South Downs Mercury

The monthly circular of South Downs Astronomical Society
Issue: 596 – May 7^{2nd} 2025 Editor: Roger Burgess

Main Talk **Peter Goodhew "Setting up and operating a robotic telescope for remote astrophotography". Live talk.**

Peter will describe how amateur astronomers go about making such discoveries, and some of the challenges involved. He will take the audience through a typical case study. He will share some of the most remarkable, and beautiful discoveries made by the team, including some strange and unexpected objects.

Please support a raffle we are organizing this month.

- Curiosity rover finds large carbon deposits on Mars

Date: April 17, 2025
Source: University of Calgary

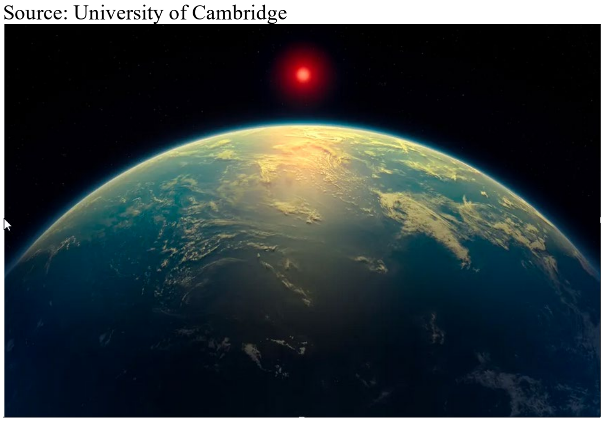
NASA's Curiosity Mars rover sees its tracks receding into the distance at a site nicknamed "Ubajara" on April 30, 2023. This site is where Curiosity made the discovery of siderite, a mineral that may help explain the fate of the planet's thicker ancient atmosphere. Credit: NASA/JPL-Caltech/MSSS

Research from NASA's Curiosity rover has found evidence of a carbon cycle on ancient Mars, bringing scientists closer to an answer on whether the Red Planet was ever capable of supporting life.
Lead author Dr. Ben Tutolo, PhD, an associate professor with the Department of Earth, Energy and Environment in the Faculty of Science at the University of Calgary, is a participating scientist on the NASA Mars Science Laboratory Curiosity Rover team.
The team is working to understand climate transitions and habitability on ancient Mars as Curiosity explores Gale Crater.
The paper, published this week in the journal *Science*, reveals that data from three of Curiosity's drill sites had siderite, an iron carbonate material, within sulphate-rich layers of Mount Sharp in Gale Crater.
"The discovery of large carbon deposits in Gale Crater represents both a surprising and important breakthrough in our understanding of the geologic and atmospheric evolution of Mars," says Tutolo.
Reaching the strata, he says, was a long-term goal of the Mars Science Laboratory mission.
"The abundance of highly soluble salts in these rocks and similar deposits mapped over much of Mars has been used as evidence of the 'great drying" of Mars during its dramatic shift from a warm and wet early Mars to its current, cold and dry state," says Tutolo.
Sedimentary carbonate has long been predicted to have formed under the CO_2-rich ancient Martian atmosphere, but Tutolo says identifications had previously been sparse.
NASA's Curiosity rover landed on Mars on Aug. 5, 2012, and has travelled more than 34 kilometres on the Martian surface. The discovery of carbonate suggests that the atmosphere contained enough carbon dioxide to support liquid water existing on the planet's surface. As the atmosphere thinned, the carbon dioxide transformed into rock form.
NASA says future missions and analysis of other sulphate-rich areas on Mars could confirm the findings and help to better understand the planet's early history and how it transformed as its atmosphere was lost.
Tutolo says scientists are ultimately trying to determine whether Mars was ever capable of supporting life -- and the latest paper brings them closer to an answer. "It tells us that the planet was habitable and that the models for habitability are correct," he says.
"The broader implications are the planet was habitable up until this time, but then, as the CO_2 that had been warming the planet started

to precipitate as siderite, it likely impacted Mars' ability to stay warm.
"The question looking forward is how much of this CO_2 from the atmosphere was actually sequestered? Was that potentially a reason we began to lose habitability?"
The latest research, he says, fits with his ongoing work on Earth -- trying to turn anthropogenic CO_2 into carbonates as a climate change solution.
"Learning about the mechanisms of making these minerals on Mars helps us to better understand how we can do it here," he says. "Studying the collapse of Mars' warm and wet early days also tells us that habitability is a very fragile thing."
Tutolo says it's clear that small changes in atmospheric CO_2 can lead to huge changes in the ability of the planet to harbour life.
"The most remarkable thing about Earth is that it's habitable and it has been for at least four billion years," he adds. "Something happened to Mars that didn't happen to Earth."

- Strongest hints yet of biological activity outside the solar system

Date: April 16, 2025
Source: University of Cambridge



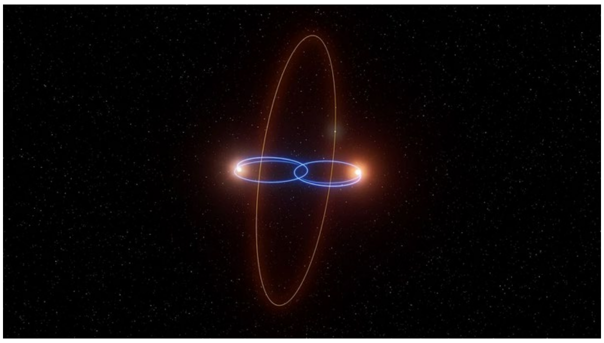
An artist's impression of K2-18b and its distant host star, visualized as if the planet had water and a hydrogen-rich atmosphere. A. Smith / N. Mandhusudhan / Cambridge University

Astronomers have detected the most promising signs yet of a possible biosignature outside the solar system, although they remain cautious.
Using data from the James Webb Space Telescope (JWST), the astronomers, led by the University of Cambridge, have detected the chemical fingerprints of dimethyl sulphide (DMS) and/or dimethyl disulfide (DMDS), in the atmosphere of the exoplanet K2-18b, which orbits its star in the habitable zone.
On Earth, DMS and DMDS are only produced by life, primarily microbial life such as marine phytoplankton. While an unknown chemical process may be the source of these molecules in K2-18b's atmosphere, the results are the strongest evidence yet that life may exist on a planet outside our solar system.
The observations have reached the 'three-sigma' level of statistical significance -- meaning there is a 0.3% probability that they occurred by chance. To reach the accepted classification for scientific discovery, the observations would have to cross the five-sigma threshold, meaning there would be below a 0.00006% probability they occurred by chance.
The researchers say between 16 and 24 hours of follow-up observation time with JWST may help them reach the all-important five-sigma significance. Their results are reported in *The Astrophysical Journal Letters*.
Earlier observations of K2-18b -- which is 8.6 times as massive and 2.6 times as large as Earth, and lies 124 light years away in the constellation of Leo -- identified methane and carbon dioxide in its atmosphere. This was the first time that carbon-based molecules were discovered in the atmosphere of an exoplanet in the habitable zone. Those results were consistent with predictions for a 'Hycean' planet: a habitable ocean-covered world underneath a hydrogen-rich atmosphere.
However, another, weaker signal hinted at the possibility of something else happening on K2-18b. "We didn't know for sure whether the signal we saw last time was due to DMS, but just the hint of it was exciting enough for us to have another look with JWST using a different instrument," said Professor Nikku Madhusudhan from Cambridge's Institute of Astronomy, who led the research.
To determine the chemical composition of the atmospheres of faraway planets, astronomers analyse the light from its parent star as the planet transits, or passes in front of the star as seen from the Earth. As K2-18b transits, JWST can detect a drop in stellar brightness, and a tiny fraction of starlight passes through the planet's atmosphere before reaching Earth. The absorption of some of the starlight in the planet's atmosphere leaves imprints in the stellar spectrum that astronomers can piece together to determine the constituent gases of the exoplanet's atmosphere.
The earlier, tentative, inference of DMS was made using JWST's NIRISS (Near-Infrared Imager and Slitless Spectrograph) and NIRSpec (Near-Infrared Spectrograph) instruments, which together cover the near-infrared (0.8-5 micron) range of wavelengths. The new, independent observation used

JWST's MIRI (Mid-Infrared Instrument) in the mid-infrared (6-12 micron) range.
"This is an independent line of evidence, using a different instrument than we did before and a different wavelength range of light, where there is no overlap with the previous observations," said Madhusudhan. "The signal came through strong and clear."
"It was an incredible realisation seeing the results emerge and remain consistent throughout the extensive independent analyses and robustness tests," said co-author Måns Holmberg, a researcher at the Space Telescope Science Institute in Baltimore, USA.
DMS and DMDS are molecules from the same chemical family, and both are predicted to be biosignatures. Both molecules have overlapping spectral features in the observed wavelength range, although further observations will help differentiate between the two molecules.
However, the concentrations of DMS and DMDS in K2-18b's atmosphere are very different than on Earth, where they are generally below one part per billion by volume. On K2-18b, they are estimated to be thousands of times stronger -- over ten parts per million.
"Earlier theoretical work had predicted that high levels of sulphur-based gases like DMS and DMDS are possible on Hycean worlds," said Madhusudhan. "And now we've observed it, in line with what was predicted. Given everything, we know about this planet, a Hycean world with an ocean that is teeming with life is the scenario that best fits the data we have."
Madhusudhan says that while the results are exciting, it's vital to obtain more data before claiming that life has been found on another world. He says that while he is cautiously optimistic, there could be previously unknown chemical processes at work on K2-18b that may account for the observations. Working with colleagues, he is hoping to conduct further theoretical and experimental work to determine whether DMS and DMDS can be produced non-biologically at the level currently inferred.
"The inference of these biosignature molecules poses profound questions concerning the processes that might be producing them" said co-author Subhajit Sarkar of Cardiff University.
"Our work is the starting point for all the investigations that are now needed to confirm and understand the implications of these exciting findings," said co-author Savvas Constantinou, also from Cambridge's Institute of Astronomy.
"It's important that we're deeply sceptical of our own results, because it's only by testing and testing again that we will be able to reach the point where we're confident in them," Madhusudhan said. "That's how science has to work."
While he is not yet claiming a definitive discovery, Madhusudhan says that with powerful tools like JWST and future planned telescopes, humanity is taking new steps toward answering that most essential of questions: are we alone?
"Decades from now, we may look back at this point in time and recognise it was when the living universe came within reach," said Madhusudhan. "This could be the tipping point, where suddenly the fundamental question of whether we're alone in the universe is one we're capable of answering."
The James Webb Space Telescope is a collaboration between NASA, ESA and the Canadian Space Agency (CSA). The research is supported by a UK Research and Innovation (UKRI) Frontier Research Grant.

- 'Big surprise': Astronomers find planet in perpendicular orbit around pair of stars

Date: April 16, 2025
Source: ESO



Astronomers have found a planet that orbits at an angle of 90 degrees around a rare pair of peculiar stars.

Astronomers have found a planet that orbits at an angle of 90 degrees around a rare pair of peculiar stars. This is the first time we have strong evidence for one of these 'polar planets' orbiting a stellar pair. The surprise discovery was made using the European Southern Observatory's Very Large Telescope (VLT). Several planets orbiting two stars at once, like the fictional Star Wars world Tatooine, have been discovered in the past years. These planets typically occupy orbits that roughly align with the plane in which their host stars orbit each other. There have previously been hints that planets on perpendicular, or polar, orbits around binary stars could exist: in theory, these orbits are stable, and planet-forming discs on polar orbits around stellar pairs have been detected. However, until now, we lacked clear evidence that these polar planets do exist.

"I am particularly excited to be involved in detecting credible evidence that this configuration exists," says Thomas Baycroft, a PhD student at the University of Birmingham, UK, who led the study published today in *Science Advances.*

The unprecedented exoplanet, named 2M1510 (AB) b, orbits a pair of young brown dwarfs -- objects bigger than gas-giant planets but too small to be proper stars. The two brown dwarfs produce eclipses of one another as seen from Earth, making them part of what astronomers call an eclipsing binary. This system is incredibly rare: it is only the second pair of eclipsing brown dwarfs known to date, and it contains the first exoplanet ever found on a path at right angles to the orbit of its two host stars.

"A planet orbiting not just a binary, but a binary brown dwarf, as well as being on a polar orbit is rather incredible and exciting," says co-author Amaury Triaud, a professor at the University of Birmingham.

The team found this planet while refining the orbital and physical parameters of the two brown dwarfs by collecting observations with the Ultraviolet and Visual Echelle Spectrograph (UVES) instrument on ESO's VLT at Paranal Observatory, Chile. The pair of brown dwarfs, known as 2M1510, were first detected in 2018 by Triaud and others with the Search for habitable Planets EClipsing ULtra-cOOl Stars (SPECULOOS), another Paranal facility.

The astronomers observed the orbital path of the two stars in 2M1510 being pushed and pulled in unusual ways, leading them to infer the existence of an exoplanet with its strange orbital angle. "We reviewed all possible scenarios, and the only one consistent with the data is if a planet is on a polar orbit about this binary," says Baycroft.

"The discovery was serendipitous, in the sense that our observations were not collected to seek such a planet, or orbital configuration. As such, it is a big surprise," says Triaud.

"Overall, I think this shows to us astronomers, but also to the public at large, what is possible in the fascinating Universe we inhabit."

- Crystal clues on Mars point to watery and possibly life-supporting past

Date: April 16, 2025
Source: Queensland University of Technology

A QUT-led study analysing data from NASA's Perseverance rover has uncovered compelling evidence of multiple mineral-forming events just beneath the Martian surface -- findings that bring scientists one step closer to answering the profound question: did life ever exist on Mars?

The QUT research team led by Dr Michael Jones, from the Central Analytical Research Facility and the School of Chemistry and Physics, includes Associate Professor David Flannery, Associate Professor Christoph Schrank, Brendan Orenstein and Peter Nemere, together with researchers from North America and Europe.

The findings were published in the journal *Science Advances*.

"Sulphate minerals exist with different amounts of water in most regions on Mars and allow us to understand how water moved around the planet, which is key to understanding its past habitability," Dr Jones said.

"However, we don't yet fully understand how or when these minerals formed. Our team found a way to measure the internal crystal structure of these minerals directly in the rock, which had thought to be impossible on the surface of Mars."

The team adapted a new analytical method called X-ray Backscatter Diffraction Mapping (XBDM) developed by Dr Jones and Professor Schrank at the Australian Synchrotron to Perseverance's onboard PIXL instrument developed by QUT alumna Abigail Allwood.

This allowed the team to determine the orientation of the crystal structures, essentially providing a fingerprint of how and when they grew, and what the environment on Mars was like at that time.

Two separate generations of calcium-sulphate minerals were uncovered at Hogwallow Flats and Yori Pass in the Shenandoah formation, part of the sedimentary fan in Jezero crater: one formed just beneath the surface and the other formed deeper underground, at least 80 meters down.

"This discovery highlights the diversity of environments that existed in the Shenandoah formation's history -- indicating multiple potential windows when life might have been possible on Mars," Dr Jones said.

Since its landing in Jezero Crater in February 2021, the Perseverance rover has been exploring a wide variety of Martian rock types, from ancient lava flows to sedimentary layers left behind by a long-vanished lake and river delta.

One of its key mission goals is to study environments that could have supported microbial life -- and collect samples that might someday be returned to Earth.

The QUT research team is part of the multidisciplinary QUT Planetary Surface Exploration Research Group which focuses on interplanetary science and is actively involved in projects within NASA and the Australian Space Agency.

Professor Flannery, long-term planner for the NASA Perseverance mission, said QUT is at the forefront of planetary science in Australia.

"Experience gained by QUT researchers exposed to the cutting edge of the robotics, automation, data science and astrobiology fields has the potential to kick start Australia's space industry," he said.

- Scientists use James Webb Space Telescope to better understand solar system's origins

Date: April 24, 2025
Source: University of Central Florida

This is an artist's concept of a craggy piece of solar system debris that belongs to a class of bodies called trans-Neptunian objects (TNOs). Most TNOs are small and faint, making them difficult to spot. Generally, they are more than 100 million times fainter than objects visible to the unaided eye. In this illustration, the distant Sun is reduced to a bright star at a distance of over 3 billion miles. (Image courtesy of NASA).

University of Central Florida (UCF) scientists and their collaborators discovered new insights into the formation of distant icy objects in space beyond Neptune, offering a deeper understanding of our solar system's formation and growth.

Using the James Webb Space Telescope (JWST), scientists analysed far-away bodies -- known as Trans-Neptunian Objects (TNOs) -- and found varying traces of methanol. The discoveries are helping them better classify different TNOs and understand the complex chemical reactions in space that may relate to the formation of our solar system and the origin of life.

The findings, recently published in *The Astronomical Journal Letters* by the American Astronomical Society, reveal two distinct groups of TNOs with surface ice methanol presence: one with a depleted amount of surface methanol and a large reservoir beneath the surface, and another -- furthest from the Sun -- with an overall weaker methanol presence. The study suggests that cosmic irradiation over billions of years may have played a role in the first group's varying methanol distribution, while raising new questions about the second group's muted signatures.

Reaching Back in Time and Space

TNOs are important to our understanding of our solar system's origins because they are incredibly well-preserved remnants of the protoplanetary disk -- or disk of gas and dust surrounding a young star such as the Sun -- and can give scientists a thorough glimpse into the past.

UCF Department of Physics Research Professor Noemí Pinilla-Alonso, who now works at the University of Oviedo in Spain, co-led the research as part of the UCF-led Discovering the Surface Compositions of Trans-Neptunian Objects (DiSCo) program which includes UCF Florida Space Institute (FSI) Associate Professor Ana Carolina de Souza-Feliciano.

Pinilla-Alonso says the research helps piece together the history of the solar system's chemistry and gain insights into exoplanets, where methanol and methane play a crucial role in shaping atmospheres and hinting at the conditions of potentially habitable worlds.

"Methanol, a simple alcohol, has been found on comets and distant TNOs, hinting that it may be a primitive ingredient inherited from the early days of our solar system -- or even from interstellar space," Pinilla-Alonso says. "But methanol is more than just a leftover from the past. When exposed to radiation, it transforms into new compounds, acting as a chemical time capsule that reveals how these icy worlds have evolved over billions of years."

Methanol ice is a key precursor that may lead to organic molecules such as sugars, and its discovery in TNOs paves the way for so much more, she says.

These spectral differences reveal that not all TNOs formed from the same molecular ingredients, Pinilla-Alonso says. Instead, their compositions reflect their origins -- where and how they formed -- and their transformations over time.

"What excited me the most was realizing that these differences were linked to the behaviour of methanol -- a key ingredient that had long been elusive on TNOs from earth-based observations," she says. "Our findings suggest that methanol is being destroyed on the surface of TNOs by irradiation, but remains more abundant in the subsurface, protected from this exposure."

Pinilla-Alonso worked alongside UCF FSI researchers, including de Souza-Feliciano, who synthesized the laboratory data with modelling to better explain the behaviour of methanol.

De Souza-Feliciano helped to better visualize the findings by reproducing some of the spectral features the scientists were seeing and therefore could give mathematical support for the data in the study.

"One of the biggest surprises came from the methanol behaviour," de Souza-Feliciano says. "From laboratory data, its signatures at shorter wavelengths differ from the fundamental ones in longer wavelengths."

De Souza-Feliciano collaborated on prior DiSCo research projects using JWST that characterized binary objects and other distant TNOs.

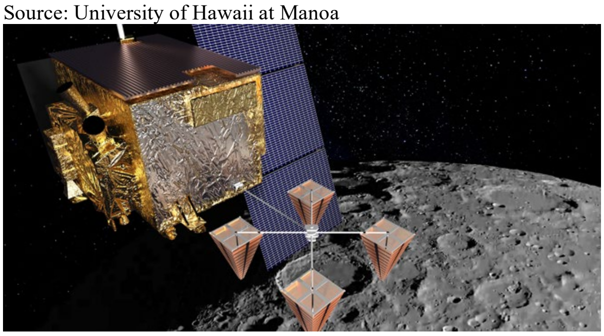
"The main DiSCo paper addressed the main characteristics of the three groups of TNOs," she says. "This paper goes into detail about one of them, known as the cliff group, which is the nickname for the spectral group where the reflectance did not increase after approximately 3.3 microns."

Not only are these cliff group TNOs time capsules for our solar system, but the group houses cold-classical TNOs which have largely stayed in place since their formation, de Souza-Feliciano says.

"One of the reasons why this group is a key for the outer solar system understanding is [because] it contains all the cold-classical TNOs," she says. "The cold-classical TNOs are the only dynamic group that probably stayed in the place where they formed from the formation of the solar system to today."

- Innovative approaches advance search for ice on the moon

Date: April 23, 2025
Source: University of Hawaii at Manoa



Rendering of future cosmic ray radar instrument over the Moon. (Image credit: Christian Miki)

Scientists and space explorers have been on the hunt to determine where and how much ice is present on the Moon. Water ice would be an important resource at a future lunar base, as it could be used to support humans or be broken down to hydrogen and oxygen, key components of rocket fuel. University of Hawai'i at Manoa researchers are using two innovative approaches to advance the search for ice on the Moon.

ShadowCam scouts for surface ice

Water ice was previously detected in the permanently shaded regions of the Moon's north and south poles by Shuai Li, assistant researcher at the Hawai'i Institute of Geophysics and Planetology (HIGP) in the UH Manoa School of Ocean and Earth Science and Technology (SOEST). A new study led by Jordan Ando, planetary sciences graduate student in Li's laboratory, examined images from a specialized camera, the "ShadowCam," that was on board the Korea Aerospace Research Institute Korea Lunar Pathfinder Orbiter.

Craters in the Moon's polar regions receive no direct sunlight, but sunlight that bounces off of one side of a crater can indirectly illuminate another side. The ShadowCam, designed specifically to look only at the dark, permanently shaded areas on the Moon, is extremely sensitive to the indirect light reflected off the lunar surface.

"Ice is generally brighter, that is, reflects more light, than rocks," said Ando. "We analysed high-quality images from this sensitive camera to look really closely into these permanently shaded areas and investigate whether water ice in these regions leads to widespread brightening of the surface."

While the ice in the shaded regions did not significantly brighten the surface, the team's analysis of the ShadowCam images helps to refine the estimate of the amount of ice that could be on the lunar surface. Li's previous method suggested that the lunar surface contains between five and 30 percent water ice. The analysis of Shadow Cam images narrows the range -- indicating that water ice makes up less than 20 percent of the lunar surface.

Cosmic rays help search for buried ice

In addition to these investigations of lunar ice at the surface, another group of UH Manoa researchers with HIGP and Department of Physics and Astronomy recently published a study in Geophysical Research Letters that outlines an innovative approach to detect buried ice deposits at the Moon's poles.

"With our recent study, we showed that a new technique for detecting buried water ice on the Moon is possible using naturally-occurring cosmic rays," said Emily S. Costello, study lead author and postdoctoral researcher at HIGP. "These ultra-high-energy cosmic rays strike the lunar surface and penetrate to the layers below. The rays emit radar waves that bounce off buried ice and rock layers, which we can use to infer what's below the surface."

The team used an advanced computer simulation that tests how radar waves travel through the lunar soil and how they encode information about possible buried ice layers.

"This method for searching for water ice on the Moon is brand new and really exciting," said Christian Tai Udovicic, a co-author on the study who presented the findings at the recent Lunar and Planetary Science Conference in Houston, Texas. "Since it relies on high-energy physics that only a few scientists in the world are experts in, even planetary scientists who are studying ways to find lunar water ice are often surprised when they hear about this technique."

A team of HIGP and Physics Department researchers are working to assemble a radar instrument specifically tuned to listen for these signals on the Moon and hope to test the full system by early 2026. They will look for opportunities to send it to the Moon to hopefully detect large deposits of buried water ice on the Moon for the first time.

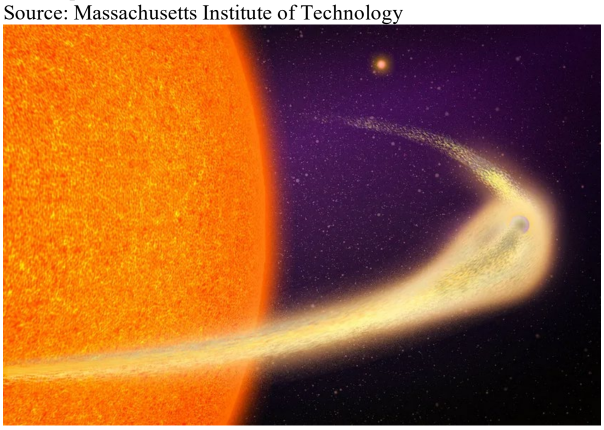
"More and more, Hawai'i is becoming a hub for space exploration, and specifically the exploration of the Moon," said Costello. "These projects, led by UH Manoa scientists, represent up-and-coming opportunities for students and professionals in Hawai'i to lead and participate in the budding space industry."

- Astronomers discover a planet that's rapidly disintegrating, producing a comet-like tail

The small and rocky lava world sheds an amount of material equivalent to the mass of Mount Everest every 30.5 hours

Date: April 22, 2025

Source: Massachusetts Institute of Technology



An artistic rendering of an exoplanet in a tight orbit, followed by a dusty, comet-like tail of debris. Jose-Luis Olivares / MIT

MIT astronomers have discovered a planet some 140 light-years from Earth that is rapidly crumbling to pieces.

The disintegrating world is about the mass of Mercury, although it circles about 20 times closer to its star than Mercury does to the sun, completing an orbit every 30.5 hours. At such close proximity to its star, the planet is likely covered in magma that is boiling off into space. As the roasting planet whizzes around its star, it is shedding an enormous amount of surface minerals and effectively evaporating away.

The astronomers spotted the planet using NASA's Transiting Exoplanet Survey Satellite (TESS), an MIT-led mission that monitors the nearest stars for transits, or periodic dips in starlight that could be signs of orbiting exoplanets. The signal that tipped the astronomers off was a peculiar transit, with a dip that fluctuated in depth every orbit.

The scientists confirmed that the signal is of a tightly orbiting rocky planet that is trailing a long, comet-like tail of debris.

"The extent of the tail is gargantuan, stretching up to 9 million kilometres long, or roughly half of the planet's entire orbit," says Marc Hon, a postdoc in MIT's Kavli Institute for Astrophysics and Space Research.

It appears that the planet is disintegrating at a dramatic rate, shedding an amount of material equivalent to one Mount Everest each time it orbits its star. At this pace, given its small mass, the researchers predict that the planet may completely disintegrate in about 1 million to 2 million years.

"We got lucky with catching it exactly when it's really going away," says Avi Shporer, a collaborator on the discovery who is also at the TESS Science Office. "It's like on its last breath."

Hon and Shporer, along with their colleagues, will publish their results in the *Astrophysical Journal Letters.* Their MIT co-authors include Saul Rappaport, Andrew Vanderburg, Jeroen Audenaert, William Fong, Jack Haviland, Katharine Hesse, Daniel Muthukrishna, Glen Petitpas, Ellie Schmelzer, Sara Seager, and George Ricker, along with collaborators from multiple other institutions.

Roasting away

The new planet, which scientists have tagged as BD+05 4868 Ab, was detected almost by happenstance.

"We weren't looking for this kind of planet," Hon says. "We were doing the typical planet vetting, and I happened to spot this signal that appeared very unusual."

The typical signal of an orbiting exoplanet looks like a brief dip in a light curve, which repeats regularly, indicating that a compact body such as a planet is briefly passing in front of, and temporarily blocking, the light from its host star.

This typical pattern was unlike what Hon and his colleagues detected from the host star BD+05 4868 A, located in the constellation of Pegasus. Though a transit appeared every 30.5 hours, the brightness took much longer to return to normal, suggesting a long trailing structure still blocking starlight. Even more intriguing, the depth of the dip changed with each orbit, suggesting that whatever was passing in front of the star wasn't always the same shape or blocking the same amount of light.

"The shape of the transit is typical of a comet with a long tail," Hon explains. "Except that it's unlikely that this tail contains volatile gases and ice as expected from a real comet -- these would not survive long at such close proximity to the host star. Mineral grains evaporated from the planetary surface, however, can linger long enough to present such a distinctive tail."

Given its proximity to its star, the team estimates that the planet is roasting at around 1,600 degrees Celsius, or close to 3,000 degrees Fahrenheit. As the star roasts the planet, any minerals on its surface are likely boiling away and escaping into space, where they cool into a long and dusty tail.

The dramatic demise of this planet is a consequence of its low mass, which is between that of Mercury and the moon. More massive terrestrial planets like the Earth have a stronger gravitational pull and therefore can hold onto their atmospheres. For BD+05 4868 Ab, the researchers suspect there is very little gravity to hold the planet together.

"This is a very tiny object, with very weak gravity, so it easily loses a lot of mass, which then further weakens its gravity, so it loses even more mass," Shporer explains. "It's a runaway process, and it's only getting worse and worse for the planet."

Mineral trail

Of the nearly 6,000 planets that astronomers have discovered to date, scientists know of only three other disintegrating planets beyond our solar system. Each of these crumbling worlds were spotted over 10 years ago using data from NASA's Kepler Space Telescope. All three planets were spotted with similar comet-like tails. BD+05 4868 Ab has the longest tail and the deepest transits out of the four known disintegrating planets to date.

"That implies that its evaporation is the most catastrophic, and it will disappear much faster than the other planets," Hon explains.
The planet's host star is relatively close, and thus brighter than the stars hosting the other three disintegrating planets, making this system ideal for further observations using NASA's James Webb Space Telescope (JWST), which can help determine the mineral makeup of the dust tail by identifying which colours of infrared light it absorbs.
This summer, Hon and graduate student Nicholas Tusay from Penn State University will lead observations of BD+05 4868 Ab using JWST. "This will be a unique opportunity to directly measure the interior composition of a rocky planet, which may tell us a lot about the diversity and potential habitability of terrestrial planets outside our solar system," Hon says.
The researchers also will look through TESS data for signs of other disintegrating worlds. "Sometimes with the food comes the appetite, and we are now trying to initiate the search for exactly these kinds of objects," Shporer says. "These are weird objects, and the shape of the signal changes over time, which is something that's difficult for us to find. But it's something we're actively working on."
This work was supported, in part, by NASA.

- Did it rain or snow on ancient Mars? New study suggests it did

Date: April 21, 2025
Source: University of Colorado at Boulder


Artist's depiction of water rushing into Mars' Jezero Crater, which billions of years ago was the site of a delta. Credit: NASA/JPL-Caltech

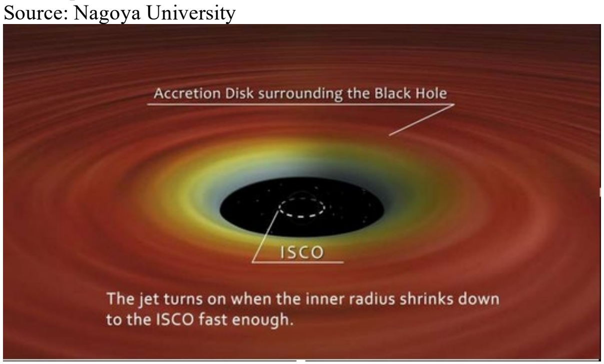
Visit ancient Mars -- a surprisingly temperate planet where snow or rain falls from the sky, and rivers rush down valleys to feed hundreds of lakes.
A new study from geologists at the University of Colorado Boulder paints this picture of a Red Planet that was relatively warm and wet, much different than the frigid wasteland we know today. The team's findings suggest that heavy precipitation likely fed many networks of valleys and channels that shaped the Martian surface billions of years ago -- adding new evidence to a long-running debate in planetary science.
The researchers, led by Amanda Steckel, who earned her doctorate in geological sciences at CU Boulder in 2024, published their findings April 21 in the *Journal of Geophysical Research: Planets*.
"You could pull up Google Earth images of places like Utah, zoom out, and you'd see the similarities to Mars," said Steckel, now at the California Institute of Technology.
Most scientists today agree that at least some water existed on the surface of Mars during the Noachian epoch, roughly 4.1 to 3.7 billion years ago.
But where that water came from has long been a mystery. Some researchers say that ancient Mars wasn't ever warm and wet, but always cold and dry. At the time, the solar system's young sun was only about 75% as bright as it is today. Sprawling ice caps may have covered the highlands around the Martian equator, occasionally melting for short periods of time.
In the new research, Steckel and her colleagues set out to investigate the warm-and-wet versus cold-and-dry theories of Mars past climate. The team drew on computer simulations to explore how water may have shaped the surface of Mars billions of years ago. They found that precipitation from snow or rain likely formed the patterns of valleys and headwaters that still exist on Mars today.
"It's very hard to make any kind of conclusive statement," Steckel said. "But we see these valleys beginning at a large range of elevations. It's hard to explain that with just ice."
A tale of two red planets
Satellite images of Mars today still reveal the fingerprints of water on the planet.
Around the equator, for example, vast networks of channels spread from Martian highlands, branching like trees and emptying into lakes and even, possibly, an ocean.
NASA's Perseverance rover, which landed on Mars in 2021, is currently exploring Jezero Crater, the site of one such ancient lake. During the Noachian, a powerful river emptied into this region, depositing a delta on top of the crater floor.
"You'd need meters deep of flowing water to deposit those kinds of boulders," said Brian Hynek, senior author of the study and a scientist at the Laboratory for Atmospheric and Space Physics (LASP) at CU Boulder.
To study that ancient past, he and Steckel, who now serves on the Perseverance science

team, created, essentially, a digital version of a portion of Mars.
The team drew on a computer simulation, or model, originally developed for Earth studies by study co-author Gregory Tucker, a professor at the Department of Geological Sciences at CU Boulder. Matthew Rossi, a research scientist at the Cooperative Institute for Research in Environmental Sciences (CIRES) at CU Boulder, also served as a co-author.
The researchers used the software to model the evolution of the landscape on synthetic terrain that resembles Mars close to its equator. In some cases, the group added water to that terrain from falling precipitation. In other cases, the researchers included melting ice caps. Then, in the simulation, they let the water flow for tens to hundreds of thousands of years.
The researchers examined the patterns that formed as a result and, specifically, where the headwaters feeding Mars' branching valleys emerged. The scenarios produced very different planets: In the case of melting ice caps, those valley heads formed largely at high elevations, roughly around the edge of where the ancient ice sat. In the precipitation examples, Martian headwaters were much more widespread, forming at elevations ranging from below the planet's average surface to more than 11,000 feet high.
"Water from these ice caps starts to form valleys only around a narrow band of elevations," Steckel said. "Whereas if you have distributed precipitation, you can have valley heads forming everywhere."
The team then compared those predictions to actual data from Mars taken by NASA's Mars Global Surveyor and Mars Odyssey spacecrafts. The simulations that included precipitation lined up more closely with the real Red Planet.
The researchers are quick to point out that the results aren't the final word on Mars' ancient climate -- in particular, how the planet managed to stay warm enough to support snow or rain still isn't clear. But Hynek said the study provides scientists with new insights into the history of another planet: our own.
"Once the erosion from flowing water stopped, Mars almost got frozen in time and probably still looks a lot like Earth did 3.5 billion years ago," he said.

- ❖ Scientists discover how stellar-mass black holes emit powerful plasma jets

Improved prediction of jet occurrences and real-time study of the mechanisms behind them are now possible

Date: April 9, 2025
Source: Nagoya University



The inner edge of the gas disk rapidly shrinks towards the innermost stable circular orbit (ISCO) near the stellar black hole, triggering the eruption of a plasma jet. The jet continues to erupt until the inner edge stops moving, at which point the jet ceases. Credit: T. Kawaguchi (University of Toyama) & K. Yamaoka (Nagoya University)

Black holes are fundamental to the structure of galaxies and critical in our understanding of gravity, space, and time. A stellar mass black hole is a type of black hole that forms from the gravitational collapse of a massive star at the end of its life cycle. These black holes typically have masses ranging from about 3 to 20 times the mass of our Sun. Sometimes black holes generate beams of ionized gas (plasma) that shoot outward at nearly light speed. Although discovered more than a century ago, how and why jets occur has remained a mystery, described as one of the "wonders of physics."
Prof. Kazutaka Yamaoka from Nagoya University in Japan, along with his colleagues from the University of Toyama and other international institutes, have discovered key conditions needed for a stellar black hole to create plasma jets. Their findings, published in *Publications of the Astronomical Society of Japan*, show that when superheated gas material experiences a rapid shrinkage towards the black hole, jet formation occurs.

Swirling disks of cosmic matter

Understanding jet ejection in black holes is crucial because it sheds light on galaxy evolution, energy distribution in the universe, and the properties of black holes themselves. Jets influence star formation, distribute energy across vast distances, and serve as cosmic beacons for locating distant black holes. Additionally, they provide insights into the fundamental physics of black holes.
Material such as dust and gas gets pulled toward black holes because of their strong

gravity. This material rotates around the black hole in a thin disk, called an accretion disk, which is needed to form a jet.

The scientists studied a black hole system consisting of a stellar-mass black hole and a sun-like star orbiting each other. In this system, 5 or 6 jets occur over a period of about 20 days, making it ideal to study this phenomenon. By analysing X-ray and radio observation data from 1999 to 2000, they could track how quickly X-ray emissions near the black hole were changing over time and measure the total amount of energy produced by the jets.

Causes of jet formation

Results showed that the jets occur when the inner radius of the accretion disk suddenly decreases and reaches the innermost stable circular orbit (ISCO), the closest that matter can orbit without falling in.

The researchers observed that initially the inner radius of the gas disk was located further away from the black hole. When the inner radius of the disk shrinks rapidly and reaches the ISCO, the jet erupts. The jet continues to erupt for a while; however, when the shrinking movement of the inner edge of the disk stops, the jet itself ceases.

From this, they identified two key conditions needed for a stellar black hole to create jets: the inner edge of the gas disk surrounding the black hole must rapidly move closer to the black hole and this movement must reach the ISCO.

Scientists already knew that when a black hole jet erupts, X-rays become "softer" (more low-energy X-rays compared to high-energy ones) and show fewer rapid fluctuations in a short time scale. This study discovered that these X-ray changes happen because the inner edge of the gas disk is rapidly moving closer to the black hole, which is the actual trigger for jet formation. As this inner edge shrinks, it produces more soft X-rays with less variability compared with highly variable hard X-rays. This explains why the X-ray patterns change right before jets form.

This study reveals that jets form under changing, dynamic conditions rather than stable, static ones, as many theoretical models have assumed. Now scientists can better predict the occurrence of plasma jets and study the mechanisms behind them in real-time.

"Our discovery about jet formation in stellar-mass black holes may provide a universal key to understanding these phenomena. While these binary systems -- where a black hole orbits a normal star -- differ significantly from the supermassive black holes located at the centre of a galaxy, we believe similar physical mechanisms operate across all black hole scales," Prof. Yamaoka explained.

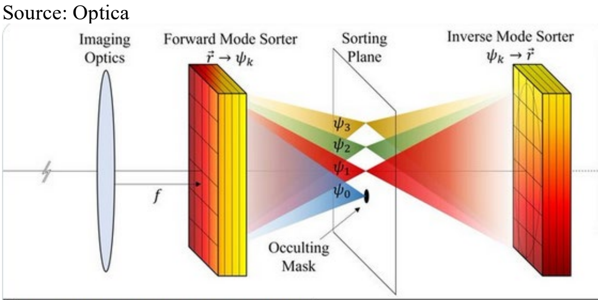
"Though challenging due to their slower time evolution and difficulty measuring their inner structures, applying our findings to supermassive black holes is our next step," he added.

- Turning down starlight to spot new exoplanets

New coronagraph could reveal hidden planets beyond our solar system

Date: April 18, 2025

Source: Optica



Turning down starlight to spot new exoplanets

Researchers have developed a new coronagraph -- an optical device that blocks out light from a bright source -- that could make it possible to see distant exoplanets obscured by light from their parent stars. The new device could reveal exoplanets beyond our solar system that today's telescopes cannot resolve, providing insights into the possibility of life beyond Earth.

"Earth-like planets in the habitable zone -- the region around a star where temperatures could allow liquid water to exist -- can easily be up to a billion times dimmer than their host star," said research team leader Nico Deshler from the University of Arizona. "This makes them difficult to detect because their faint light is overwhelmed by the star's brightness. Our new coronagraph design siphons away starlight that might obscure exoplanet light before capturing an image."

In *Optica*, the researchers show that the new coronagraph can theoretically achieve the fundamental limits of exoplanet detection and localization set by quantum optics. They also used it to capture images that allowed them to estimate the position of artificial exoplanets with distances from their host star up to 50 times smaller than what the telescope's resolution limit would normally allow.

"Compared to other coronagraph designs, ours promises to supply more information about so-called sub-diffraction exoplanets -- those which lie below the resolution limits of the telescope," said Deshler. "This could allow us to potentially detect biosignatures and discover the presence of life among the stars."

Blinded by the light

Optically analysing exoplanets poses a formidable challenge because, at astronomical scales, they are often too close to their parent star for current telescopes to resolve. Exoplanets can also be orders of magnitude dimmer than their host star. Although astronomers have developed various ways to indirectly infer the presence of a planet around a prospective star, directly observing exoplanets in images would be ideal.

With NASA's next-generation space telescope, the Habitable Worlds Observatory (HWO), being dedicated to exoplanet science, many coronagraph designs have emerged, each with different practical and theoretical performance trade-offs. At the same time, recent work has shown that traditional notions of resolution for telescopes do not reflect fundamental limits and can be circumvented with careful optical pre-processing.

Inspired by these developments, the researchers decided to use a spatial mode sorter available in their lab to develop an improved coronagraph that theoretically rejects all the light from an on-axis star while achieving maximal throughput of an off-axis exoplanet.

Much like piano notes emit different acoustic frequencies, light sources in space excite different spatial modes -- unique shapes and patterns of oscillation -- depending on their position. The researchers separated these different modes using a mode sorter to isolate and eliminate light from a star and an inverse mode sorter to recompose the optical field after the starlight is rejected. This made it possible to capture an image of the exoplanet without the star.

"Our coronagraph directly captures an image of the exoplanet, as opposed to measuring only the quantity of light from the exoplanet without any spatial orientation," said Deshler. "Images can provide context and composition information that can be used to determine exoplanet orbits and identify other objects that scatter light from a star such as exozodiacal dust clouds."

Imaging faint exoplanets

After configuring their coronagraph in the lab, the researchers constructed an artificial star-exoplanet scene in which the exoplanet was positioned close enough to the star to be unresolvable with a traditional telescope. The contrast ratio between the star and the planet was set to 1000:1.

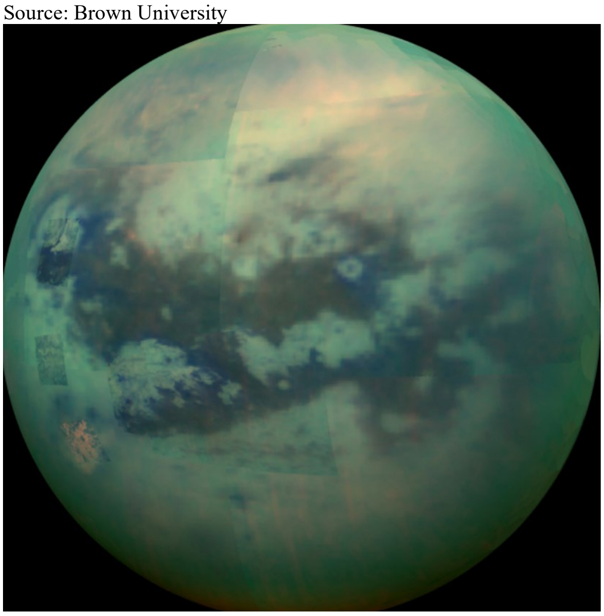
The researchers scanned the position of the exoplanet to simulate an orbit where the planet traverses in front of the star and then tried to determine its position in each frame. The images captured with their experimental setup incorporating the new coronagraph allowed them to estimate the position of the exoplanet at sub-diffraction planet-star separations.

The researchers are working to improve the mode sorter to reduce crosstalk, a type of interference in which light leaks across different optical modes. For scenes with moderate contrast levels, crosstalk is not very problematic. However, the extreme contrasts found in exoplanet science would require a very high-fidelity spatial mode sorter to sufficiently isolate light from the star.

The researchers say that this proof-of-principle experiment could inspire further exploration of optical pre-processing with spatial mode sorters in future astronomical instrumentation. For example, the spatial mode filtering methods they used could address more complex scenarios, such as treating stars as extended objects, and may also lead to new imaging methods for quantum sensing, medical imaging and communications.

- Scientists probe the mystery of Titan's missing deltas

Date: April 18, 2025
Source: Brown University



For scientists who want to learn about the geological history of a planet, river deltas are a great place to start. Deltas gather sediment from a large area into one place, which can be studied to reveal climate and tectonic histories or signs of past life. That's why NASA sent its most recent Mars rover to Jezero Crater, home to a prominent and well-preserved delta.

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And that's why planetary scientists are also interested in finding deltas on Saturn's moon Titan. Titan is the only planetary body in the solar system besides Earth that has liquid currently flowing across its surface, so its deltas could be a scientific treasure trove.

One problem: Titan appears to be largely devoid of deltas, a new study finds, despite its large rivers of liquid methane and ethane.

"It's kind of disappointing as a geomorphologist because deltas should preserve so much of Titan's history," said Sam Birch, an assistant professor in Brown University's Department of Earth, Environmental and Planetary Sciences who led the work.

But the absence of deltas raises a host of new questions.

"We take it for granted that if you have rivers and sediments, you get deltas," Birch said. "But Titan is weird. It's a playground for studying processes we thought we understood."

Titan is the largest of Saturn's 274 confirmed moons. Its thick nitrogen and methane atmosphere gives rise to a host of Earth-like climate and weather features. Titan has clouds, wind and rain as well as rivers, lakes and seas. But instead of water, Titan's fluid bodies contain methane and ethane, which are liquid at Titan's chilly surface temperatures.

Scientists learned of Titan's liquid bodies when the Cassini spacecraft flew by in 2006. Peering through Titan's thick atmosphere with Cassini's synthetic aperture radar (SAR), the spacecraft revealed spidering channels and large flat areas consistent with large bodies of liquid.

Largely missing from Cassini's SAR images, however, were deltas -- even at the mouths of large rivers. It wasn't clear, however, whether the deltas were truly absent, or whether they just didn't show up in Cassini's SAR data. That's the question Birch and his colleagues tried to answer with this new study, published in the *Journal of Geophysical Research: Planets*.

The problem with Cassini's SAR data is that shallow liquid methane is largely transparent in any images. So, while the SAR images could see the broad seas and river channels, it's harder to confidently make out coastal features because it's difficult to see where the coast ends and where the sea floor begins.

For the study, Birch developed a numerical model to simulate what Cassini's SAR would see if it looked at a landscape scientists understand well: Earth. In the model, the water in Earth's rivers and oceans was replaced by Titan's methane liquid, which has different radar absorption properties compared to water.

"We basically made synthetic SAR images of Earth that assume properties of Titan's liquid instead of Earth's," Birch said. "Once we see SAR images of a landscape we know very well, we can go back to Titan and understand a bit better what we're looking at."

The research found that the synthetic SAR images of Earth clearly resolved large deltas and many other large coastal landscapes.

"If there are deltas the size of the one at the mouth of the Mississippi River, we should be able to see it," Birch said. "If there are large barrier islands and similar coastal landscapes like those, we see all along the U.S. Gulf Coast, we should be able to see those."

But when Birch and his colleagues combed over the Titan images in light of their new analysis, they came up mostly empty. Aside from two probable deltas near Titan's south pole, the rest of the moon's rivers were entirely delta-free. The researchers found that only about 1.3% of Titan's large rivers that terminate at coastlines have deltas. On Earth, in contrast, nearly every river of similar size has a delta.

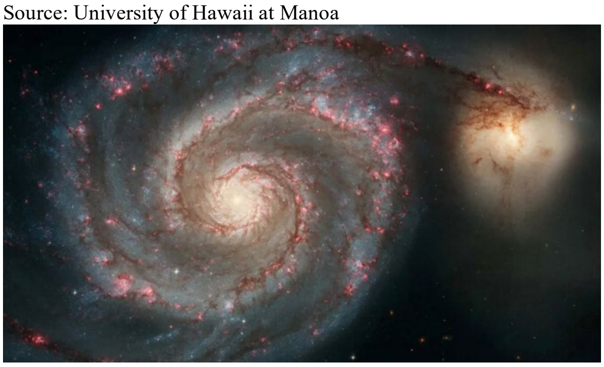
It's not entirely clear why Titan generally lacks deltas, Birch says. The fluid properties of Titan's rivers should make them perfectly capable of carrying and depositing sediment. It could be, the researchers say, that sea levels on Titan rise and fall so rapidly that deltas are smeared across the landscape more quickly than they can be built up in a single spot. Winds and tidal currents along Titan's coasts may also play an equally large role in preventing delta formation.

And missing deltas aren't the only mystery raised by the new research. The new analysis

of Cassini SAR data of Titan's coasts revealed pits of unknown origin deep within lakes and seas. The study also found deep channels on the floors of the seas that seem to have been carved by river flows, but it's not clear how they got there.
All of these surprises will require more research to fully understand, Birch says.
"This is really not what we expected," Birch said. "But Titan does this to us a lot. I think that's what makes it such an engaging place to study."

- Cosmic twist: The universe could be spinning

Date: April 16, 2025
Source: University of Hawaii at Manoa



The Whirlpool Galaxy, M51, is a spiral galaxy located 31 million light-years away. (Image credit: NASA)

A new study in *Monthly Notices of the Royal Astronomical Society* by researchers including István Szapudi of the University of Hawai'i Institute for Astronomy suggests the universe may rotate -- just extremely slowly. The finding could help solve one of astronomy's biggest puzzles.
"To paraphrase the Greek philosopher Heraclitus of Ephesus, who famously said "Panta Rhei" -- everything moves, we thought that perhaps Panta Kykloutai -- everything turns," said Szapudi.
Current models say the universe expands evenly in all directions, with no sign of rotation. This idea fits most of what astronomers observe. But it doesn't explain the so-called "Hubble tension" -- a long-standing disagreement between two ways of measuring how fast the universe is expanding.

Supernovae, Big Bang

One method looks at distant exploding stars or supernovae, to measure the distances to galaxies, and gives an expansion rate for the universe throughout the past few billion years. The other method uses the relic radiation from the Big Bang and gives the expansion rate of the very early Universe, about 13 billion years ago. Each gives a different value for the expansion rate.

Szapudi's team developed a mathematical model of the universe. First, it followed standard rules. Then they added a tiny amount of rotation. That small change made a big difference.
"Much to our surprise, we found that our model with rotation resolves the paradox without contradicting current astronomical measurements. Even better, it is compatible with other models that assume rotation. Therefore, perhaps, everything really does turn. Or, Panta Kykloutai! " noted Szapudi.
Their model suggests the universe could rotate once every 500 billion years -- too slow to detect easily, but enough to affect how space expands over time.
The idea doesn't break any known laws of physics. And it might explain why measurements of the universe's growth don't quite agree.
The next step is turning the theory into a full computer model -- and finding ways to spot signs of this slow cosmic spin.

- Ever wonder why some meteor showers are so unpredictable?

Date: April 16, 2025
Source: SETI Institute

This meteoroid broke up by thermal stresses just before entering Earth's atmosphere, creating a cluster of meteors over Norway on October 30, 2022, recorded by Allsky7 station AMS119 operated by Gaustabanen and
Steinar Midtskogen of the Norway Meteor Network. Video courtesy of Mike Hankey, American Meteor Society.

Why do comets and their meteoroid streams weave in and out of Earth's orbit and their orbits disperse over time? In a paper published online in the journal *Icarus* this week, two SETI Institute researchers show that this is not due to the random pull of the planets, but rather the kick they receive from a moving Sun.
"Contrary to popular conception, everything in the solar system does not orbit the Sun," said lead author and SETI Institute scientist Stuart Pilorz. "Rather, the Sun and planets all orbit their common centre of mass, known to scientists as the solar system barycenter."
The Solar System barycenter is the proverbial point where the Greek god Atlas would keep his finger to balance the mass of Sun and planets. All planets circle this barycenter, but so does the Sun.
"Usually when we build our numerical models," said Pilorz, "we put the Sun at the centre out of convenience because it's the most massive body in the solar system, and it simplifies the relativistic equations."
The team found that this perspective may not be the best way to understand the physical processes underlying the orbital evolution of long-period comets. Those move in orbits that take longer than 200 years to circle the Sun.
"Long-period comets spend most of their lives so far away from the solar system that they feel the tug from the barycenter," said Pilorz. "But every few hundred years they swoop inside Jupiter's orbit and come under the Sun's influence."
Close to the Sun, the comets shed particles called "meteoroids." These meteoroids follow along with the comet, but some travel a shorter orbit and return early, others late, creating a meteoroid stream. When they first form, these streams are extremely thin and chances of hitting Earth are low.
"Back in 1995, our field was in its infancy and many thought that predicting when these streams would cause a meteor shower on Earth was as hard as predicting the weather," said meteor astronomer and co-author Peter Jenniskens of the SETI Institute and NASA Ames Research Centre.
Jenniskens noticed that the streams were weaving in and out of Earth's orbit following the Sun's wobble around the solar system barycenter. He predicted that the shower would return when Jupiter and Saturn were back at certain positions along their orbit.
"We travelled to Spain in an attempt to record one of these showers and saw what was described in the past as 'stars fall at midnight'," said Jenniskens. "The whole shower lasted only 40 minutes, but there was a bright meteor every minute at the peak."
That prediction had been based on how the Sun's wobble mostly mirrors the motion of the two most massive planets, Jupiter and Saturn, in their orbit around it. The wobble is small, barely outside the Sun itself, but enough to move the position of the Sun and its velocity over periods of 12 years (Jupiter's orbit) and 30 years (Saturn's orbit), roughly causing a 60-year pattern.
"We were previously able to show in computer models that these streams do wander in and out of Earth's path and do follow the Sun's wobble," said Jenniskens, "but we didn't know why."
In this newly published study, Jenniskens teamed up with Pilorz to investigate how the meteoroid streams of long-period comets disperse over time to learn how best to use that trail of crumbs to search for their parent comets.
"A principal result of this study," said Pilorz, "was merely noticing that if we keep track of the fact that the Sun is in motion about the barycenter, we see that most of what actually causes the comets and meteoroids to disperse is that they each pick up a gravitational boost or braking from the moving Sun as they pass close to it -- exactly in the same way that we use planetary encounters to speed or slow down spacecraft."
The phenomenon of gravitational boost or braking is often compared to bouncing a tennis ball off the front or back of a moving train.
"But the train has to be moving for it to work," Pilorz noted. "In our case, if we consider the Sun fixed at the centre, we don't see that this is all that's happening."
The researchers noticed that inside the orbit of Jupiter, the meteoroid changed from moving around the barycenter to moving around the Sun's centre.
"We found that the two jumps in the plane of motion, when the Sun takes control as the comet approaches and then again when it hands control back to the barycenter as the comet heads away, kicked the inclination and node of the orbit by a small amount," said Pilorz. "Again, if we consider the Sun fixed at

the centre, the reason for this change is not obvious."
Meteoroids at different locations in the stream encounter the Sun at different times, so they get different kicks over time and the stream weaves and disperses. The randomness is primarily due to the Sun's place and velocity in its orbit around the barycenter when each meteoroid encounters it.
"This is where one's point of view can be important," added Pilorz. "We're used to telling ourselves that a comet's motion changes randomly due to a series of complex perturbations from the planets. That isn't wrong, but if we recall that the Sun also orbits the barycenter, the explanation becomes much simpler."
To be fair, the planets determine the Sun's motion equally as much as it determines theirs. However, to know how quickly long-period comet streams tend to disperse, the details of this dance are not needed.
"It's still necessary to account for the planetary forces to provide a systematic torque that causes precession," said Pilorz. "This happens mostly when the meteoroids are between the orbits of Jupiter and Saturn."
From the measured shower dispersions, the team calculated the ages of over 200 long-period comet meteoroid streams, which were published in Jenniskens' most recent book "Atlas of Earth's Meteor Showers," an Association of American Publishers' 2025 PROSE Book Award Finalist.

- Scientists find evidence that overturns theories of the origin of water on Earth

Date: April 16, 2025
Source: University of Oxford

University of Oxford researchers have helped overturn the popular theory that water on Earth originated from asteroids bombarding its surface. Instead, the material which built our planet was far richer in hydrogen than previously thought. The findings have been published today in the journal *Icarus.*

A team of researchers at the University of Oxford have uncovered crucial evidence for the origin of water on Earth. Using a rare type of meteorite, known as an enstatite chondrite, which has a composition analogous to that of the early Earth (4.55 billion years ago), they have found a source of hydrogen which would have been critical for the formation of water molecules.
Crucially, they demonstrated that the hydrogen present in this material was intrinsic, and not from contamination. This suggests that the material which our planet was built from was far richer in hydrogen than previously thought.
Without hydrogen, a fundamental elemental building-block of water, it would have been impossible for our planet to develop the conditions to support life. The origin of hydrogen, and by extension water, on Earth has been highly debated, with many believing that the necessary hydrogen was delivered by asteroids from outer space during Earth's first approximately 100 million years. But these new findings contradict this, suggesting instead that Earth had the hydrogen it needed to create water from when it first formed.
The research team analysed the elemental composition of a meteorite known as LAR 12252, originally collected from Antarctica. They used an elemental analysis technique called X-Ray Absorption Near Edge Structure (XANES) spectroscopy* at the Diamond Light Source synchrotron at Harwell, Oxfordshire.
A previous study led by a French team had originally identified traces of hydrogen within the meteorite inside organic materials and non-crystalline parts of the chondrules (millimetre-sized spherical objects within the meteorite). However, the remainder was unaccounted for -- meaning it was unclear whether the hydrogen was native or due to terrestrial contamination.
The Oxford team suspected that significant amounts of the hydrogen may be attached to the meteorite's abundant sulphur. Using the synchrotron, they shone a powerful beam of X-rays onto the meteorite's structure to search for sulphur-bearing compounds.
When initially scanning the sample, the team focussed their efforts on the non-crystalline parts of the chondrules, where hydrogen had been found before. But when serendipitously analysing the material just outside of one of these chondrules, composed of a matrix of

extremely fine (sub-micrometre) material, the team discovered that the matrix itself was incredibly rich in hydrogen sulphide. In fact, their analysis found that the amount of hydrogen in the matrix was five times higher than that of the non-crystalline sections.
In contrast, in other parts of the meteorite that had cracks and signs of obvious terrestrial contamination (such as rust), very little or no hydrogen was present. This makes it highly unlikely that the hydrogen sulphide compounds detected by the team originated from an Earthly source.
Since the proto-Earth was made of material similar to enstatite chondrites, this suggests that by the time the forming planet had become large enough to be struck by asteroids, it would have amassed enough reserves of hydrogen to explain Earth's present-day water abundance.
Tom Barrett, DPhil student in the Department of Earth Sciences at the University of Oxford, who led the study, said: "We were incredibly excited when the analysis told us the sample contained hydrogen sulphide -- just not where we expected! Because the likelihood of this hydrogen sulphide originating from terrestrial contamination is very low, this research provides vital evidence to support the theory that water on Earth is native -- that it is a natural outcome of what our planet is made of."
Co-author Associate Professor James Bryson (Department of Earth Sciences, University of Oxford) added: "A fundamental question for planetary scientists is how Earth came to look like it does today. We now think that the material that built our planet -- which we can study using these rare meteorites -- was far richer in hydrogen than we thought previously. This finding supports the idea that the formation of water on Earth was a natural process, rather than a fluke of hydrated asteroids bombarding our planet after it formed."
* X-ray Absorption Near Edge Structure (XANES) spectroscopy is a technique that is used to identify what elements are in a material and what their chemical state is. It works by shining X-rays onto a sample, causing the atoms to absorb energy in a way that depends on what the element is, the chemical form it is in (e.g., an oxide, a sulphide, etc), and how the atoms are bonded with others.