistic jet, since they “are highly energetic and are probably not thermal.” A relativistic jet is created when a small fraction of particles are accelerated near the speed of light as a result of an enormous amount of energy. This differs from the behavior of other LFBOT transients. Professor Ho and her colleagues performed observations using different parts of the light spectrum and found that the X-ray luminosity for AT2022tsd is an order of magnitude greater than previous LFBOT transients.

Afterwards, Professor Ho and her team analyzed over 647 photos taken by the Zwicky Transient Facility before AT2022tsd was detected of possible galactic flares. Only one of these photos had a flux access that was over three, meaning three times the noise than typically expected was detected in that image. This seems expected as the team anticipated that there is a 60% chance that one would have a flux greater than three out of 647 photos according to statistical models they ran.

However, in the 65 photos taken by the California-based survey, three images had a flux greater than 3 W/m^2. The team determined this is significantly more rare as it determined the probability of finding three such cases out of the post-detection flux observations is 0.01%.

Given the incredibly rare nature of this occurrence, it is reasonable to believe these increases in flux are tied to the same transient event. In addition, the team was more confident that the flare data is relevant to the multi-wavelength data.

With this data, it seems possible that AT2022tsd could be a nova event less luminous than a supernova. In a classical nova, a white dwarf star draws matter from a companion star. However, AT2022tsd would be too close. Dwarf novae, similar to classical novae but dimmer, seem plausible, but the team could not find any existing examples similar to AT2022tsd.

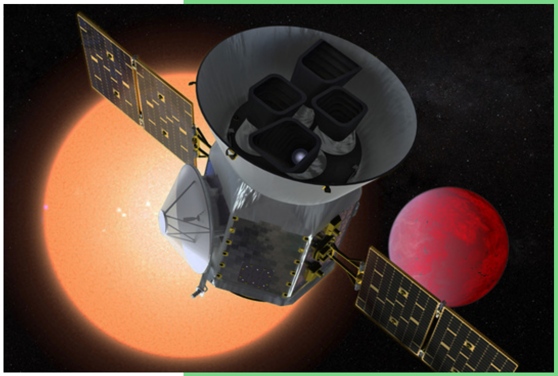
While the team acknowledged an intermediate-mass black hole as a possibility, considering how long the flares lasted, they ultimately considered the “simplest” explanation to be massive-star events. The flaring could be explained by highly energetic jets emitted from a black hole at the center of the LFBOT. The team recognized that flashes of light observed from AT2022tsd can be the result of these jets pointing directly at Earth as the object rotates. Given how quickly these flashes occur, at about every ten seconds, Professor Ho and her colleagues believe that they come from a stellar remnant, such as a neutron star or black hole.

“[AT2022tsd’s cause] settles years of debate about what powers this type of explosion, and reveals an unusually direct method of studying the activity of stellar corpses,” Professor Ho told CNN. By studying AT2022tsd and other LFBOTs, astronomers can better understand how stars behave after they die. Research into LFBOTs will be aided by the completion of the Vera C. Rubin Observatory, anticipated in early 2025, which Professor Ho believes might find “10 to 100 times more of these objects.”

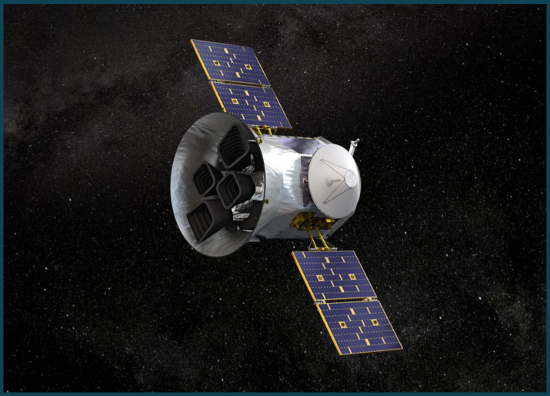
EXOPLANET SPOTLIGHT: TOI 700 E AND WOLF 1069 B

BY VALENE MCINERNEY

December is here, and life as we know it is wrapping up yet another orbit around the Sun. As we transition from the old year to the new, we tend to ponder our place in spacetime, and some of us wonder: *where is life going*? When we mull over questions like these, we sometimes look to Earthlings for answers. Other times, we look to the stars—and their planets.

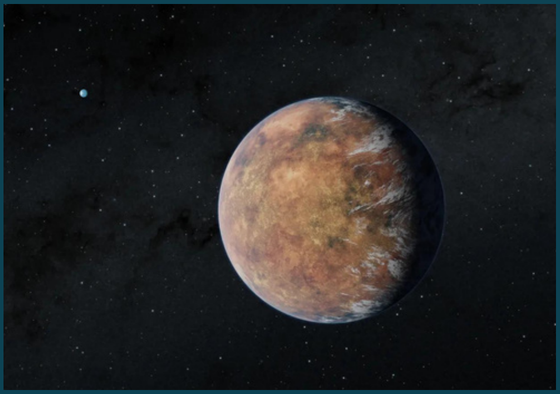


Artist's concept of TESS
Credit: NASA



Artist's concept of TESS
Credit: NASA

Since the first exoplanets were discovered in 1992, over 60 habitable exoplanets have been confirmed. In 2023, two more were added to the list. The first to be announced was TOI 700 e. Initially detected by the Transiting Exoplanet Survey Satellite (TESS) in 2021, TOI 700 e is a rocky planet, one of five orbiting TOI 700, a young red dwarf star. The exoplanet is similar in size to Earth and almost as massive, making it large enough to create a detectable dip in TOI 700's starlight when the exoplanet passes in front of TOI 700 as seen from Earth. These brief interruptions in starlight are called transits, and TESS uses them to detect exoplanets and determine their size.



Artist's concept of TOI 700 e. Its Earth-size sibling, TOI 700 d, can be seen in the distance.
Credit: NASA/JPL-Caltech/Robert Hurt

Aside from TOI 700 e's size, its close orbit also predisposes it to transit detection. The distance between TOI 700 e and its host star is only around 0.134 times the distance between the Earth and the Sun. If the Earth was that close to the Sun, our planet would be a wasteland, but TOI 700 e's star is much dimmer and smaller than our Sun. TOI 700 e can keep a relatively close orbit around the red dwarf and still be roughly habitable, capable of hosting liquid water, and by extension, life. An unavoidable symptom of TOI 700 e's short orbit, though, is a very short orbital period. On TOI 700 e, one year is just 27.8 Earth days. So if life has gained a footing on TOI 700 e, they'll be ringing in the New Year with us this Decem-ber—and every month thereafter.

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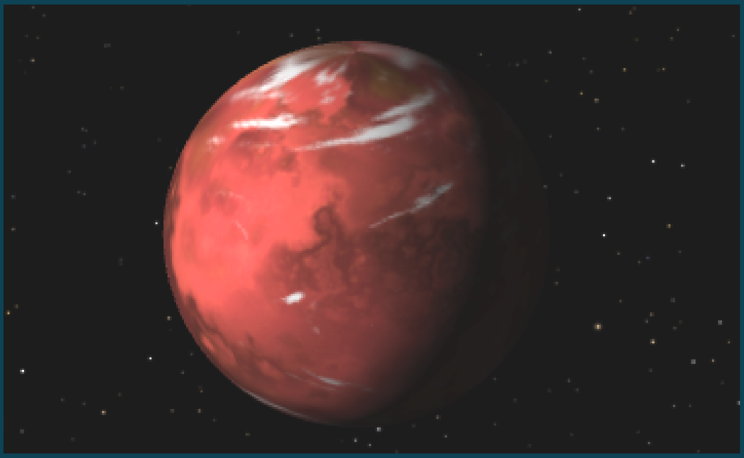
Of course, life may have a hard time finding that foothold. Even though TOI 700 is a cool red dwarf, TOI 700 e receives 1.2 times the radiation that Earth does. This may not seem like a lot, but planets orbiting red dwarfs need to receive less radiation than Earth to be considered habitable. Whether or not this amount of radiation would prove deadly to budding microbes depends on the exoplanet's atmosphere. If the exoplanet's atmosphere is rich in greenhouse gasses like carbon dioxide or methane, TOI 700 e's surface could get a bit too toasty for life. But with a more reflective atmosphere to deflect harmful radiation, TOI 700 e's surface could be more like Earth's. For this reason, astronomers have placed TOI 700 e firmly in the "optimistic" habitable zone, the region in which water could exist if the planet receives more radiation than Mars did 3.8 billion years ago and less radiation than Venus did 1 billion years ago. Little is known about TOI 700 e's atmosphere, but learning more will be possible with the James Webb Space Telescope (JWST).

Unfortunately, the same cannot be said for the second habitable exoplanet confirmed this year. Wolf 1069 b is another approximately Earth-sized terrestrial exoplanet with a mass 1.26 times the mass of Earth. Its orbit is also far tighter than Earth's, so it takes Wolf 1069 b only 15.6 Earth days to circle its star, Wolf 1069. Despite its close orbit, the recently uncovered exoplanet rarely transits and has only been detected through radial-velocity data from the CARMENES spectrograph, making it an unsuitable target for telescopes without a spectrograph such as JWST. CARMENES' radial-velocity data is obtained from the slight shifts in starlight that occur as a star's planets tug on the star and move it in small circles. Detecting these subtle wobbles in starlight enables us to determine the mass and orbital period of Wolf 1069 b.



Hypothetical visualization of Wolf 1069 b.
Credit: NASA

Wolf 1069 is another red dwarf star, which is part of the reason that Wolf 1069 b can orbit so closely and still be possibly habitable. The exoplanet receives only 65% of the radiation that Earth does, placing it firmly in the conservative habitable zone. The conservative habitable zone is narrower than the optimistic habitable zone, and planets within the conservative habitable zone are more likely to be capable of maintaining liquid water on their surface. Astronomers believe that Wolf 1069 b may also be Earth-like in its composition, which would imply that 32.5% of the exoplanet's mass is likely iron and 67.5% is likely silicates. Given the importance of silicon and silicates in geochemical cycling and soil formation, this bodes well for life on Wolf 1069 b.

Additionally, astronomers believe that Wolf 1069 is the only Earth-sized planet in its system, and that Wolf 1069 b could have experienced a large collision early in its history. Earth is thought to have experienced a similar collision when it was young, shaking loose molten pieces of Earth's surface to give rise to our Moon. While we cannot yet detect exomoons, it is possible that something similar happened to Wolf 1069 b, creating yet another potential similarity between our home and this distant world.

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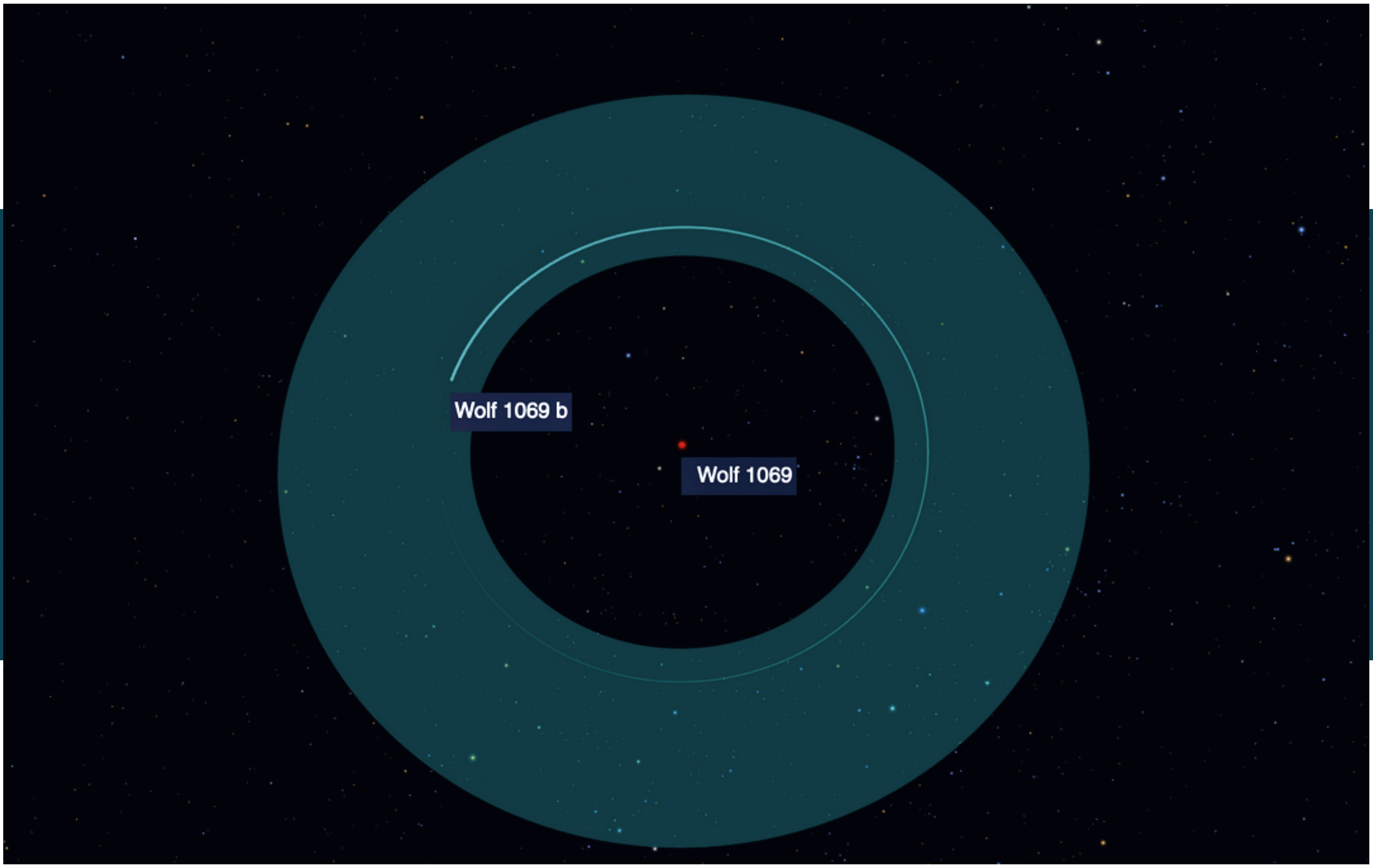
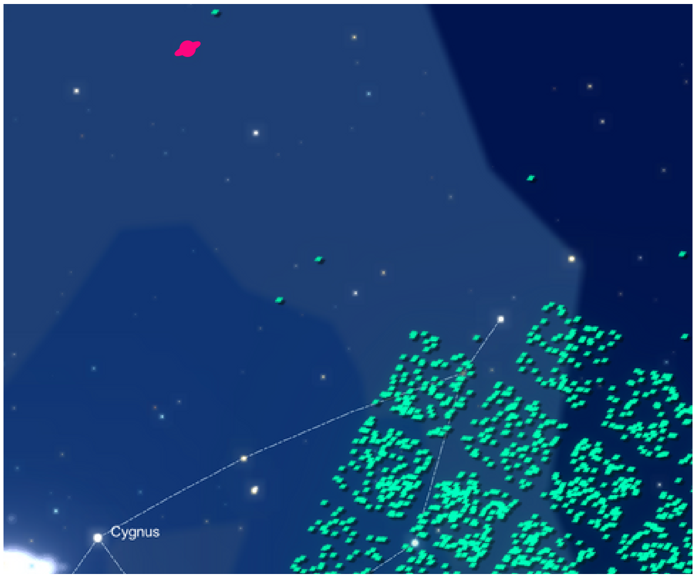


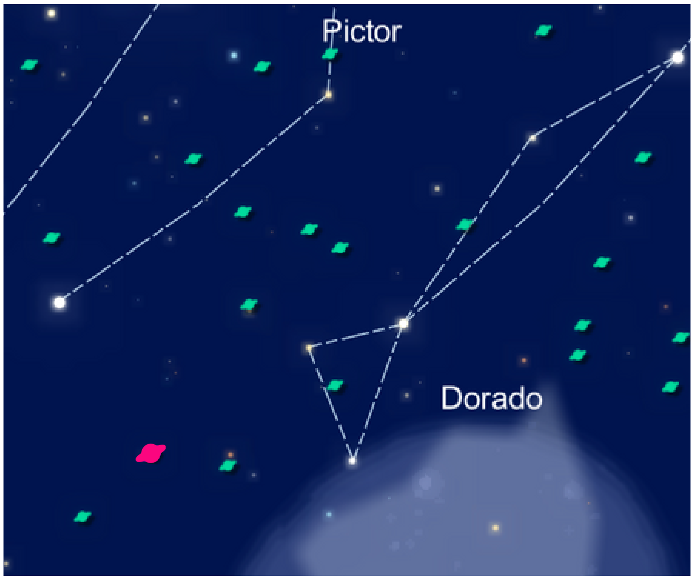
Wolf 1069 b orbiting in the habitable zone of its red dwarf star
Credit: NASA Exoplanet Archive

Despite all of these commonalities between Earth and Wolf 1069 b, the two are differentiated by a striking difference in their rotational speeds. As Earthlings, we are in tune with Earth's 24-hour rotation cycle and the way it turns our sky from day to night. Wolf 1069 b's rotation is much slower—so much so that the planet is considered "tidally locked," with one side suspended in constant daylight and the other cast into permanent night. Since living organisms rely on an external source of energy, life on Wolf 1069 b would likely be confined to the illuminated half of the planet where light energy abounds, unless the planet's shadowed half is hiding an alternative energy source. Either way, this idiosyncrasy in the exoplanet's rotation would lead life on Wolf 1069 b to look very different from life as we know it.

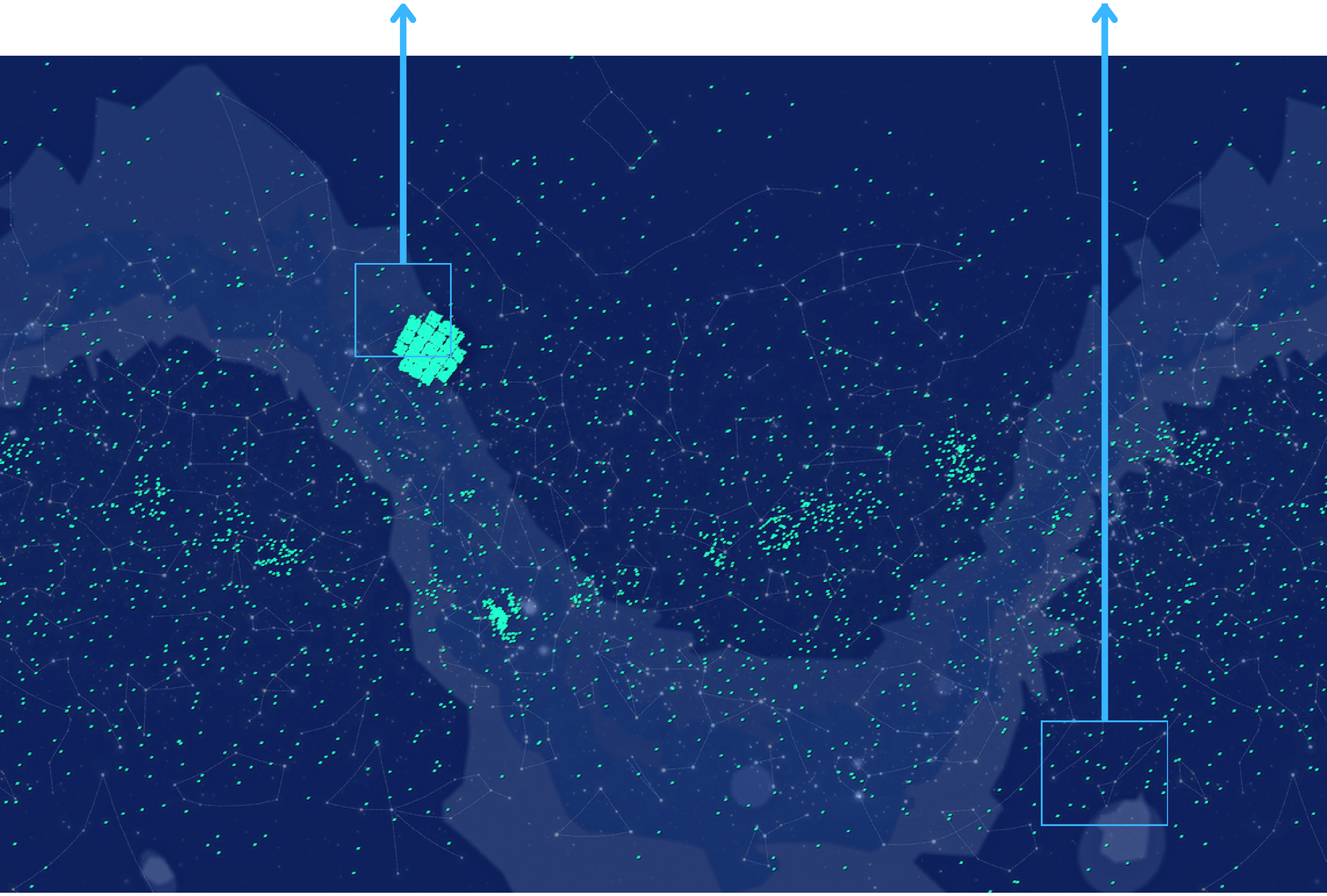
As we imagine these far-off worlds, it is easy to forget the distance that separates us. Wolf 1069 and its exoplanet lie in the Cygnus constellation, 31 lightyears away. TOI 700 e lies in the Dorado constellation, just over 101 lightyears away. We may never reach these planets or know the organisms who might call them home, but thanks to the Earthlings of 2023 and all the years that came before, we can look up, and we can wonder.



Potentially habitable exoplanet, Wolf 1069 b, in magenta



Potentially habitable exoplanet, TOI 700 e, in magenta



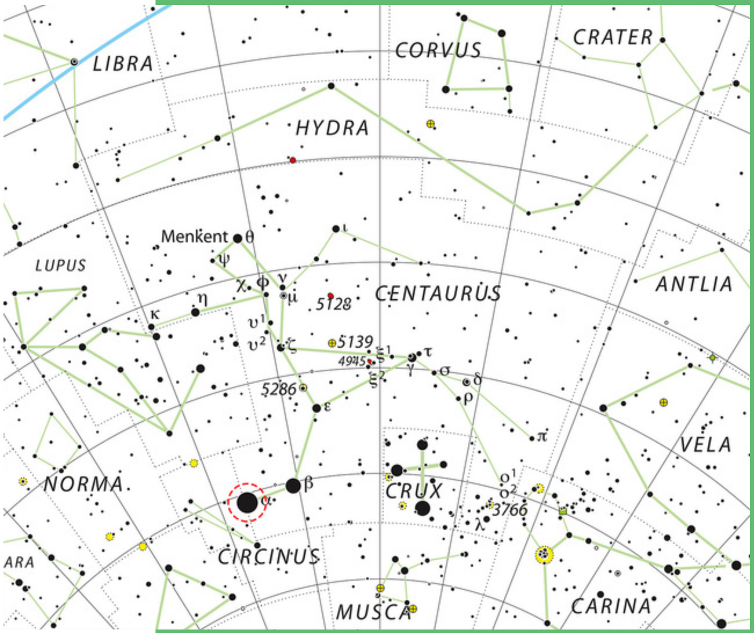
Over 5500 currently discovered exoplanets (as of November 2023) mapped as green dots across the night sky, with close-ups on Wolf 1069 and TOI 700 | Credit: Gillis Lowry

ALPHA CENTAURI

BY DYLAN JACKAWAY

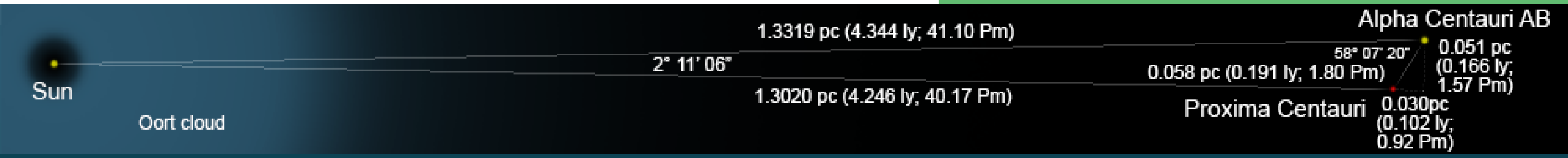
Alpha Centauri sits 4.34 lightyears away in the constellation Centaurus of the Southern hemisphere, visible to any observer below a latitude of 29°N. Let's take a look at our closest cosmic neighbors outside the Solar System.

Although it appears as a single point in the night sky, Alpha Centauri is actually composed of three [stars](#): two Sun-like stars and a red dwarf. The two Sun-like stars, Alpha Centauri A and B, circle one another in an elliptical orbit ranging from 11.2 to 35.6 astronomical units, or AU (where the distance between the Earth and the Sun is 1 AU). The red dwarf, Alpha Centauri C, circles this pair at a much further 8,700 AU or 0.138 lightyears, far enough that it would appear as a distinct point in the sky if it were bright enough. Because of this, Alpha Centauri C is currently the closest of the three to us at only 4.25 lightyears away, earning it the more frequently-used designation of Proxima Centauri.



Alpha Centauri's location in the night sky (circled in red)

Credit: [ESO/Digitized Sky Survey 2](#)



The main Alpha Centauri binary star system's location relative to us, with Proxima Centauri off to the side

Credit: [Chermundy](#)

No planets have been confirmed to orbit either Alpha Centauri A or B, but Proxima Centauri is known to have at least two planets. One of these planets, Proxima Centauri b, made headlines in 2016 when it was found to have a mass similar to that of Earth and orbit in the so-called "Goldilocks" or "habitable zone," where the temperature would be right for liquid water to exist on the surface. This offered scientists the tantalizing possibility of finding signs of extraterrestrial life only an astronomical stone's throw away from home—although there are a few factors that could limit the ability of Proxima Centauri b to host life.

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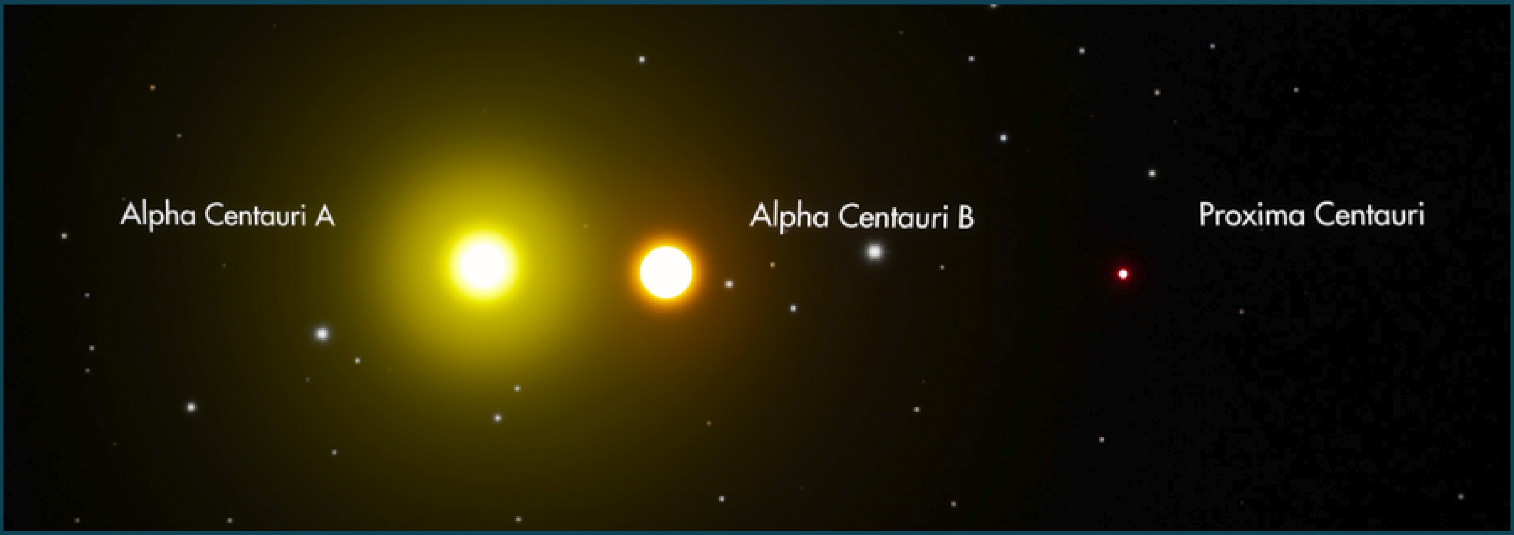

A diagram showing the sizes of the three stars in Alpha Centauri. Alpha Centauri A and B are also known as Rigil Kentaurus ("foot of the centaur" in Arabic) and Toliman ("ostrich") respectively
Credit: NASA

Among these are the fact that its tight orbit means it could be hit by intense solar storms that could wipe any atmosphere clean off its surface. In addition, it would be certain to be tidally locked, meaning that one side would be in perpetual daytime and one side in perpetual night (much as our Moon always shows the same face to the Earth), which could create some extreme climatic conditions. In addition, a second, much less massive rocky planet has been confirmed to lie inside Proxima Centauri b's orbit, while a third much more massive gas giant may orbit at around 1.5 AU.

In the coming years and decades, we will continue to learn more about this dynamic system, not just through far-away observations, but potentially through sending physical probes, described in a proposal known as the Breakthrough Starshot Initiative. This proposal, promoted by the late Stephen Hawking, would entail constructing a fleet of miniature spacecraft weighing as little as one gram each, equipped with light sails that would catch the energy from a ground-based laser array. These lasers could propel them up to 20% the speed of light, orders of magnitude faster than any other spacecraft to date. They would speed toward their destination over the course of 20 years and collect data and photos to be sent back to Earth, which would arrive after another four years due to the time delay in sending signals across such vast distances. Inspired by this proposal, Cornell's own Alpha CubeSat project in the College of Engineering aims to test similar light sail technology in space in the near future.

The search for extraterrestrial life continues. If you ever have a chance to stargaze from the Southern hemisphere, be sure to look for Alpha Centauri (or Proxima if you have a telescope), since who knows; someone may be looking back at you!

HOW-TO ASTROPHOTOGRAPHY

BY MARQUICE SANCHEZ-FLEMING

To witness the stunningly beautiful visuals of the universe through a telescope is indeed a magical experience, but sharing that view with other people who might not own a telescope is also a magical experience of its own. As the name “astrophotography” implies, simple photography of the night sky can achieve extraordinary images without high-end astronomical cameras. And while it is possible to use one's phone held up to the eyepiece of a telescope, and while those images can end up being incredible, if you have a camera, it is possible to do better.

It is often said that simpler is better, and in this case the Cornell Astronomical Society uses nothing more than a mirrorless camera, a Canon DSLR.

M42 / Orion Nebula (11/5/23)
1 x 3-second exposure (iPhone)
Credit: Marquice Sanchez-Fleming

With our DSLR and a suitable adapter to fit the camera body onto the telescope, we are ready to take our first deep-sky picture. Since we are shooting in manual mode, we must set our exposure time and ISO manually. Exposure time is simply how long we are telling the camera to collect light from our sample, which in this case is the Orion Nebula. ISO is a measure of how strong the signal of our image is: a lower ISO will result in a dimmer image, whereas a higher ISO will result in a brighter image. For deep-sky astrophotography (which is different from planetary astrophotography, for which we would need much shorter exposure times) we aim for 25-30 second exposures, and roughly between 1600 and 6400 ISO, depending on the light conditions of your environment and where you are shooting from.

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However, we are not done! In order to make our image the best we can, we must also take what we call calibration frames, which helps to increase the signal-to-noise ratio and increase the quality of our image. There are three main calibration frames that need to be taken after we finish collecting the RAW images: bias frames, dark frames, and flat frames.

For bias frames, put the cap on the camera, or the lens cap on the telescope, and set the exposure time to the shortest time possible and take somewhere between 50-100 frames. For dark frames, with the cap still on the camera, or lens cap on the telescope, set the exposure time to the same exposure time used to take the RAW photos earlier in the night. For flat frames, it is best to put a white t-shirt over the lens of the camera and point the camera at an even white color light source, such as a laptop screen or an early morning sky.

M42 / Orion Nebula (11/5/23)
1 x 30-second exposure (Raw)
Credit: Marquice Sanchez-Fleming

M42 / Orion Nebula (11/5/23)
42 x 30-second exposure
Credit: Marquice Sanchez-Fleming

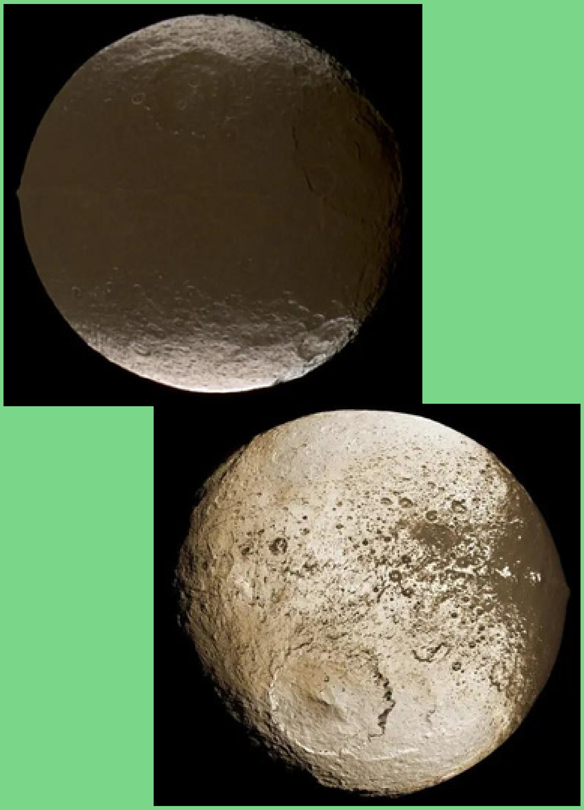
Finally, now that we have all of our image files, we can stack them with the help of software called Siril, or any other software that one feels comfortable using. The software process is mostly straightforward, but tutorials and guides exist online for those first starting out. After combining all of our files, stacking them, and touching them up in a graphics editor such as Adobe Photoshop (optional), we finally get our desired photo.

IAPETUS

BY JUSTINE SINGLETON

Picture this: You are pulling a sled up a steep hill. Trudging through the snow seems to take forever, but you know it'll all be worth it once you reach the top.

As you steadily make your way up the icy slope, you try to pretend you're on the side of Mount Everest. Or maybe somewhere even higher. Saturn's moon Iapetus (pronounced eye-APP-eh-tuss) has an equatorial ridge, a band of mountains at least 6 miles tall stretching across almost all of its circumference. The tallest mountains reach up to 12 miles. You imagine yourself on the ridge, the edges of your snowy hill fading into the distance. Iapetus only has about 2 percent of Earth's surface gravity, but this is your imagination. Bouncing to the top would be very convenient, though.



These two global images show the extreme brightness dichotomy on Iapetus
Credit: [NASA/JPL-Caltech/SSI]()

Craters and equatorial ridge on Iapetus
Credit: [NASA/JPL/Space Science Institute]()

The first thing you would notice is the craters across the mountainside. It is as cratered on the equatorial ridge as anywhere else on the Saturnian moon, since they are very close in age. How the ridge formed is still a mystery. Some think Iapetus used to have a ring and it collapsed. Others think the ridge is from a time when Iapetus used to rotate much faster. But so far, neither of these ideas completely explain the bulge at the moon's center. The fact that the equatorial ridge isn't entirely continuous makes things more confusing. On one quarter of Iapetus, the ridge breaks into individual mountains, such as the first ones discovered by the Voyager probes, now known as the Voyager Mountains.

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Climbing your own hill, you stop for a moment to catch your breath. You stretch your hands to keep the cold from numbing your fingertips. Iapetus doesn't have snow like Earth, but it is mostly made of ice. Unfortunately, this means it also has avalanches. Specifically, it has more landslides than anything in the Solar System other than Mars. And its icy composition only makes things worse. The friction of the landslide flash-heats the ice enough to partially melt it, making the deluge of rock and ice travel farther. On Earth, it's called a long runout landslide. You steady your feet on the inclined path, suddenly more aware of the wet slush beneath them.

Finally, you reach the top. You look down the other side of the hill and see a thick glossy layer of white snow untouched by footprints. On Iapetus, this view would look very different. Only one side of the Iapetian surface is white. The other side is a deep pristine black. Or maybe more of a reddish brown. Whatever its exact shade, the dark side of this moon is called Cassini Regio. This patch's formation is better understood than the equatorial ridge. It comes from dust particles shed by one of Saturn's other moons, Phoebe. When particles first landed on one side of Iapetus, it made that side warmer, which meant ice formed more readily on the side without particles. Ice that formed on the side with particles was more likely to sublimate and leave more particles behind. This became a self-sustaining cycle, where the lighter half became covered in ice and the darker half became covered in particles.

You turn around with your sled and look at the crisp, dark evening sky. It's a clear night. They always seem to happen on the coldest nights somehow. If you look carefully, you can see Saturn. Then you remember one more special thing about Iapetus. It orbits in a tilted plane, at a different angle from most of Saturn's other moons. With the naked eye on Iapetus, you would have a perfect view of Saturn's rings from the tilt.

The view might not be as picturesque from Earth, and your hill might not be as tall as the equatorial ridge, but both feel just right for the winter evening. You climb onto your sled and slide down.

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Gillis Lowry
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Nicholas Vasilescu

Sources for “Lecture Recap: Professor Anna Ho”

1 - 2 - 3

Sources for “Exoplanet Spotlight: TOI 700 e and Wolf 1069 b”

1 - 2

Sources for “Iapetus”

1 - 2 - 3 - 4 - 5 - 6

Image

The Cornell Astronomical Society (CAS) is a registered student non-profit organization founded in 1972 at Cornell University.

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