

CORNELL ASTRONOMICAL SOCIETY NEWSLETTER

ISSUE 6 • NOVEMBER 2022



LETTER FROM THE VICE PRESIDENT

Greetings, readers! Welcome to our November newsletter. Inside, you will find wonderful articles ranging from stellar nuclear physics to a touching tribute to Carl Sagan for his upcoming birthday!

The Astronomical Society has had a packed month, running some great events. The centennial celebration for our telescope, Irv, went wonderfully (happy birthday!) and had a huge turnout, along with Cornell's "Family Weekend" the week after. And to finish off the month, we had a spoooooky pirate-themed Halloween open house. Keep an eye on our listserv for future events and lectures—we have a big month ahead of us!

Thanks so much for reading, and we hope to see you soon!

Sincerely,
Anthony Fine
Vice President (and First Mate), Cornell Astronomical Society

TABLE OF CONTENTS

Upcoming Carl Sagan Birthday • 2

Letter to Carl Sagan • 3

Photography by Club Members & Sudoku • 8

Dark Matter and Dark Energy • 10

Why Do Stars Shine? • 13

Umbriel • 14

Review of Telescope 100th Anniversary • 16

Crossword • 17

Credits • 18

UPCOMING: HONORING CARL SAGAN'S 88TH BIRTHDAY

Carl Sagan's birthday is November 9, just a few days from now! On Friday, November 11, be sure to catch the festivities in and around Fuertes Observatory!

7:30 PM in Appel Multipurpose Room 303:
"Alien Earths" with Carl Sagan Institute Director Lisa Kaltenegger

Professor Kaltenegger follows in Sagan's footsteps to search for life in the universe. She'll talk about exoplanets beyond our solar system that might resemble Earth! Apple pie will be served.

[Zoom](#) is available, but if attending in person, [REGISTER HERE](#).

9:00 PM in the Fuertes Observatory Classroom:
Outreach Coordinator Gillis Lowry will lead a discussion of Sagan's life and work, his lesser-known contributions to astronomy, and some fun facts!

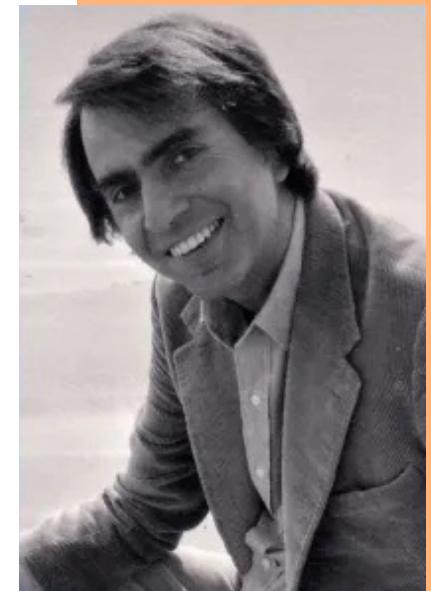
9:45 PM to midnight in the Fuertes Observatory Classroom:
Showings of Carl Sagan's 1980 television show *Cosmos*.

Open house and observing will take place as usual in the rest of the building!

Saturday, November 12, 12:30 – 2:00 PM:
Carl Sagan Planet Walk 25th Anniversary

Meet at the Sun in the center of Ithaca Commons. In collaboration with the Sciencenter, CAS members will be leading a guided tour of the Carl Sagan Planet Walk in downtown Ithaca! We'll conclude our walk at the Sciencenter, where there's even more space programming!

We hope to see you there!



*From the cover of
Conversations with
Carl Sagan, edited by
Tom Head*

"If you wish to make an apple pie from scratch, you must first invent the universe."

—Carl Sagan

An update on an essay from 2019, by Gillis Lowry.

TO CARL SAGAN—

On your sixty-seventh birthday, I was born into a world you've never known.

I first heard your name when I was eight. I'd searched the date on *famousbirthdays.com*, and you'd appeared in the thirty-first spot—honestly, much lower on the list than you should've been. For the rest of my time in elementary school, filling up six notebooks of stories a year and hiding under the covers with glow-in-the-dark space books, I took pride in the fact I had anything in common with you. When grown-ups asked, I told them I wanted to be an astrophysicist and an author.

I first watched *Cosmos* when I was barely thirteen. I'd started writing a novel two months before, and around the same time, I lay awake on Christmas Eve not from excitement, but from fear that everything, all of me, would one day cease to exist. I watched *Cosmos* as an anxious teenager, bitter with the hurt on television news and the limits on our lives. But you said that we were made of stars; when we spoke, we spoke for the universe; that cognizance can come from chaos and humans might not blow themselves up after all. Through the course of long nights and four years, I wrote about a kid who learned these truths. She was barely thirteen. She would never grow old.

And then it was nearing your eighty-fourth birthday. I'd read five of your books, and I owned many more, my searched-for first editions, but I knew once I read them it would all be over; I'd never turn a new page at night under my covers. I was still deeply saddened by the end of all things. I was afraid to finish my novel. I'd written the last chapter, but I could find no relief, constantly revising the remnants of the writer I'd aged beyond. Those four years would feel a waste if I didn't publish young. Friends gave positive reviews, as did grandmothers, and I felt emboldened enough to seek an editor.

A good first novel, she said, but not commercially viable.

In hindsight, I'd been afraid to move on.

Twenty-two years after you died, and one month after I buried my novel, I made a sad sort of pilgrimage to Ithaca. Maybe it was strange that I cried at the grave of a man I never knew; maybe it was justified when everything felt like an end, when you were gone so long before you reached this future full of new frontiers; the only world I'd ever known. But somehow, even if you weren't around to see them, you'd changed worlds you couldn't have imagined.

I sat on the path beside the grass. I gazed at the gravestone, its trinkets and tributes, and realized that even in death, our cycles live on. We are stars, and may return to stars—but we are more than our chemical fuel. We are books that rewrite and reform. We are stories that sometimes aren't ready to be told. But as old works live to inspire new, our thoughts and dreams pass down through the ages. We are cycles of mass and energy, but also of kindness and knowledge and hope.

And sitting on the path beside your grave, I realized those four years had been practice so that someday, I might change the world of another kid with a book under the covers at night. And then all the ends—and all the new beginnings—didn't seem quite so bad.

This week will be your eighty-eighth birthday.

Even in the four years that have passed since I left a letter on your grave, I've grown so much. The world has grown, too, for better or worse—JWST is finally sending its stunning images back to Earth, and we've found over five thousand exoplanets. But we are clawing our way through a pandemic of sickness and pseudoscience, wishing CEOs would have the sense to stop smothering us in blanket after blanket of pumped CO₂, hoping to visit landmarks by the coast even once before they sink into a silent, dying ocean.

There have been yet new fears, new demons, since you died. We are still afraid of the dark. I can't help but wish you were here to hold a candle to the truth.

Soon after I wrote the first half of this piece, just months before the pandemic hit, I stumbled across the letter I'd left you, the letter in which I'd written that surely, a paper as flimsy as this would be swept away in the coming days. Some person might read it, but it wouldn't be you—and it wouldn't be many.

But I was proven wrong. My message had mattered enough to someone that they'd taken a picture and posted it online. What I thought was ephemeral had been captured in photo—and tens of people had responded.

They saw it—

Leto_ · 4 yr. ago

Gillis, it mattered that you wrote this -thank you

Danaynuh OP · 4 yr. ago

I'm so glad to share! It was honestly a surreal experience reading this and seeing his grave and all of the mementos left behind. I felt connected to something much bigger than myself, to everyone who felt connected to him and his ideas. And I guess that was his goal

↑ 1 ↓ Reply Give Award Share Report Save Follow

70M70M · 4 yr. ago

This is incredible.

herecomesthesun83 · 4 yr. ago

This is awesome.

↑ 6 ↓ Reply Give Award

WorldlyWiseWeary · 4 yr. ago

This is wonderful - and thank you so much for posting it. If I'm interpreting the opening sentence correctly, and this was recently placed on Carl's grave, then the writer is 17 years old. I was 15 years old when the original Cosmos series aired, and I was, like so many, completely blown away by it. "Transformative" is the perhaps the best word to use. It caught me at the exact time when I would have to start making life decisions, and his show absolutely shaped what I did and who I am. I still watch the series about once a year, I still get a tingle down my spine at the opening theme from Vangelis, and I still quote scenes from that show frequently. And now awesome to see that Carl is still having that effect on a teenager.

Thanks again.

somewhatcaffeinated · 4 yr. ago

Thank you, Danayuh, so much for sharing this letter. And thank you Gillis, whomever you are, for sharing your thoughts. Carl's words have truly been inspirational and life changing.

They saw me.

I think all I ever wanted was to be a messenger like you. It was never enough just to know things for myself. I wanted to uncover the secrets of the natural world, but also make them not so secret anymore. I wanted to speak for the universe. I wanted to brave the dark and blink out my message to a sea of empty space. I could only hope someone would hear me on the other side.

Those forty people taught me there's always someone who listens.

I've visited the grave a few times each semester I've been at Cornell. Sometimes I've left a message or two. Though I have to admit they've never been as good as the first:

My favorite quote of your writing comes from Contact. “For small creatures such as we,” you wrote, “the vastness is bearable only through love”—but I have come to believe that the vastness is not only bearable, but filled. For as long as humans send their hearts into the dark we will live on in that empty space—for that long and ever longer—we make moments last until the end of time. Quite possibly, you’ve filled the space with more hope and awe than most who have ever lived. But speaking only on my own behalf, you’ve bestowed enough wonder to convince me, even during the worst of nights, that life truly matters on a cosmic scale. That even my own life will matter, however brief. That we speak for the universe—and is there not no greater cause?

It was nearing your eighty-sixth birthday, the pandemic in full swing, when I ended up at the grave again. Forty people had heard my message, but now I was alone once more, at a new school in a still-new pandemic. Sometimes five days would pass and I wouldn’t have a single conversation outside the stoic faces on my screen. The weather didn’t help matters.

It was cloudy that day at the grave. I sat on the grass. I gazed at the gravestone, its trinkets and tributes.

I didn’t realize it then, but I’d already met some of my best friends in the entire world.

Still, the fact remains that you lived, that you died, that your words touched so many minds; that Voyager, too, speeds on, though the twins will soon cease to speak; that the golden record still shines; that humanity has not, of yet, destroyed itself; that you are buried here in Ithaca and I have left you a letter you will never read. That I feel a bit silly for writing it, too, but that maybe it’s not a bad thing, to be so moved as to talk to the dead—to be human.

The clouds were starting to part. I was trying to steady my breathing. I was trying to assure myself that someday it would all be okay. There was a lawn mower in the distance, birds and bright blue flowers. It was beautiful.

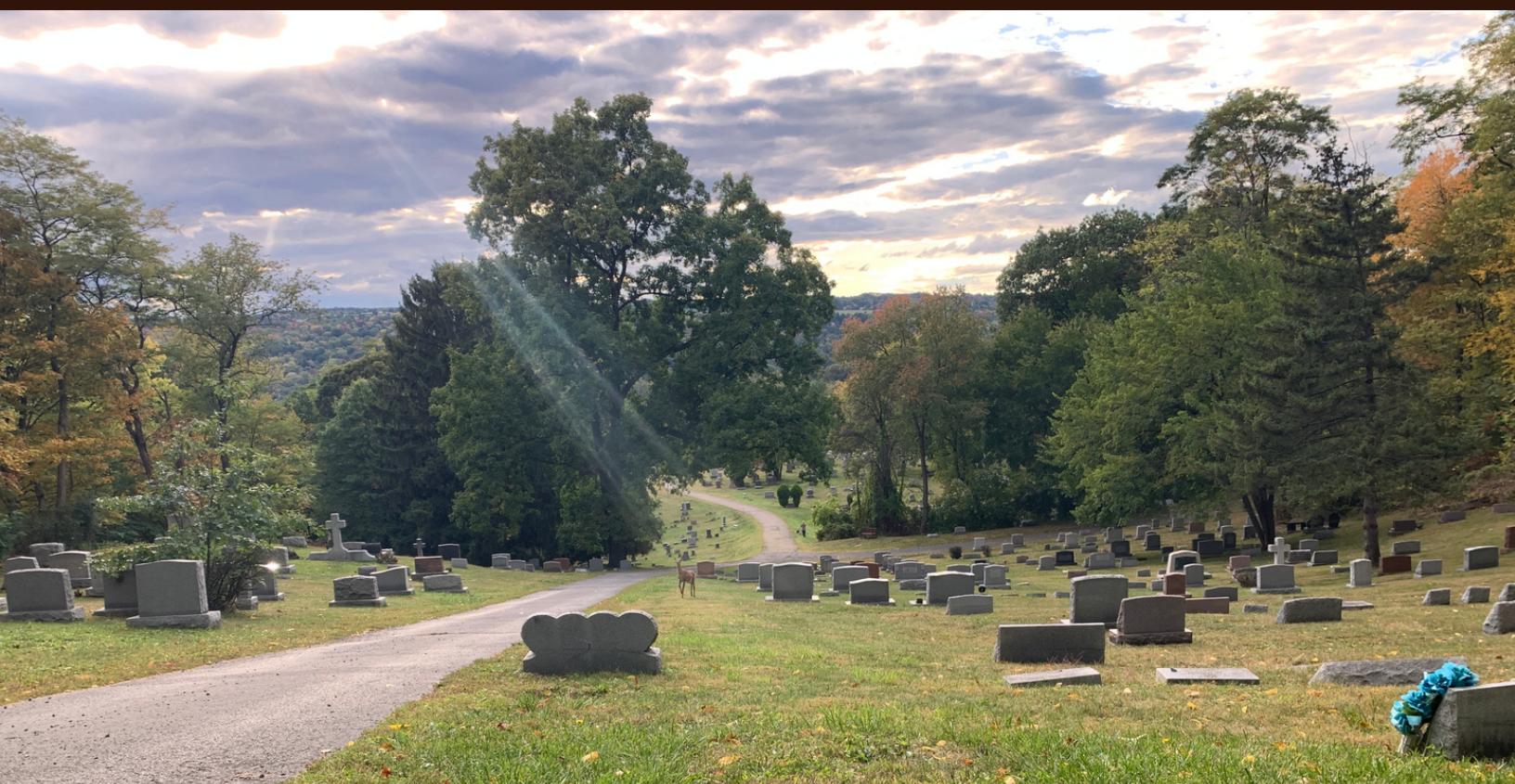
I pulled out my phone to take a shaky picture of the sky.

In a billion years, maybe, all will be forgotten. But in this moment I live. I exist. So do you, in some time or another, and even when the Voyagers return to stardust the facts will all remain. You lived. You live, in moments that last for all of time. You're filling the space between the stars.

The clouds were parting. Down the hill from your grave was a single deer, standing in a ray of sun.

*And in the end, what I've wanted to say most of all
is thank you for that.*

We were suspended in a sunbeam.



ASTROPHOTOGRAPHY BY CLUB MEMBERS

RING NEBULA BY GREG POWERS



The Ring Nebula is a planetary nebula in the constellation Lyra.

Long-exposure photography is a powerful tool. With the naked eye, no colors can be discerned; the nebula looks like a faint gray ring. However, with exposures of 30 seconds or more, colors and more features pop out. This image is the average of 11 photos.



JUPITER BY GREG POWERS

On September 26, Jupiter was closer to Earth than it had been in 59 years. This brought about exceptional conditions for viewing and photographing Jupiter. This image was taken on September 22, capturing the transit of Jupiter's largest moon, Ganymede. The black dot is Ganymede's shadow. This image was made by aligning and averaging the best 35 of 100 individual photos of Jupiter taken in quick succession in order to improve the signal-to-noise ratio.

(continued on next page)

THE MOON BY CLAIRE CAHILL

This is a photo of Gassendi crater, an impact crater thought to have been flooded with lava during the creation of the mare it sits on the edge of. It was taken in Andover, Massachusetts in June using an 8" reflecting telescope and an iPhone.

This picture features the Moon's terminator: the area between where the Sun is shining on the Moon's surface and where it isn't. Long shadows in this location tend to exaggerate crater details.



Out of This World Sudoku

BY SHAUNJAE SUAREZ

		9		5		6		
6					4			
								7
	2		5					
					7			9
		7					2	
				1		4		
8							3	
	4		6					

DARK MATTER AND DARK ENERGY

BY DYLAN JACKAWAY

The spooky season on Earth may come and go, but in the spaces between stars and galaxies, there are shadowy, mysterious forces that make their presence felt all year round—dark matter and dark energy.

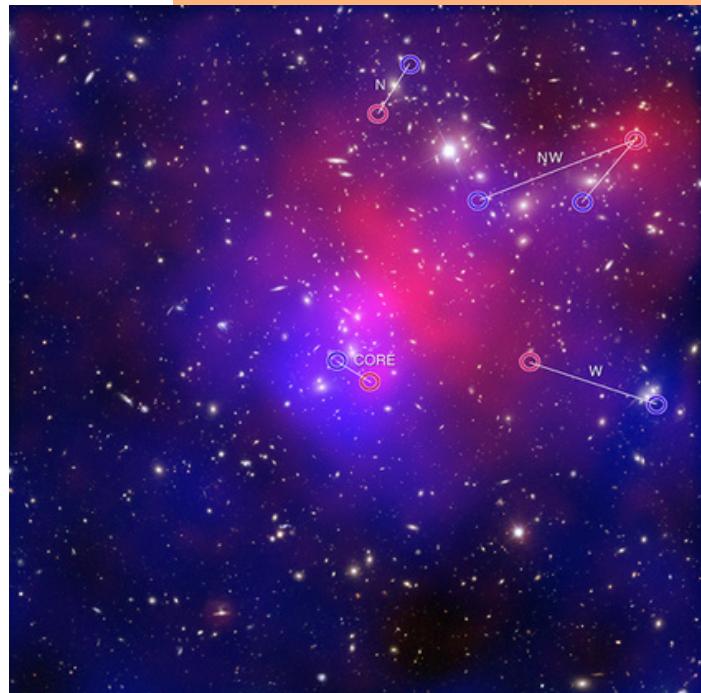
In stark contrast with the enchanting wallpapers delivered by the James Webb Space Telescope, our knowledge of dark matter and dark energy is defined by what we don't see, which, in this case, appears to be the overwhelming majority of the mass-energy content of the universe. Most estimates describe the composition of the universe as being around [70% dark energy, 25% dark matter, and only 5% ordinary matter](#). There could even be dark matter and dark energy surrounding you right now!

But what do these invisible phenomena do, and what makes us think they actually exist?

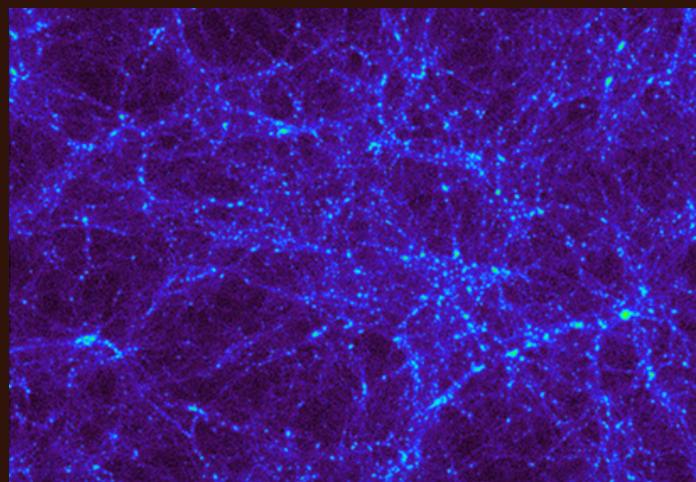
DARK MATTER

In 1933, Swiss astrophysicist Fritz Zwicky, a researcher at Caltech, was observing the motion of galaxies within what appeared to be gravitationally bound clusters. Except, according to his measurements, they weren't gravitationally bound at all—at the velocities with which these galaxies were moving, one would expect them to have flown away from each other long ago. So what could explain their continued association?

(continued on next page)



Most of Abell 2744's mass, shown in blue, is dark matter | Credit: [NASA](#)



Numerical simulation of dark matter in our universe when it was 3 billion years old | Credit: [ESA](#)

Based on a hypothesis first put forward by the British physicist Lord Kelvin in the late 1800s, Zwicky proposed that there was in fact far more matter present than could be observed. This so-called *dark matter* exerts its gravitational influence to maintain the cosmological structures that we see today.

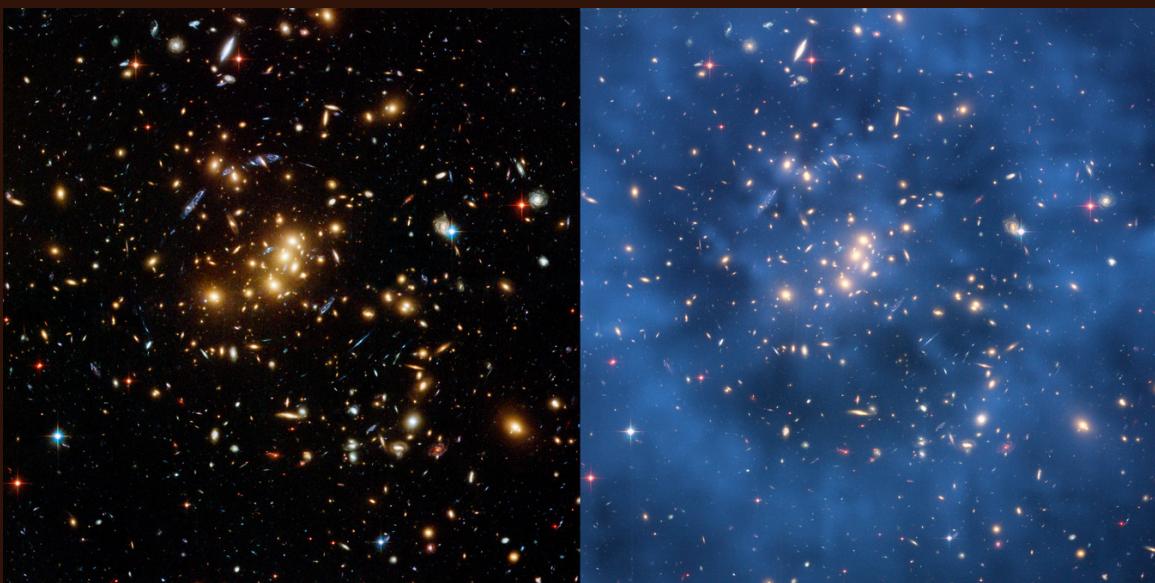
Despite being initially viewed with skepticism by the astronomical community, Vera Rubin and her team showed in the 1970s that individual stars within other galaxies were moving at what appeared to be a fairly constant speed, regardless of their distance from the galactic core. This is in contrast with what we find in places like the solar system, where planets closer to the Sun orbit it much more quickly.

This became the leading explanation for these anomalous findings, alongside a few less popular hypotheses that instead modified the laws of gravity on large scales. Dark matter would likely be made of particles that do not participate in electromagnetic interactions, meaning that they could pass through ordinary matter and be practically undetectable (hence their invisibility).

DARK ENERGY

Around the time when scientists discovered dark matter, they still believed that our expanding universe would gradually slow to a halt under the gravitational influence of its contents. It might then begin contracting, culminating in a reverse of the Big Bang. The astronomical community was stunned in 1998 by the discovery that the universe's expansion was actually accelerating, and had been for roughly the past five billion years.

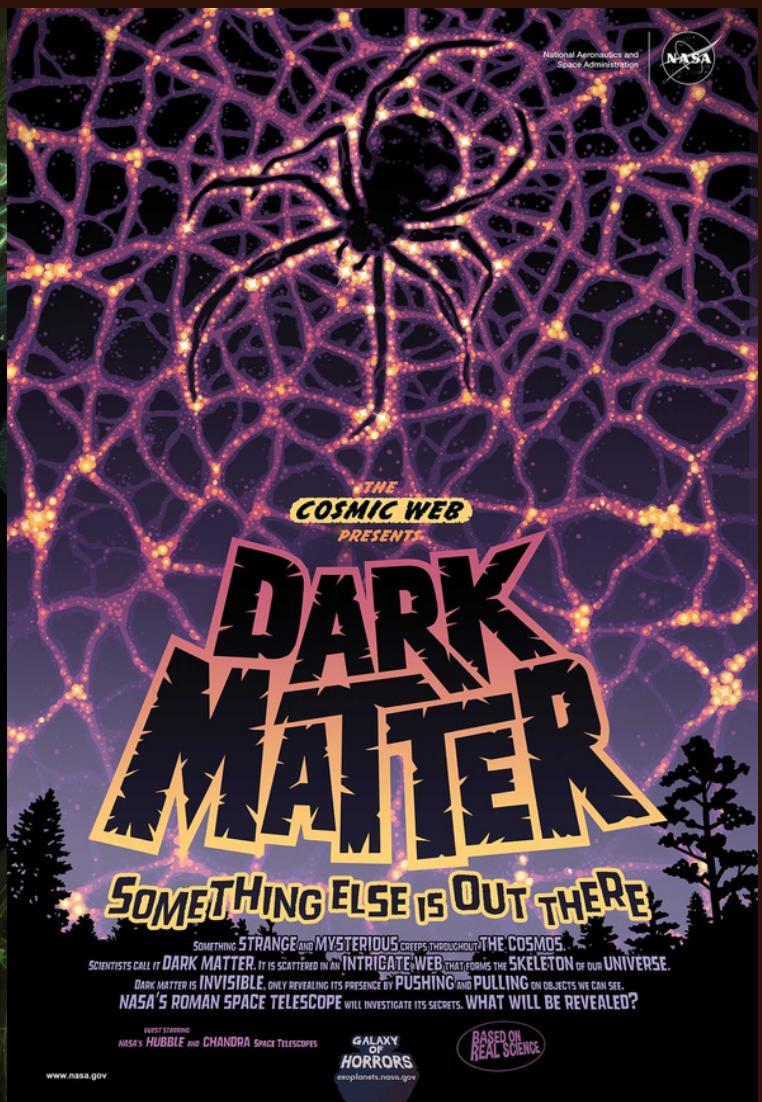
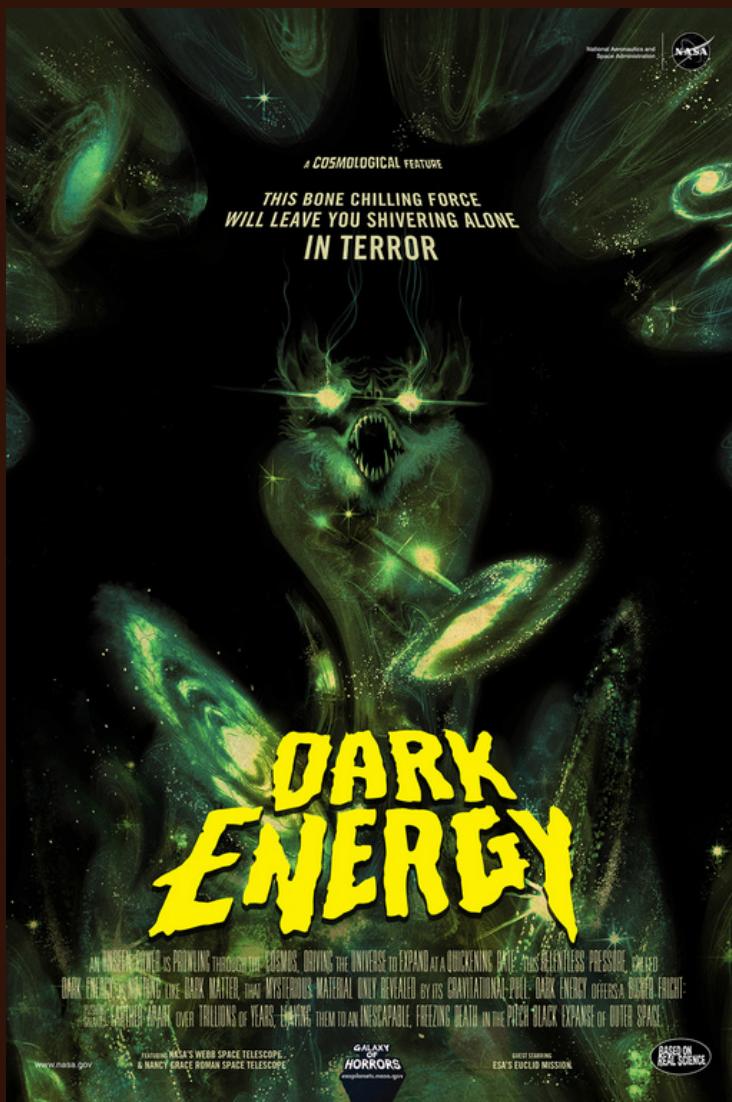
Because no other known phenomena appear to exhibit anti-gravitational properties, the nature of this repellent force remains a topic of debate. But many suspect this *dark energy* to be the result of quantum fluctuations inherent to the vacuum of space, therefore remaining at a constant "density" even as ordinary and dark matter are gradually thinned out.



Galaxy cluster CL0024+17 is likely the result of an ancient cluster collision, which caused a "ripple" of dark matter. At left is a visible-light image; at right, the mathematical model showing dark matter has been overlaid in blue. Dark matter is our only current explanation for why this cluster has so much gravity | Credit: [NASA](#)

(continued on next page)

A key takeaway, in my view, is the pace at which our understanding of the cosmos has evolved, and will continue to do so. Many find the implication that the universe will eventually expand to the point where no two galaxy clusters are close enough to ever be observable to be disheartening, but such an outcome, if it does occur, is still not projected to take place for many times longer than the current age of the universe, and our species is facing much more pressing concerns. The next time you look through a telescope, though, remember how much there is that we can't yet see.



eCredit: [NASA](#)

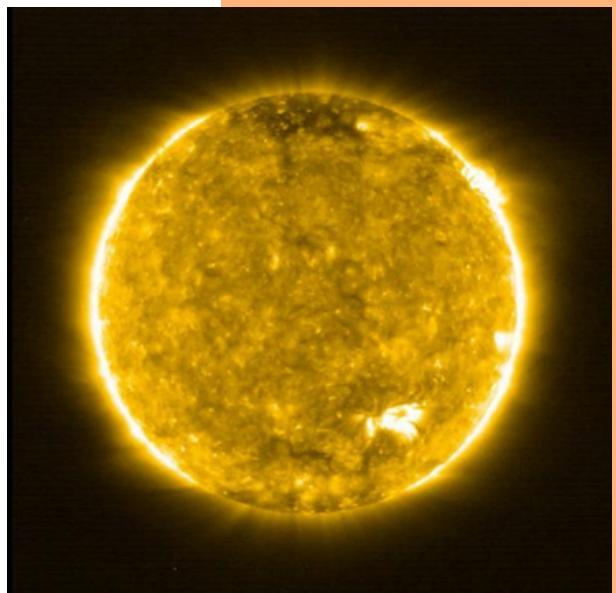
eCredit: [NASA](#)

WHY DO STARS SHINE?

BY ABRA GEIGER

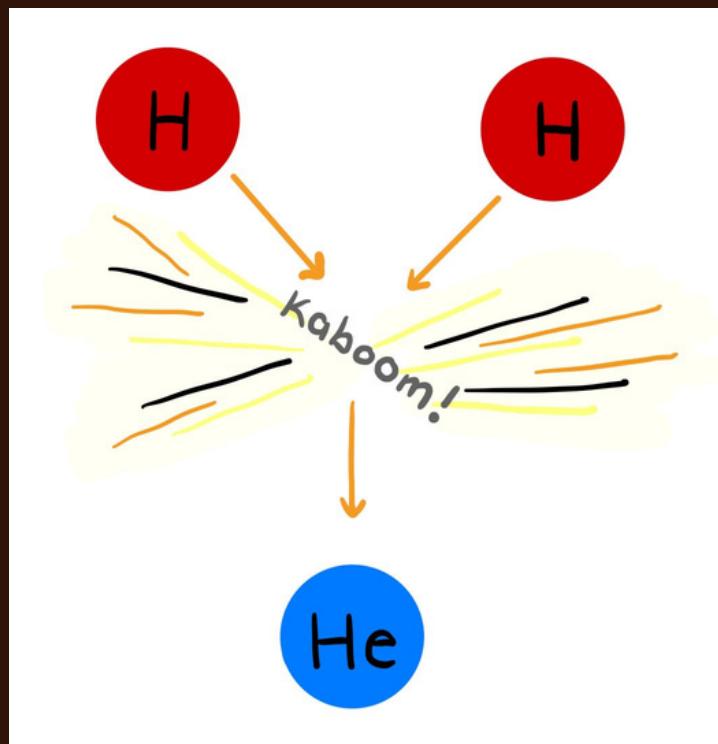
Every day, the 200 nonillion (that's 30 zeros) kilogram ball of light in our sky rises and sets, giving life to all on Earth. Humanity owes its existence to our wonderful Sun. Let us explore the mechanism behind the sun's incredible light energy.

Electromagnetic radiation, or light, is produced by reactions; however, familiar chemical reactions such as fire can't create nearly enough energy to fuel the sun's luminosity. Instead, stars are powered by nuclear reactions. The study of nuclear reactions in stars is termed stellar nuclear physics.



Our Sun

Credit: [ESA/NASA](#)



The Sun is powered by nuclear reactions such as the fusion of hydrogen atoms to form helium, which releases incredible amounts of energy

Credit: Abra Geiger

Nuclear fusion is the prominent nuclear energy source in stars. Fusion occurs when there is such high pressure and temperature that two hydrogen atoms combine to form a helium atom. This process releases incredible amounts of energy. Most stars are powered by fusion of hydrogen atoms, but the fusion of heavier elements is common in stars as well. Especially later in the lives of higher-mass stars than the Sun, heavier elements can fuse, releasing immense amounts of electromagnetic radiation.

Cornell's very own Hans Bethe was an instrumental scientist in the field of stellar nuclear physics. He was awarded a Nobel Prize in Physics in 1967 for his work concerning energy production in stars. Bethe proved that nuclear fusion was the process that produced their enormous amount of energy.

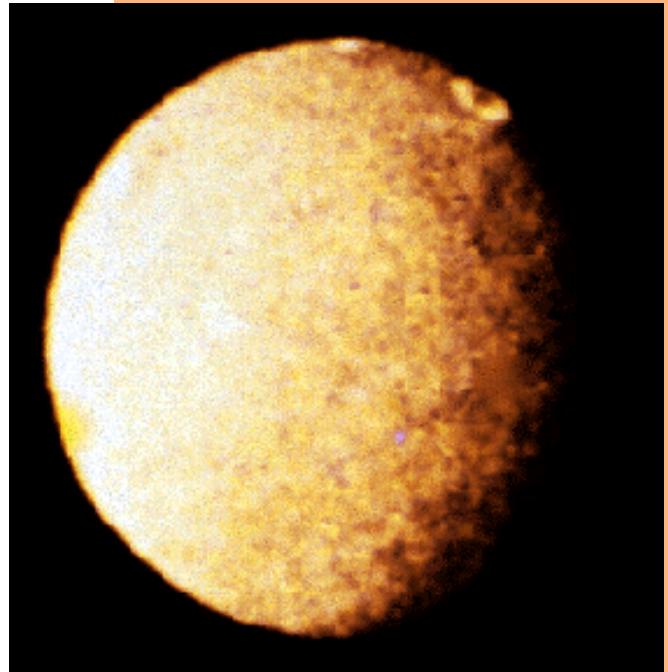
(continued on next page)

UMBRIEL

BY JUSTINE SINGLETON

Picture this: It's a bright day in autumn, and you are sitting under a tree. The weather hasn't gotten cold enough to make sitting outside uncomfortable yet, so you might as well enjoy it while you still can. A soft wind blows, and you watch the shadows from jagged leaves dance across your skin.

The veil of darkness reminds you of another moon. Umbriel. The shadowy moon of Uranus is the darkest of its kind, reflecting only 16 percent of the sunlight that reaches it. You remember, however, that it is not necessarily the darkest moon in the Solar System. In fact, Earth's moon has a smaller albedo than Umbriel. But the Uranian moon is uniformly dark. This, ironically, makes it stand out.



The southern hemisphere of Umbriel
Credit: [NASA/JPL](#)



Size comparison of the Earth, Moon, and Umbriel
Credit: [Tom Reding](#)

It's difficult to imagine this moon, since only one mission has ever been there. Voyager 2 passed it during a flyby of Uranus in 1986. The outer Solar System takes a long time to reach, so very few missions have ever gone there. As a result, very little is known about Umbriel and its sibling moons.

Still, you try to picture yourself on its surface. The shade around you morphs into near-darkness. Uranus is over a billion miles away from the Sun, so not much light reaches the ice giant and its moons in the first place. It might be slippery. Umbriel's surface is thought to be a mix of rock and ice, though it is not clear if it is a layer of rock on top of ice, a layer of ice on top of rock, or an even mix of both.

(continued on next page)

You glance up, returning to Earth for a moment. The leaves on the branches above you sway in vivid flashes of red and yellow. All of them are so bright, especially when compared to the shadow beneath. It's like the Wunda crater. The most prominent of Umbriel's many craters has a distinctive bright ring surrounding it. Scientists still aren't entirely sure why, but there are two main theories. The ring might have formed due to the impact that carved out the crater, or from frozen carbon dioxide that traveled across Umbriel and got trapped inside the crater's surface.

That is essentially everything we know about Umbriel.

You sit up suddenly. That can't be right. There has to be more. You pull out your phone, search for everything you can on Umbriel, scroll through every source you can find, but there's not much else there. It takes a moment to accept this, but once you do, you find a silver lining. There's still hope for new observations. The James Webb Space Telescope will have observation time specifically reserved for Uranus, including its moons. In this year's Decadal Survey, the National Academy of Sciences identified a Uranus Orbiter and Probe as a high-priority mission. The launch window is in 2031. You hope they make it.

It starts getting colder out. As the sun lowers in the sky, the shadows around you grow longer. You brush the grass and dirt off your pants or skirt and head inside. Long after you leave the shade of the tree, your mind is still on Umbriel. How long will that moon of mystery remain in the shadows?



REVIEW OF IRVING PORTER CHURCH MEMORIAL TELESCOPE'S 100TH ANNIVERSARY

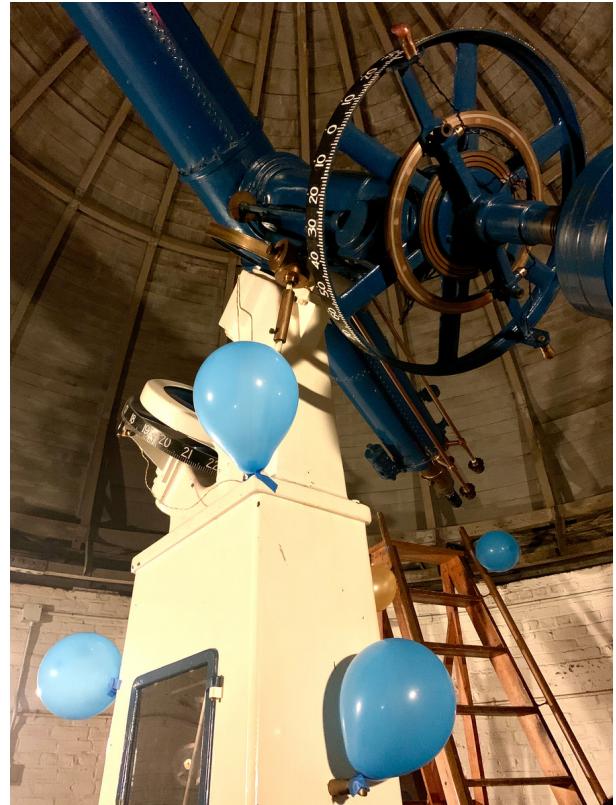
Thank you to everyone who attended the lecture and open house on October 14!

Professor Phil Nicholson gave a highly detailed talk on the history of Fuertes Observatory and the Irving Porter Church Memorial Telescope. You can find the recording at the bottom of [this page](#).

Current club members and alumni sent in wonderful photos and memories of Irv! We compiled them into [a slideshow](#), which played in the classroom throughout the night.

The Cornell Chronicle also [reported on the event](#), and we were featured in some [cinematic shots](#) on the Cornell Instagram.

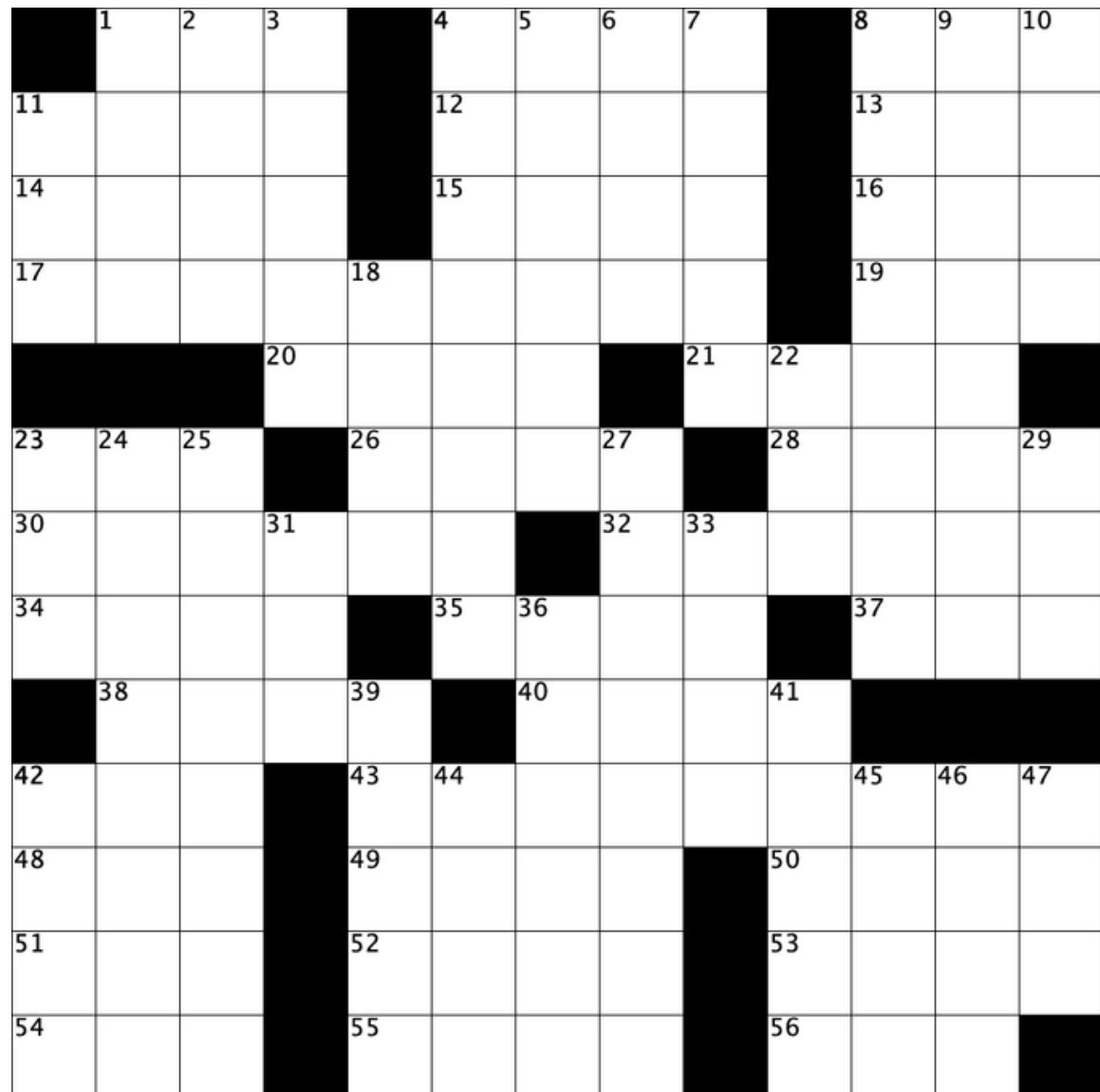
Here's to another hundred years of Irv!



On the left, our space-themed cupcakes from Emoticakes! On the right, a group picture with the birthday scope

ACROSS

1. Fruit spread
4. Alum
8. D&D, e.g.
11. El ___, Texas
12. Prefix meaning "wine"
13. Atmospheric medium
14. Take, as a photo
15. Ballet skirt
16. Louis XIV, par exemple
17. First exoplanet discovered orbiting a main-sequence star
19. Culmination
20. Price-reducing event
21. Opening of a famous Hamlet quote
23. Suffix for Manhattan streets running north-south
26. In need of directions
28. "Little piggies," in a nursery rhyme
30. With 32-Across, payload on 24-Down and its twin
32. See 30-Across
34. Centers of hurricanes
35. Ancient Greek personification of the earth
37. Police dogs
38. Parts of a stage production
40. Nimble
42. "__ Pepper's Lonely Hearts Club Band"
43. Star system with seven confirmed exoplanets
48. Director Anderson
49. Spa amenity
50. Supergirl's first name



51. Piece in a museum, perhaps
52. Slightly open
53. Prelim, e.g.
54. Laughing gas, chemically
55. Ellipses, essentially
56. Allergen in tofu

DOWN

1. NYE follower
2. "Stat!"
3. Sulks
4. Clicked (with)
5. Gets more mileage out of
6. Not in favor of
7. View with skepticism

8. Piece in a bibliophile's collection, perhaps
9. Spacecraft with which NASA lost contact in 1983
10. Crossword puzzle, e.g.
11. Sony release of 2020, for short
12. Strong wind
13. Like Advil and Tylenol: Abbr.
14. A tree's can be measured by counting its rings
15. Only spacecraft (so far!) to visit Uranus and Neptune (1986 and 1989)
16. Decides that one will
17. Ones on acid
18. Cornell org. that provides Accommodation Letters, among other things
19. "Spring forward" hrs.
20. Old West lawman Wyatt
21. Blind ___,
22. Sought-after violin, for short
23. "Zoinks!"
24. Cygnus, with "The"
25. Red, como un rubí
26. Instrumental prefix with -phone
27. It's often used while waiting
28. Post-midnight hour

CREDITS

CAS Officers

Annika Deutsch, President
Anthony Fine, Vice President
Ben Jacobson-Bell, Treasurer
Gillis Lowry, Outreach Coordinator
Phil Nicholson, Faculty Advisor

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

Contact:
209 Cradit Farm Dr.
Ithaca, NY 14853
astrosociety@cornell.edu

Contributors to this issue

Abigail Bohl
Abra Geiger
Ben Jacobson-Bell
Claire Cahill
Dylan Jackaway
Gillis Lowry
Greg Powers
Justine Singleton
Shaunjae Suarez

Special thanks

Carl Sagan

Sources for "Umbriel":

[1](#) - [2](#) - [3](#) - [4](#) - [5](#) - [6](#) - [7](#) - [8](#) - [9](#)

Image credit NASA:

[1](#)