First Solid Evidence for a Rocky Exoplanet (w/ Video)

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The star CoRoT-7 is located towards the constellation of Monoceros (the Unicorn) at a distance of about 500 light-years. This image shows a larger field of view around the star, covering about 9 square degrees or about 11 times the size of the Full Moon. CoRoT-7 is in the centre of the image. Image: ESO/Digitized Sky Survey

(PhysOrg.com) -- 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 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. 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 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," 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."

The exoplanet Corot-7b is so close to its Sun-like host star that it must

experience extreme conditions. This planet has a mass five times that of Earth's and is in fact 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. The probable temperature on its "day-face" is above 2000 degrees, but minus 200 degrees on its night face. Theoretical models suggest that the planet may have lava or boiling oceans on its surface. Our artist has provided an impression of how it may look like if it were covered by lava. The sister planet, Corot-7c, is seen in the distance. Image: ESO/L. Calcada

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.

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.

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.

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