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First study with CHEOPS data describes one of the most extreme planets in the universe

CHEOPS keeps its promise: Observations with the space telescope reveal details of the exoplanet WASP-189b – one of the most extreme planets known. CHEOPS is a joint mission by the European Space Agency (ESA) and Switzerland, under the aegis of the University of Bern in collaboration with the University of Geneva.

Eight months after the space telescope CHEOPS started its journey into space, the first scientific publication using data from CHEOPS has been issued. CHEOPS is the first ESA mission dedicated to characterising known exoplanets. Exoplanets, i.e. planets outside the Solar system, were first found in 1995 by two Swiss astronomers, Michel Mayor and Didier Queloz, who were last year awarded the Nobel Prize for this discovery. CHEOPS was developed as part of a partnership between ESA and Switzerland. Under the leadership of the University of Bern and ESA, a consortium of more than a hundred scientists and engineers from eleven European states was involved in constructing the satellite over five years. The Science Operations Center of CHEOPS is located at the observatory of the University of Geneva.

Using data from CHEOPS, scientists have recently carried out a detailed study of the exoplanet WASP-189b. The results have just been accepted for publication in the journal “Astronomy & Astrophysics. Willy Benz, professor of astrophysics at the University of Bern and head of the CHEOPS consortium, was delighted about the findings: “These observations demonstrate that CHEOPS fully meets the high expectations regarding its performance.”

One of the most extreme planets in the universe

WASP-189b, the target of the CHEOPS observations, is an exoplanet orbiting the star HD 133112, one of the hottest stars known to have a planetary system. “The WASP-189 system is 322 light years away and located in the constellation Libra (the weighing scales),” explains Monika Lendl, lead author of the study from the University of Geneva, and member of the National Centre of Competence in Research PlanetS.

“WASP-189b is especially interesting because it is a gas giant that orbits very close to its host star. It takes less than 3 days for it to circle its star, and it is 20 times closer to it than Earth is to the Sun,” Monika Lendl describes the planet, which is more than one and a half times as large as Jupiter, the largest planet of the Solar system.

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Monika Lendl further explains that planetary objects like WASP-189b are very exotic: “They have a permanent day side, which is always exposed to the light of the star, and, accordingly, a permanent night side.” This means that its climate is completely different from that of the gas giants Jupiter and Saturn in our solar system. “Based on the observations using CHEOPS, we estimate the temperature of WASP-189b to be 3,200 degrees Celsius. Planets like WASP-189b are called “ultra-hot Jupiters”. Iron melts at such a high temperature, and even becomes gaseous. This object is one of the most extreme planets we know so far,” says Lendl.

Highly precise brightness measurements

“We cannot see the planet itself as it is too far away and too close to its host star, so we have to rely on indirect methods,” explains Lendl. For this, CHEOPS uses highly precise brightness measurements: When a planet passes in front of its star as seen from Earth, the star seems fainter for a short time. This phenomenon is called a transit. Monika Lendl explains: “Because the exoplanet WASP-189b is so close to its star, its dayside is so bright that we can even measure the ‘missing’ light when the planet passes behind its star; this is called an occultation. We have observed several such occultations of WASP-189b with CHEOPS,” says Lendl. “It appears that the planet does not reflect a lot of starlight. Instead, most of the starlight gets absorbed by the planet, heating it up and making it shine.” The researchers believe that the planet is not very reflective because there are no clouds present on its dayside: “This is not surprising, as theoretical models tell us that clouds cannot form at such high temperatures.”

And the star is special too

“We also found that the transit of the gas giant in front of its star is asymmetrical. This happens when the star possesses brighter and darker zones on its surface,“ adds Willy Benz. “Thanks to CHEOPS data, we can conclude that the star itself rotates so quickly that its shape is no longer spherical; but ellipsoidal. The star is being pulled outwards at its equator.” continues Benz.

The star around which WASP-189b orbits is very different from the sun. Monika Lendl says: “The star is considerably larger and more than two thousand degrees Celsius hotter than our sun. Because it is so hot, the star appears blue and not yellow-white like the sun.” Willy Benz adds: “Only a handful of planets are known to orbit such hot stars, and this system is the brightest by far.” As a consequence, it forms a benchmark for further studies.

In conclusion, Willy Benz explains: “We are expecting further spectacular findings on exoplanets thanks to observations with CHEOPS. The next papers are already in preparation.”

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CHEOPS – in search of potential habitable planets
The CHEOPS mission (CHaracterising ExOPlanet Satellite) is the first of ESA's newly created "S-class missions" – small-class missions with an ESA budget much smaller than that of large- and medium-size missions, and a shorter timespan from project inception to launch.
CHEOPS is dedicated to characterizing the transits of exoplanets. It measures the changes in the brightness of a star when a planet passes in front of that star. This measured value allows the size of the planet to be derived, and for its density to be determined on the basis of existing data. This provides important information on these planets – for example, whether they are predominantly rocky, are composed of gases, or if they have deep oceans. This, in turn, is an important step in determining whether a planet has conditions that are hospitable to life.
CHEOPS was developed as part of a partnership between the European Space Agency (ESA) and Switzerland. Under the leadership of the University of Bern and ESA, a consortium of more than a hundred scientists and engineers from eleven European states was involved in constructing the satellite over five years.
CHEOPS began its journey into space on Wednesday, December 18, 2019 on board a Soyuz Fregat rocket from the European spaceport in Kourou, French Guiana. Since then, it has been orbiting the Earth on a polar orbit in roughly an hour and a half at an altitude of 700 kilometers following the terminator.
The Swiss Confederation participates in the CHEOPS telescope within the PRODEX programme (PROgramme de Développement d'EXpériences scientifiques) of the European Space Agency ESA. Through this programme, national contributions for science missions can be developed and built by project teams from research and industry. This transfer of knowledge and technology between science and industry ultimately also gives Switzerland a structural competitive advantage as a business location – and enables technologies, processes and products to flow into other markets and thus generate added value for our economy.
More information: https://cheops.unibe.ch

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 and the results analysed 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. The numbers are impressive: 25 times were instruments flown into the upper atmosphere and ionosphere using rockets (1967-1993), 9 times into the stratosphere with balloon flights (1991-2008), over 30 instruments were flown on space probes, and with CHEOPS the University of Bern shares responsibility with ESA for a whole mission.

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.

Exoplanet research in Geneva: 25 years of expertise awarded a Nobel Prize

CHEOPS will provide crucial information on the size, shape, formation and evolution of known exoplanets. The installation of the "Science Operation Center" of the CHEOPS mission in Geneva, under the supervision of two professors from the UNIGE Astronomy Department, is a logical continuation of the history of research in the field of exoplanets, since it is here that the first was discovered in 1995 by Michel Mayor and Didier Queloz, winners of the 2019 Nobel Prize in Physics. This discovery has enabled the Astronomy Department 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's 3.6m telescope at La Silla in 2003, a spectrograph that remained the most efficient in the world for two decades to determine the mass of exoplanets. However, this year HARPS was surpassed by ESPRESSO, another spectrograph built in Geneva and installed on the VLT in Paranal.

CHEOPS is therefore the result of two national expertises, on the one hand the space know-how of the University of Bern with the collaboration of its Geneva counterpart and on the other hand the ground experience of the University of Geneva supported by its colleague in the Swiss capital. Two scientific and technical competences that have also made it possible to create the National Center of Competence in Research (NCCR) PlanetS.