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Media release, August 25, 2022

James Webb Space Telescope detects carbon dioxide in exoplanet atmosphere

The James Webb Space Telescope delivers a sensation right away with its first scientific result: for the first time, CO2 has been conclusively detected in the atmosphere of a planet outside the solar system. Researchers from the University of Bern, the University of Geneva and the National Centre of Competence in Research (NCCR) PlanetS are involved in the study.

Due to its role in regulating the climate, carbon dioxide is a central component of the Earth's atmosphere. Being able to clearly detect the molecule in the atmosphere of distant exoplanets is therefore an essential step in the search for life-friendly worlds. This is exactly what an international team of researchers, with participation from the University of Bern, the University of Geneva and the National Centre of Competence in Research (NCCR) PlanetS, has achieved thanks to observations with the James Webb Space Telescope. The telescope is operated jointly by the European Space Agency ESA, the National Aeronautics and Space Administration NASA, and the Canadian Space Agency CSA, and has started its scientific work in June 2022. The first results will be published in the scientific journal *Nature* next week.

Starlight filtered through a bloated planet's atmosphere

The planet WASP-39b is a hot gas-giant orbiting a Sun-like star at a distance of 700 light-years from Earth. Unlike the gas giants in our solar system, WASP-39b orbits very close to its star – only about one-eighth the distance between the Sun and Mercury – completing one revolution in just over four Earth-days. Due to the intense insolation it receives, the planet heats up to around 900°C. "The heat causes the planet's atmosphere to expand, making WASP-39b a third larger than Jupiter, the largest gas giant in our solar system", study co-author, astronomy professor at the University of Geneva and NCCR PlanetS member Monika Lendl explains.

When a planet passes directly in front of its host star, some of the star's light passes through the planetary atmosphere before it reaches the telescope. "The atmosphere filters out some colors of this light more efficiently than others, depending on factors such as its composition, its thickness, and its cloud content", Lendl says. With the James Webb Telescope, researchers can break down light into its colours to identify characteristic "fingerprints" of different gases and determine the composition of the atmosphere.

First clear detection of carbon dioxide on an exoplanet

Using the Webb Telescope's Near-Infrared Spectrograph (NIRSpec) instrument, the team of researchers were able to detect the fingerprint of carbon dioxide in the light that passed through the

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atmosphere of WASP-39b. "From the first glance at the data, it was already clear that we were dealing with a spectacular discovery," says Dominique Petit dit de la Roche, researcher at the University of Geneva, co-author of the study and NCCR PlanetS member. "For the first time, carbon dioxide has been clearly detected on a planet outside the solar system".

“Detecting such a clear signal of carbon dioxide on WASP-39b bodes well for the detection of atmospheres on smaller, terrestrial-sized planets as well as for measuring abundances of other gases like water and methane,” said Natalie Batalha of the University of California at Santa Cruz, the leader of the international research team that carried out the observations.

Understanding the composition of a planet’s atmosphere also allows insights into the origin of the planet and its evolution. “Carbon dioxide molecules are sensitive tracers of the story of planet formation,” says Elspeth Lee, co-author of the study, Ambizione fellow at the University of Bern and member of the NCCR PlanetS. "The clear detection of carbon dioxide in WASP-39b gives us information about the inventory of carbon and oxygen molecules in the atmosphere. This gives us an idea of the diverse chemical processes that take place in atmospheres under such extreme conditions, as well as the possible rock and gas material that the planet may have picked up during its formation phases," says Lee.

Early Release Science

The NIRSpec observations of WASP-39b are only one part of a larger investigation with the James Webb Telescope, which includes further observations of WASP-39b as well as observations of two other planets. The observations are part of the so-called Early Release Science programme, which was developed to make scientific data from the James Webb Telescope available to the international research community as quickly as possible, thereby ensuring the best possible scientific use of the space telescope.

Publication details:

JWST Transiting Exoplanet Community Early Release Science Team: *Identification of carbon dioxide in an exoplanet atmosphere*, Accepted for publication in *Nature*
https://arxiv.org/abs/2208.11692

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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.

Exoplanets in Geneva: 25 years of expertise crowned by a Nobel Prize
The first exoplanet was discovered in 1995 by two researchers from the University of Geneva, Michel Mayor and Didier Queloz, laureates of the 2019 Nobel Prize in Physics. This discovery allowed the Department of Astronomy of the University of Geneva to be at the forefront of research in the field, with the construction and installation of HARPS on the ESO 3.6m telescope in La Silla in 2003. For two decades, this spectrograph was the most efficient in the world for determining the mass of exoplanets. However, HARPS was surpassed in 2018 by ESPRESSO, another spectrograph built in Geneva and installed on the Very Large Telescope (VLT) in Paranal, Chile. Switzerland has also been involved in space-based observations of exoplanets with the CHEOPS mission, the result of two national expertises: the space know-how of the University of Bern in collaboration with its Geneva counterpart, and the ground-based experience of the University of Geneva assisted by its colleague in the Swiss capital. These two scientific and technical skills have also made it possible to create the National Center of Competence in Research (NCCR) PlanetS.

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