CORNELL ASTRONOMICAL SOCIETY NEWSLETTER

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LETTER FROM THE PRESIDENT

Hello students, amateur astronomers, Earthers, dome lovers, Irving Porter Church worshippers and lifetime learners alike. On behalf of our team of talented writers I would like to again extend a warm welcome to our March issue of the Cornell Astronomical Society Newsletter. In the following articles we take a look at a bit of the history of space probes, from the 50th anniversary of the Pioneer 10 mission, to the recent achievements of the Parker Solar Probe, to Cornell's (hopefully) soon to be launched Alpha CubeSat. Not only are these probes an amazing source of scientific knowledge, but they are as of yet our only material method for making contact with intelligent life outside of our solar system.

With regards to the CAS itself, we just had our first public lecture on Friday, Feb 25 and will be hosting our second this Friday, Mar 4 at 7:30 pm, so keep an eye out for an email from our listserv with details!

I hope you enjoy reading our newsletter as much as we enjoyed crafting it!

Sincerely,
Chase Funkhouser
President, Cornell Astronomical Society

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50TH ANNIVERSARY OF PIONEER 10

BY GILLIS LOWRY

Fifty years ago, on March 2, 1972, Pioneer 10 touched off from Cape Canaveral on humanity's first mission to the outer Solar System.

All missions prior to Pioneer 10 had been bound by the asteroid belt, the realm of Mercury, Venus, and Mars—that is, assuming their spacecraft got off the ground at all. Pioneers 0, 1, 2, 3, P-1, P-3, P-30, P-31, and E all either exploded on launch or fell back to Earth without reaching the Moon as planned.

Artist concept of Pioneer 10 | NASA

Pioneer 10 launch at 8:49 EST on March 2, 1972 | NASA

As the space program matured and was met with much less fiery failure, Pioneer 4 managed to orbit the Moon, and 6 through 9 explored the inner Solar System in the latter 1960s, taking measurements of solar wind, the Sun's magnetic field, and cosmic rays.

Just five months before the first Moon landing in 1969, NASA approved a pair of spacecraft designated Pioneer F and G. They would use entirely nuclear power and travel faster than any previous man-made object. They would also contain a wide range of instruments, hoping to account for just how little was known about the outer Solar System.

As it sped into a windy night sky aboard the Atlas Centaur launch vehicle, and Pioneer F became Pioneer 10, it was unclear how many dangerous particles might await in the asteroid belt. But Pioneer 10 emerged almost entirely unscathed. It became the first space probe to reach our fifth planet, arriving a whole minute earlier than the calculations based on a now-outdated mass of Jupiter had predicted.

Once there, Pioneer 10 photographed the largest Jovian moons, Callisto, Ganymede, and Europa, and only missed Io when the photopolarimeter succumbed to Jupiter's intense radiation.

Though often overshadowed by the later Voyager mission, Pioneer 10 provided priceless scientific knowledge in its own right. It studied the radiation belts around the equator of Jupiter, as well as the atmosphere and magnetosphere. The spacecraft communicated across a larger distance than ever before to send back "real-time" photos—or as fast as they could be, despite the forty-five minute delay, a limit imposed by the speed of light.

At its closest approach, Pioneer 10 passed behind Jupiter, leaving the team to wait in apprehension until the spacecraft could regain a clear line of sight. Lyn R. Doose, part of the imaging team, described the moment: "We watched ... as the signals came back from the distant planet. A single bright spot appeared, and then another, until a line gradually built up." A crescent; Pioneer 10 watched a Jovian sunrise.

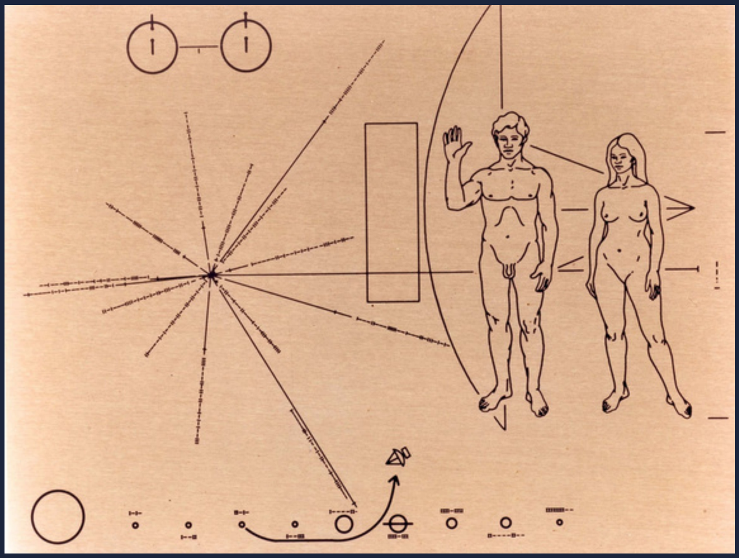
Bottom, left to right, is Pioneer 10's approach to Jupiter; top, right to left, is a crescent sunrise and departure | NASA

Pioneer 10 fulfilled all its objectives save for photographing Io. Though it did not visit Saturn, the spacecraft crossed the planet's orbit in 1976, confirming Jupiter's magnetic presence could be felt even as far as the next planet over. It passed the orbit of Neptune in 1983.

Jupiter, Europa (top right) and Ganymede (bottom right)

Pioneer 10, followed by 11, is the oldest man-made object to set its sights beyond the outer planets—but the younger and faster Voyagers have since surpassed the Pioneers to claim the title of first out of the Solar System. Though their photos may be less glamorous, the Pioneers also gave us the very first close glimpses at Jupiter, four hundred years after Galileo aimed his telescope at the sky.

When communication with Pioneer 10 was lost in 2003, the mission was twenty-eight years past its original design. The spacecraft still flies, now twelve billion miles from home. On it is a golden plaque with a pulsar map and two human figures, one hand raised in greeting. In two million years, they will wave to the red star Aldebaran, to any life that dares to brave the expanse as we did.



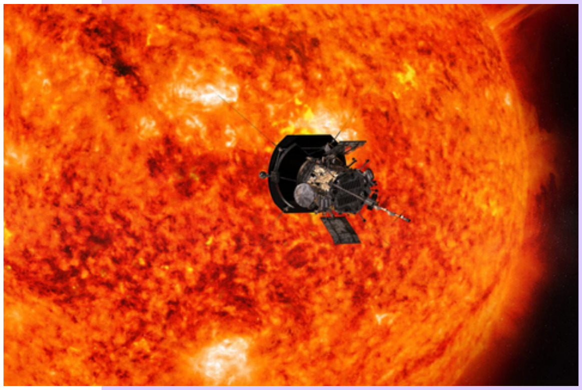
The Pioneer plaque, made of gold-covered aluminum, created by Frank Drake, Carl Sagan, and Linda Salzman

NASA'S SOLAR PROBE RETURNS TO CORONA, MAKES HISTORY AROUND VENUS

BY TIM WILLIAMS

The Parker Solar Probe (PSP) was launched from Cape Canaveral on August 12, 2018. It is an unmanned spacecraft built and currently operated by the Applied Physics Laboratory at Johns Hopkins University. PSP's primary contributions and objectives are in heliophysics—the study of our Sun and its interaction with the planets. The goal of the mission is to complete twenty-four orbits with increasingly close perihelions around and through the Sun's corona between 2020 and 2025. Each pass through the Sun's atmosphere will advance our understanding of our Sun's structure and the formation of the Solar System.

These orbits include seven gravitational assist maneuvers around the planet Venus. Gravitational assists, performed to alter a flight course, accelerate a spacecraft without using excess fuel. They always involve using the gravitational pull of an object significantly more massive than the craft, such as a planet. For this mission, these maneuvers specifically use Venus's gravity to accelerate PSP to record speeds on its way to the Sun's outer atmosphere. Scheduled for June 2025, its closest approach will bring the probe less than four million miles from the Sun at breakneck speeds of around 430,000 mph (or within nearly six million kilometers at around 690,000 km/h).



Artist's conception of the Parker Solar Probe spacecraft approaching the Sun

Credit: NASA/Johns Hopkins APL/Steve Gribben

PSP has already made remarkable accomplishments in the field of heliophysics. The probe achieved its tenth perihelion on November 21, 2021, and has set records as the closest a man-made object has ever been to a star, at nearly five million miles from its surface. The craft made another perihelion approach last month, where it continued its study of solar wind and coronal structure.

During its Venusian gravity assists, the PSP has also contributed to exciting planetary science research. The Applied Physics Laboratory (APL) at Johns Hopkins University conducted a previously unplanned planetary science mission while PSP was approaching Venus's upper atmosphere. One of the instruments onboard the probe is a WISPR, or wide-field imaging device. The WISPR is essentially a camera designed to view structures of the Sun's outer atmosphere in the visible and near-infrared spectrum. Scientists determined the device was also capable of measuring the speed of Venus's clouds and the surface of the planet in great detail. News of the camera's success on its third Venus flyby in July 2020 convinced scientists at the Applied Physics Laboratory to activate the camera once more on PSP's fourth flyby of Venus in February 2021.

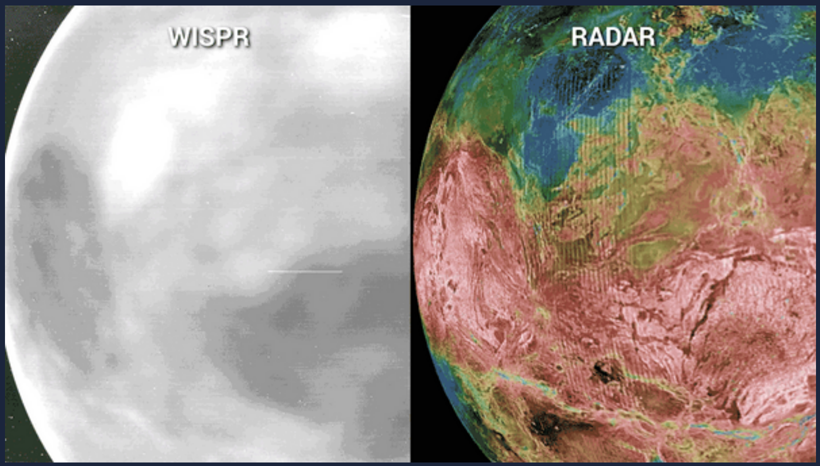
(continued on next page)

The full analysis of these images of the planet's nightside was published almost a full year later, on February 9, 2022. The images it took of the Venusian surface are the first images of Venus's atmosphere and its surface in the visible spectrum. Before now, most images mapping Venus had used radar and infrared light to pierce the planet's thick clouds, neither of which is very useful when trying to examine a surface's more specific geological makeup from orbit.

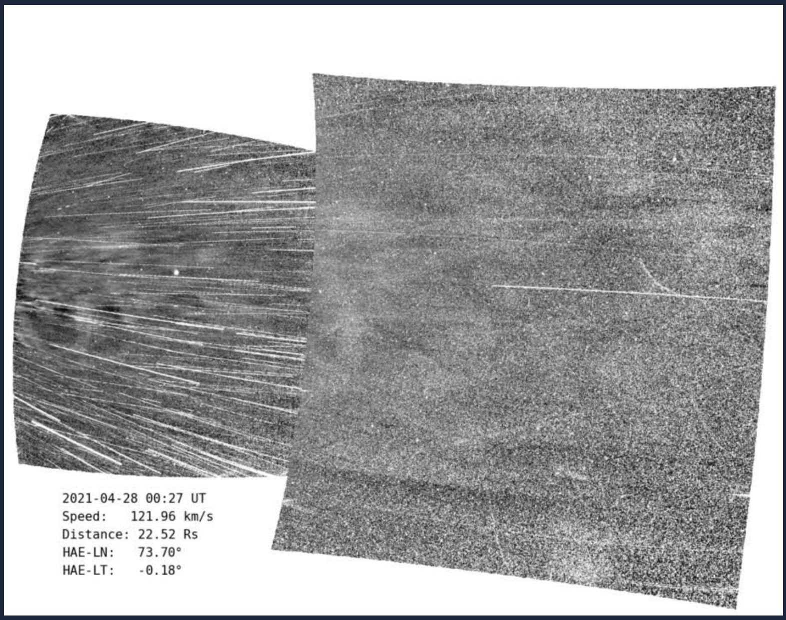
These images have allowed us to peer at Venus like never before, helping scientists to take the first steps at understanding its mineral composition and geological features. This new view of Venus has answered some long-standing questions and opened up many more. Only future missions will unlock some of the amazing secrets surrounding this unforgiving planet.

The Parker Solar Probe is providing very exciting information regarding our Sun and Venus. The probe's eleventh and most recent perihelion occurred on February 25, 2022, where it gathered more valuable data. NASA scientists are already analyzing the information and images the PSP transferred during its ninth encounter with the corona, where it captured details of solar winds and passed between massive structures in the outer edge of the solar atmosphere.

However, the Parker Solar Probe's mission is still not complete. It will continue to add to its already groundbreaking resume in the field of heliophysics until mid-2025.



The above is a comparison of radar images of Venus's surface from the Magellan mission in the 1990s and images of the same region from July 2021 captured by the WISPR device aboard the Parker Solar Probe using near-infrared



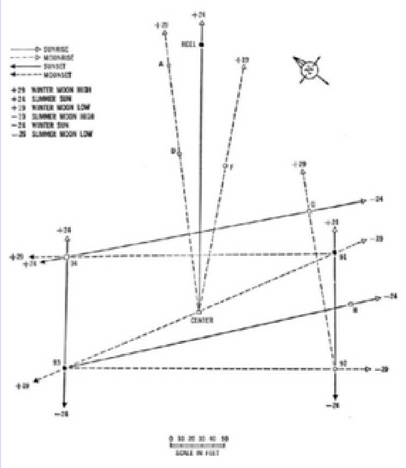
This image from the August '21 perihelion shows some of the corona's features in the form of streaks on the left side while keeping the blinding Sun out of the view field of the camera

MONOLITHIC ASTRONOMY: STONEHENGE

BY PAUL RUSSELL

Stonehenge's origins lie around 3000 BCE, though its construction lasted centuries and can be divided into three distinct phases. The first, Stonehenge 1, consisted of a circle of fifty-six pits of chalk. One interpretation of these pits, known as the Aubrey Holes, is that they served as a sort of lunar calendar for predicting eclipses. Marking one hole as the Moon and another as the Sun, each would be moved two spaces every day and every thirteen days, respectively, to roughly line up with their cycles.

Diagram showing the rectangular and diagonal shapes in Stonehenge Credit: Gerald Hawkins



Around a hundred years later, a second phase of construction began by a separate group of people. Referred to as Stonehenge 2, it consisted largely of an enclosure of the existing structure as well as several monuments using timber, though it is no longer there. Instead, the timber was replaced with the stone we can see today in the final phase of construction, Stonehenge 3.

This phase was completed by yet another distinct group, and was completed over a period of centuries. In this period, stone was most likely moved from a quarry in Wales and rearranged into the formation that remains today.

Given the age of the monument and the fact that several cultures worked on it over different periods, interpretations of its purpose are often contested, though there are certain aspects of it that give credibility to the notion of its relation to astronomy. First of all, Stonehenge's location is one of symmetrical significance. The directions of the maxima of the sun and moon in winter and summer form a rectangle, and another maximum of the moon forms a diagonal across it. This is only in the area near where Stonehenge was built, however, and is not true throughout the rest of the British Isles (let alone the Northern Hemisphere).

Another stone, Heel Stone, is placed in a spot such that when looking from the center, if the winter Moon rises above it, an eclipse will take place. From the center of the enclosure, only a few direc-tions can clearly be seen through without being obscured by the boulders. Through these arches (trilithons), the directions that make up the afore-mentioned rectangle can be seen through, as well as a view of the Heel Stone, implying that the placement of the trilithons is intentional. While it is not well known how much the various cultures that built it knew, Stonehenge proves the significance of astronomy across time and space.

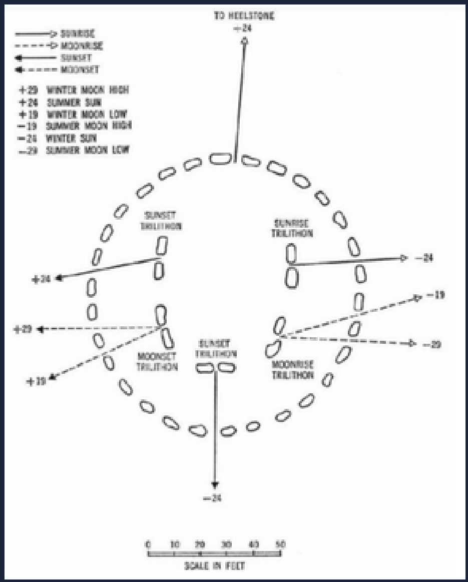


Diagram showing the Heel Stone and trilithons Credit: Gerald Hawkins

This month's space poetry comes from a CAS member.

BIG FREEZE

BY PEDRO DE OLIVEIRA

a wish a wish a wish a wish upon a star
sorry, but a star
is just a globe that glows
bullshit to keep you at your toes
to the light from years ago
make eventually a blackhole
you only watch the sun’s afterglow
forgive me, but i have to let it go
for i am not romeo
all i need to know
their truth is written in the structure of the cosmos
errors can only be washed with sorrow
but wish wish wish upon a star.

still wish wish wish upon a star
truthfully they only have a high density
they make a hefty gravity
don’t use them for self-pity
care is the least last they will do specially
if you leash them with tenancy
you miss the point with all your entropy
hurting you will leave this stargazing activity
still you wish wish upon a star

why not wish wish upon multiple stars
they carry thousands splashes of hue
care not only for the shades of blue
if only you had any clue
i see them spinning with boiling tissue
accept that you were once one that blew
their metallic shield that flew
sorrows that shine something worthy of looking up to
now you continue to wish upon a star
?–??
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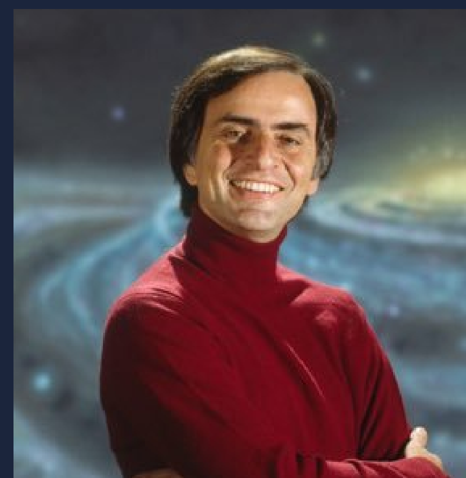
??? –
?

SPACE TRIVIA

How many different languages were on the Voyager Golden Record, an interstellar message created by Carl Sagan and colleagues?



Carl Sagan
Credit: Tony Korody / Sygma / Corbis

Voyager Golden Record | NASA

Answer:

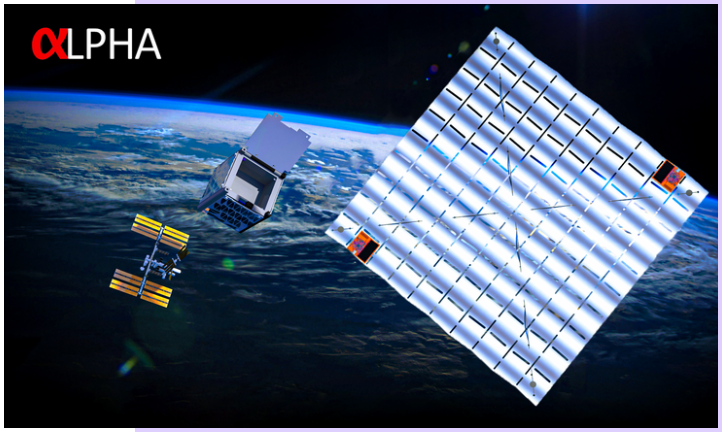
55 (plus one whale language!)

Trivia selected by Gillis Lowry

LIGHT SAILS AND SPACE HOLOGRAMS: ALPHA CUBESAT

BY GILLIS LOWRY

Cornell's Alpha CubeSat is a one-unit cube-shaped satellite—and a stepping stone to our nearest star system. Its technological innovations pave the way for future light sails to reach one-fifth the speed of light, four hundred times faster than any current spacecraft.



Artist interpretation by Stephanie Young

BUT, YOU MAY BE ASKING, WHAT *ARE* LIGHT SAILS?

Light sails, as the name suggests, are shiny sails pushed by photons of light rather than wind. JAXA's IKAROS in 2010 made this a reality, and the Planetary Society's LightSail 2 demonstrated sailing with sunlight while in low-Earth orbit. NEA Scout, part of NASA's Artemis mission, plans to visit a meteor via solar sailing.

Alpha CubeSat's light sail design is different from its predecessors. The sail's surface area is a hundred times smaller than Lightsail 2, but just as mechanically efficient, making it low-cost and easily reproducible.

Alpha's palm-sized computers, in the form of "ChipSats", are what allow the light sail to be so small. Most previous sails have been attached to spacecraft, but Alpha will be the first-ever free-flying light sail in space.

Lastly, the retro-reflective nature of Alpha's light sail—the same effect seen in cats' eyes or signs at night—causes photons to bounce back along the exact direction they came. This exerts a larger force and allows the sail to gather as much energy as possible.

WHEN DOES IT LAUNCH?

Alpha CubeSat will hopefully launch in the latter half of 2022, then deploy from the International Space Station. During a twenty-four-hour waiting period—meant to ensure no components hit the ISS—the CubeSat will stabilize and align itself with Earth's magnetic field, to allow easy contact and prevent the light sail from tumbling out by accident. This will be accomplished using *only* magnetorquers—coils that produce their own magnetic field that interacts with Earth's.

Alpha's prototype balloon launch in October 2021 successfully tested communications from thirty kilometers away, as well as light sail deployment

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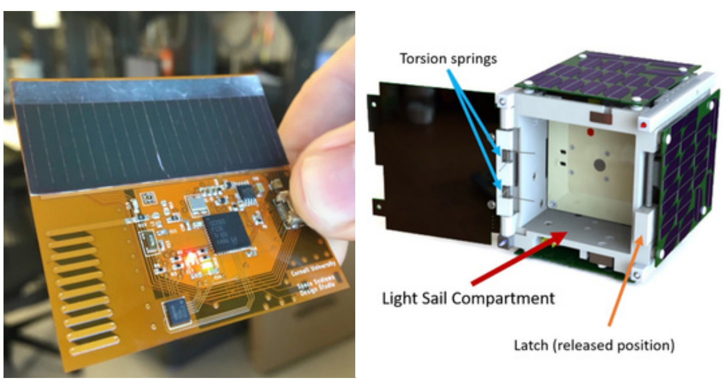
Because it's so small, Alpha's light sail doesn't need any motors to unfold: an origami folding technique and a shape-memory alloy frame do the trick. The compartment storing the sail takes up half the 3D-printed body—another of Alpha's quick, cost-efficient innovations.

The other half of the satellite is devoted to the CubeSat's own electronics, such as the Rock-Block, a modem making its debut CubeSat mission with Alpha. The RockBlock allows the team to communicate with the satellite simply over a website.

When commands are sent to deploy, a fishing line holding back a spring-loaded latch is cut, and the door beneath one of six solar panels opens, releasing the sail. The CubeSat will take a picture to make sure the light sail deployed properly, and then the rest of the sailing mission is up to the ChipSats.



Monarch ChipSat (left) and CubeSat mockup (right)

THE FIRST HOLOGRAMS IN SPACE

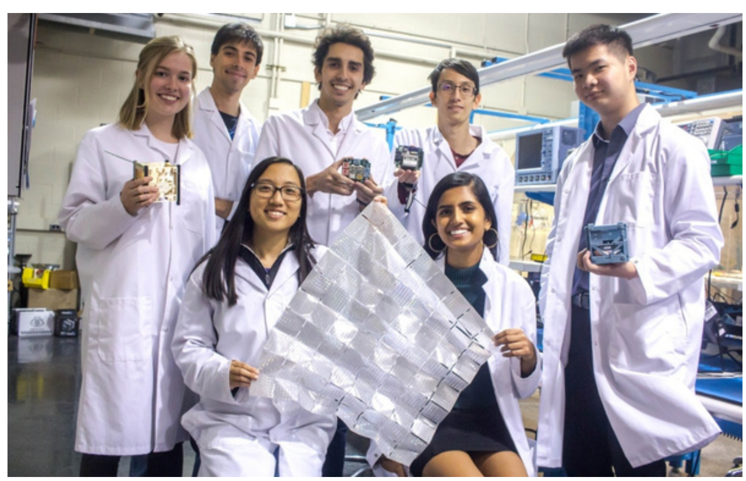
Although Alpha will stay just above Earth, its successors may be speeding through other star systems. Taking after the Pioneer Plaques and Voyager Golden Records, Alpha will demonstrate a new medium for interstellar messages in the form of holograms.

Above the CubeSat's solar panels are four pieces of holographic art, created with sculptures by artist C Bangs. Alpha has one picture per panel, but due to the parallax nature of holograms—how you can move your head from side to side and see different images—it's possible to include much more information in a holographic message than any metal plaque before it.

Hologram of a moth (left) and fish (right), created by C Bangs

These will be the first pieces of holographic art in space, hopefully paving the way for many more. As we look to Alpha's inspirations—Breakthrough Starshot, and the hopes of propelling light sails to Alpha Centauri with lasers—we can't help but want a little piece of home to hitch a ride.

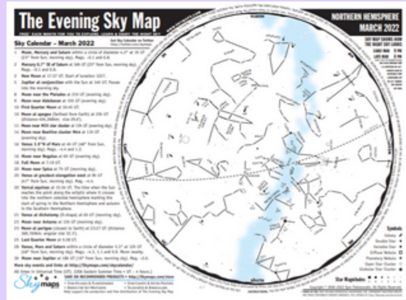
It's a long journey from concept to CubeSat. But Alpha is making major steps towards real advancements in spaceflight—even towards long-distance, light-powered missions to the stars.



Alpha team members holding the light sail and prototype CubeSats.

MARCH SKY MAP

Scan the QR code at right to view this month's evening sky map, courtesy of skymaps.com.



THE PLEIADES: WHAT THEY ARE AND HOW TO FIND THEM

BY LUCAS LAWRENCE

Among the most beautiful objects visible in the night sky are the Pleiades, a cluster of blue-hot stars some 444 lightyears away from Earth. Cultures across the world have known these stars by many names, including the Seven Sisters—a fitting name for a group of stars most likely born of the same nebula. However, while our eyes can only see the brightest stars, the Pleiades may contain over a thousand members, most being small red and brown dwarfs.

Whether in Ithaca or elsewhere, we can join in the ancient tradition of marveling at the Pleiades. With a little bit of basic constellation knowledge, this famous cluster is easy to find.

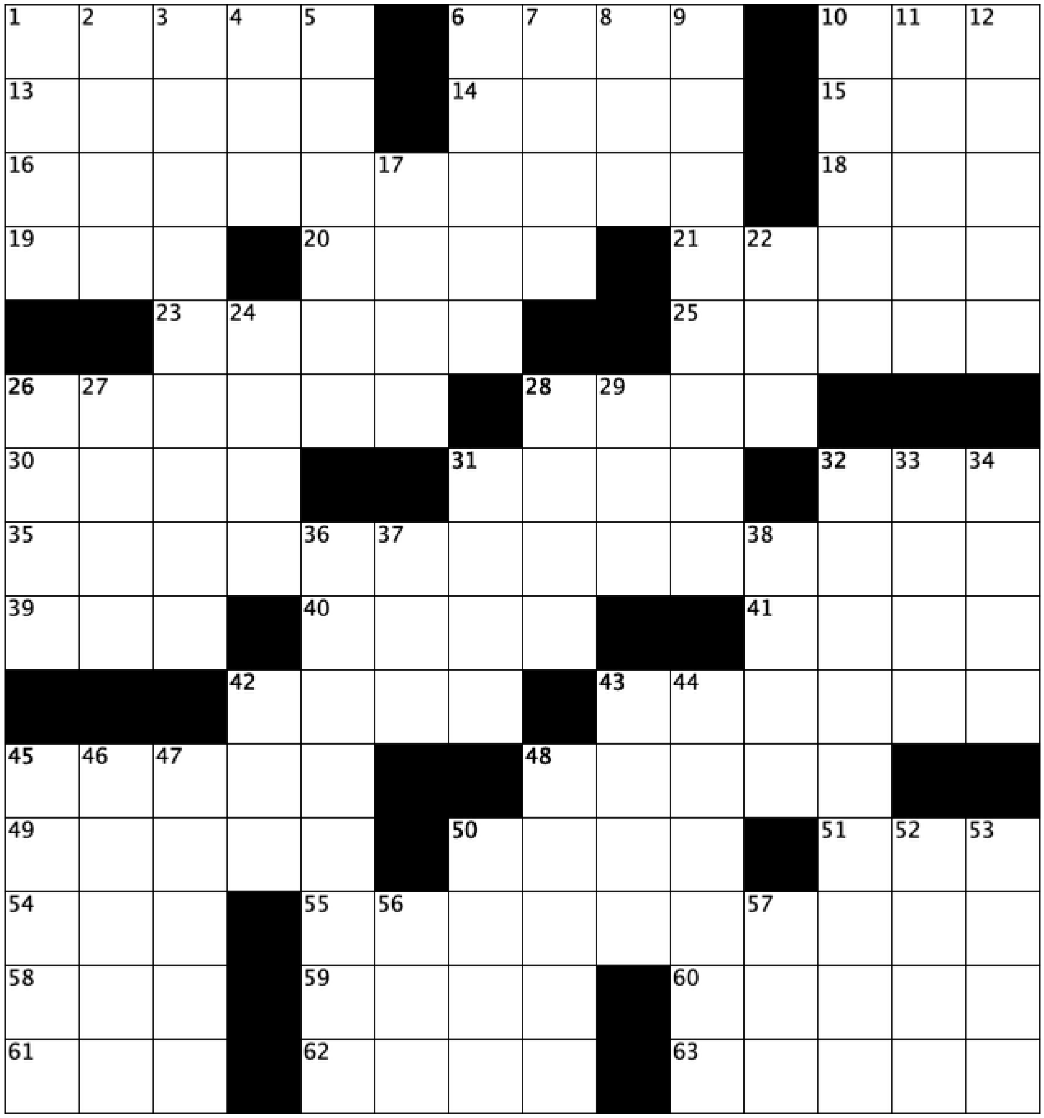
On a clear winter's night, look up at the southern half of the sky and find the man-shaped constellation of Orion. This is made easier by the fact that Orion is one of the few constellations that actually resembles what it supposedly represents!

Next, identify Orion's Belt: a short line of three stars in the middle of the constellation. Then, imagine a line connecting these three stars and mentally extend it far to the right of Orion. Follow this line, and you will eventually find the Pleiades. Note that halfway between Orion and the Pleiades you should find the bright red-orange star Aldebaran. If you get lost among the stars, consult the image of Orion to the right to find your way.

Star chart of Orion and surrounding objects of interest. Credit: NASA/JPL

Fun Fact: In Japan, the Pleiades are known as *subaru* (昴). The eponymous car company's logo happens to be a cluster of six stars, representing the Pleiades.

BY BEN JACOBSON-BELL
& ANTHONY FINE



ACROSS
1. North Star location?
6. Cain's victim
10. Racetrack unit
13. Cancer treatment, in brief
14. Zilch
15. ___-Wan Kenobi
16. Clock*
18. Competed like Usain Bolt
19. Suffix with legal
20. Still alive, say
21. "I'm out!"
23. "Somebody That I Used to Know" singer
25. Compass*
26. Furnace*
28. Adrift ice sheet
30. Garfield's canine counterpart
31. Dove sounds
32. The "2%" of 2% milk
35. Group that includes the starred clues (all inanimate objects!)
39. Wrath
40. One in charge
41. ___ Lisa
42. Askew
43. Cup*
45. Scales*
48. Where waves are caught
49. Comparatively frosty
50. Give caution
51. ___ B. Wells, co-founder of the NAACP
54. Yoga need
55. Triangle*
58. Resident of Fangorn Forest, in Tolkien
59. Make less difficult
60. Not rented out
61. Stereotypically messy place
62. Artificially colored
63. Some social media messages

DOWN
1. Yearn (for)
2. Noodle soups in Vietnamese cuisine
3. Fastest falcon
4. Fall Out Boy genre
5. Banned Nabokov novel
6. Founder of a noted list
7. Worms, for fish
8. "cornell." follower
9. It might need to be gaslit
10. He speaks for the trees, in Seuss
11. Antiquated calculators
12. Trees with needles
17. Banded gemstone
22. Calm part of a storm
24. Aces, in some games
26. Two of them define an ellipse
27. Result of leaving food in the fridge too long, say
28. Origami step
29. Mauna with an eponymous solar observatory
31. Certain deposit
32. The Piedmont, to the Appalachians
33. Hathaway married to Shakespeare
34. Title derived from "Caesar"
36. Defeated, as plans
37. Always, poetically
38. Apple console for Nanosaur 2 (2004)
42. Odds ___
43. Lab with the world's largest machine
44. Totaled, as a bill
45. Margarita ingredients
46. Words of defeat
47. Itty-___
48. Said sheepishly?
50. Sage
52. Piece for two
53. Qtys.
56. Soul singer Charles
57. Game with a BTS version

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Sources for "Monolithic Astronomy: Stonehenge":

Feyerabend, Paul K. *Philosophy of Nature*. Polity Press, 2018.
Hawkins, Gerald S. *Stonehenge Decoded*, Garden City, 1965
Owens, James. “Scientists Try to Crack Stonehenge's Prehistoric Puzzles.” *History*, National Geographic, 4 May 2021.

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

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