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Hints of a possible atmosphere around a rocky exoplanet

Researchers using NASA/ESA/CSA James Webb Space Telescope may have detected an atmosphere surrounding 55 Cancri e, a rocky exoplanet 41 light-years from Earth. This is the best evidence to date for a rocky planet atmosphere outside our solar system. Brice-Olivier Demory, Professor of Astrophysics at the University of Bern and member of the the National Centre of Competence in Research (NCCR) PlanetS, was part of the international research team that just published the results in *Nature*.

55 Cancri e is one of five known planets orbiting a Sun-like star in the constellation Cancer. With a diameter nearly twice that of Earth and a density slightly greater, the planet is classified as a super-Earth: larger than Earth, smaller than Neptune, and similar in composition to the rocky planets in our solar system.

Brice-Olivier Demory from the Center for Space and Habitability CSH of the University of Bern and member of the NCCR PlanetS is co-author of the study that has just been published in *Nature*. He says: “55 Cancri e is one of the most enigmatic exoplanets. Despite enormous amounts of observing time obtained with a dozen of ground and space facilities in the past decade, its very nature has remained elusive, until today, when parts of the puzzle could finally be put together thanks to the James Webb Space Telescope (JWST)”. Unexpectedly, these observations show that it might be possible for a hot and highly irradiated rocky planet to sustain a gaseous atmosphere, and bodes well for JWST’s ability to characterize cooler – potentially habitable – rocky planets orbiting Sun-like stars. Renyu Hu from NASA’s Jet Propulsion Laboratory (JPL) leads the team publishing their results in *Nature*. “JWST is really pushing the frontiers of exoplanet characterization to rocky exoplanets,” Hu said. “It is truly enabling a new type of science.”

Bern space telescope CHEOPS delivered important findings

Demory was invited on the research programm by Hu who was one of his colleagues when he was at the Massachusetts Institute of Technology (MIT). Demory has been studying 55 Cancri e since the beginning of his career: “As a Postdoc at MIT I led the discovery of the first transit of 55 Cancri e, and in 2016 my team published the first map of a rocky exoplanet, which was 55 Cancri e”. The 2016 result already hinted at the possible presence of an atmosphere around 55 Cancri e. For the current study, Demory conducted an independent analysis of the JWST dataset. He explains: “In the past two years, the space telescope CHEOPS which has been developed and built at the University of Bern, has been key in solving several questions that astrophysicists had about 55 Cancri e. JWST complemented this picture at infrared wavelengths in showing that the super-Earth 55 Cancri e might be surrounded by an atmosphere with a composition consistent with carbon monoxide or carbon dioxide”.

Super-Hot Super-Earth and still cooler than expected

Although 55 Cancri e is similar in composition to the rocky planets in our solar system, describing it as “rocky” could leave the wrong impression. The planet orbits so close to its star (a full orbit lasts 18 hours, compared to the 365 days of our Earth) that its surface must be molten – a deep, bubbling ocean of magma. With such a tight orbit, the planet is also likely to be tidally locked, with a dayside that faces the star at all times and a nightside in perpetual darkness. “The planet is so hot that some of the molten rock should evaporate,” explained Hu.

Although JWST cannot capture a direct image of 55 Cancri e, it can measure subtle changes in light from the system as the planet orbits the star. The team used JWST’s NIRCам (Near-Infrared Camera) and MIRI (Mid-Infrared Instrument) to measure infrared light originating from the planet. By subtracting the brightness during the secondary eclipse, when the planet is behind the star (starlight only), from the brightness when the planet is right beside the star (light from the star and planet combined), the team was able to calculate the amount of infrared light coming from the dayside of the planet at multiple wavelengths simultaneously.

The first indication that 55 Cancri could have a substantial atmosphere came from temperature measurements based on its thermal emission, or heat energy given off in the form of infrared light. If the planet is covered in dark molten rock with a thin veil of vaporized rock or no atmosphere at all, the dayside should be around 2200 degrees Celsius. “Instead, the MIRI data showed a relatively low temperature of about 1500 degrees Celsius,” said Hu. “This is a very strong indication that energy is being distributed from the dayside to the nightside, most likely by a volatile-rich atmosphere.” While currents of lava can carry some heat around to the nightside, they cannot move it efficiently enough to explain the cooling effect. In fact, the dayside looks several hundred degrees cooler than it should, even if heat is spread evenly around the planet. This makes sense if some of the infrared light emitted by the surface is being absorbed by the atmosphere, and never reaches the telescope.

Bubbling Magma Ocean

The team thinks that the gases blanketing 55 Cancri e are bubbling out from the interior. The primary atmosphere would be long gone because of the high temperature and intense radiation from the star. This would be a secondary atmosphere that is continuously replenished by the magma ocean. Magma is not just crystals and liquid rock, there’s a lot of dissolved gas in it, too.

While 55 Cancri e is far too hot to be habitable, it could provide a unique window for studying interactions between atmospheres, surfaces, and interiors of rocky planets, and perhaps provide insights into the early Earth, Venus and Mars, which are thought to have been covered in magma oceans far in the past. “Ultimately, we want to understand what conditions make it possible for a rocky planet to sustain a gas-rich atmosphere: the key ingredient for a habitable planet,” said Hu.

Publication details:

A *Secondary Atmosphere on the Rocky Exoplanet 55 Cnc e* by Renyu Hu and al. is published in *Nature*.

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The James Webb Space Telescope

The James Webb Space Telescope is the world's premier space science observatory. JWST is solving mysteries in our solar system, looking beyond to distant worlds around other stars, and probing the mysterious structures and origins of our universe and our place in it. JWST is an international program led by NASA with its partners, ESA (European Space Agency) and the Canadian Space Agency. Researchers of the University of Bern are involved in various scientific programs exploiting the James Webb Space Telescope.

Bernese space exploration: With the world's elite since the first moon landing

When the second man, "Buzz" Aldrin, stepped out of the lunar module on July 21, 1969, the first task he did was to set up the Bernese Solar Wind Composition experiment (SWC) also known as the "solar wind sail" by planting it in the ground of the moon, even before the American flag. This experiment, which was planned, built and the results analyzed by Prof. Dr. Johannes Geiss and his team from the Physics Institute of the University of Bern, was the first great highlight in the history of Bernese space exploration.

Ever since Bernese space exploration has been among the world's elite, and the University of Bern has been participating in space missions of the major space organizations, such as ESA, NASA, and JAXA. With CHEOPS the University of Bern shares responsibility with ESA for a whole mission. In addition, Bernese researchers are among the world leaders when it comes to models and simulations of the formation and development of planets.

The successful work of the [Department of Space Research and Planetary Sciences \(WP\)](#) from the Physics Institute of the University of Bern was consolidated by the foundation of a university competence center, the [Center for Space and Habitability \(CSH\)](#). The Swiss National Fund also awarded the University of Bern the [National Center of Competence in Research \(NCCR\) PlanetS](#), which it manages together with the University of Geneva.