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Astronomy

Exoplanet CO_2 spotted for first time

The distant world WASP-39b may have formed similarly to planets in our solar system

Leah Crane

NASA's James Webb Space Telescope (JWST) has detected carbon dioxide in the atmosphere of a planet 700 light years away called WASP-39b. This is the first time the compound has been found in any exoplanet. The observations also suggest hints of a mystery within the distant world.

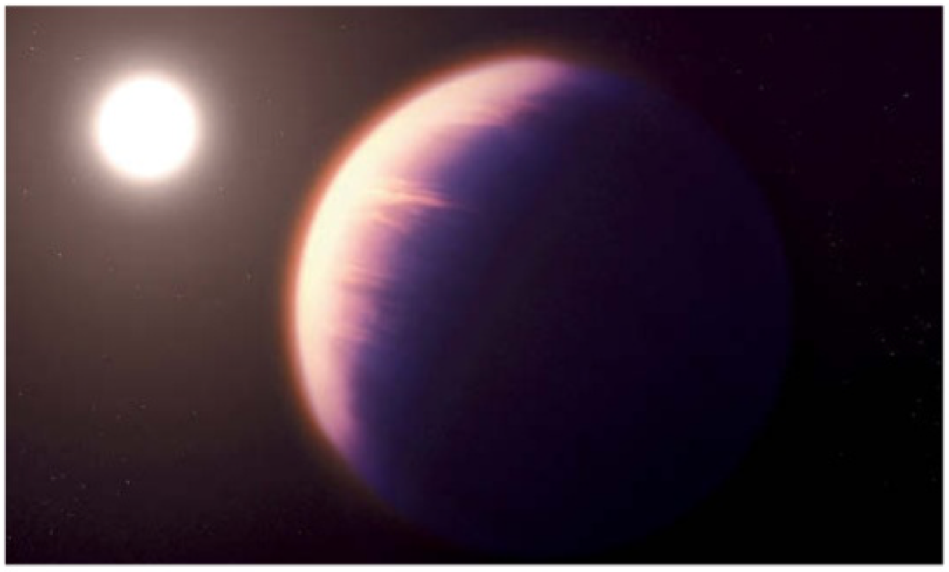
WASP-39b is huge. It has a mass similar to Saturn's and a diameter 1.3 times that of Jupiter. It orbits relatively close to its star, giving it an average temperature of 900°C, which puffs up the atmosphere, making it easier for JWST to see starlight shining through it.

When light from a star shines through a planet's atmosphere, molecules in the atmosphere absorb some of the light in unique wavelength ranges. Carbon dioxide absorbs infrared light, which is the same range JWST uses for its observations.

Natalie Batalha at the University of California, Santa Cruz, and a team of more than 100 researchers examined JWST observations, running them through four separate algorithms to be sure of the results. All four showed the clear signature of CO_2. "The carbon dioxide signature was just screaming at us," says Batalha. "It was honestly beautiful."

The result has a statistical significance of 26 sigma, meaning that the likelihood of finding such a signature as a statistical fluke is less than 1 in 10^{149}. "It's just exquisite," says Eliza Kempton at the University of Maryland, part of the research team. "I've never seen anything like 26 sigma in this field."

Artist's impression of the exoplanet WASP-39b orbiting its star



NASA, ESA, CSA, AND J. OLMSTED (STSCI)

The researchers found that WASP-39b has more carbon and oxygen than its host star, implying that it didn't form when gas around the star collapsed all at once, but rather its rocky core formed first and then accreted the gas that makes up its atmosphere. This is similar to how we think the planets in our own solar system formed. Studying the exoplanet's atmosphere could reveal more about how and where it formed (arXiv, doi.org/h9c4).

Aside from carbon dioxide, the researchers found another bump in their data, indicating that something unexpected in WASP-39b's atmosphere was absorbing some of the starlight. "There's something else there, some other molecule or some kind of cloud or haze – something that's not predicted by the basic model" of exoplanet atmospheres says Kempton. The researchers aren't sure yet what this mystery molecule may be, but they are working to figure it out with additional data from JWST and different models.

The fact that we were able to see carbon dioxide in this gas giant's atmosphere is a good sign for our ability to eventually understand the atmospheres of rocky worlds similar to Earth, one of the main goals of JWST, says Batalha.

It may also be useful in the hunt for alien life. "Down the road, it may be an interesting biosignature when found in combination with other molecules like methane," says Jessie Christiansen at the NASA Exoplanet Science Institute in California. ▮

Mathematics

The complex rules of wrinkling have been worked out

WE NOW know the rules for wrinkling, at least in certain circumstances. Using experiments, simulations and mathematical proofs, researchers have worked out how very thin curved shapes wrinkle when flattened.

Pinning down the mathematics of wrinkling is surprisingly hard. As something wrinkles, its properties change and so mathematical models of the situation must constantly change as well.

To try to better understand how the process works, Eleni Katifori at the University of Pennsylvania and her colleagues investigated how curved pieces of a plastic material thousands of times thinner than a human hair wrinkle. The team chose this scenario because thin materials wrinkle particularly well and Katifori could simulate them on a computer.

Originally, the researchers couldn't predict any wrinkling patterns. The breakthrough came when they realised Ian Tobasco at the University of Illinois at Chicago had already independently developed a mathematical theory based on the energy cost of certain patterns of wrinkles and they could team up to refine it. Through a back-and-forth between experiments, simulations and mathematics, they turned the theory into wrinkling rules for different shapes.

They found that whether wrinkles form in rows of ripples or only on the edges of the plastic depends on the shape of its curve. For instance, saddle-like shapes stay smoother at their centre than sphere-like ones.

"Pinning down the mathematics of how things wrinkle is surprisingly hard"

The researchers also found they could predict where wrinkles would form by splitting shapes into smaller sub-shapes. Tobasco's mathematics then provided rules for what kind of ripples would show up in each of those smaller sections (*Nature Physics*, doi.org/h9cz).

Robert Kohn at New York University says that predicting wrinkling patterns on a thin sheet is mathematically so complex that it is surprising to see the researchers determine any rules at all. ▮

Karmela Padavic-Callaghan

Astronomy

See the gas giant glow

The James Webb Space Telescope has taken an incredible image of Jupiter

Leah Crane

THIS stunning James Webb Space Telescope (JWST) image reveals the complexities of Jupiter. While the telescope's previous images of the gas giant used only one wavelength of light, this is a composite, showing its glowing auroras, shifting haze and two of its small moons.

Because JWST observes in infrared light, the image doesn't show Jupiter as it would look to the naked eye. Instead, different infrared wavelengths have been mapped to different colours to highlight particular features.

The orange glow at the poles is Jupiter's aurora. The green represents layers of tenuous high-altitude haze, while blue shows the main cloud layer. The white areas show the tops of storms, including the Great Red Spot.

"We hadn't really expected it to be this good," said Imke de Pater at the University of California, Berkeley, in a statement.

NASA, ESA, CSA, JUPITER ERS TEAM/JUDY SCHMIDT

Technology

AI-created lenses let camera ignore objects

A CAMERA equipped with 3D-printed plastic lenses designed by artificial intelligence can take photographs that capture only certain objects and ignore everything else in the frame. The selective lenses use no power and instead rely on complex patterns printed into the plastic to diffract light in different ways.

Aydogan Ozcan at the University of California, Los Angeles, and his colleagues trained a deep-learning AI model to recognise images of numbers from a huge online repository of handwritten digits inside a simulation. Some numbers were designated as targets to appear in images, some as objects to ignore.

The AI was shown thousands of images, one at a time, and told when those that were supposed to reach the camera's sensor did and didn't pass through a series of three lenses, as well as when numbers that weren't meant to reach the sensor did. The AI tweaked its lens design to better achieve the desired effect.

Once the model had a working solution in the simulation, the lenses were 3D printed with clear plastic and tested in the lab on new images of numbers.

Each target image was placed in turn between the AI-designed lenses and a terahertz radiation source that was used instead of visible light. This radiation is better suited to the 3D-printed lenses, but Ozcan says using visible light instead would be possible with better-quality lenses. A sensor was added at the other end of the lenses.

The AI-designed camera successfully photographed the target numbers, while diffracting away light relating to anything else so that it didn't appear in the photo. Other tests on images of clothing such as trainers and trousers were also successful. The lens designs allow certain shapes from objects to pass, but diffract others so their light never reaches the sensor (*eLight*, doi.org/gqnnqn).

"I cannot define mathematically what trousers are. That's where deep learning comes in"

Ozcan says the AI creates lenses that would be impossible to design mathematically from scratch. "Basically, it's a puzzle," he says. "I cannot define mathematically what trousers are. That's where deep learning comes in. Mathematically, what this does is difficult to explain."

As the processing is done physically, no image editing is needed by computer. But because the lenses are physical, once made, they will only work for one set of target shapes. ▮

Matthew Sparkes