THE PLANETARY REPORT

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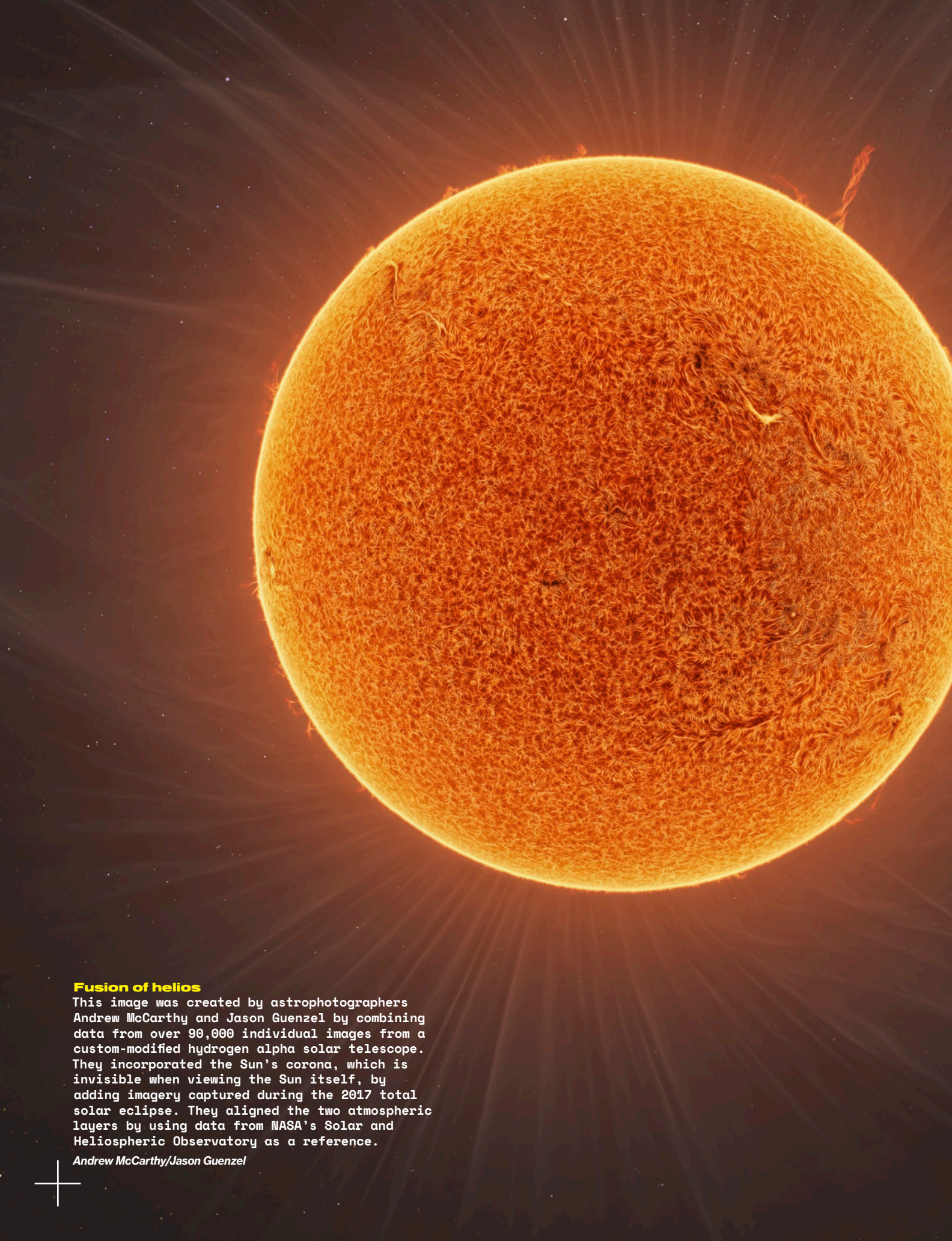
SOLAR MAXIMUM

OUR DYNAMIC STAR'S REACH THROUGHOUT THE SOLAR SYSTEM

THE PLANETARY SOCIETY 45 CELEBRATING 45 YEARS



Fusion of helios

This image was created by astrophotographers Andrew McCarthy and Jason Guenzel by combining data from over 90,000 individual images from a custom-modified hydrogen alpha solar telescope. They incorporated the Sun's corona, which is invisible when viewing the Sun itself, by adding imagery captured during the 2017 total solar eclipse. They aligned the two atmospheric layers by using data from NASA's Solar and Heliospheric Observatory as a reference.

Andrew McCarthy/Jason Guenzel

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ON THE COVER

NASA's Solar Dynamics Observatory captured this extreme-ultraviolet image of an X1.8 solar flare, seen here as a bright flash in the center of the Sun's disk. At the time, Oct. 8, 2024, the Sun was nearing its peak activity.

NASA/SDO

▲ This image captured by Firefly Aerospace's Blue Ghost lander on March 3 shows sunrise on the lunar surface.

Firefly Aerospace

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WHO LOVES THE SUN?

One way or another, it's a force to be reckoned with

by Bill Nye

Our star is beautiful and fascinating, a celestial object worthy of great appreciation and scientific investigation. This is why we send out missions like the Parker Solar Probe to study the Sun up close. Engineers challenged the spacecraft to dive very, very close to the Sun's surface in death-defying feats of robotic bravery. You'll read about those in this issue.

Right now, the Sun is at a peak in its activity cycle; its surface is especially speckled with storms. If you have a nice telescope equipped with a solar filter, you can see these for yourself. And around solar maximum, you're more likely than ever to see the aurora dancing across Earth's night sky. You'll read more in this issue about how to enhance your chance of observing these magical phenomena. You'll even get a look at the same process on other off-Earth worlds.

Now, people who love space often love to live the nightlife — by that, I mean looking up and into the sky at night. After all, it's only after Earth's spin makes the Sun set that we can readily observe that we are among planets, stars, nebulas, galaxies, and a great many more celestial objects. Simply put, the nighttime is the right time to glimpse our place in space.

It's not that we don't love a sunny day. We do. But let's face it: Sometimes, sunlight gets in the way — like if you're an astronomer concerned with hunting asteroids. On the one hand, since they don't emit any visible light of their own, reflected sunlight allows us to spot asteroids in the first place. But asteroids coming our way from the Sun's general direction can be hidden in its blinding glare. These are the incoming objects we worry about most, as they have the potential to catch us off guard.

With this in mind, you've probably heard of at least two asteroids lately: Apophis (named after an Egyptian god of chaos) and 2024 YR4 (named after the year and calendar period of its discovery). They're both going to miss us. But if their trajectories were to shift just a little, either one of these could have been big trouble for us down here. And of course, we don't know exactly what other as yet undetected objects might be headed our way. Our planet's position in the Solar System gives us all the more reason to continue developing better and better asteroid-hunting capabilities.

NASA's NEO (near-Earth object) Surveyor is one such project — a space telescope designed to find the most challenging asteroids, including those coming from the direction of the Sun. Thanks to the support of members like you, The Planetary Society has been a strong advocate for NEO Surveyor. We've also provided grants to asteroid hunters around the world through our Shoemaker NEO Grant program. With your help, we'll keep up this work for many years to come.

We also continue to depend on the support of our members as we fight for space science as a whole. These past few months have not been easy for NASA, and it's more important than ever to work together to ensure the future of exploration.

Whether you love to be under the Sun or prefer the night, there's one thing we all agree on: Without our star, we wouldn't be here. So, as we approach solar maximum, let's take some time to appreciate the Sun, the feats of exploration we undertake to study it, and the many beautiful phenomena that it creates. Read on!

CAPTURING MAGIC

A photographer's guide to auroras

by Jonah Bryson, Planetary Society member and photographer

An arctic fox running across the sky, igniting sparks of every color; a horse-drawn carriage carrying guests to a heavenly wedding; a god sending angels to retrieve the souls of fallen warriors — these cultural stories all try to capture the magic of the aurora.

While these dancing lights usually appear close to Earth's poles, this year is the best time in more than 20 years for people elsewhere to catch a glimpse.

Solar activity creates auroras, and we're nearing solar maximum: the peak in the Sun's 11-year activity cycle. This manifests in spectacular displays that are more colorful, frequent, and intense than usual and sometimes visible much farther from the poles.

As an avid photographer, I spent the winter in the far North. This close to the poles, the lights danced almost nightly in shades of green, pink, purple, red, yellow, and blue — the result of solar particles interacting with elements like nitrogen and oxygen in different layers of our atmosphere.

Sometime this year, you may hear that a solar storm is coming and that the aurora might be visible in your area. To improve your odds of seeing something spectacular, try to find a dark, clear sky. Get away from the light pollution of the city if you can and try to avoid cloudy skies since auroras happen in the upper atmosphere.

If you really want to make the most of solar maximum, you might consider traveling toward the best views. Auroras happen close to Earth's poles, around 60 to 70 degrees north or south of the equator. Heightened solar activity may mean that auroras will stretch farther from the poles than usual, but the closer you can be to those latitudes, the more spectacular your show will be. You'll want to time your travel carefully, as each pole's winter is the best time to see the aurora. Right now, it's winter at the south pole, and from December to March, it will be winter at the north pole.

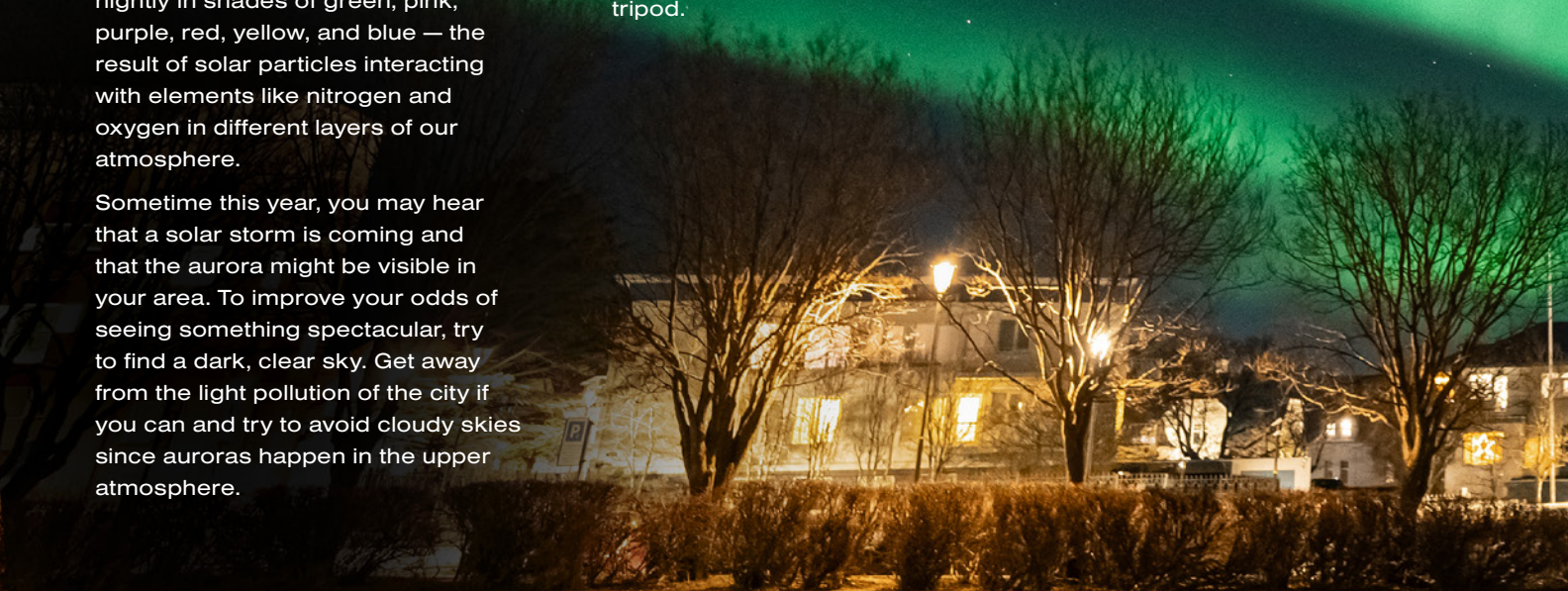
Whether you travel to find an aurora or get lucky enough to witness one near where you live, you'll definitely want to snap some amazing photos. You can capture awe-inspiring shots using nothing more than your phone. Here's what I've found helpful:

- Turn on long-exposure settings: 3-, 5-, or even 30-second exposures will greatly enhance your images.
- Stabilize your phone: Long exposures can create blur if your phone is moving. I recommend setting your phone against something stable or using a tripod.
- Tell a story: Seeing a house, a tree, or something else in the foreground of an image allows the viewers to picture themselves in that environment and helps convey the sheer scale of the event. Providing context will make your photo more than a souvenir; it will tell a story.

If you have a digital camera or other equipment, you can do even more to enhance your photos:

- Set your exposure to one second initially and adjust from there. A longer exposure means a brighter image, but the moving lights may get blurred.
- Boost your ISO (mine is usually around 3200).
- Use a steady tripod that can handle strong winds.
- Use a wide-angle lens to capture the full view (I use a 16mm, f1.8).

The aurora borealis is the closest thing to magic that I've ever encountered. It reminds me of the vast beauty of our Universe and the responsibility we all share to care for this floating rock we inhabit. If you've always dreamed of seeing this celestial show, believe me — this is the year to do it.



IT'S NOT MAGIC; IT'S MAGNETIC!

The magnetism behind spectacular phenomena

by Kate Howells

Roughly every 11 years, the Sun completes a cycle of heightened and lowered activity. At its peak, called solar maximum, we see more sunspots, stronger magnetic activity, and an increase in solar flares and coronal mass ejections. At minimum, the Sun is calmer and more serene.

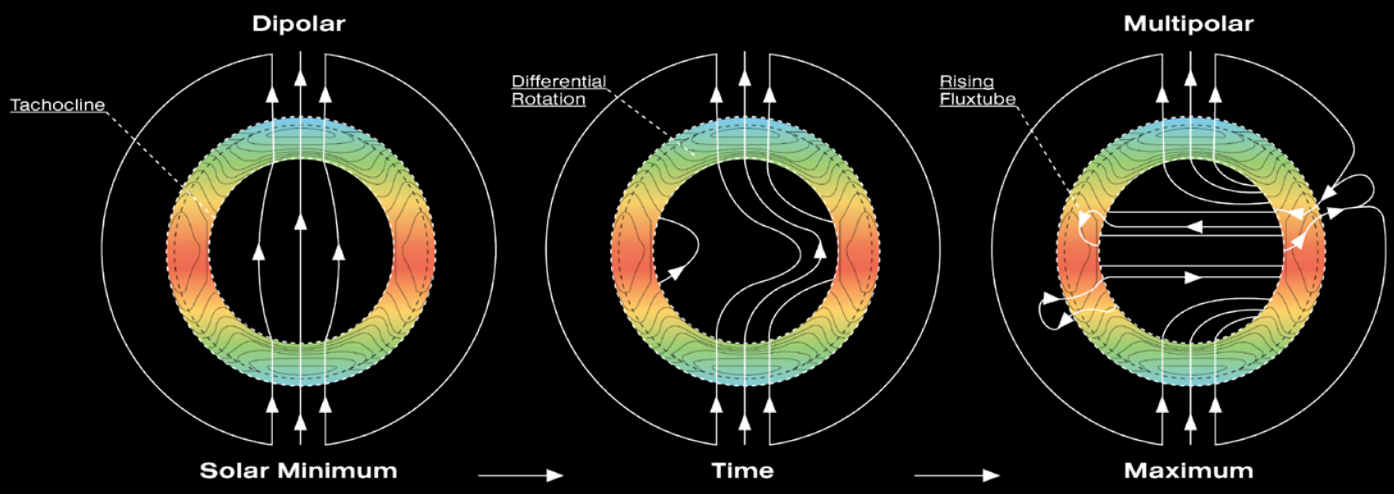
Solar maximum is responsible for some pretty impressive phenomena, from auroras to power blackouts. Behind it all is the powerful, invisible force of magnetism.

The Sun's cycle all has to do with its magnetic field. In a mechanism called the solar dynamo, the movement of plasma within the Sun's different layers creates electric currents, which in turn produce magnetic fields. Because different parts of the Sun move at different speeds as it rotates, those magnetic field lines can get tangled up, forming knots and loops. Those distortions manifest on the Sun's surface as sunspots, solar flares, and coronal mass ejections.

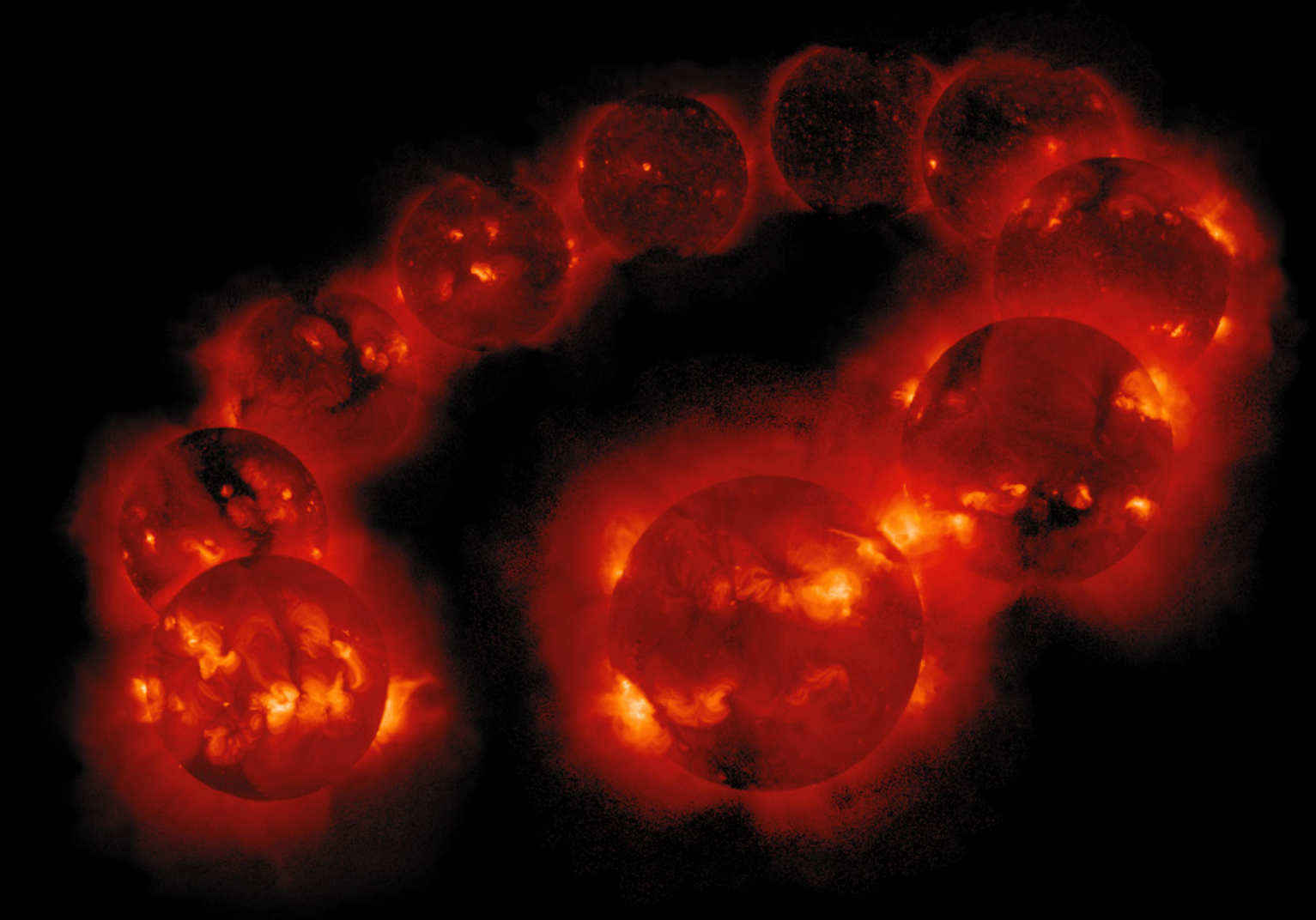
As the Sun's magnetic field lines get more and more tangled, all of this solar activity increases in frequency and intensity, peaking at solar maximum. Eventually, as the tangled field lines reconnect and reorganize, the Sun's overall magnetic polarity flips, and its activity decreases. The Sun reaches solar minimum, and a new cycle begins as the continued movement of the plasma inevitably begins to tangle things up again.

This cyclical process isn't unique to the Sun. Observations of other stars show similar patterns with activity cycles of varying lengths depending on their rotation rate.

Earth's magnetic field is also known to periodically flip polarity, but the mechanism behind this change is very different. Our planet's magnetic field is generated by the movement of molten metals in its outer core, in a process called the geodynamo. These liquid metals move much more slowly than plasma, meaning that Earth doesn't experience the same kind of quick and frequent magnetic reversals that we see on the Sun. The last full polarity flip of Earth's magnetic field happened around 780,000 years ago, and another isn't expected for at least several thousand more years. However, unlike the Sun's reliable cycle, Earth's pole reversals happen at seemingly random intervals, so we aren't sure exactly when to expect it.



Schematic of the solar hydromagnetic dynamo.
Paul Higgins/Arielle Wilkins



This montage of images from Japan's Yohkoh Soft X-Ray Telescope shows the variation in solar activity from August 1991 to September 2001.

Yohkoh/ISAS/Lockheed-Martin/NAOJ/U. Tokyo/NASA

Though our planet's magnetic shifts operate on a vastly different timescale, both the Sun and Earth are governed by the unseen but ever-present forces of magnetism. What's particularly fascinating is what happens when the magnetic forces of Earth and the Sun interact.

When a solar flare erupts from the Sun, the electrically charged particles it sends out into space interact with Earth's magnetic field, which deflects them toward our planet's poles. Here, they collide with atoms in the atmosphere and create the colorful light show we know as the aurora — a magnetic effect truly magical to behold.

An astronaut aboard the International Space Station captured this image of the aurora borealis over Canada. Auroral light is seen as green wisps and spikes. The yellow band above the edge of Earth is instead caused by airglow, a separate phenomenon.

NASA

EXTRATERRESTRIAL LIGHTS

How other worlds experience auroras

by Asa Stahl

We're not the only world with dazzling auroras. Moons, planets, and even comets can have their own light shows, and some are very different from what we have on Earth. Auroras can be big or small, faint or bright, sputtering, steady, and virtually every color of the rainbow. These swirls and arcs often reveal hidden aspects of other worlds, and sometimes, they pose mysteries of their own.

Most auroras in the Solar System are powered by the solar wind: a torrent of charged particles constantly unleashed by our Sun. On Earth, the aurora borealis (northern lights) and aurora australis (southern lights) both get triggered when the solar wind dumps energy into our magnetic field, causing ions to rain down over the north and south poles. When this shower hits our atmosphere, it excites gases like oxygen and nitrogen into giving off an ethereal glow.

But not every aurora works the same way. Though all auroras are powered by charged particles running into something, some don't rely on the solar wind. Others don't depend on thick atmospheres, and a few don't even need strong magnetic fields.

Take Venus. Scientists have seen faint green and blue auroras from our neighboring world, but it has no global magnetic field. Instead, Venus has local magnetic fields that form when the solar wind interacts with ions in the planet's atmosphere. These fields are weak and patchy, but they're still able to capture other solar wind particles and make the sky glow.

Mars takes this one step further: It has no global magnetic field and only a thin atmosphere, but it boasts at least four different kinds of auroras. One appears on the sunlit side of the planet, another extends like ribbons across its skies, and a third is caused by the solar wind getting trapped by weak magnetic fields in the Martian crust. The fourth kind of aurora, which sometimes spreads over the entire planet, was spotted by the Perseverance rover in 2024. This marked the first time an aurora has ever been observed from the surface of another world.

Compared to Jupiter, though, these spectacles are like candles in the wind. Auroras on Jupiter are the most powerful in the Solar System and up to 1,000 times brighter than those on Earth. Though they mostly shine in the ultraviolet and infrared, someone standing atop Jupiter's cloud deck might be able to spot faint colors in its night sky. The glows would look red and possibly also purple and blue because of the hydrogen in the planet's atmosphere.

Unlike Earth, Jupiter's auroras can shine without the solar wind. The bulk of their brightness comes from the fact that while Jupiter rotates — at a breakneck speed of over 43,000 kilometers per

hour (28,000 miles per hour) at some altitudes — its strong magnetic field whips up debris ejected from volcanoes on its moon Io. This channels electrons down toward the planet's poles, where they trigger ring-shaped auroras. Sometimes, these rings are also joined by bright spots, each one powered by a magnetic connection between Jupiter and one of its moons.

Some of these moons have their own auroras too. On the volcanic moon Io, auroras could even appear as a full-color rainbow. Astronomers expect this world's skies to glow red from sulfur and oxygen, orange-yellow from sodium, green from oxygen, and blue from sulfur dioxide.

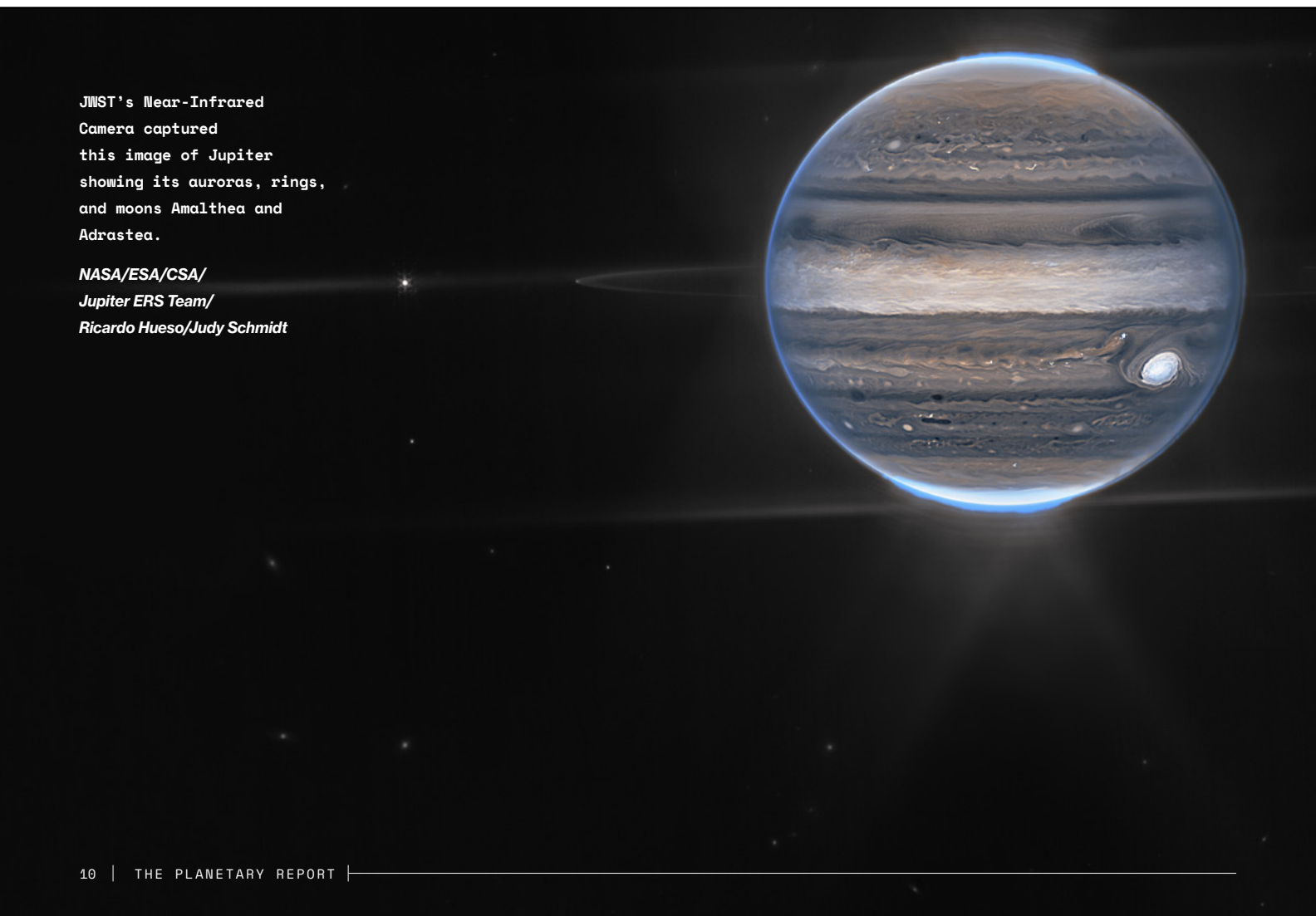
The moons Europa and Ganymede have auroras that are spectacular in a different way: Each provides a strong sign of a vast, hidden ocean. The trick is that auroras, like the charged particles that make them, follow patterns in magnetic fields. As Jupiter's magnetic field changes, it gives rise to electric currents in the water of these buried oceans, and those currents then generate their own magnetic fields. By watching the auroras on Ganymede and Europa, scientists concluded both moons are very likely to have subsurface oceans — in Europa's case, a potentially habitable ocean.

Saturn's auroras are a lot like those on Jupiter. It has glowing rings wrapped around its poles, plus occasional spots and arcs from connections with its moons. To the naked eye, these auroras might look like a pink glow with purple streaks.

Auroras on Uranus and Neptune may be the most mysterious in the Solar System. Since the magnetic fields of these ice giants are tilted and off-center, they tend to interact with the solar wind in odd ways, making for sporadic auroras in a variety of places on both planets. But Uranus and Neptune are also far enough away from the Sun that the solar wind tends to affect them less. This makes their auroras weak and, for the most part, unexplored.

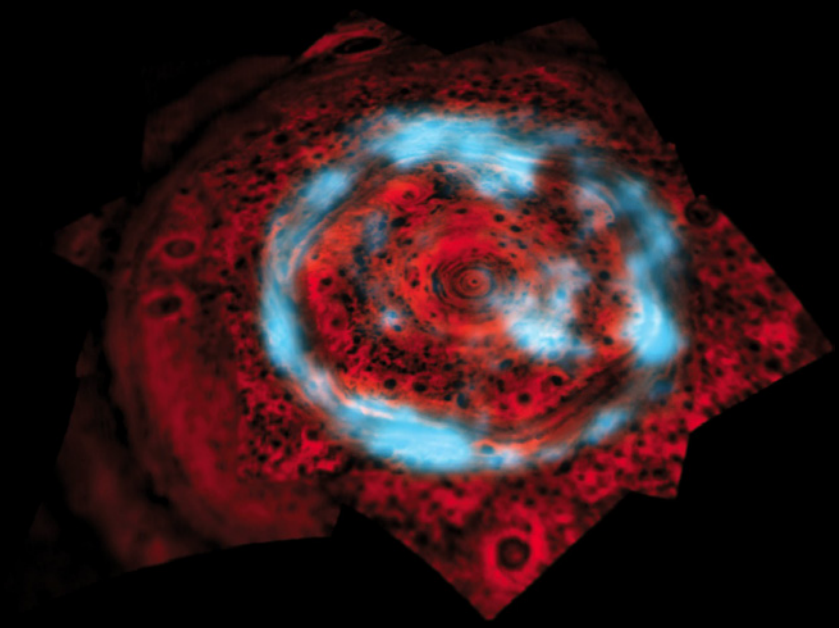
Then there are the oddballs. For instance, worlds that are not quite massive enough to become stars, called "brown dwarfs," could also have auroras. Since brown dwarfs tend to have strong magnetic fields and rotate quickly, all they would need is a source of charged particles, like a volcanic planet, to produce auroras even brighter than Jupiter's.

It gets weirder. Using data from the European Space Agency's Rosetta spacecraft, scientists have found auroralike radiation coming



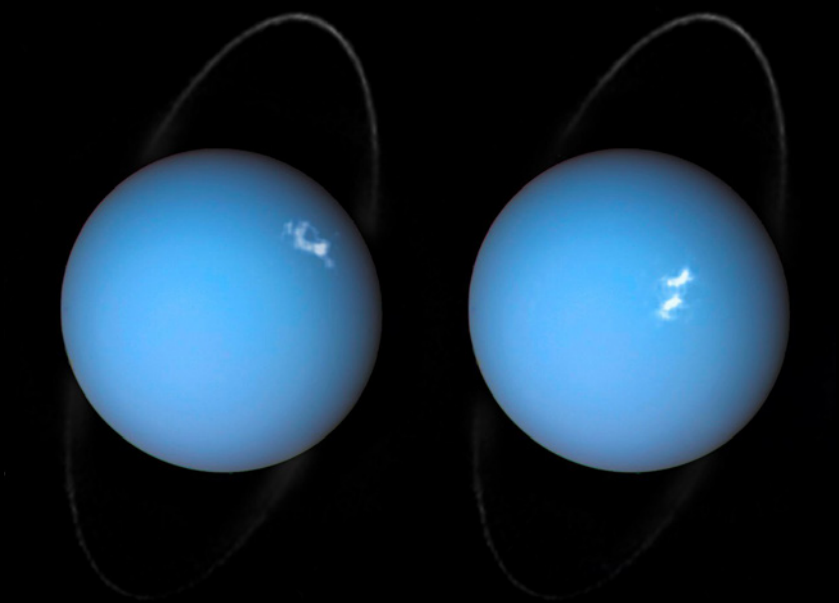
JWST's Near-Infrared Camera captured this image of Jupiter showing its auroras, rings, and moons Amalthea and Adrastea.

NASA/ESA/CSA/ Jupiter ERS Team/ Ricardo Hueso/Judy Schmidt



Saturn's north pole is shown here at two different wavelengths of infrared light. Blue corresponds to the aurora and red to the hexagonal storm in the atmosphere below. The image was captured by NASA's Cassini spacecraft.

NASA/JPL/University of Arizona



Here Uranus is seen in visible light, as imaged by NASA's Voyager 2 probe, overlaid with ultraviolet observations of the planet's aurora taken by the Hubble Space Telescope.

ESA/NASA/L. Lamy/Observatoire de Paris

from the comet 67P/Churyumov-Gerasimenko. Though the comet has no significant magnetic field, solar wind particles still collide with it and trigger ultraviolet and X-ray glows.

Or take Mercury, a planet whose atmosphere is too thin to have conventional auroras. The solar wind often makes particles rain down on Mercury's surface, exciting molecules on the ground to emit light. The process isn't so different from how the solar wind causes showers of charged particles on Earth, but instead of hitting a planet's atmosphere, the particles smack straight into its surface. Does that still technically count as auroras?

Questions like this continue to surprise scientists. The glows on Mercury were only confirmed by the joint European-Japanese BepiColombo mission in 2023, while comet auroras first made the news in 2020. There might still be other undiscovered auroras out there, waiting to tell us more about their worlds. And since these lights get more intense at solar maximum, when the solar wind is strongest, now is the time when our clues are shining brightest.

NOT TOO HOT TO HANDLE

How a spacecraft is able to touch the Sun

by Kate Howells

NASA's Parker Solar Probe is one of the most daring missions in the Solar System.

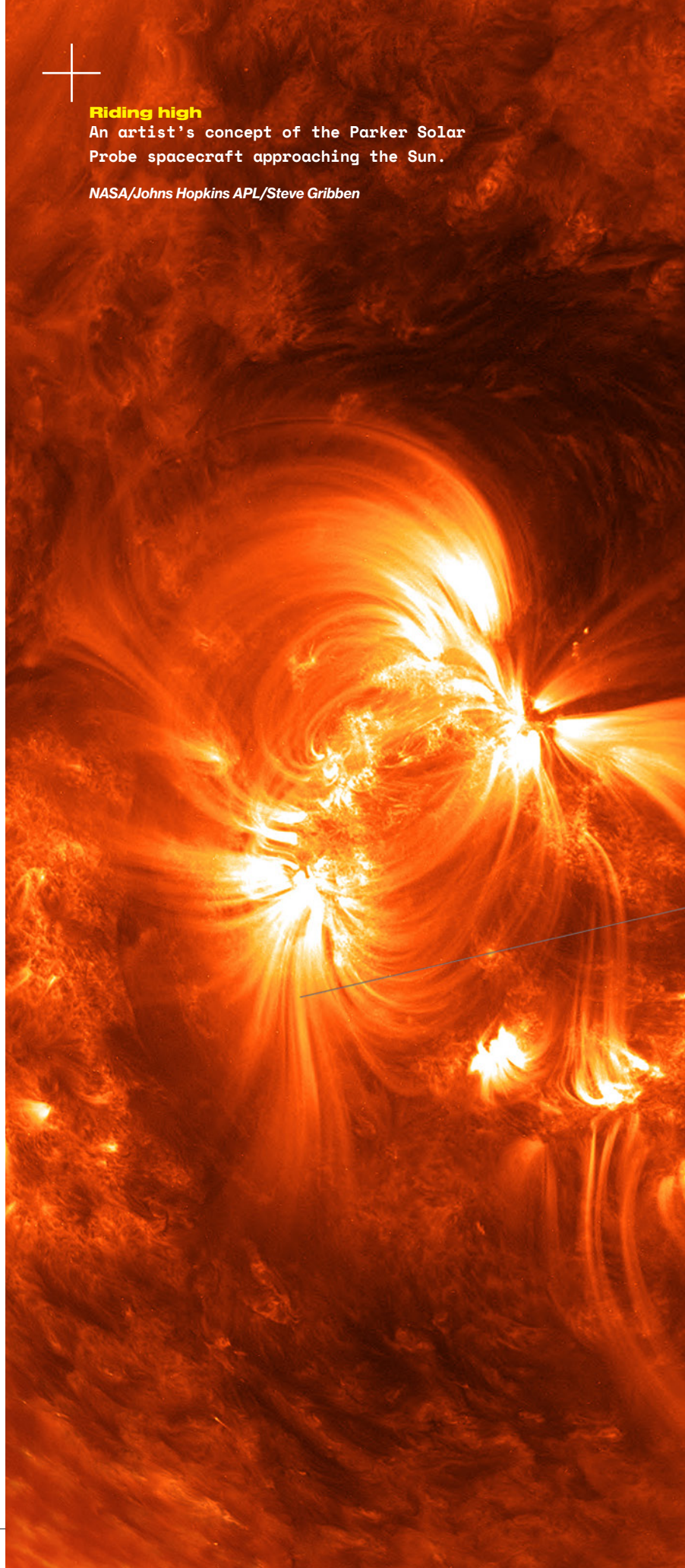
Led by the Applied Physics Laboratory at Johns Hopkins University, the mission made history in 2021 when it became the first spacecraft to touch part of the Sun. It flew 13 million kilometers (8.1 million miles) above the Sun's surface, passing through and sampling the outer atmosphere, called the corona. In September 2022, it passed through one of the most powerful coronal mass ejections ever recorded, becoming the first spacecraft ever to do so. And in December 2024, the probe went even closer to the Sun, flying 6.1 million kilometers (3.8 million miles) above the surface, nearly 10 times closer than Mercury's orbit.

This close to the Sun, temperatures can reach nearly a million degrees Celsius (over a million degrees Fahrenheit), even hotter than the Sun's surface.

The question that naturally arises is: How can anything survive temperatures that high?

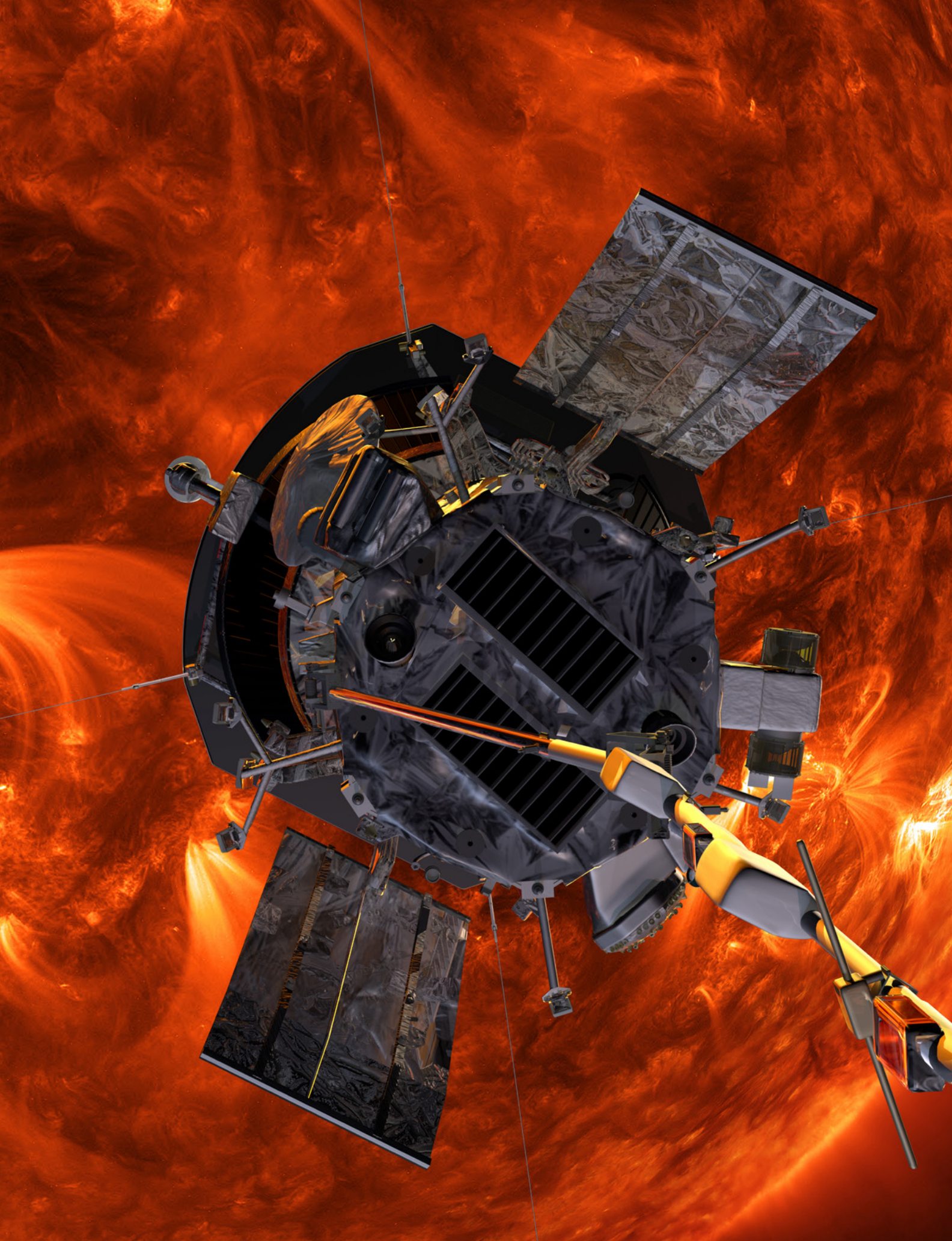
"People started thinking about building a probe to fly close to the Sun back in the late '50s," said the mission's project scientist Nour Rawafi in an interview with Planetary Radio host Sarah Al-Ahmed. "But it took us over six decades to get to the point technologically where we could build a spacecraft robust enough to withstand the harsh environment around the star. It's probably one of the harshest environments you can ever fly through."

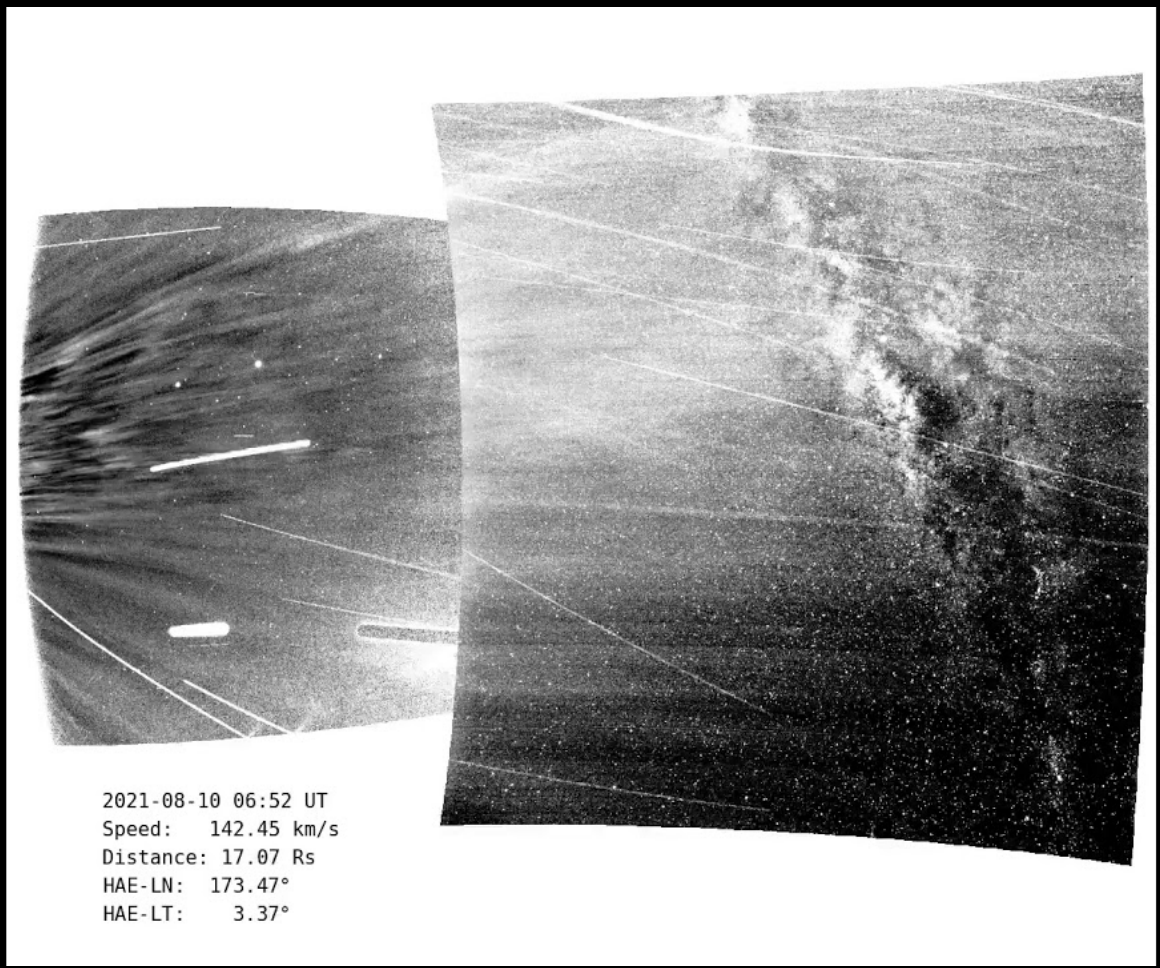
One crucial component of Parker Solar Probe's death-defying stunt is its heat shield. It is about 11.5 centimeters (4.5 inches) thick and made of carbon composite foam sandwiched between two



Riding high
An artist's concept of the Parker Solar Probe spacecraft approaching the Sun.

NASA/Johns Hopkins APL/Steve Gribben





NASA's Parker Solar Probe captured this view of the Milky Way as it flew through the Sun's corona in 2021. Solar particles can be seen flying past as white streaks.

NASA/Johns Hopkins APL

When Parker Solar Probe made its close pass in December 2024, it broke another record. As it whizzed past the Sun, it was traveling at over 190 kilometers per second (about 120 miles per second) — the fastest that any human-made object has ever moved.

carbon plates, painted white to reflect as much heat as possible. As it passes the Sun, the spacecraft's autonomous systems keep it oriented so that the heat shield is always between the probe and the Sun.

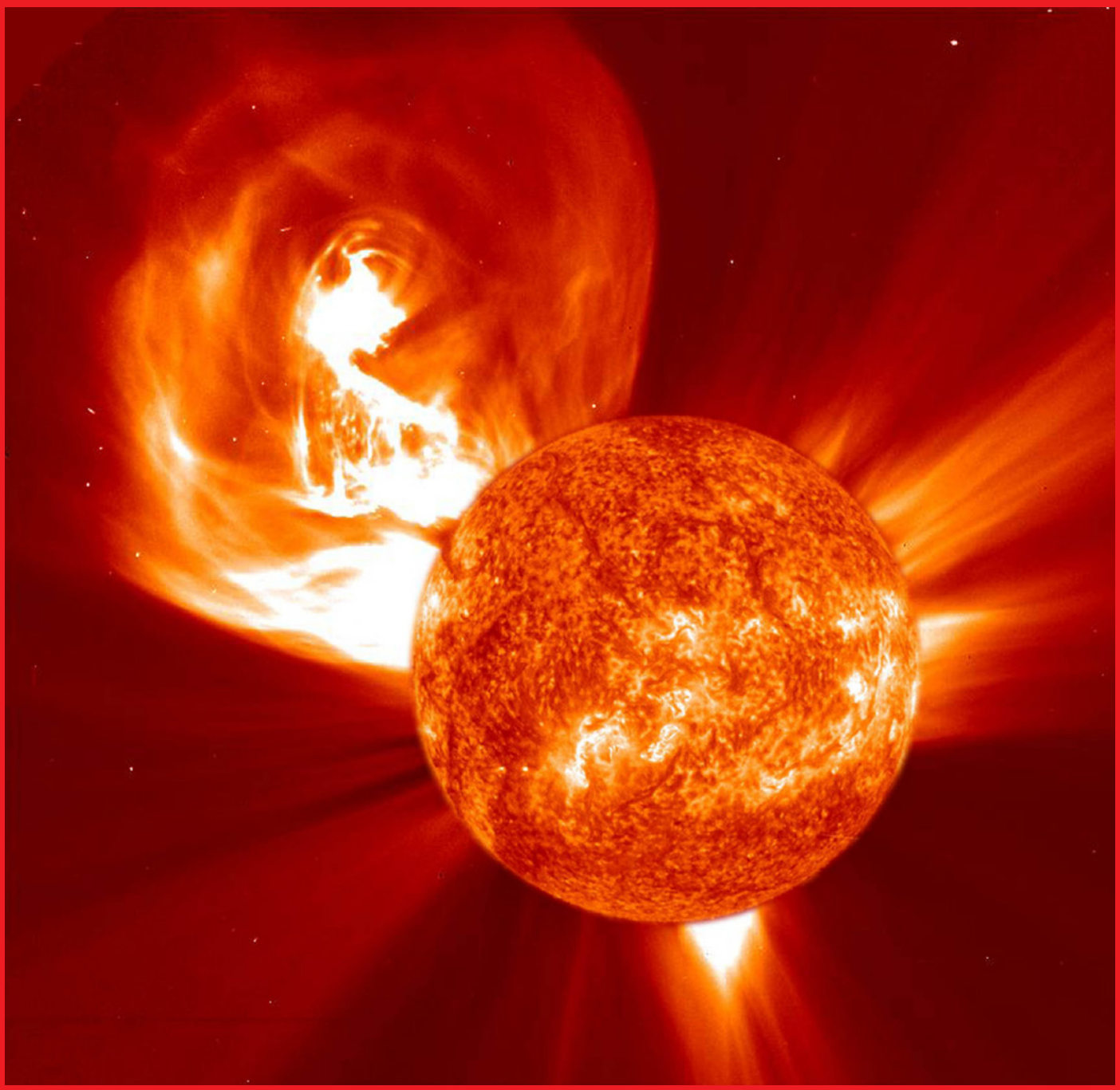
Another factor that helps make the mission possible is the nature of how heat is transferred in the vacuum of space. The Sun's corona has very low density, meaning that there aren't a lot of particles that can transfer heat. So although the overall temperature in the corona is around a million degrees, Parker Solar Probe's heat shield is predicted to only get heated to a maximum of about 1,400 degrees Celsius (about 2,500 degrees Fahrenheit) during its closest passes.

Before flight, the heat shield was tested to withstand temperatures up to 1,650 degrees Celsius (3,000 degrees Fahrenheit). Although this might seem paltry if you'd been imagining a shield capable of handling million-degree temperatures, it is still an extraordinary feat. Parker Solar Probe's heat shield would even survive direct contact with the hottest lava on Earth.

"The heat shield is the key technology that enabled the whole mission," said Rawafi. "But, wherever you look on this spacecraft, there is cutting-edge technology." And nearly seven years after launching, that technology is still performing well.

"The spacecraft is very healthy, knock on wood. We launched in 2018 when the Sun was very quiet, and we'll end the prime mission [in 2025] at solar maximum. Hopefully, we'll extend it to cover the whole solar cycle and go beyond that."

As Parker Solar Probe continues its mission to get up close and personal with the Sun, we can surely expect some more astounding feats of exploration.



This composite image from NASA and ESA's Solar and Heliospheric Observatory shows an enormous coronal mass ejection.

SOHO/ESA/NASA

THE LIGHTSAIL MISSION: FROM CONCEPT TO REALITY

LightSail 2 high-resolution deployment sequence
These high-resolution images were captured by LightSail 2's camera during sail deployment on July 23, 2019. The sail appears slightly curved due to the spacecraft's 185-degree fisheye camera lens; no corrections have been made to the pictures.
The Planetary Society

How a grassroots movement sailed on sunlight

by Jason Davis

This year, The Planetary Society celebrates its 45th anniversary. Since 1980, the Society has been empowering members to advance space science and exploration through public education, political advocacy, innovative science and technology projects, and international collaborations. One particular effort has been ongoing for much of the organization's history: solar sailing. In 2019, LightSail 2 succeeded at using sunlight alone to change its orbit around Earth, achieving a goal that The Planetary Society had been working toward since its very beginnings.

The concept of sailing on sunlight stretches back much farther than our organization. After observing Halley's Comet in 1607, Johannes Kepler mused that people might one day surf on the same force that causes a comet's tail to spread: "Provide ships or sails adapted to the heavenly breezes, and there will be some who will brave even that void."

It would take centuries for Kepler's romantic idea to get serious consideration. In the 1970s, engineer Jerome Wright discovered that a spacecraft propelled by the gentle push of sunlight might be able to rendezvous with Halley's Comet in 1986, marking a full-circle moment for the concept.

NASA was interested and funded a Halley solar sail spacecraft study. One of the engineers on the project was Louis Friedman, who would later become a co-founder of The Planetary Society. The spacecraft's eventual design resembled two spinning ceiling fans stacked on top of one another, each with six blades measuring more than 6 kilometers (4 miles) long. Ultimately, the design was deemed too ambitious, and the U.S. did not send a mission to Halley's Comet.

In 1980, Friedman, Carl Sagan, and Bruce Murray founded The Planetary Society. All three were solar sail enthusiasts, with Murray having supported the Halley sail study when he was the director of NASA's Jet Propulsion Laboratory and Sagan having written a popular article about the concept for Parade magazine.

As an independent, nongovernmental group, The Planetary Society was able to forge connections with Soviet scientists during the Cold War. After the fall of the Soviet Union, Russia converted some of its submarine-launched missiles into satellite launchers under the name Volna (Russian for "wave"). In 1999, the Society's Russian colleagues came to them with a proposal: Work with us to build a solar sail and we'll fly it on the Volna. Thus was born Cosmos 1, the world's first solar sail spacecraft.

Cosmos 1 was equipped with eight triangular solar sails held rigid by inflatable booms approximately 15 meters (50 feet) long. Each sail could be individually tilted, allowing the spacecraft to maneuver and track the Sun. The Society's contribution to the mission was funded by members as well as Cosmos Studios, a venture by Carl Sagan's widow, Ann Druyan.

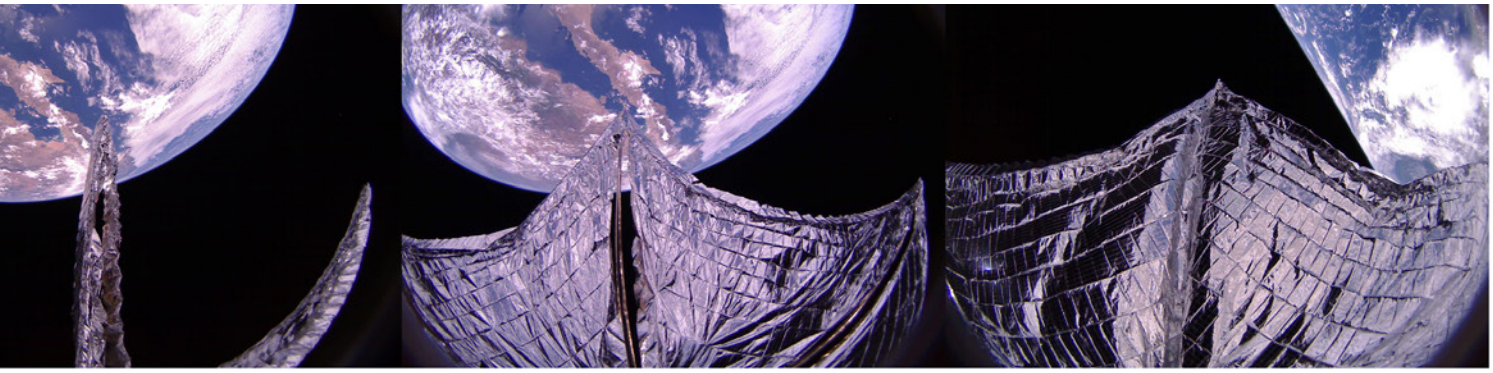
A 2001 test flight using a scaled-down version of Cosmos 1 ended with a Volna mishap. The full-scale Cosmos 1 launched in 2005, but its Volna rocket failed 82 seconds after launch, sending the solar sail plummeting into the sea.

NASA reentered the solar sailing game in 2008 with NanoSail-D, a technology demonstration aimed at deploying a solar sail from a CubeSat — a small, modular spacecraft the size of a loaf of bread. Like Cosmos 1, the flight of NanoSail-D ended prematurely due to a rocket mishap when its SpaceX Falcon 1 failed to reach orbit.

For a time, NASA considered giving a NanoSail-D flight spare to The Planetary Society. That effort stalled, so the Society decided to develop its own similar mission called LightSail.

Like NanoSail-D, the spacecraft would be based on a three-unit CubeSat. Unlike NanoSail-D, LightSail would be equipped with attitude control, cameras, and two-way communication. And unlike Cosmos 1, LightSail would be a mission undertaken entirely by The Planetary Society, not just as a partner.

Starting in 2009, the LightSail program was funded by members, donors, and 23,500 Kickstarter backers.



The initial spacecraft development was completed in 2012, and in 2015, LightSail 1 hitched a free ride to orbit aboard an Atlas V rocket. It successfully tested the deployment of its sails and beamed an image of those sparkling sails home to Earth.

LightSail 2 lifted off in 2019 aboard a SpaceX Falcon Heavy, flying to a high enough orbit where the gentle push from sunlight could combat atmospheric drag. During its three-year mission, it became the first small spacecraft to successfully demonstrate controlled solar sailing and was the first to do so in Earth orbit, even raising its orbit some of the time.

From Kepler's celestial musings to LightSail 2's triumphant flight, The Planetary Society's solar sail story has been one of ambition, setbacks, and perseverance. What began as a mission to the world's most famous comet evolved into a crowdfunded spacecraft that soared gracefully around the world, carrying humanity a little closer to harnessing the push of sunlight for space exploration.

Sailing through the Sun
The United Launch Alliance Atlas V rocket carrying The Planetary Society's LightSail 1 spacecraft slips through a sunbeam en route to orbit in 2015.

Josh Spradling / The Planetary Society

NEEDLES IN THE HAYSTACK

How advanced amateurs defend Earth from asteroids

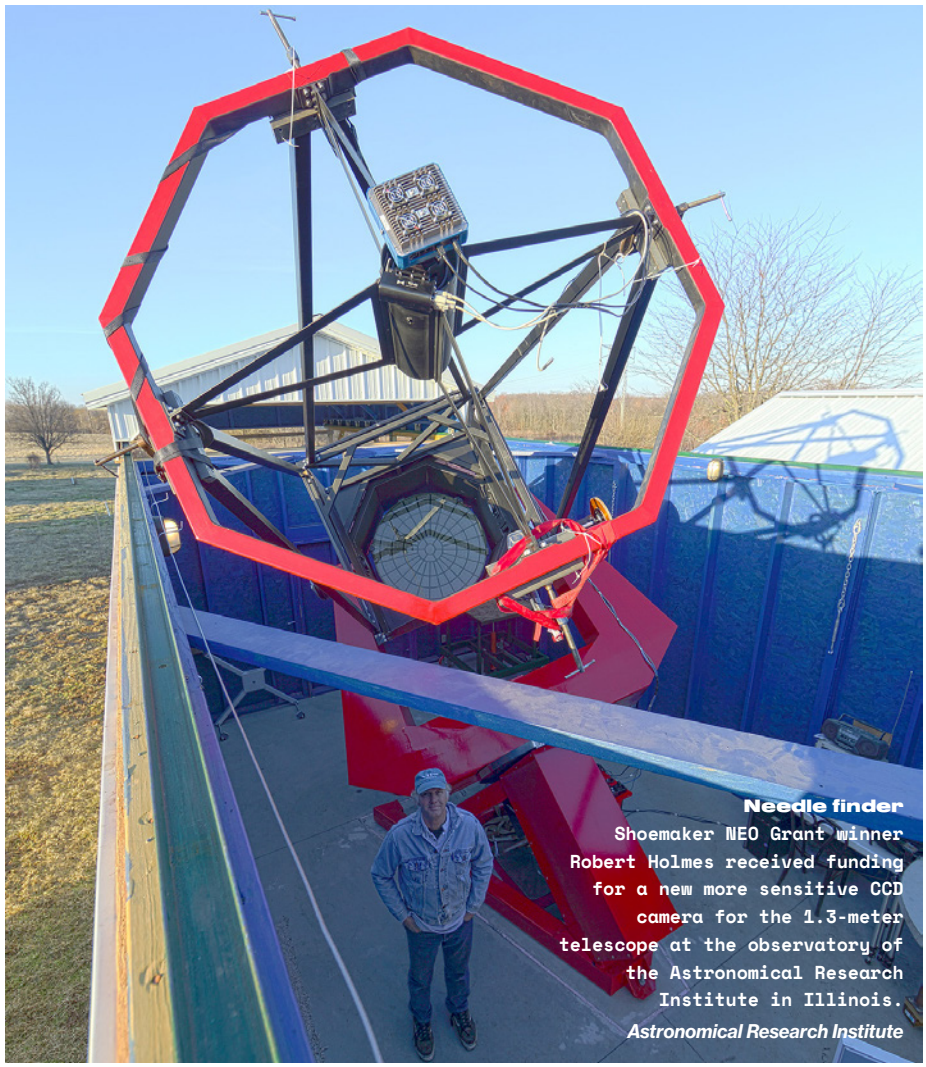
by Asa Stahl

For nearly 30 years, The Planetary Society has supported a global network of amateur astronomers dedicated to finding, tracking, and studying potentially dangerous asteroids. If our planet were hit by just one of these objects — say, one as big as a 50-story building — the explosion could be as powerful as several nuclear bombs and could leave behind a crater as wide as the Grand Canyon.

Over 10,000 asteroids at least this big are known to pass near Earth. Though none have any chance of hitting us in the near future, experts still worry about the ones we haven't found yet.

This is why The Planetary Society began awarding grants to amateur asteroid hunters in 1997. Back then, only a few hundred near-Earth objects (NEOs) of any size had been found, and even the truly gigantic asteroids were only about 20% discovered.

Our Shoemaker NEO Grants help people, most of whom volunteer their time and resources, to fight this threat. We solicit proposals from proven observers with already impressive telescopes and award the best with grants to fund their requested upgrades to their equipment so they can better hunt for asteroids. As of today, our grants have helped discover nearly 500 NEOs and powered detailed investigations of over 19,000 more. Again and again, our awardees have helped humanity learn whether anything out there is on a collision course with Earth.



Needle finder Shoemaker NEO Grant winner Robert Holmes received funding for a new more sensitive CCD camera for the 1.3-meter telescope at the observatory of the Astronomical Research Institute in Illinois. *Astronomical Research Institute*

"Though most awardees are technically amateurs, their experience and their facilities allow them to fill crucial roles in planetary defense," said Bruce Betts, chief scientist at The Planetary Society.

No two winners are exactly alike. Shoemaker Grants have supported everyone from a lone college student in China to entire astronomy clubs in Italy. One recipient in rural Illinois started as a backyard stargazer and is now funded in part by NASA because of his crucial asteroid follow-up observations. Nearly half of our grantees have their own asteroids named after them. Amazingly, most help defend our planet on the side while working around full-time jobs.

"Thanks to our members supporting our grants program, the awardees are able to make significant contributions to asteroid tracking, characterization, and discovery," Betts said.

Until 2005, Shoemaker Grants were one of only a handful of programs dedicated to discovering asteroids. Then, planetary defense began to hit the mainstream. The U.S. Congress instructed NASA to discover 90% of all NEOs beyond a certain size, and around the same time, ground-based surveys began finding hundreds of new NEOs per year. Soon, professional facilities were dominating the number of NEO discoveries.

But amateur astronomers have had as much to do as ever. Since discovering an asteroid is only useful if you're able to find it again later, taking follow-up observations is crucial. That's where everyday astronomers "really shine," said Amy Mainzer,

professor in the Department of Earth, Planetary, and Space Sciences at the University of California Los Angeles.

According to Mainzer, having these contributions come from all around the world makes a big difference. Since Shoemaker award winners span almost 25 countries and six continents, there's a good chance one is available to watch an asteroid on short notice. And even when an asteroid is not expected to hit anytime soon, the more eyes we have on it, the more powerful its discovery.

"That's the beauty of it," Mainzer added. "You can actually do quite a lot with a pretty modest-size telescope."

Now, a new mission stands to benefit from asteroid hunters more than ever. NASA's NEO Surveyor, set to launch in 2027, intends to finally reach the goal Congress set 20 years ago and discover up to 300,000 new NEOs. But the spacecraft will not be able to track a lot of what it finds for very long. Others, like our Shoemaker Grant winners, will have to step up to fill the gap.

"Planetary defense is a team sport," said Mainzer, who is the principal investigator for NEO Surveyor. "We really rely on all of our follow-up observers all over the place."

Shoemaker awardees will also study many of these worlds in more detail. By measuring the shape of an individual asteroid or how fast it rotates, they often help scientists better understand asteroids throughout the Solar System. If a dangerous asteroid were ever on track to hit Earth, knowing these properties would be crucial to redirecting it.

The sooner we make these discoveries, the better. We're still far away from the day when we discover the last asteroid that might pose a threat to our planet. Until then, Shoemaker Grants and the everyday heroes they support will continue to watch the skies.

FROM THE CHIEF SCIENTIST

A cosmic roundup from The Planetary Society's chief scientist

by Bruce Betts

IN THE SKY

In the evening sky, reddish Mars is in the west, getting closer to the horizon as the weeks pass. Mercury is low in the early evening west from mid-June to mid-July. Yellowish Saturn rises in the late evening in June. It rises earlier as the weeks pass so that by late September, it rises around sunset. In the predawn sky, super-bright Venus is in the east. Very bright Jupiter joins it in July, moving higher up as the weeks pass. Venus and Jupiter are very close together on Aug. 11-12, after which Jupiter will appear above Venus. Mercury is below them in mid to late August. The Perseid meteor shower, usually one of the top meteor showers of the year, peaks Aug. 11-12, with increased activity several days before and after. This year, a nearly full Moon will wash out many of the fainter meteors. A total lunar eclipse on Sept. 7 will be visible from Asia, Australia, and portions of Africa and Europe. On Sept. 21, a partial solar eclipse will be visible over southern Australia and Antarctica.

For more night sky tips, you can always check out planetary.org/night-sky.

TRIVIA CONTEST

Our December Solstice contest winner is Robert Skwierawski of Nottingham, U.K. Congratulations!

The question was: *Who has spent the most time in space (over multiple missions)?*

The answer: *Oleg Dmitriyevich Kononenko spent 1,111 days in space over five missions. He broke the previous record during his 2024 stay on the International Space Station.*

Try to win a copy of the new book "Mars: The Red Planet with The Planetary Society" by Bruce Betts and a Planetary Radio T-shirt by answering this question:

Which of the 88 standard (IAU) constellations are named after marine mammals?

Email your answer to planetaryreport@planetary.org or mail your answer to The Planetary Report, 60 S. Los Robles Ave., Pasadena, CA 91101. Make sure you include the answer and your name, mailing address, and email address (if you have one). By entering this contest, you are authorizing The Planetary Report to publish your name and hometown. Submissions must be received by Sept. 1, 2025. One entry per person. The winner will be chosen in a random drawing from among all the correct entries received.

RANDOM SPACE FACT

The time for light to reach Earth from the Sun is approximately the length of the Led Zeppelin song "Stairway to Heaven," about eight minutes.

Danielle Rose Baker

SEEING SPOTS

Danielle Rose Baker

Planetary Society member Danielle Rose Baker made this watercolor painting of an X-class solar flare, based on an image captured at Sacramento Peak in New Mexico. "I painted this on a work trip, several hundred miles from my home and studio," said Danielle. "I created the Sun's texture using table salt over wet paint and added sunspots in ink and marker."

DO YOU WANT TO SEE YOUR ARTWORK HERE?

We love to feature our members throughout this magazine.

Send your original, space-related artwork to connect@planetary.org.

WHAT HAPPENED IN WASHINGTON

The Planetary Society's political advocacy in the first part of 2025

by Jack Kiraly

Members gathered in Washington, D.C., on March 24, 2025, to meet with their representatives in support of NASA science funding.
Tushar Dayal for The Planetary Society

In early February, it was announced that the Trump administration was planning to abruptly lay off more than 1,000 recently promoted and early career scientists, engineers, and space professionals, all classified as "probationary employees." Responding swiftly, The Planetary Society mobilized more than 1,000 advocates to send letters to their legislators and the White House in less than 72 hours. The layoffs didn't occur, demonstrating the power and necessity of grassroots advocacy.

Soon thereafter, a new challenge crested the horizon. Rumors began circulating in early March that NASA's Science Mission Directorate (SMD) may be facing catastrophic budget cuts — potentially as much as 50% in fiscal year 2026. The Planetary Society was the first space organization to act, mobilizing advocates from across the country to send nearly 16,000 letters opposing further cuts to NASA and reaffirming public support for the scientific exploration of space.

It was under these unprecedented circumstances that more than 100 advocates from 27 states arrived in Washington, D.C., in late March for The Planetary Society's annual Day of Action, making this year's event the largest in-person advocacy gathering in our organization's history.

Advocates voiced a critical message: NASA works. Participants highlighted the agency's profound scientific, economic, and cultural impacts, emphasizing the exceptional return on investment. Every dollar invested in NASA generates three dollars back into the U.S. economy, supporting over 300,000 jobs nationwide and enabling near-daily advancements in science and technology.

First-time participants Mike Pereira and Su-Zette Sparks from New Mexico initially felt nervous about meeting with legislators, yet they quickly found confidence thanks to comprehensive resources provided by The Planetary Society. "The economic impact handouts for our state and district were fantastic," they said. "It was incredibly empowering, especially in these fraught political times, to see our voices truly being heard."

Similarly, Ariel Gozlan from Florida reflected enthusiastically on his first advocacy experience: "The Planetary Society has always inspired me, from championing VERITAS and New Horizons to supporting Europa Clipper and Cassini. It was an honor advocating alongside this team. I'm now more convinced than ever of the importance of this work."

Indeed, the urgency is clear. In April, leaked documents indicated the administration was preparing a budget that included a staggering 47% budget cut to NASA's Science Mission Directorate. If enacted, this would represent an extinction-level event for the U.S. space science enterprise.

Despite this serious threat, the Day of Action showcased amazing resilience and unity among advocates. They passionately conveyed that NASA's mission transcends politics, embodying humanity's shared desire for discovery and knowledge.

This crisis is still unfolding at the time of writing. I hope you will stand with us during these challenging times when so much is on the line. If you've never spoken up or written to your elected officials about your enthusiasm for space exploration, now's the time. Our aim, and my personal goal, is to make civic activism as easy as possible.

To see the latest developments and get involved, go to planetary.org/save-nasa-science.

CELEBRATING OUR SUPPORTERS

On April 5, Planetary Society members and special guests came together at the Cosmic Shores Gala to celebrate the organization's 45th anniversary, our achievements over the years, and the invaluable role of our members who make it all possible.

A highlight of the event was the presentation of the C. Wallace Hooser Award for Visionary Philanthropy to Taner Halicioglu.

To receive this award, one must have a track record of exceptional generosity in advancing space science, exploration, and education. They must also demonstrate outstanding civic responsibility and inspire others to take philanthropic leadership roles. Most importantly, they must share their time, talent, and treasure in a manner consistent with the example set by longtime Planetary Society board member Wally Hooser.

Taner Halicioglu exemplifies all of these qualities and more. Taner's contributions to philanthropy have been nothing short of transformational. In 2017, he made a landmark $75 million gift to establish the Halicioglu Data Science Institute at UC San Diego, ensuring the advancement of data science education and research. He expanded that commitment in 2024 with a $25 million pledge to help build the Triton Center, a central hub for students, alumni, and visitors. He founded the Halicioglu Family Foundation, which supports causes ranging from COVID-19 relief to animal welfare. He also launched the Data Science Alliance, a nonprofit that uses data science and AI to drive meaningful change in communities.

Taner's passion for exploration extends beyond Earth. Since 2014, he has been a dedicated supporter of The Planetary Society, making nearly $5 million in early contributions to advance space science. In 2021, he became the lead donor for our Beyond the Horizon campaign, making an extraordinary $9 million gift to propel the Society's vision forward.

Through his generosity, leadership, and vision, Taner Halicioglu embodies the spirit of the C. Wallace Hooser Award for Visionary Philanthropy.

Planetary Society board chairman Dan Geraci (left) presenting the C. Wallace Hooser Award to Taner Halicioglu (right).

The Planetary Society

PLANETVAC IS ON THE MOON!

On March 2, 2025, Firefly Aerospace's Blue Ghost lander touched down on the Moon. The privately developed mission, funded through NASA's Commercial Lunar Payload Services program, carried several scientific instruments and experiments. It also carried PlanetVac, a sample collection technology developed by Honeybee Robotics with support from The Planetary Society.

In 2013 and 2018, Planetary Society members and supporters funded crucial tests that helped refine PlanetVac's sample collection system and prove it was ready for real space missions.

PlanetVac's tests on the Moon were just the beginning. NASA has also agreed to provide a modified PlanetVac to Japan's Martian Moons eXplorer mission (MMX). MMX will launch in 2026 to collect samples from Mars' moon Phobos. The samples from PlanetVac and another collection instrument will return to Earth in 2031 and are expected to reveal where the moon came from and other insights about early Mars.

The lunar PlanetVac instrument is seen here on the end of Blue Ghost's surface access arm shortly after landing on the Moon.

Firefly Aerospace

One for the road

This total solar eclipse photo was captured during a 2019 expedition to Chile.

Julia Icenogle

SOCIETY TRAVEL

We invite you to join other members and friends of The Planetary Society to discover the world on a Betchart Expeditions adventure!

Please contact Terri or Taunya at Betchart Expeditions for brochures and updated information. Call 1-800-252-4910 or email info@betchartexpeditions.com.

Aug. 26 – Sept. 10, 2025

MAGNIFICENT MADAGASCAR & LUNAR ECLIPSE

Explore the unique heritage of Madagascar and see the lunar eclipse and the spectacular southern skies! Isolated from the African continent for over 30 million years, Madagascar is home to fauna and flora found nowhere else!

Nov. 11–20, 2025

EASTER ISLAND & LEONIDS METEOR SHOWER

Come join this adventure to Easter Island, including cultural and astronomical sites in Santiago, Chile, and see the Leonid meteor shower over Easter Island. Learn about the heritage of this unique culture while exploring the major sites. We'll rise early during the meteor shower peak to watch the numerous streaks of this celestial light show from one of the most remote locations on Earth!

Aug. 3–13, 2026

MAJORCA, SPAIN & TOTAL SOLAR ECLIPSE

We invite you to join our Spain total solar eclipse adventure, including special visits to Madrid's historic Royal Observatory, the Castile La Mancha Science Museum in Cuenca, the remarkable City of Arts and Sciences center in Valencia, and the enchanting Mediterranean island of Majorca to see the total solar eclipse at sunset!

Aug. 8–16, 2026

WILD ICELAND & TOTAL SOLAR ECLIPSE

Come with us to discover the "land of fire and ice" in all its great beauty and see the total solar eclipse from Iceland's remote Westfjords. Spend days outdoors with long hours of sunlight exploring the striking waterfalls, fjords, lava fields, hot springs, and charming small villages. With leadership by an excellent Icelandic naturalist and astronomer, this will be a memorable outdoor adventure!

THE PLANETARY SOCIETY
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ADVANCE THE SEARCH FOR NEAR-EARTH OBJECTS

As a member of The Planetary Society, you support a global network of amateur astronomers dedicated to finding, tracking, and studying potentially dangerous asteroids.

You can further help advance the search for these near-Earth objects with a gift of any amount in support of our Shoemaker NEO Grant program today. Plus, when you make a gift, a fellow Society member who cares deeply about planetary defense will match your gift dollar for dollar, up to a total of $25,000.

Visit **planetary.org/neo** to make your contribution today!