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CHEOPS reveals a rugby ball-shaped exoplanet

With the help of the CHEOPS space telescope, an international team including researchers from the Universities of Bern and Geneva as well as the National Centre of Competence in Research (NCCR) PlanetS, was able to detect the deformation of an exoplanet for the first time. Due to strong tidal forces, the appearance of the planet WASP-103b resembles a rugby ball rather than a sphere.

On coasts, the tides determine the rhythm of events. At low tide, boats remain on land; at high tide, the way out to sea is cleared for them again. On Earth, the tides are mainly generated by the moon. Its gravitational pull causes an accumulation of water in the ocean region below, which is then missing in surrounding regions and thus accounts for the low tide. Although this deformation of the ocean causes striking differences in level in many places, it is hardly recognisable from space.

On the planet WASP-103b, tides are much more extreme. The planet orbits its star in just one day and is deformed by the strong tidal forces so drastically, that its appearance resembles a rugby ball. This is shown by a new study involving researchers from the Universities of Bern and Geneva as well as the National Centre of Competence in Research (NCCR) PlanetS, published today in the scientific journal *Astronomy & Astrophysics*. This finding was made possible thanks to observations with the CHEOPS space telescope. CHEOPS is a joint mission of the European Space Agency (ESA) and Switzerland, led by the University of Bern in collaboration with the University of Geneva.

A groundbreaking measurement

The planet WASP-103b is located in the constellation Hercules, is almost twice the size of Jupiter, has one and a half times its mass and is about ten times closer to its star than Earth is to the Sun. "Because of its great proximity to its star, we had already suspected that very large tides are caused on the planet. But, we had not yet been able to verify this," explains study co-author Yann Alibert, professor of astrophysics at the University of Bern and member of the NCCR PlanetS.

The NASA/ESA Hubble Space Telescope and NASA's Spitzer Space Telescope had already observed the planet. In combination with the high precision and pointing flexibility of CHEOPS, this enabled the researchers to measure the tiny signal of the tidal deformation of the planet light years away. In doing so, they took advantage of the fact that the planet dims the light of the star slightly each time it passes in front of it. "After observing several such so-called "transits", we were able to measure the deformation. It's incredible that we were able to do this – it’s the first time such an analysis has been done," reports Babatunde Akinsanmi, a researcher at the University of Geneva, co-author of the study and NFS PlanetS associate.

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The planet is inflated

The researchers' results not only allow conclusions to be drawn about the shape of the planet, but also about its interior. This is because the team was also able to derive a parameter called the “Love number” (named after the British mathematician Augustus E. H. Love) from the transit light curve of WASP-103b. It indicates how the mass is distributed within the planet and thus also gives clues about its inner structure. "The resistance of a material to deformation depends on its composition," explains Akinsanmi. "We can only see the tides on Earth in the oceans. The rocky part doesn't move that much. Therefore, by measuring how much the planet is deformed, we can determine how much of it is made up of rock, gas or water."

WASP-103b's Love number is like Jupiter's, our Solar System’s biggest gas giant. It suggests that the internal structures of WASP-103b and Jupiter are similar – even though WASP-103b is twice as large. "In principle, we would expect a planet with 1.5 times the mass of Jupiter to be about the same size. Therefore, WASP-103b must be highly inflated due to heating by its nearby star, and perhaps other mechanisms," says Monika Lendl, professor of astronomy at the University of Geneva and co-author of the study.

However, since the measurement uncertainty in the Love number is still quite high, future observations with CHEOPS and the James Webb Space Telescope will be needed to decipher the details of the tidal deformation and internal structure of WASP-103b and comparable exoplanets. "This would improve our understanding of these so-called ‘hot Jupiters’ and allow a better comparison between them and giant planets in the Solar System,” Lendl concludes.

Publication details:

Cheops reveals the tidal deformation of WASP-103b’ by S.C.C. Barros et al. (2021) is published in Astronomy & Astrophysics. DOI: https://www.aanda.org/10.1051/0004-6361/202142196

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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.

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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.

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