ESO 33/09 - Science Release

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First Solid Evidence for a Rocky Exoplanet

Mass and density of smallest exoplanet finally measured

The longest set of HARPS measurements ever made has firmly established the nature of the smallest and fastest-orbiting exoplanet known, CoRoT-7b, revealing its mass as five times that of Earth's. Combined with CoRoT-7b's known radius, which is less than twice that of our terrestrial home, this tells us that the exoplanet's density is quite similar to the Earth's, suggesting a solid, rocky world. The extensive dataset also reveals the presence of another so-called super-Earth in this alien solar system.

"*This is science at its thrilling and amazing best,*" says Didier Queloz, leader of the team that made the observations. "*We did everything we could to learn what the object discovered by the CoRoT satellite looks like and we found a unique system.*"

In February 2009, the discovery by the CoRoT satellite [1] of a small exoplanet around a rather unremarkable star named TYC 4799-1733-1 was announced one year after its detection and after several months of painstaking measurements with many telescopes on the ground, including several from ESO. The star, now known as CoRoT-7, is located towards the constellation of Monoceros (the Unicorn) at a distance of about 500 light-years. Slightly smaller and cooler than our Sun, CoRoT-7 is also thought to be younger, with an age of about 1.5 billion years.

Every 20.4 hours, the planet eclipses a small fraction of the light of the star for a little over one hour by one part in 3000 [2]. This planet, designated CoRoT-7b, is only 2.5 million kilometres away from its host star, or 23 times closer than Mercury is to the Sun. It has a radius that is about 80% greater than the Earth's.

The initial set of measurements, however, could not provide the mass of the exoplanet. Such a result requires extremely precise measurements of the velocity of the star, which is pulled a tiny amount by the gravitational tug of the orbiting exoplanet. The problem with CoRoT-7b is that these tiny signals are blurred by stellar activity in the form of "starspots" (just like sunspots on our Sun), which are cooler regions on the surface of the star. Therefore, the main signal is linked to the rotation of the star, with makes one complete revolution in about 23 days.

To get an answer, astronomers had to call upon the best exoplanet-hunting device in the world, the High Accuracy Radial

Images and video captions
and credits are available here

ESO PR Photo 33a/09
Artist's impression of Corot-7b
Full Size Original TIFF (65.12M)
Full Size Original JPG (33.10M)
Screensize JPG (166 K)

ESO PR Photo 33b/09
The planet-hosting star CoRot-7
Full Size Original TIFF (65.12M)
Full Size Original JPG (33.10M)
Screensize JPG (166 K)

velocity Planet Searcher (HARPS) spectrograph attached to the ESO 3.6-metre telescope at the La Silla Observatory in Chile.

"*Even though HARPS is certainly unbeaten when it comes to detecting small exoplanets, the measurements of CoRoT-7b proved to be so demanding that we had to gather 70 hours of observations on the star,*" says co-author François Bouchy.

HARPS delivered, allowing the astronomers to tease out the 20.4-hour signal in the data. This figure led them to infer that CoRoT-7b has a mass of about five Earth masses, placing it in rare company as one of the lightest exoplanets yet found.

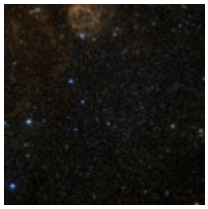
"*Since the planet's orbit is aligned so that we see it crossing the face of its parent star — it is said to be transiting — we can actually measure, and not simply infer, the mass of the exoplanet, which is the smallest that has been precisely measured for an exoplanet [3],*" says team member Claire Moutou. "*Moreover, as we have both the radius and the mass, we can determine the density and get a better idea of the internal structure of this planet.*"

With a mass much closer to that of Earth than, for example, ice giant Neptune's 17 Earth masses, CoRoT-7b belongs to the category of "super-Earth" exoplanets. About a dozen of these bodies have been detected, though in the case of CoRoT-7b, this is the first time that the density has been measured for such a small exoplanet. The calculated density is close to Earth's, suggesting that the planet's composition is similarly rocky.

"*CoRoT-7b resulted in a 'tour de force' of astronomical measurements. The superb light curves of the space telescope CoRoT gave us the best radius measurement, and HARPS the best mass measurement for an exoplanet. Both were needed to discover a rocky planet with the same density as the Earth,*" says co-author Artie Hatzes.

CoRoT-7b earns another distinction as the closest known exoplanet to its host star, which also makes it the fastest — it orbits its star at a speed of more than 750 000 kilometres per hour, more than seven times faster than the Earth's motion around the Sun. "*In fact, CoRoT-7b is so close that the place may well look like Dante's Inferno, with a probable temperature on its 'day-face' above 2000 degrees and minus 200 degrees on its night face. Theoretical models suggest that the planet may have lava or boiling oceans on its surface. With such extreme conditions this planet is definitively not a place for life to develop,*" says Queloz.

As a further testament to HARPS' sublime precision, the astronomers found from their dataset that CoRoT-7 hosts another exoplanet slightly further away than CoRoT-7b. Designated CoRoT-7c, it circles its host star in 3 days and 17 hours and has a mass about eight times that of Earth, so it too is classified as a super-Earth. Unlike CoRoT-7b, this sister world does not pass in front of its star as seen from Earth, so astronomers cannot measure its radius and thus its density.



ESO PR Photo 33c/09
Field around the planet-hosting star CoRot-7
Full Size Original TIFF (65.12M)
Full Size Original JPG (33.10M)
Screensize JPG (166 K)

ESO PR Video 33a/09
Zoom in on the star CoRoT-7

Preview Formats
QT Preview, 8.18 MB
QT Screen Size, 15.31 MB

Apple TV
Single File, 30.37 MB

Podcast
Single File, 11.02 MB

MPEG
Single File, 20.78 MB

Standard Definition
(Broadcasters only!)
Single File, 83.39 MB

High Definition 720p25
(Broadcasters only!)
Single File, 174.39 GB

ESO PR Video 33b/09
Pan over the artist's impression of CoRoT-7b

Preview Formats
QT Preview, 8.18 MB
QT Screen Size, 15.31 MB

Apple TV
Single File, 30.37 MB

Podcast
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Given these findings, CoRoT-7 stands as the first star known to have a planetary system made of two short period super-Earths with one that transits its host.

Notes

[1] The CoRoT mission is a cooperation between France and its international partners: ESA, Austria, Belgium, Brazil, Germany and Spain.

[2] We see exactly the same effect in our Solar System when Mercury or Venus transits the solar disc, as Venus did on 8 June 2004 (ESO PR 03/04). In the past centuries such events were used to estimate the Sunâ□Earth distance, with extremely useful implications for astrophysics and celestial mechanics.

[3] Gliese 581e, also discovered with HARPS, has a minimum mass about twice the Earth's mass (see ESO 15/09), but the exact geometry of the orbit is undefined, making its real mass unknown. In the case of CoRoT-7b, as the planet is transiting, the geometry is well defined, allowing the astronomers to measure the mass of the planet precisely.

More Information

This research was presented in a paper to appear in a special issue of the Astronomy and Astrophysics journal on CoRoT, volume 506-1, 22 October 2009: "The CoRoT-7 planetary system: two orbiting Super-Earths", by D. Queloz et al.

The team is composed of D. Queloz, R. Alonso, C. Lovis, M. Mayor, F. Pepe, D. Segransan, and S. Udry (Observatoire de Genève, Switzerland), F. Bouchy, F. and G. Hébrard, G. (IAP, Paris, France), C. Moutou, M. Barbieri, P. Barge, M. Deleuil, L. Jorda, and A. Llebaria (Laboratoire d'Astrophysique de Marseille, France), A. Hatzes, D. Gandolfi, E. Guenther, M. Hartmann, and G. Wuchterl (ThÃ¼ringer Landessternwarte Tautenburg, Germany), M. Auvergne, A. Baglin, D. Rouan, and J. Schneider (LESIA, CNRS, Observatoire de Paris, France), W. Benz (University of Bern, Switzerland), P. Bordé, A. Léger, and M. Ollivier (IAS, UMR 8617 CNRS, Université Paris-Sud, France), H. Deeg (Instituto de Astrofísica de Canarias, Spain), R. Dvorak (University of Vienna, Austria), A. Erikson and H. Rauer (DLR, Berlin, Germany), S. Ferraz Mello (IAG-Universidade de Sao Paulo, Brazil), M. Fridlund (European Space Agency, ESTEC, The Netherlands), M. Gillon and P. Magain (Université de Liège, Belgium), T. Guillot (Observatoire de la Côte d'Azur, CNRS UMR 6202, Nice France), H. Lammer (Austrian Academy of Sciences), T. Mazeh (Tel Aviv University, Israel), and M. Pätzold (Köln University, Germany).

ESO, the European Southern Observatory, is the foremost intergovernmental astronomy organisation in Europe and the world's most productive astronomical observatory. It is supported by 14 countries: Austria, Belgium, the Czech Republic, Denmark, France, Finland, Germany, Italy, the Netherlands, Portugal, Spain, Sweden, Switzerland and the United Kingdom. ESO carries out an ambitious programme focused on the design, construction and operation of powerful ground-based observing facilities enabling astronomers to make important scientific discoveries. ESO also plays a leading role in promoting and organising cooperation in astronomical research. ESO operates three unique world-class observing sites in Chile: La Silla, Paranal and Chajnantor. At Paranal, ESO operates the Very Large Telescope, the world's most advanced visible-light astronomical observatory. ESO is the European partner of a revolutionary astronomical telescope ALMA, the largest astronomical project in existence. ESO is currently planning a 42-metre European Extremely Large optical/near-infrared Telescope, the E-ELT, which will become "the world's biggest eye on the sky".

Links

- Science paper: http://www.aanda.org/10.1051/0004-6361/200913096/pdf (Free access)

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Zoom in the artist's impression of CoRoT-7b

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- More info: Exoplanet — media kit

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