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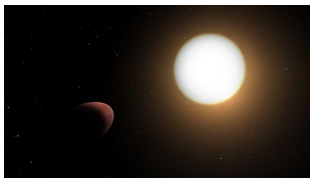
Press release

Cheops reveals a rugby ball-shaped exoplanet

(Under embargo until Tuesday 11 January 2022 - 9am CET)



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ESA's Cheops mission has revealed that an exoplanet orbiting its host star in one day has a non-spherical, rugby ball-like shape. This is the first time that the deformation of an exoplanet has been detected, providing new information about the internal structure of these planets that are extremely close to their star. This work is the subject of a study to be published on 11 January 2022 in the journal Astronomy & Astrophysics, to which researchers from the Observatoire de Paris - PSL, Sorbonne University and the CNRS contributed.

The planet, known as WASP-103b is located in the constellation of Hercules. It has been deformed by the strong tidal forces between the planet and its host star WASP-103, which is about 200 degrees hotter and 1.7 times larger than the Sun.

Tidal tug

We experience tides in the oceans of Earth mainly due to the Moon tugging slightly on our planet as it orbits us. The Sun also has a small but significant effect on tides, however it is too far from Earth to cause major deformations of our planet. The same cannot be said for WASP-103b, a planet almost twice the size of Jupiter with 1.5 times its mass, orbiting its host star in less than a day. Astronomers have suspected that such a close proximity would cause monumental tides, but up until now they haven't been able to measure them

Using new data from ESA's Cheops space telescope, combined with data that had already been obtained by the NASA/ESA Hubble Space Telescope and NASA's Spitzer Space Telescope, astronomers have now been able to detect how tidal forces deform exoplanet WASP-103b from a usual sphere into a rugby ball shape.

Cheops measures exoplanet transits – the dip in light caused when a planet passes in front of its star from our point of view. Ordinarily, studying the shape of the light curve will reveal details about the planet such as its size. The high precision of Cheops together with its pointing flexibility, which enables the satellite to return to a target and to observe multiple transits, has allowed astronomers to detect the minute signal of the tidal deformation of WASP-103b. This distinct signature can be used to unveil even more about the planet.

"With my former student, Alexandre Correia, now associated professor in Coimbra University, we proposed six years ago that Cheops would be able to detect the tidal deformation of a planet. This was motivated by a theoretical study that Alexandre had just published. We knew that it would be extremely challenging, and after searching for all possible candidates, we selected WASP-103b as the best target for this quest. Despite we predict it, I am amazed that Cheops was actually able to reveal this tiny deformation. This is the first time

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such analysis is made, and we can hope that observing over a longer time interval will strengthen this observation and lead to better knowledge of the planet internal structure" declared Jacques Laskar Director of the Institut de Mécanique Céleste et de Calcul des éphémérides in Observatoire de Paris, Université PSL, and co-author of the research.

Inflated planet

The team was able to use the transit light curve of WASP-103b to derive a parameter – the Love number – that measures how mass is distributed within a planet. Understanding how mass is distributed can reveal details on the internal structure of the planet.

“The resistance of a material to being deformed depends on its composition,” explains Susana Barros of Instituto de Astrofísica e Ciências do Espaço and University of Porto, Portugal, and lead author of the research. “For example, here on Earth we have tides due to the Moon and the Sun but we can only see tides in the oceans. The rocky part doesn’t move that much. By measuring how much the planet is deformed we can tell how much of it is rocky, gaseous or water.”

The Love number for WASP-103b is similar to Jupiter, which tentatively suggests that the internal structure is similar, despite WASP-103b having twice the radius.

“In principle we would expect a planet with 1.5 times the mass of the Jupiter to be roughly the same size, so WASP-103b must be very inflated due to heating from its star and maybe other mechanisms,” says Susana.

“If we can confirm the details of its internal structure with future observations maybe we could better understand what makes it so inflated. Knowing the size of the core of this exoplanet will also be important to better understand how it formed.”

Since the uncertainty in the Love number is still quite high, it will take future observations with Cheops and the James Webb Space Telescope (Webb) to decipher the details. The extremely high precision of Webb will improve the measurements of tidal deformation of exoplanets, enabling a better comparison between these so-called “hot Jupiters” and giant planets in the Solar System.

Mysterious motion

Another mystery also surrounds WASP-103b. The tidal interactions between a star and a very close-in Jupiter-sized planet would usually cause the planet’s orbital period to shorten, bringing it gradually closer to the star before it is eventually engulfed by the parent star. However, measurements of WASP-103b seem to indicate that the orbital period might be increasing and that the planet is drifting slowly away from the star. This would indicate that something other than tidal forces is the dominant factor affecting this planet.

Susana and her colleagues looked at other potential scenarios, such as a companion star to the host affecting the dynamics of the system or the orbit of the planet being slightly elliptical. They weren’t able to confirm these scenarios, but couldn’t rule them out either. It is also possible that the orbital

period is actually decreasing, rather than increasing, but only additional observations of the transits of WASP-103b with Cheops and other telescopes will help shed light on this mystery.

"The size of the effect of tidal deformation on an exoplanet transit light curve is very small, but thanks to the very high precision of Cheops we are able to see this for the first time," says ESA's Project Scientist for Cheops, Kate Isaak. "This study is an excellent example of the very diverse questions that exoplanet scientists are able to tackle with Cheops, illustrating the importance of this flexible follow-up mission."

Reference

'Cheops reveals the tidal deformation of WASP-103b' by S.C.C. Barros, B. Akinsanmi, G. Boué, A.M.S. Smith, J. Laskar, et al. (2021) is published in *Astronomy & Astrophysics*.
DOI: https://www.aanda.org/10.1051/0004-6361/202142196

More about Cheops

Cheops is an ESA mission developed in partnership with Switzerland, with a dedicated consortium led by the University of Bern, and with important contributions from Austria, Belgium, France, Germany, Hungary, Italy, Portugal, Spain, Sweden and the UK.

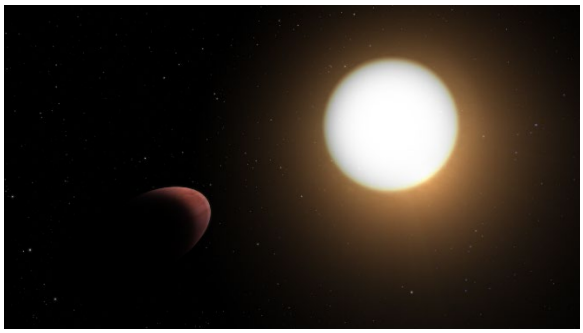
ESA is the Cheops mission architect, responsible for procurement and testing of the satellite, the launch and early operations phase, and in-orbit commissioning, as well as the Guest Observers' Programme through which scientists world-wide can apply to observe with Cheops. The consortium of 11 ESA Member States led by Switzerland provided essential elements of the mission.

For more information, visit: https://www.esa.int/Cheops

French involvement in Cheops:

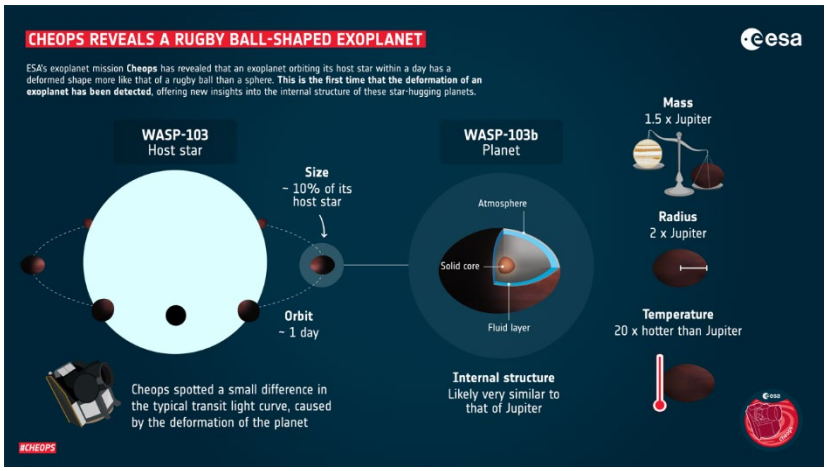
France participates actively in the Cheops mission. The Laboratoire d'Astrophysique de Marseille (LAM, CNRS/Aix-Marseille University/CNES) has developed the data processing and calibration software. Scientists from LAM, IMCCE, Institut de Planétologie et d'Astrophysique de Grenoble (LAOG, CNRS/Université Grenoble Alpes), Institut du Physique du Globe de Paris (CNRS/IPGP/Université de Paris) and Institut d'Astrophysique de Paris (IAP, CNRS/Sorbonne University) are involved in the scientific analysis of the Cheops data and are co-authors of this study.

Image



Caption: Artist impression of planet WASP-103b and its host star.
Credit: ESA

Infographic



Caption: Cheops reveals a rugby ball-shaped exoplanet
Credit: ESA