Space News Update

— February 18, 2020 —

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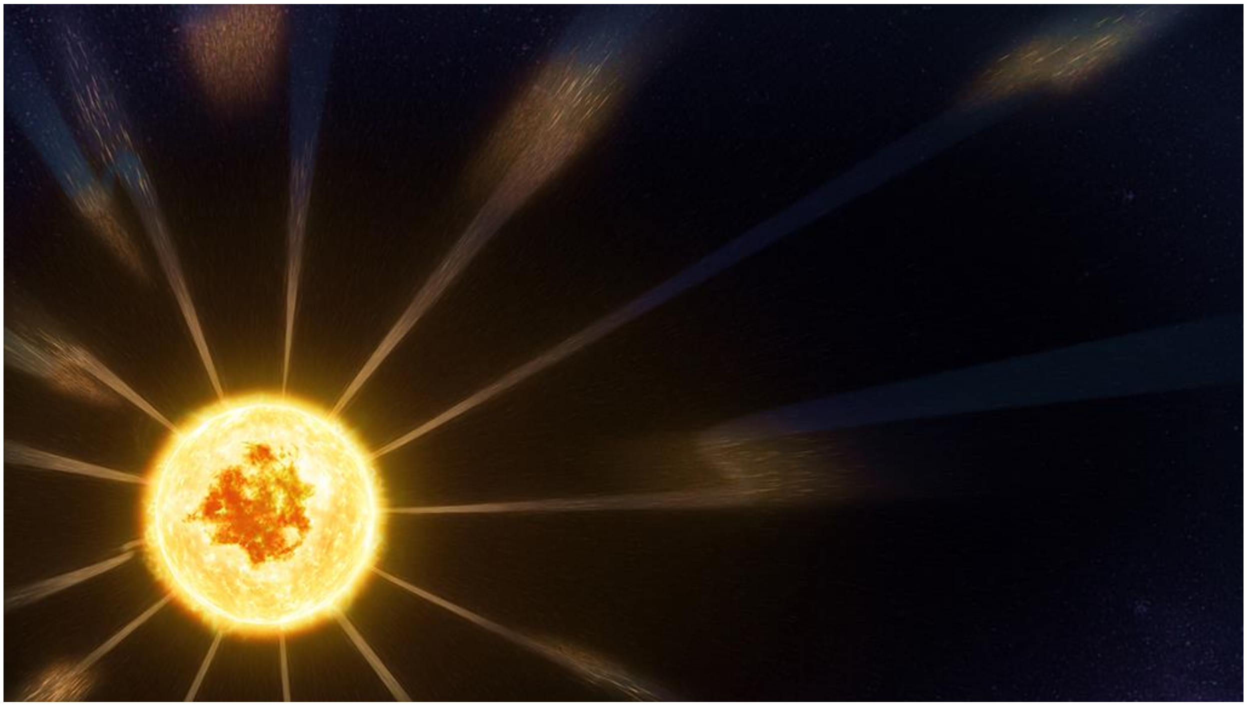
In the News

Departments

1. Parker Solar Probe Releases New Details on Solar Wind



An artist's depiction of rogue waves, aka switchbacks, in the solar wind.
NASA / Conceptual Image Lab / Adriana Manrique Gutierrez

As one solar mission — Solar Orbiter — lifted to the skies last week, scientists released results (a whole lot of 'em) from another mission to the Sun. NASA's Parker Solar Probe has passed well within Mercury's orbit four times now to explore the birthplace of the solar wind, a stream of charged particles that ultimately flow by and even onto Earth.

Scientists present results from the first two perihelion passes in a total of 52 articles in a special issue of the *Astrophysical Journal Supplement Series.* Those first passes took the spacecraft to within 0.16 astronomical units (a.u.) from the Sun's surface, less than half the average distance to Mercury. These studies follow up on the preliminary results released in *Nature* last November, providing more details on the origins of so-called *rogue waves*, as well as the unexpectedly speedy rotation of the solar wind.

Finding the Source of Rogue Waves

Perhaps the biggest surprise to come out of Parker's first passes near the Sun was the discovery of rogue waves, folds in the magnetic field that accompany surges of charged particles.

Other missions have seen these rogue waves for decades now, even though they didn't come quite so close to the Sun. In fact, NASA's Helios satellites saw rogue waves after they launched back in the 1970s. But by the number of other names scientists have used to describe rogue waves — such as jets, spikes, foldings, field reversals, deflections, and switchbacks — it's clear that we don't yet have a handle on the phenomenon.

Now, Parker's observations are adding a closer-in view to the equation, showing the waves on a different scale. "The sheer number of them and the size of them is surprising," says instrument scientist Tony Case (Smithsonian Astrophysical Observatory).

A number of studies in the special issue reveal additional details about the roughly thousand rogue waves detected during the first two passes by the Sun. The waves last between a fraction of a second to almost an hour, they tend to cluster together, and while they tend to involve a fold in the magnetic field, the direction of the fold is pretty much random. Multiple studies suggest that the rogue waves originate from deep within the corona, nearer the solar surface.

Successive orbits will take Parker as close as 10 solar radii (0.05 a.u.) from the Sun's surface, so even if Parker never sees the actual origin of the rogue waves, it will see them in more of their original state, Case says.

Full Speed Ahead

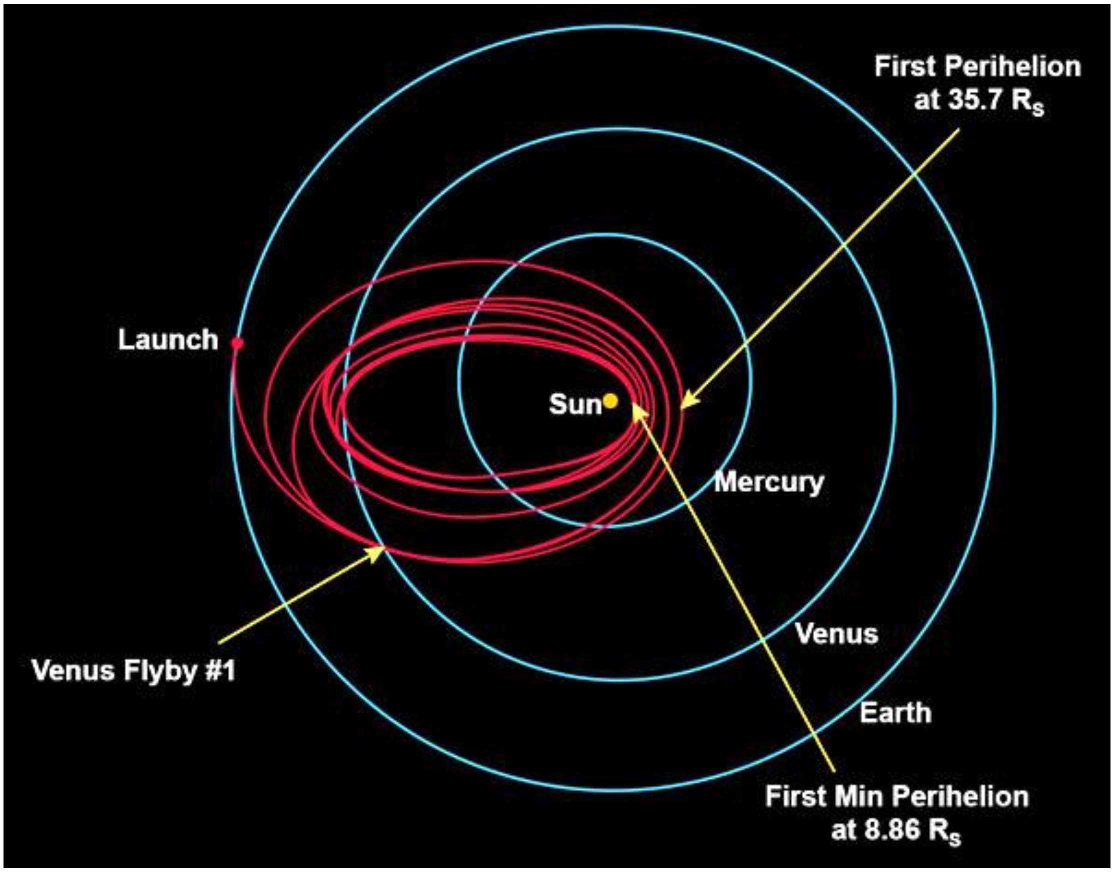
Another result that surprised Parker mission scientists is the unexpectedly speedy rotation of the solar wind.

If you were to watch a movie of a solar prominence erupting out of the visible surface, you would see it rotate as if it were part of the Sun itself. Indeed, the Sun's magnetic field keeps it anchored in place. Yet by the time solar wind plasma passes by Earth, it's flying straight outward — generally, there's no rotation at all. As Parker swooped near the Sun, scientists expected the solar wind to pick up its rotational speed. But as Justin Kasper (University of Michigan) and colleagues announced last November, the rotational speed turned out to be off the charts, peaking at speeds of 35 to 50 km/s (80,000 to 110,000 mph).

Now, two studies in the special issue attempt to reproduce this speed within their computer simulations — but as yet, they can't. Victor Réville (UCLA and University of Toulouse, France) and colleagues used a simulation to show what was happening in the solar wind during Parker's first encounter with the Sun. The simulation could reproduce most of the properties of the solar wind that Parker saw, such as its density and its outward (radial) velocity, but it failed to reproduce its fast rotational speed.

Solving this riddle may come back to the rogue waves, Réville and colleagues say, which temporarily but severely change the conditions of the solar wind. Scientists will need to study the problem further to see if rogue waves might be the answer.

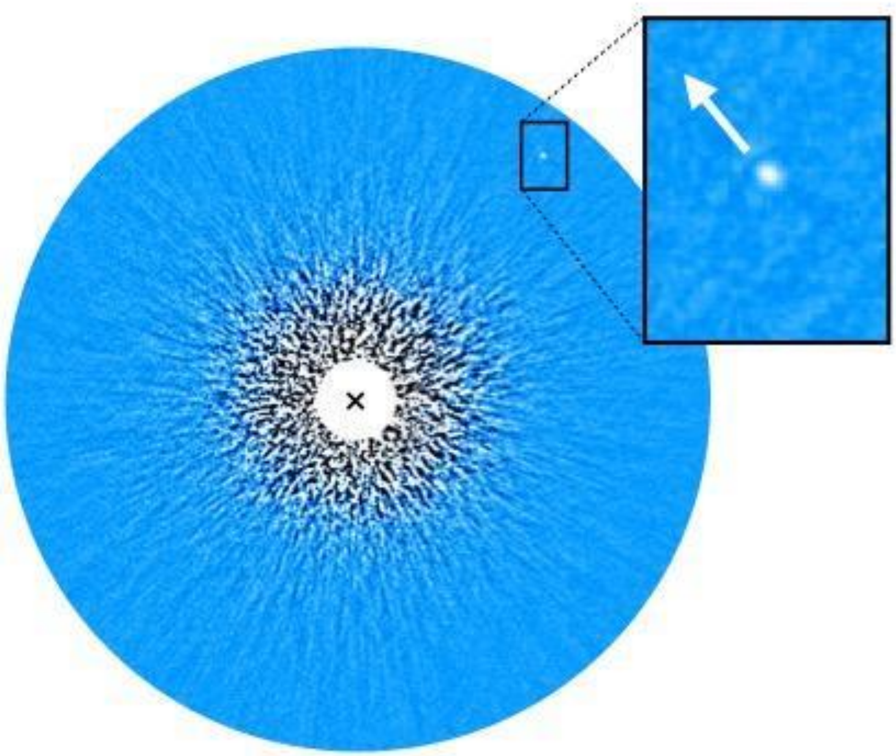
Meanwhile, Parker is on its way out from its fourth and closest-yet perihelion pass on January 29th. This orbit took the spacecraft within 0.12 a.u., thanks to a gravity-assist maneuver on December 26, 2019, that sent Parker slingshot-ting around Venus. The orbits will only get closer and we'll continue to delve into the new answers and questions Parker brings us.



Parker Solar Probe has completed two of the seven Venus flybys that will ultimately shrink its orbit around the Sun to within 9 times the solar radius.
Credit: NASA

Source: [Sky and Telescope] [Return to Contents]

2. Distant Giant Planets Form Differently Than 'Failed Stars'



This image of the low-mass brown dwarf GJ 504 b was taken by Bowler and his team using adaptive optics with the NIRC2 camera at Keck Observatory in Hawaii. The image has been processed to remove light from the host star (whose position is marked with an "x"). The companion is located at a separation of about 40 times the earth-sun distance and has an orbital period of about 240 years. By returning to this and other systems year after year, the team is able to slowly trace out part of the companion's orbit to constrain its shape, which provides clues about its formation and history. Credit: Brendan Bowler (UT-Austin)/W. M. Keck Observatory

A team of astronomers led by Brendan Bowler of The University of Texas at Austin has probed the formation process of giant exoplanets and brown dwarfs, a class of objects that are more massive than giant planets, but not massive enough to ignite nuclear fusion in their cores to shine like true stars.

Using direct imaging with ground-based telescopes in Hawaii – W. M. Keck Observatory and Subaru Telescope on Mauna Kea – the team studied the orbits of these faint companions orbiting stars in 27 systems. These data, combined with modeling of the orbits,

The research is published in the current issue of *The Astronomical Journal*.

In the last two decades, technological leaps have allowed telescopes to separate the light from a parent star and a much-dimmer orbiting object. In 1995, this new capability produced the first direct images of a brown dwarf orbiting a star. The first direct image of planets orbiting another star followed in 2008.

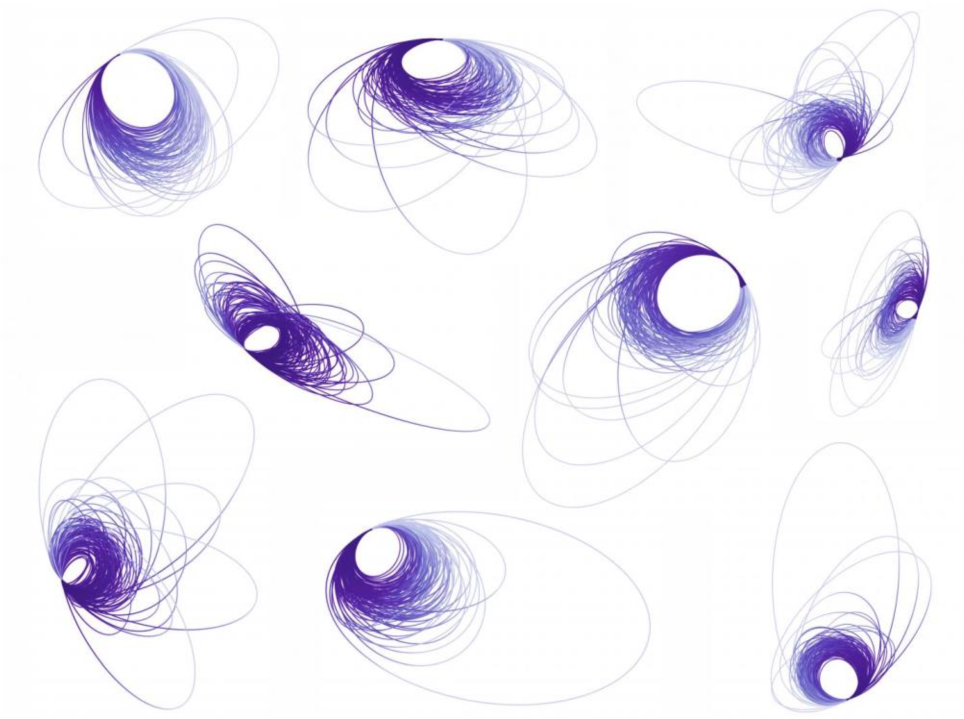
"Over the past 20 years, we've been leaping down and down in mass," Bowler said of the direct imaging capability, noting that the current limit is about 1 Jupiter mass. As the technology has improved, "One of the big questions that has emerged is 'What's the nature of the companions we're finding?'"

Brown dwarfs, as defined by astronomers, have masses between 13 and 75 Jupiter masses. They have characteristics in common with both planets and with stars, and Bowler and his team wanted to settle the question: Are gas giant planets on the outer fringes of planetary systems the tip of the planetary iceberg, or the low-mass end of brown dwarfs? Past research has shown that brown dwarfs orbiting stars likely formed like low-mass stars, but it's been less clear what is the lowest mass companion this formation mechanism can produce.

"One way to get at this is to study the dynamics of the system — to look at the orbits," Bowler said. Their orbits today hold the key to unlocking their evolution.

Using Keck Observatory's adaptive optics (AO) system with the Near-Infrared Camera, second generation (NIRC2) instrument on the Keck II telescope, as well as the Subaru Telescope, Bowler's team took images of giant planets and brown dwarfs as they orbit their parent stars.

It's a long process. The gas giants and brown dwarfs they studied are so distant from their parent stars that one orbit may take hundreds of years. To determine even a small percentage of the orbit, "You take an image, you wait a year," for the faint companion to travel a bit, Bowler said. Then "you take another image, you wait another year."



By patiently watching giant planets and brown dwarfs orbit their host stars, Bowler and his team were able to constrain the orbit shapes even though only a small portion of the orbit has been monitored. The longer the time baseline, the smaller the range of possible orbits. These plots show nine of the 27 systems from their study. Credit: Brendan Bowler (UT-Austin)

This research relied on AO technology, which allows astronomers to correct for distortions caused by the Earth's atmosphere. As AO instruments have continually improved over the past three decades, more brown dwarfs and giant planets have been directly imaged. But since most of these discoveries have been made over the past decade or two, the team only has images corresponding to a few percent of each object's total orbit. They combined their new observations of 27 systems with all of the previous observations published by other astronomers or available in telescope archives.

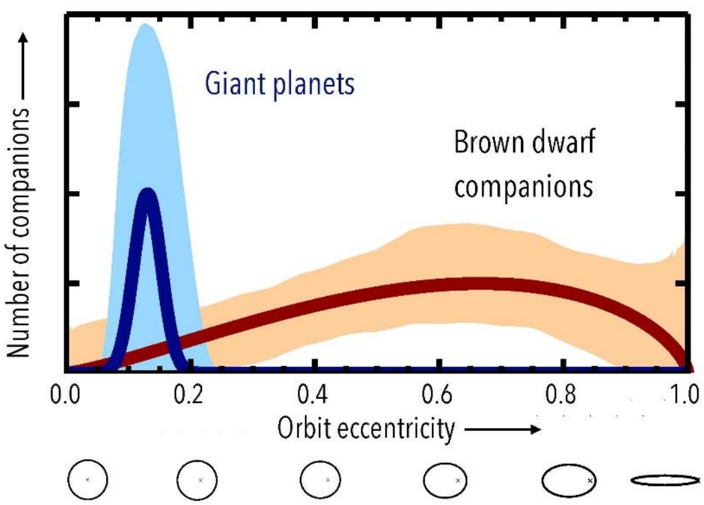
At this point, computer modeling comes in. Coauthors on this paper have helped create an orbit-fitting code called "Orbitize!" which uses Kepler's laws of planetary motion to identify which types of orbits are consistent with the measured positions, and which are not.

The code generates a set of possible orbits for each companion. The slight motion of each giant planet or brown dwarf forms a "cloud" of possible orbits. The smaller the cloud, the more astronomers are closing in on the companion's true orbit. And more data points — that is, more direct images of each object as it orbits — will refine the shape of the orbit.

"Rather than wait decades or centuries for a planet to complete one orbit, we can make up for the shorter time baseline of our data with very accurate position measurements," said team member Eric Nielsen of Stanford University. "A part of Orbitize! that we developed specifically to fit partial orbits, OFTI [Orbits For The Impatient], allowed us to find orbits even for the longest period companions."

Finding the shape of the orbit is key: Objects that have more circular orbits probably formed like planets. That is, when a cloud of gas and dust collapsed to form a star, the distant companion (and any other planets) formed out of a flattened disk of gas and dust rotating around that star.

On the other hand, the ones that have more elongated orbits probably formed like stars. In this scenario, a clump of gas and dust was collapsing to form a star, but it fractured into two clumps. Each clump then collapsed, one forming a star, and the other a brown dwarf orbiting around that star. This is essentially a binary star system, albeit containing one real star and one "failed star."



These two curves show the final distribution of orbit shapes for giant planets and brown dwarfs. The orbital eccentricity determines how elongated the ellipse is, with a value of 0.0 corresponding to a circular orbit and a high value near 1.0 being a flattened ellipse. Gas giant planets located at wide separations from their host stars have low eccentricities, but the brown dwarfs have a wide range of eccentricities similar to binary star systems. For reference, the giant planets in our solar system have eccentricities less than 0.1. Credit: Brendan Bowler (UT-Austin)

"Even though these companions are millions of years old, the memory of how they formed is still encoded in their present-day eccentricity," Nielsen added. Eccentricity is a measure of how circular or elongated an object's orbit is.

The results of the team's study of 27 distant companions was unambiguous.

"The punchline is, we found that when you divide these objects at this canonical boundary of more than about 15 Jupiter masses, the things that we've been calling planets do indeed have more circular orbits, as a population, compared to the rest," Bowler said. "And the rest look like binary stars."

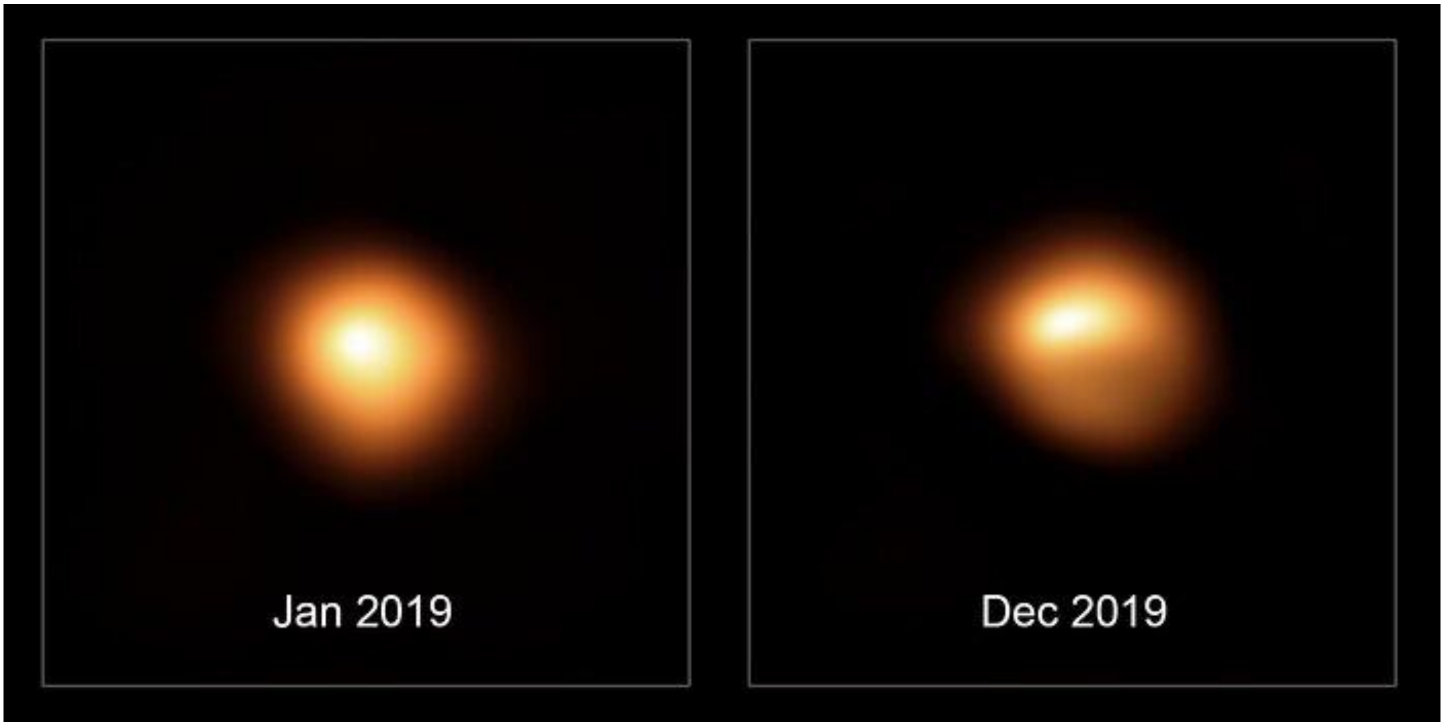
The future of this work involves both continuing to monitor these 27 objects, as well as identifying new ones to widen the study. "The sample size is still modest, at the moment," Bowler said. His team is using the Gaia satellite to look for additional candidates to follow up using direct imaging with even greater sensitivity at the forthcoming Giant Magellan Telescope (GMT) and other facilities. UT-Austin is a founding member of the GMT collaboration.

Bowler's team's results reinforce similar conclusions recently reached by the GPIES direct imaging survey with the Gemini Planet Imager, which found evidence for a different formation channel for brown dwarfs and giant planets based on their statistical properties.

This work was supported by a NASA Keck PI Data Award, administered by the NASA Exoplanet Science Institute. The Keck Observatory is managed by Caltech and the University of California.

Source: Keck Observatory/EurekAlert Return to Contents

3. ESO Telescope Sees Surface of Dim Betelgeuse



This comparison image shows the star Betelgeuse before and after its unprecedented dimming. The observations, taken with the SPHERE instrument on ESO's Very Large Telescope in January and December 2019, show how much the star has faded and how its apparent shape has changed. Credit: ESO/M. Montargès et al.

Using ESO's Very Large Telescope (VLT), astronomers have captured the unprecedented dimming of Betelgeuse, a red supergiant star in the constellation of Orion. The stunning new images of the star's surface show not only the fading red supergiant but also how its apparent shape is changing.

Betelgeuse has been a beacon in the night sky for stellar observers but it began to dim late last year. At the time of writing Betelgeuse is at about 36% of its normal brightness, a change noticeable even to the naked eye. Astronomy enthusiasts and scientists alike were excitedly hoping to find out more about this unprecedented dimming.

A team led by Miguel Montargès, an astronomer at KU Leuven in Belgium, has been observing the star with ESO's Very Large Telescope since December, aiming to understand why it's becoming fainter. Among the first observations to come out of their campaign is a stunning new image of Betelgeuse's surface, taken late last year with the SPHERE instrument.

The team also happened to observe the star with SPHERE in January 2019, before it began to dim, giving us a before-and-after picture of Betelgeuse. Taken in visible light, the images highlight the changes occurring to the star both in brightness and in apparent shape.

Many astronomy enthusiasts wondered if Betelgeuse's dimming meant it was about to explode. Like all red supergiants, Betelgeuse will one day go supernova, but astronomers don't think this is happening now. They have other hypotheses to explain what exactly is causing the shift in shape and brightness seen in the SPHERE images. "*The two scenarios we are working on are a cooling of the surface due to exceptional stellar activity or dust ejection towards us,*" says Montargès [1]. "*Of course, our knowledge of red supergiants remains incomplete, and this is still a work in progress, so a surprise can still happen.*"

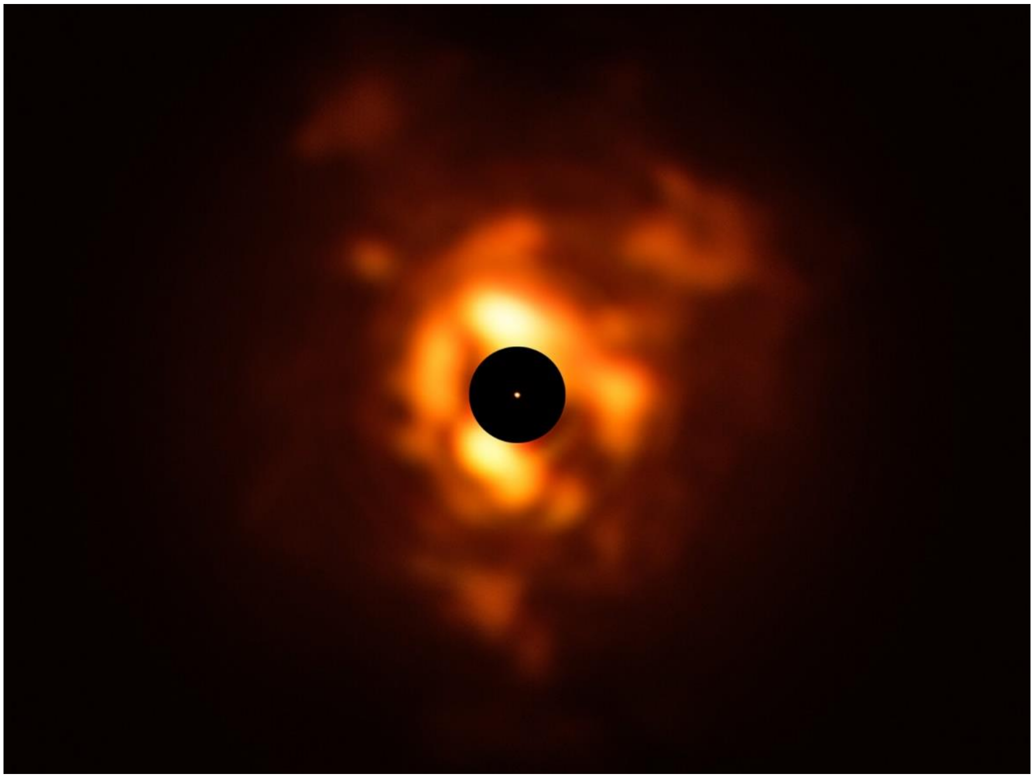
Montargès and his team needed the VLT at Cerro Paranal in Chile to study the star, which is over 700 light-years away, and gather clues on its dimming. "*ESO's Paranal Observatory is one of few facilities capable of* *imaging the surface of Betelgeuse*," he says. Instruments on ESO's VLT allow observations from the visible to the mid-infrared, meaning astronomers can see both the surface of Betelgeuse and the material around it. "*This is the only way we can understand what is happening to the star.*"

Another new image, obtained with the VISIR instrument on the VLT, shows the infrared light being emitted by the dust surrounding Betelgeuse in December 2019. These observations were made by a team led by Pierre Kervella from the Observatory of Paris in France who explained that the wavelength of the image is similar to that detected by heat cameras. The clouds of dust, which resemble flames in the VISIR image, are formed when the star sheds its material back into space.

"*The phrase 'we are all made of stardust' is one we hear a lot in popular astronomy, but where exactly does this dust come from?*" says Emily Cannon, a PhD student at KU Leuven working with SPHERE images of red supergiants. "*Over their lifetimes, red supergiants like Betelgeuse create and eject vast amounts of material even before they explode as supernovae. Modern technology has enabled us to study these objects, hundreds of light-years away, in unprecedented detail giving us the opportunity to unravel the mystery of what triggers their mass loss.*"

Notes

[1] Betelgeuse's irregular surface is made up of giant convective cells that move, shrink and swell. The star also pulsates, like a beating heart, periodically changing in brightness. These convection and pulsation changes in Betelgeuse are referred to as stellar activity.



This image, obtained with the VISIR instrument on ESO's Very Large Telescope, shows the infrared light being emitted by the dust surrounding Betelgeuse in December 2019. The clouds of dust, which resemble flames in this dramatic image, are formed when the star sheds its material back into space. The black disc obscures the star's center and much of its surroundings, which are very bright and must be masked to allow the fainter dust plumes to be seen. The orange dot in the middle is the SPHERE image of Betelgeuse's surface, which has a size close to that of Jupiter's orbit. Credit: ESO/P. Kervella/M. Montargès et al., Acknowledgement: Eric Pantin

Source: European Southern Observatory Return to Contents

The Night Sky

Tuesday, Feb. 18

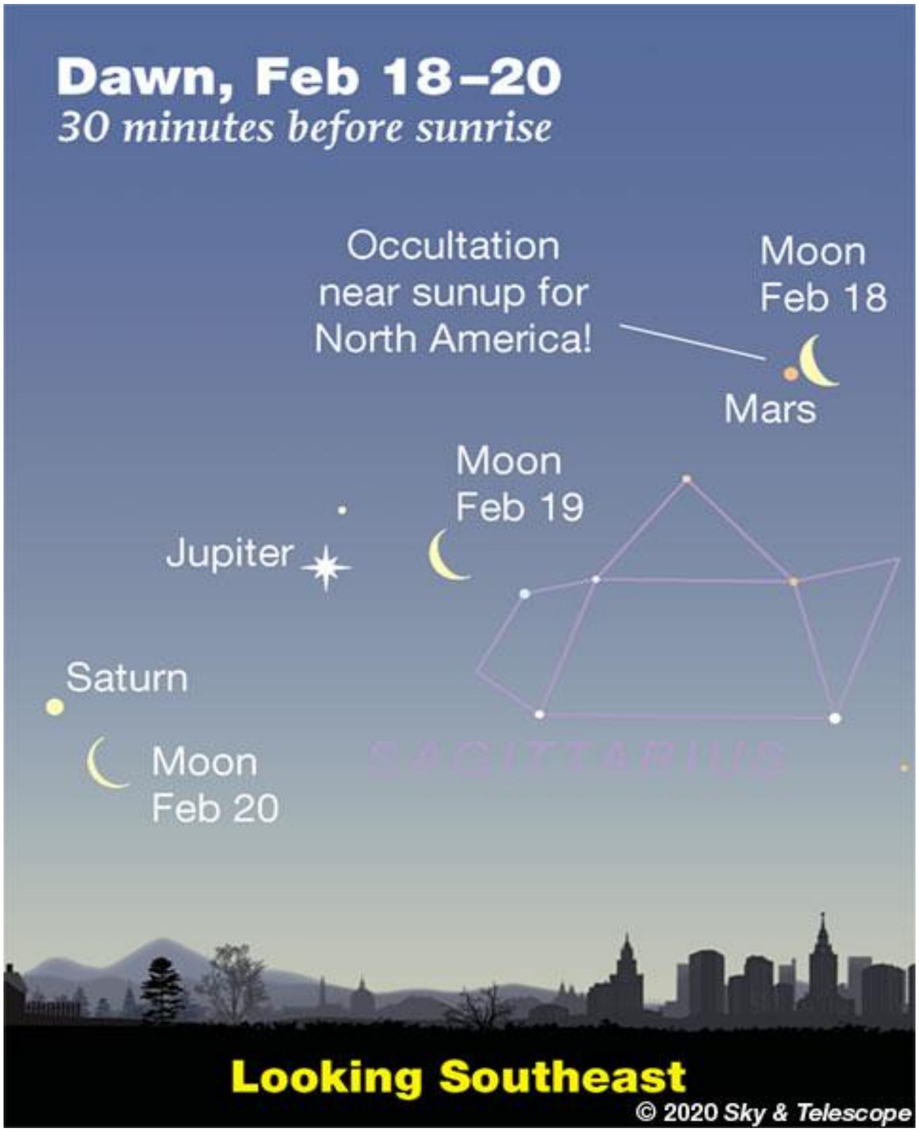
• In early dawn Wednesday, the crescent Moon shines near Jupiter low in the southeast.

Wednesday, Feb. 19

• Right after dark the W of Cassiopeia shines high in the northwest, standing almost on end. The brightest star between Cassiopeia and the zenith, at that time for the world's mid-northern latitudes, is Alpha Persei (Mirfak). Around and upper left of it is the Perseus OB1 Association: a loose swarm of modestly bright stars about the size of your thumb-tip at arm's length. They show well in binoculars.

A stellar *association* is a group of stars born around the same place and time but too large and loose to hold together gravitationally as a longer-lasting star cluster.

• In early dawn Thursday, the Moon hangs closely to the lower right of Saturn (for North America). They're just over the southeast horizon to the lower left of Jupiter. Bring binoculars.



The Moon passes through the dawn planet array. (For clarity, the Moon is shown three times its actual apparent size.)

Thursday, Feb. 20

• With the Moon out of the evening sky, this is a fine week to look for the zodiacal light if you live in the mid-northern latitudes — now that the ecliptic tilts high upward from the western horizon at nightfall. From a clear, clean-aired, dark site, look west at the very end of twilight for a vague but huge, tall pyramid of pearly light. It's tilted to the left, aligning along the constellations of the zodiac. You're looking at sunlit interplanetary dust orbiting the Sun near the ecliptic plane.

Friday, Feb. 21

• High over Venus after dark are the two brightest stars of Aries, lined up almost vertically.

High above Aries and perhaps a bit left are the Pleiades. Venus is a good 42° away from the Pleiades right now. But watch for the next six weeks as they head straight toward each other. On the evening of April 3rd, Venus will shine just inside the cluster's edge.

Source: Sky and Telescope Return to Contents

ISS Sighting Opportunities (from Denver)

Date	Visible	Max Height	Appears	Disappears
Wed Feb 19, 5:38 AM	< 1 min	10°	10° above SE	10° above SE
Thu Feb 20, 6:25 AM	< 1 min	10°	10° above SW	10° above SW
Fri Feb 21, 5:37 AM	4 min	33°	10° above SSW	30° above ESE
Sat Feb 22, 4:51 AM	2 min	19°	14° above SSE	17° above ESE

Sighting information for other cities can be found at NASA's Satellite Sighting Information

NASA-TV Highlights (all times Eastern Time Zone)

February 19, Wednesday

- 12:40 p.m.– International Space Station Expedition 62 educational in-flight event with the East Middle School in Grand Blanc, Michigan, to discuss the Zero-G Oven with NASA astronaut Jessica Meir (All Channels)

February 21, Friday

- 11 a.m. – SpaceCast Weekly – Johnson Space Center (All Channels)

Watch NASA TV online by going to the NASA website.

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Space Calendar

- **Feb 18 - JCSAT-17/ GEO-KOMPSAT-2B Ariane 5 Launch**
- Feb 18 - Moon Occults Mars
- Feb 18 - Asteroid 2020 DD Near-Earth Flyby (0.006 AU)
- Feb 18 - Apollo Asteroid 2020 DB Near-Earth Flyby (0.010 AU)
- Feb 18 - Apollo Asteroid 2020 BA10 Near-Earth Flyby (0.031 AU)
- Feb 18 - Lecture: Weird New Worlds, Edinburgh, Scotland, United Kingdom
- Feb 18 - Colloquium: Impacts on Space Science from the Growth of the Entrepreneurial Space Sector, Tucson, Arizona
- Feb 18 - Lecture: Our Rapidly Changing Biosphere, Tucson, Arizona
- Feb 18 - 90th Anniversary (1930), Clyde Tombaugh's Discovery of Pluto
- Feb 18-21 - 3rd International Planetary Caves Conference, San Antonio, Texas
- Feb 19 - Moon Occults Jupiter
- Feb 19 - Aten Asteroid 2020 DA Near-Earth Flyby (0.020 AU)
- Feb 19 - Apollo Asteroid 2020 CU2 Near-Earth Flyby (0.034 AU)
- Feb 19 - Apollo Asteroid 2020 BL7 Near-Earth Flyby (0.035 AU)
- Feb 19 - Aten Asteroid 2020 CX1 Near-Earth Flyby (0.036 AU)
- Feb 19 - Astro2020 Teleconference: Panel on State of the Profession and Societal Impacts
- Feb 19 - Lecture: How Did Earth Get Its Water? / Researching Comets: The Forgotten Dust Particles, Tucson, Arizona
- Feb 19 - John C. Lindsay Memorial Lecture: A NICER View - Physics and Astrophysics from the International Space Station, Greenbelt, Maryland
- Feb 19-20 - AA-UT Space Traffic Management Conference, Austin, Texas
- Feb 19-21 - East-Asian ALMA Science Workshop 2019, Taipei, Taiwan
- **Feb 20 - Meridian-M Soyuz-2.1b/Fregat Launch**
- Feb 20 - Moon Occults Dwarf Planet Pluto
- Feb 20 - Asteroid 2020 DE Near-Earth Flyby (0.009 AU)
- Feb 20 - Apollo Asteroid 2020 DC Near-Earth Flyby (0.015 AU)
- Feb 20 - Apollo Asteroid 2020 CP2 Near-Earth Flyby (0.013 AU)
- Feb 20 - Aten Asteroid 2019 BE5 Near-Earth Flyby (0.035 AU)
- Feb 20 - Apollo Asteroid 2020 BC9 Near-Earth Flyby (0.036 AU)
- Feb 20 - Lecture: To c or not to c - Physics in Science Fiction Writing, Staffordshire, United Kingdom
- Feb 20 - Webinar: Navigating the New Arctic
- Feb 20-22 - 10th Central European Relativity Seminar, Potsdam-Golm, Germany
- Feb 21 - Comet 297P/Beshore Closest Approach To Earth (2.092 AU)
- Feb 21 - Hyperbolic Object A/2019 G4 At Opposition (5.972 AU)
- Feb 21 - Comet C/2017 AB5 (PANSTARRS) Closest Approach To Earth (9.256 AU)
- Feb 21 - 35th Annual New Mexico Symposium, Socorro, New Mexico
- **Feb 21 - Night Sky Program, Florissant Fossil Beds National Monument, Florissant, Colorado**
- Feb 21-24 - WCRP/SPARC SATIO-TCS Joint Workshop on Stratosphere-Troposphere Dynamical Coupling in the Tropics, Kyoto, Japan

Source: JPL Space Calendar Return to Contents

Food for Thought

Earth Climate Models and the Search for Life on Other Planets

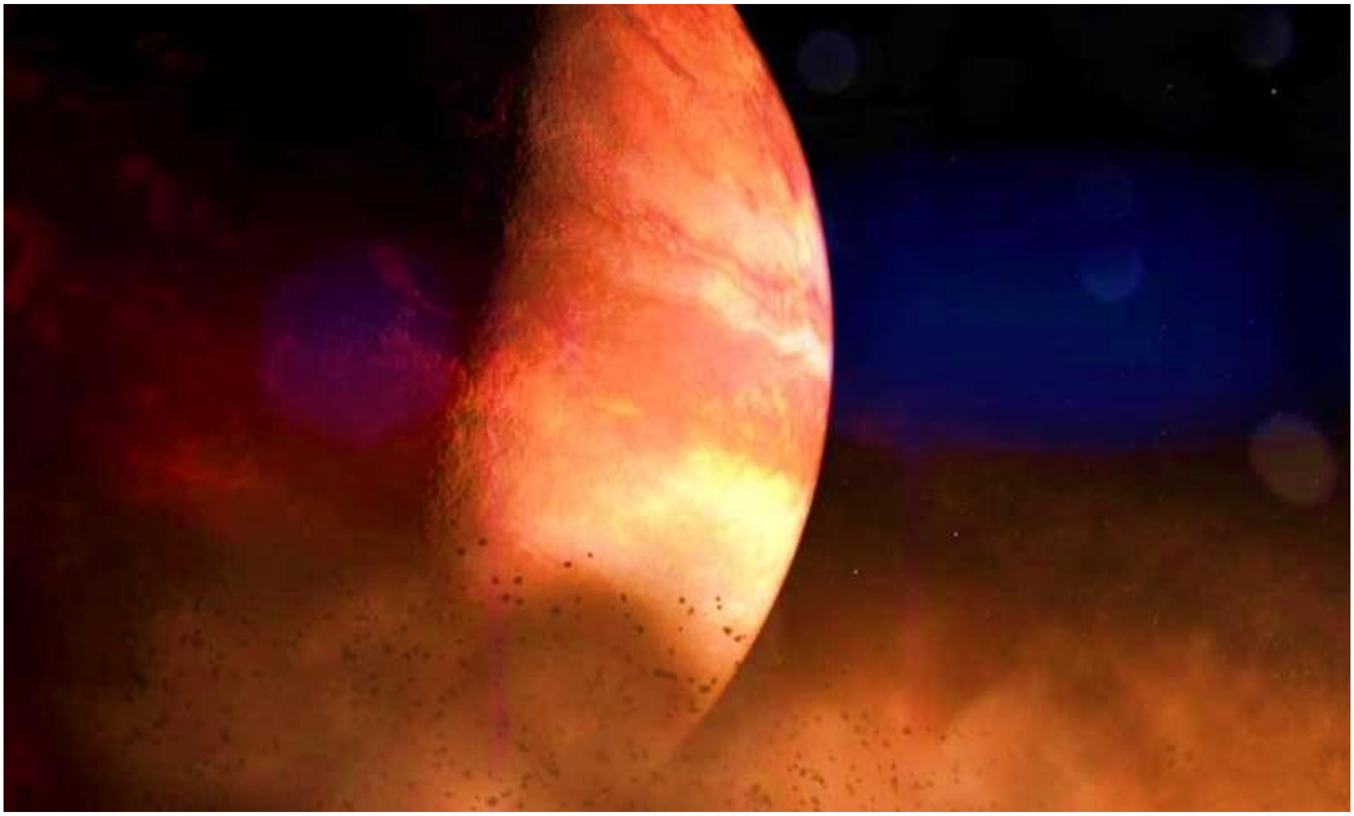


Illustration of an exoplanet. Credit: NASA's Goddard Space Flight Center/Chris Smith

In a generic brick building on the northwestern edge of NASA's Goddard Space Flight Center campus in Greenbelt, Maryland, thousands of computers packed in racks the size of vending machines hum in a deafening chorus of data crunching. Day and night, they spit out 7 quadrillion calculations per second. These machines collectively are known as NASA's Discover supercomputer and they are tasked with running sophisticated climate models to predict Earth's future climate.

But now, they're also sussing out something much farther away: whether any of the more than 4,000 curiously weird planets beyond our solar system discovered in the past two decades could support life.

Scientists are finding that the answer not only is yes, but that it's yes under a range of surprising conditions compared to Earth. This revelation has prompted many of them to grapple with a question vital to NASA's search for life beyond Earth. Is it possible that our notions of what makes a planet suitable for life are too limiting?

The next generation of powerful telescopes and space observatories will surely give us more clues. These instruments will allow scientists for the first time to analyze the atmospheres of the most tantalizing planets out there: rocky ones, like Earth, that could have an essential ingredient for life—liquid water—flowing on their surfaces.

For the time being, it's difficult to probe far-off atmospheres. Sending a spacecraft to the closest planet outside our solar system, or exoplanet, would take 75,000 years with today's technology. Even with powerful telescopes nearby exoplanets are virtually impossible to study in detail. The trouble is that they're too small and too drowned out by the light of their stars for scientists to make out the faint light signatures they reflect—signatures that could reveal the chemistry of life at the surface.

In other words, detecting the ingredients of the atmospheres around these phantom planets, as many scientists like to point out, is like standing in Washington, D.C., and trying to glimpse a firefly next to a searchlight in Los Angeles. This reality makes climate models critical to exploration, said chief exoplanetary scientist Karl Stapelfeldt, who's based at NASA's Jet Propulsion Laboratory in Pasadena, California.

"The models make specific, testable predictions of what we should see," he said. "These are very important for designing our future telescopes and observing strategies."

Is the solar system a good role model?

In scanning the cosmos with large ground-based and space telescopes, astronomers have discovered an eclectic assortment of worlds that seem drawn from the imagination.

"For a long time, scientists were really focused on finding sun- and Earth-like systems. That's all we knew," said Elisa Quintana, a NASA Goddard astrophysicist who led the 2014 discovery of Earth-sized planet Kepler-186f. "But we found out that there's this whole crazy diversity in planets. We found planets as small as the moon. We found giant planets. And we found some that orbit tiny stars, giant stars and multiple stars."

Indeed, most of the planets detected by NASA's Kepler space telescope and the new Transiting Exoplanet Survey Satellite, as well as ground-based observations, don't exist in our solar system. They fall between the size of a terrestrial Earth and a gaseous Uranus, which is four times bigger than this planet.

Planets closest in size to Earth, and most likely in theory to have habitable conditions, so far have been found only around "red dwarf" stars, which make up a vast majority of stars in the galaxy. But that's likely because red dwarfs are smaller and dimmer than the sun, so the signal from planets orbiting them is easier for telescopes to detect.

Because red dwarfs are small, planets have to lap uncomfortably close—closer than Mercury is to the sun—to stay gravitationally attached to them. And because red dwarfs are cool, compared to all other stars, planets have to be closer to them to draw enough heat to allow liquid water to pool on their surfaces.

Among the most alluring recent discoveries in red dwarf systems are planets like Proxima Centauri b, or simply Proxima b. It's the closest exoplanet. There are also seven rocky planets in the nearby system TRAPPIST-1. Whether or not these planets could sustain life is still a matter of debate. Scientists point out that red dwarfs can spew up to 500 times more harmful ultraviolet and X-ray radiation at their planets than the sun ejects into the solar system. On the face of it, this environment would strip atmospheres, evaporate oceans and fry DNA on any planet close to a red dwarf.

Yet, maybe not. Earth climate models are showing that rocky exoplanets around red dwarfs could be habitable despite the radiation.

The magic is in the clouds

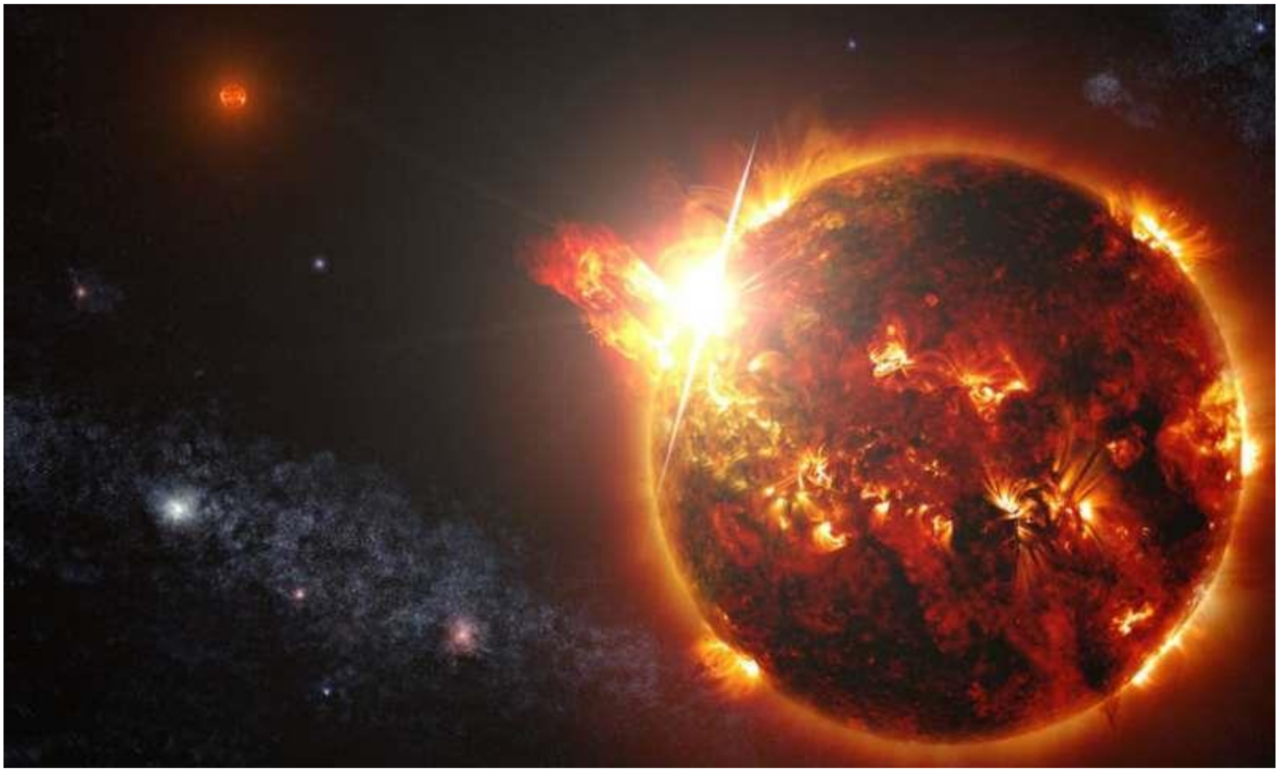
Anthony Del Genio is a recently retired planetary climate scientist from NASA's Goddard Institute for Space Studies in New York City. During his career he simulated the climates of Earth and of other planets, including Proxima b.

Del Genio's team recently simulated possible climates on Proxima b to test how many would leave it warm and wet enough to host life. This type of modeling work helps NASA scientists identify a handful of promising planets worthy of more rigorous study with NASA's forthcoming James Webb Space Telescope.

"While our work can't tell observers if any planet is habitable or not, we can tell them whether a planet is smack in the midrange of good candidates to search further," Del Genio said.

Proxima b orbits Proxima Centauri in a three-star system located just 4.2 light years from the sun. Besides that, scientists don't know much about it. They believe it's rocky, based on its estimated mass, which is slightly larger than Earth's. Scientists can infer mass by watching how much Proxima b tugs on its star as it orbits it.

The problem with Proxima b is that it's 20 times closer to its star than Earth is to the sun. Therefore, it takes the planet only 11.2 days to make one orbit (Earth takes 365 days to orbit the sun once). Physics tells scientists that this cozy arrangement could leave Proxima b gravitationally locked to its star, like the moon is gravitationally locked to Earth. If true, one side of Proxima b faces the star's intense radiation while the other one freezes in the darkness of space in a planetary recipe that doesn't bode well for life on either side.



In 2014, NASA's Swift mission detected a record-setting series of X-ray flares unleashed by DG CVn, a nearby binary consisting of two red dwarf stars, illustrated here. At its peak, the initial flare was brighter in X-rays than the combined light from both stars at all wavelengths under normal conditions. Credit: NASA's Goddard Space Flight Center

But Del Genio's simulations show that Proxima b, or any planet with similar characteristics, could be habitable despite the forces conspiring against it. "And the clouds and oceans play a fundamental role in that," Del Genio said.

Del Genio's team upgraded an Earth climate model first developed in the 1970s to create a planetary simulator called ROCKE-3-D. Whether Proxima b has an atmosphere is an open and critical question that will hopefully be settled by future telescopes. But Del Genio's team assumed that it does.

With each simulation Del Genio's team varied the types and amounts of greenhouse gases in Proxima b's air. They also changed the depth, size, and salinity of its oceans and adjusted the ratio of land to water to see how these tweaks would influence the planet's climate.

Models such as ROCKE-3-D begin with only grains of basic information about an exoplanet: its size, mass, and distance from its star. Scientists can infer these things by watching the light from a star dip as a planet crosses in front of it, or by measuring the gravitational tugging on a star as a planet circles it.

These scant physical details inform equations that comprise up to a million lines of computer code needed to build the most sophisticated climate models. The code instructs a computer like NASA's Discover supercomputer to use established rules of nature to simulate global climate systems. Among many other factors, climate models consider how clouds and oceans circulate and interact and how radiation from a sun interacts with a planet's atmosphere and surface.

When Del Genio's team ran ROCKE-3-D on Discover they saw that Proxima b's hypothetical clouds acted like a massive sun umbrella by deflecting radiation. This could lower the temperature on Proxima b's sun-facing side from too hot to warm.

Other scientists have found that Proxima b could form clouds so massive they would blot out the entire sky if one were looking up from the surface.

"If a planet is gravitationally locked and rotating slowly on its axis a circle of clouds forms in front of the star, always pointing towards it. This is due to a force known as the Coriolis Effect, which causes convection at the location where the star is heating the atmosphere," said Ravi Kopparapu, a NASA Goddard planetary scientist who also models the potential climates of exoplanets. "Our modeling shows that Proxima b could look like this."

In addition to making Proxima b's day side more temperate than expected, a combination of atmosphere and ocean circulation would move warm air and water around the planet, thereby transporting heat to the cold side. "So you not only keep the atmosphere on the night side from freezing out, you create parts on the night side that actually maintain liquid water on the surface, even though those parts see no light," Del Genio said.

Taking a new look at an old role model

Atmospheres are envelopes of molecules around planets. Besides helping maintain and circulate heat, atmospheres distribute gases that nourish life or are produced by it.

These gases are the so-called "biosignatures" scientists will look for in the atmospheres of exoplanets. But what exactly they should be looking for is still undecided.

Earth's is the only evidence scientists have of the chemistry of a life-sustaining atmosphere. Yet, they have to be cautious when using Earth's chemistry as a model for the rest of the galaxy. Simulations from Goddard planetary scientist Giada Arney, for instance, show that even something as simple as oxygen—the quintessential sign of plant life and photosynthesis on modern Earth—could present a trap.

Arney's work highlights something interesting. Had alien civilizations pointed their telescopes toward Earth billions of years ago hoping to find a blue planet swimming in oxygen, they would have been disappointed; maybe they would have turned their telescopes toward another world. But instead of oxygen, methane could have been the best biosignature to look for 3.8 to 2.5 billion years ago. This molecule was produced in abundance back then, likely by the microorganisms quietly flourishing in the oceans.

"What is interesting about this phase of Earth's history is that it was so alien compared to modern Earth," Arney said. "There was no oxygen yet, so it wasn't even a pale blue dot. It was a pale orange dot," she said, referencing the orange haze produced by the methane smog that may have shrouded early Earth.

Findings like this one, Arney said, "have broadened our thinking about what's possible among exoplanets," helping expand the list of biosignatures planetary scientists will look for in distant atmospheres.

Building a blueprint for atmosphere hunters

While the lessons from planetary climate models are theoretical—meaning scientists haven't had an opportunity to test them in the real world—they offer a blueprint for future observations.

One major goal of simulating climates is to identify the most promising planets to turn to with the Webb telescope and other missions so that scientists can use limited and expensive telescope time most efficiently. Additionally, these simulations are helping scientists create a catalog of potential chemical signatures that they will one day detect. Having such a database to draw from will help them quickly determine the type of planet they're looking at and decide whether to keep probing or turn their telescopes elsewhere.

Discovering life on distant planets is a gamble, Del Genio noted: "So if we want to observe most wisely, we have to take recommendations from climate models, because that's just increasing the odds."

Source: NASA/Phys.org Return to Contents

Space Image of the Week

NGC 2392: Double-Shelled Planetary Nebula

Image Credit: NASA, ESA, Hubble, Chandra; Processing & License: Judy Schmidt

Explanation: To some, this huge nebula resembles a person's head surrounded by a parka hood. In 1787, astronomer William Herschel discovered this unusual planetary nebula: NGC 2392. More recently, the Hubble Space Telescope imaged the nebula in visible light, while the nebula was also imaged in X-rays by the Chandra X-ray Observatory. The featured combined visible-X ray image, shows X-rays emitted by central hot gas in pink.

The nebula displays gas clouds so complex they are not fully understood. NGC 2392 is a double-shelled planetary nebula, with the more distant gas having composed the outer layers of a Sun-like star only 10,000 years ago. The outer shell contains unusual light-year long orange filaments. The inner filaments visible are being ejected by strong wind of particles from the central star. The NGC 2392 Nebula spans about 1/3 of a light year and lies in our Milky Way Galaxy, about 3,000 light years distant, toward the constellation of the Twins (Gemini).

Source: NASA APOD Return to Contents