CORNELL ASTRONOMICAL SOCIETY NEWSLETTER

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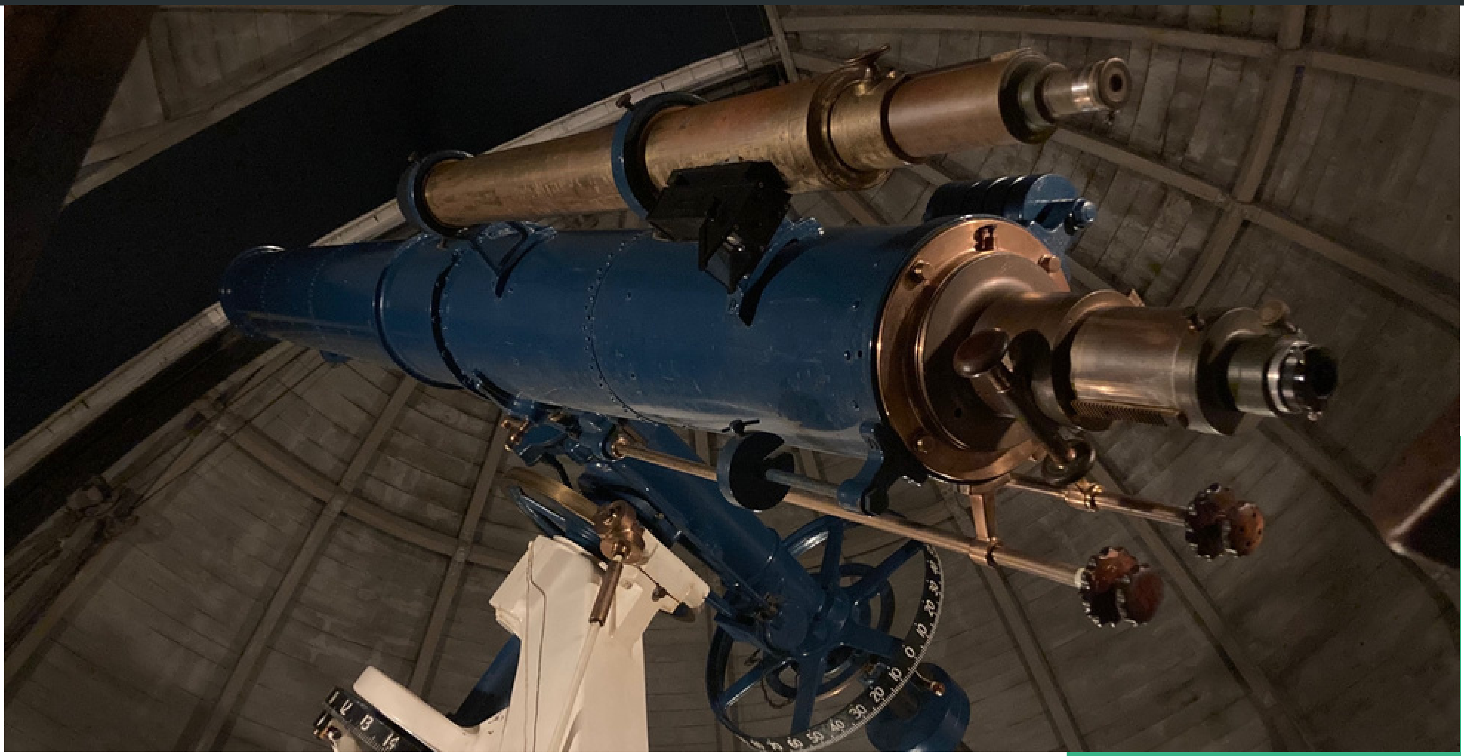

LETTER FROM THE EDITOR

Greetings astronomical enthusiasts and welcome to the March edition of the Cornell Astronomical Society newsletter! This month, we focus on our solar system, from a new discovery in the Kuiper Belt to the Green Comet that recently passed by Earth. Not only are these events and discoveries exciting, but they show us how much we have left to learn about universe around us. Thank you to the writers and crossword-creators that made this edition possible and happy reading!

In terms of CAS news, our Spring 2023 Lecture Series will commence this Friday, March 3, with a talk on antimatter by Professor Yuval Grossman. We will be hosting more lectures in the upcoming weeks as well, so keep an eye out for an email from our listserv with more details. We hope to see you there!

Sincerely,
Abigail Bohl, Editor in Chief

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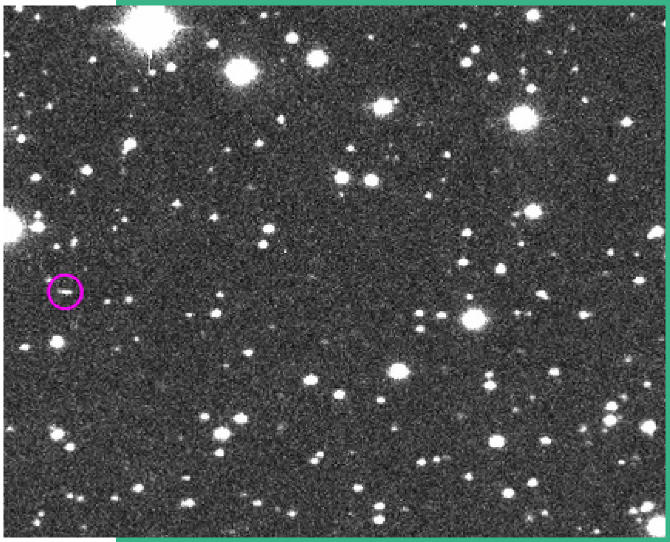
QUAOAR'S IMPOSSIBLE RING

BY ABIGAIL BOHL AND CLAIRE CAHILL

Quaoar, an icy dwarf planet even smaller than Pluto, has created a huge stir in the astronomical community: it has rings that should not exist, and astronomers do not know why. Observations of Quaoar have revealed that the dwarf planet's rings are too far away to maintain their structure without collapsing into a moon, and yet they have been observed multiple times between 2018 and 2021. We talked to Professor Philip Nicholson, a noted ring dynamicist, about what this discovery means.



Quaoar | Credit: NASA/JHUAPL/SwRI

Quaoar's ring was not observed directly, as it is too small to be seen through a telescope. Instead, it was discovered through a method called stellar occultation. When an object passes in front of a star, the object blocks some of the light that reaches Earth. By looking at dips in the apparent brightness of the star, astronomers can infer information about the object blocking the light.

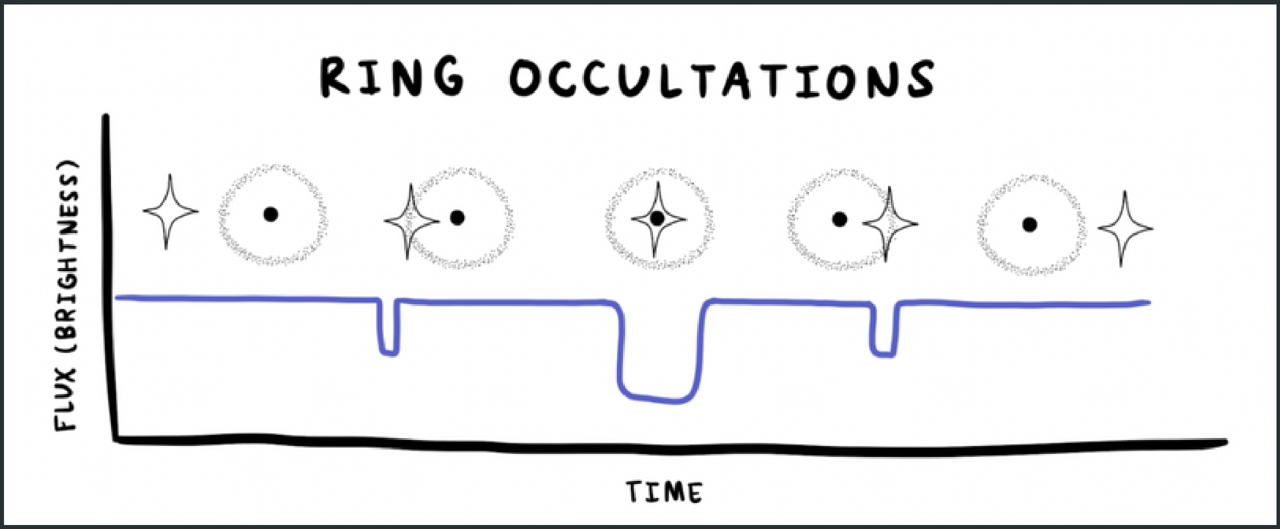


Diagram of stellar occultations. When the star passes behind an object with rings, one will see a small dip in the light curve on either side of the main body, as shown in the diagram.

Using this method, astronomers discovered that not only does Quaoar have a ring, but its ring is much farther away than was previously thought to be possible.

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The dividing line that determines whether debris around a planet will become a ring or a moon is called the Roche limit. If material comes closer to a planet than the Roche limit, it will be torn apart by tidal forces and form a ring. If material orbits at a distance farther than the Roche limit, it will eventually coalesce to form a moon.

Up until this point, the Roche limit has served as a good generalization for the behavior of moons and rings. The large planets in our solar system—Jupiter, Saturn, Uranus, and Neptune—have rings that tend to stay within the Roche limit. Similarly, Chariklo and Haumea, the two other known Kuiper Belt objects with rings, have theirs within or just outside of the Roche limit. On the other hand, Quaoar's calculated Roche limit is around 1,110 miles away, but its rings sit at a distance of 2,500 miles—over twice as far away as the Roche limit. In other words, its ring should be a moon. So, why isn't it?

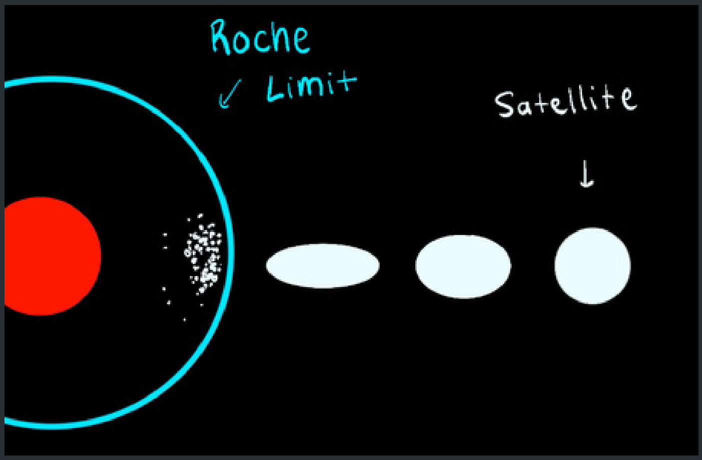

Diagram of the Roche limit. The Roche limit is shown as a teal blue line, with a red planet and white satellite. The closer the satellite is to the planet, the more it is stretched by tidal forces. When the satellite is within the Roche limit, the tidal forces are strong enough that the satellite is shredded into ring particles.

Professor Nicholson raises one theory as to why this seemingly impossible ring exists. Since the Quaoar ring is "dense," there are a significant number of collisions between ring particles as they move through their orbits. In a standard situation, the large distance between the ring system and the planet would mean that there are not enough tidal forces to break apart the ring particles and they should clump together until they form a satellite. However, Professor Nicholson suggests that if the ring particles have enough random velocity and the collisions are elastic (i.e. they conserve energy), the ring particles would just continually bounce off each other instead of sticking together to form a moon.

On this idea, Professor Nicholson says that "the Roche limit argument—the idea of tidal forces versus gravity—only works if the ring particles come together, if they have their collisions pretty gently so that gravity can tie them together." If small ring particles (around one meter across) are colliding continuously with too much energy to clump together, Quaoar's rings could still exist.

Lab tests simulating icy ring particle collision support this idea. The Quaoar research group performed multiple simulations involving the collisions of ice particles similar to those in Quaoar's rings. Ultimately, the simulations showed that with sufficient elasticity, dense, icy rings can exist at these farther distances.

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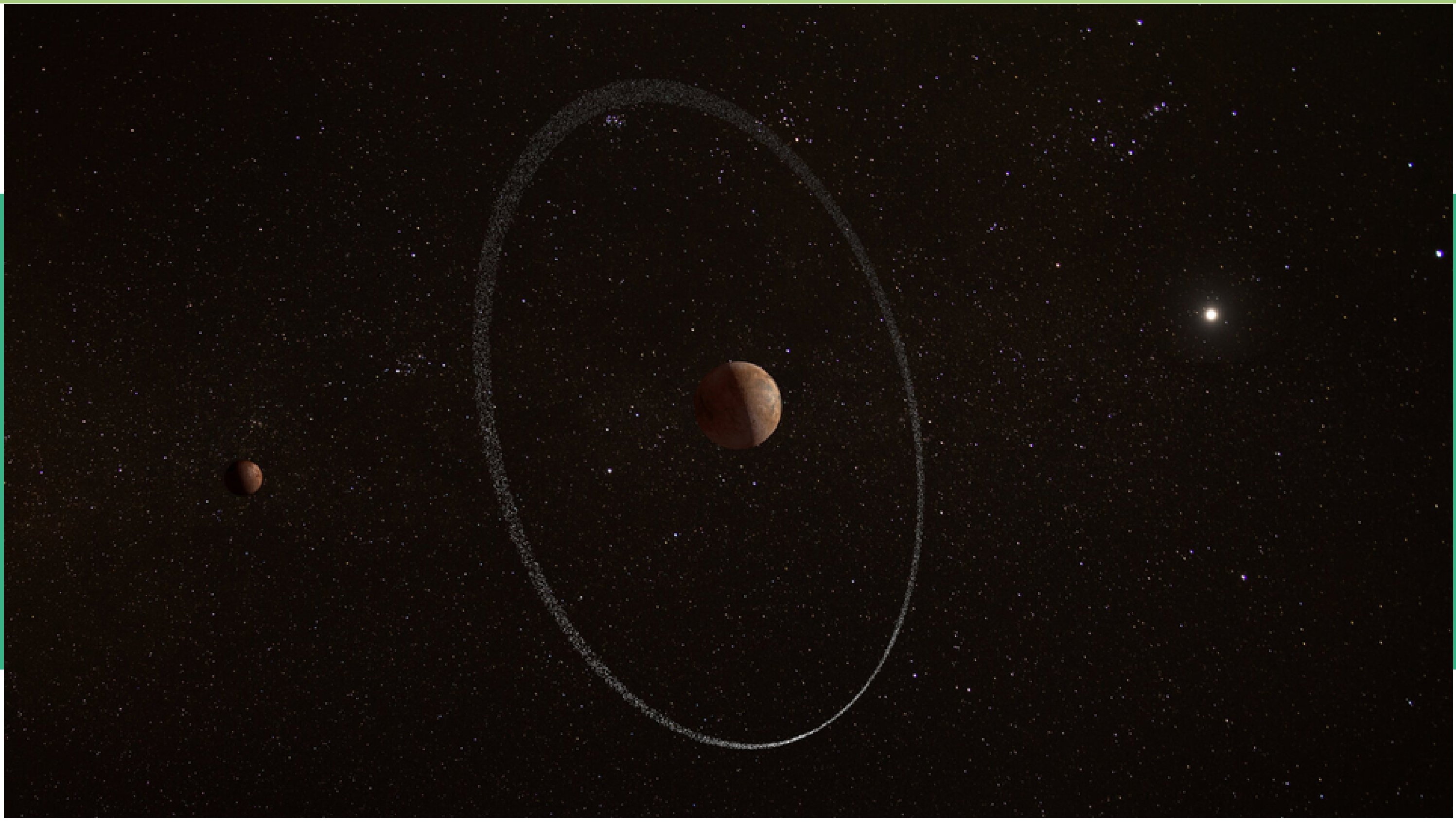


An artist illustration of the Quaoar system in front of a background of white stars
Credit: [ESA, CC BY-SA 3.0 IGO]

Professor Nicholson identified another theory, involving the potential relationship between the spin rate of Quaoar and the orbital period of its ring. There are two suggested rotational periods for Quaoar, one being 8.8 hours and the other being exactly twice that: 17.6 hours. If the 17.6-hour estimate is accurate, that would yield a 3:1 ratio between the spin rate of Quaoar and the rotational period of the rings. This integer relationship is called a resonance.

A 3:1 resonance is especially relevant because Chariklo and Haumea display the same ratio. Why the 3:1 ratio itself is so important is unclear, but the authors of the Quaoar paper have theorized that perhaps in cases with Kuiper Belt objects, the 3:1 resonance takes precedence and ring material accumulates at a distance, even if this places the ring outside the Roche limit.

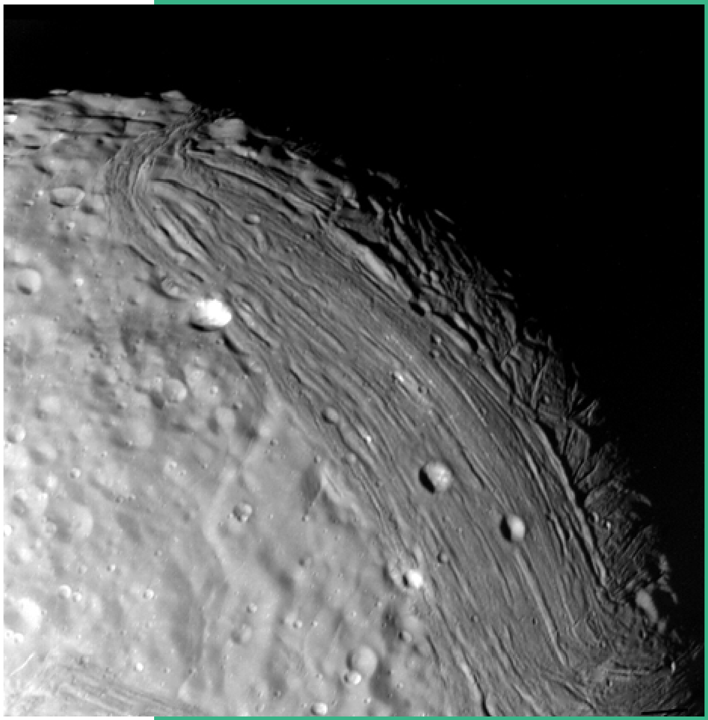
With lots of compelling theories out there, only further investigation of Quaoar and its ring will answer our questions for sure. Perhaps Quaoar is only the beginning, and even more strange ring systems are still waiting to be discovered.

MIRANDA

BY JUSTINE SINGLETON

Picture this: It's a mostly clear night, and you are out stargazing. Or moongazing, more aptly.

Last month, on February 16th, was the 75th anniversary of the discovery of Uranus' moon Miranda. Gerard Kuiper found it in 1948 using the 82-inch Otto Struve Telescope at the McDonald Observatory in Texas. 75 is called the diamond anniversary, you remember. Miranda doesn't have any diamonds as far as you know, but its host planet Uranus is thought to have diamond rain. You know that Uranus is hard to find, and seeing its faint moons will be even harder, but you have decided to try anyway. It would be fun, at least, even if you don't find Uranus or Miranda.



Voyager 2 image of Miranda | Credit: JPL

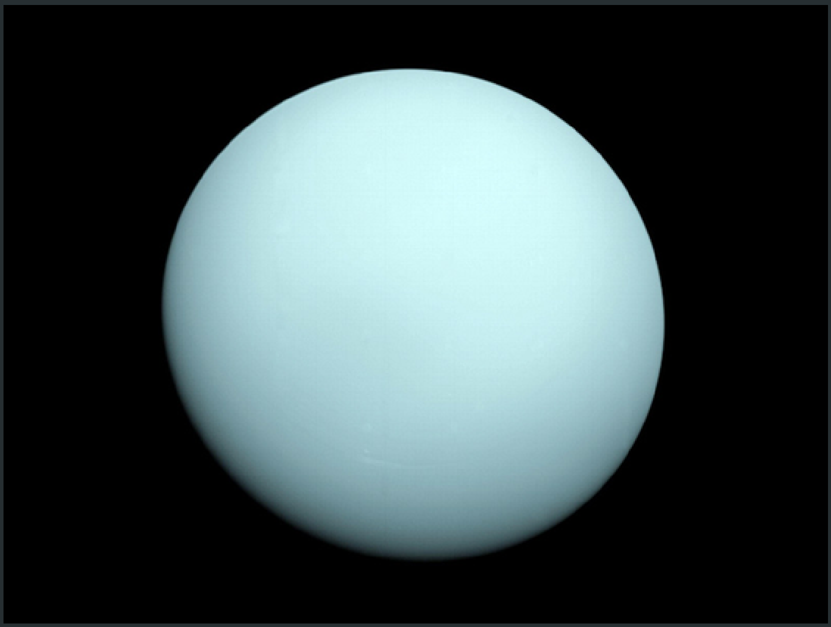


Image of Miranda's host planet, Uranus
Credit: NASA/JPL

You adjust your telescope and search the sky. What have we learned about Miranda in the past 75 years? For one thing, it's very weird. When Voyager 2 flew by the Uranian moon, its photographs showed mismatched terrain across the Mirandan surface. Some even call Miranda the "Frankenstein moon" because of this stitched-together appearance. Despite being one-seventh the size of Earth's moon, it has a wide range of features such as cliffs, ridges, and canyons.

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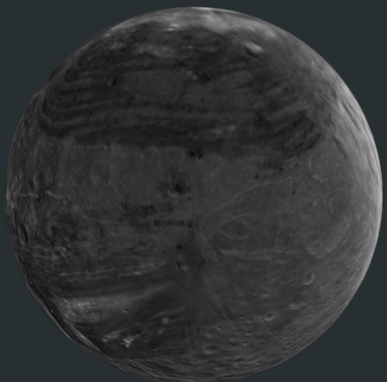
Miranda also has three distinct patches of ridges and valleys known as coronae. These sections of terrain, named Arden, Elsinore, and Inverness, stretch over 120 miles wide across the patchwork moon's southern hemisphere. Since Miranda's northern hemisphere has never been seen, it is possible that there are even more coronae on that side, but so far, only three are known.

You imagine yourself standing in the middle of a Mirandan corona. Depending on which one you stood in, you would be surrounded by an oval, trapezoidal, or rectangular shape. You would see clusters of ridges across the terrain, with the exact features varying between the three patches. Despite this, the coronae have fewer craters than the rest of Miranda's surface. Some scientists think the patches formed from newer crust of ice and rock rising to the surface, powered by tidal heating when Miranda orbited very close to Uranus. However, that still leaves the question of how they formed in their distinct shapes. Coronae are only known to exist on Miranda and Venus, so there is still much to learn about them.

You pull away from the eyepiece and make sure you are pointed at the right position. So much is happening on Miranda, yet from Earth its host planet is barely a speck in the sky, let alone the satellite itself. The Uranian moon's size also hides something extreme. It has the tallest cliff in the Solar System, Verona Rupes, which is ten times higher than the edge of the Grand Canyon. Due to Miranda's lower gravity, if you fell off the edge, it would take about 12 minutes to reach the bottom. Better pack a parachute.

It occurs to you that Miranda likely doesn't have an atmosphere. Without one, there wouldn't be any air to collect under a parachute and break your fall. However, Miranda does have one of the thickest surface layers of rock and dust, or regolith, in the Solar System. Would the regolith be enough to cushion your fall? Probably not. If you somehow did find yourself on Miranda's surface, it might be best to stay away from the cliffs entirely.

You try to search for Uranus again, but a familiar sheet of gray blocks your view. There is too much cloud cover. But you can always try again on another clear night. The faint glow of the largest Uranian moons will still be there. You begin packing up your things. 75 years of studying Miranda has brought so much more than just a bright speck in a telescope, and yet there is still so much to discover. You look at the sky one last time before heading inside. Who knows what we will learn by 2048, the centennial of Miranda's discovery? Maybe by then there will be new missions to explore the outer planets, their moons, and whatever brave new worlds lie beyond.

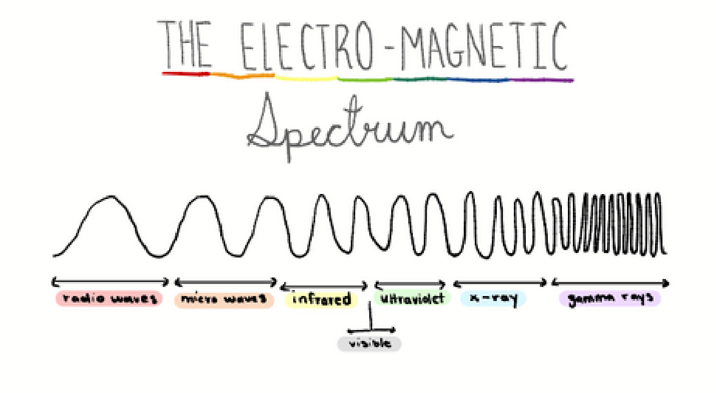


WHAT IS MULTIWAVELENGTH ASTRONOMY?

BY ABRA GEIGER

The key to astronomy is light. More scientifically known as electromagnetic radiation, it is the astronomer's tool to probe the universe. However, electromagnetic radiation is not limited to the range of light observable by the human eye. There is an abundance of electromagnetic radiation beyond the visible spectrum, and observing beyond the limits of the human eye is the foundation of modern astronomy.

When you think of astronomy, you may think of optical telescopes: telescopes that you can peer through with your naked eye. However, the light that humans can see only spans about 0.0035% of the electromagnetic spectrum. That means we're missing out on 99.9965% of the light from the universe! Thankfully, astronomical tools are not limited to the rainbow of light our human eyes see. By tapping into the wavelengths beyond, we can develop a deeper and more comprehensive understanding of how the universe works.



But what causes light to vary in frequency? Often temperature is the answer. Objects at very high temperatures tend to emit more high-energy, high-frequency radiation. Alternatively, objects at very cool temperatures tend to emit more low-energy, low-frequency radiation. Additionally, the relative motion of astronomical objects we observe can affect the frequency of the light we receive at Earth. This is called doppler shift, and it means that light emitted by objects moving away from Earth is shifted to lower energy (redshift) and light from objects moving towards Earth is shifted to higher energy (blueshift).

Some examples of varying wavelength applications are as follows: high-energy gamma rays can provide insight into the transfer of mass onto black holes that occurs at millions of degrees, the slightly less energetic ultraviolet spectrum can tell us about hot stars and the remnants of supernovae, and the infrared spectrum be used to observe redshifted galaxies and the expansion of the universe. Observation of the entire electromagnetic spectrum is invaluable for modern astronomers—it results in a more comprehensive understanding of astronomical objects and the universe as a whole.

THE GREEN COMET

BY DARIA KUZOVKOVA

In early February, a dim green dot could be seen by the naked eyes of viewers in the Northern Hemisphere. Nicknamed “the Green Comet” is a long-period comet that passed Earth on February 1, 2023. The comet’s astronomical name of C/2022 E3 (ZTF) is relatively easy to decipher: C means that its orbital period is longer than 200 years, 2022 stands for the year the comet was located in the sky, E3 clarifies that it was discovered in early March, and ZTF stands for the Palomar observatory’s Zwicky Transient Facility, which first discovered the comet in March 2022. With a period of 50,000 years, the comet originated in a collection of icy bodies on the very edge of the Solar System called the Oort Cloud. Scientists believe that most long-period comets originate in this cloud, even though no objects have been directly observed inside it yet.

Image of Comet C/2022 E3 (ZTF)s
Credit: NASA/ Dan Bartlett

The Green Comet is 1 to 10 km long, made of mostly ice and dust. The comet is moving through space at around 128,500 mph, but it is set apart from others by the green glow around its nucleus. Sunlight shining on the comet interacts with diatomic carbon molecules in the comet’s atmosphere, breaking them up into carbon atoms responsible for the green glow of the comet. On top of its color, the last time the comet passed by Earth was in the Upper Paleolithic period, also known as the Stone Age! As Rivka Galchen puts it in The New Yorker, “there were rhinoceros-size wombats living in Australia, along with some ginormous kangaroos,” making the comet's appearance even more exciting.

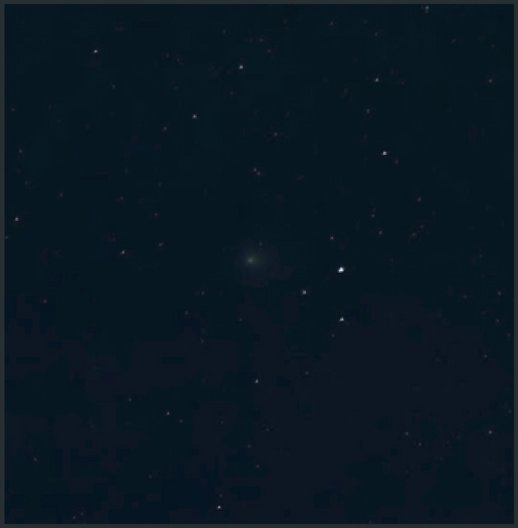
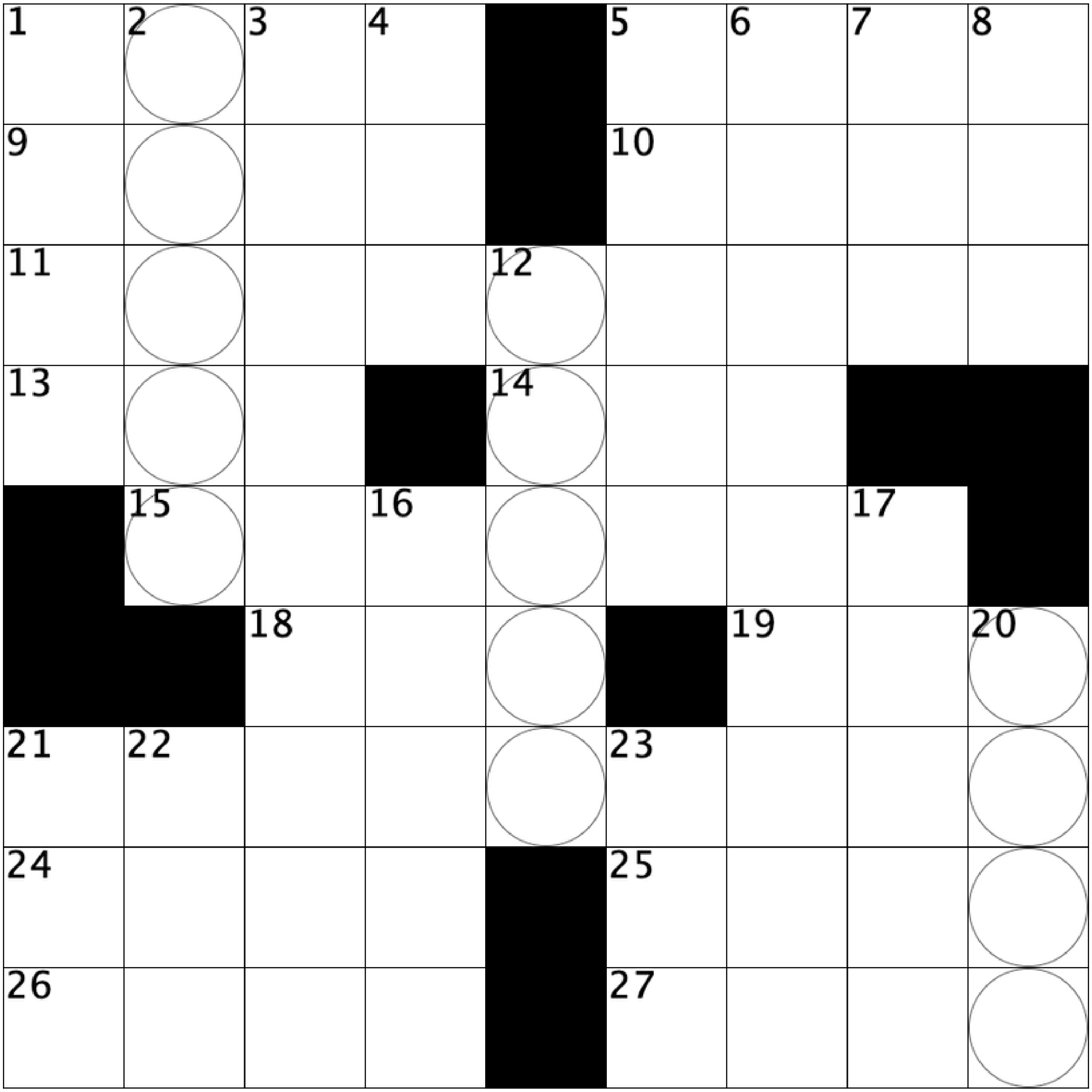


Image of Comet C/2022 E3 (ZTF)s
Credit: Kendrick Nakamura, taken from Fuertes

The Cornell Astronomical Society held two open houses to show the comet to Cornell students, faculty, and the general public. Despite the freezing weather, the event was well-attended, and the club members were able to locate the comet while facing significant difficulties caused by the crowd, air moisture, and the comet’s location close to the horizon.

BY BEN JACOBSON-BELL



ACROSS

1. Cable divider?
5. Got an "A" on
9. Nevada city
10. One in a chess player's octet
11. Around, say
13. Opposite of "non"
14. Exist
15. Launched
18. Bad thing to be stuck in
19. Sleep phase: Abbr.
21. Gist, say
24. High-toned
25. Last name in "The Incredibles"
26. Suffrage activist Lucretia
27. Votes in favor

DOWN

1. One shy of a quartet
2. World that's just a little too close ...
3. Like some breakups?
4. Homer Simpson's catchphrase
5. Separate
6. Time to think about the future?
7. Mother of a lamb
8. Molecules made up of "A," "C," "G," and "T"
12. World that's just right!
16. It's not nothing
17. Tractor maker John
20. World that's just a little too far ...
21. Units for a record player or engine: Abbr.
22. Winning tic-tac-toe line
23. Whence ə: Abbr.

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Cornell Astronomical Society (CAS) is a student-run non-profit organization founded in 1972.

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