Smallest rocky planet outside our solar system discovered

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NASA has confirmed this month that its Kepler space observatory has now identified the smallest yet planet outside our solar system, exoplanet Kepler-10b. It is also the first time that NASA has found a planet known to be made of rock, as opposed to gas giants that are similar to Jupiter. This is because its diameter is known to be 1.4 times that of the earth and its mass is 4.6 times that of the earth, so its density is comparable to that of iron.

However, it is otherwise quite different from our planet as it orbits its star in less than one day, and is 20 times closer to it than Mercury is to the sun. Its surface will consequently be very hot and it cannot be in the habitable zone that would support life. Nevertheless, it is a considerable step towards finding earth-like planets in other solar systems. Geoffrey Marcy, of the University of California Berkeley a pioneer of exoplanet research, said that the find "will be marked as among the most profound scientific discoveries in human history."

NASA's Kepler mission was launched in 2009 specifically designed to look for earth-like planets orbiting stars in our Milky Way galaxy. The existence of Kepler-10b was based on data collected from May 2009 to January last year. Kepler uses a specially designed, extremely accurate photometer that measures the change in the brightness of a star when a planet passes in front of it.

Because the parent star of 10-b is one of the brighter stars targeted by Kepler, scientists can observe variations in its light very accurately, telling them much about its properties. Kepler is in orbit round the sun, not the earth, enabling it to focus continuously on selected stars without the earth blocking its field of vision.

Observations made by the ground-based Keck telescope in Hawaii of the light spectrum from the parent star confirmed the existence of a planet. These observations showed characteristic movements, known as a Doppler shift, which show that the star is wobbling slightly under the gravitational pull of the planet going round it.

Professor Natalie Batalha of San Jose State University, who helps lead the Kepler science mission for NASA, stressed the significance of the observation to the BBC.

"We're always pushing down toward smaller and less massive, so it's natural that we're arriving there," she said. "But perhaps what's not so natural is that we've pinned down the properties of this planet with such fantastic accuracy that we're able to say without a doubt that this is a rocky world, something that you could actually stand on."

At the end of last year the official NASA count of confirmed exoplanets observed reached 500, compared to only 50 a decade ago [1]. More than 100 of these were discovered in 2010. The Paris-based Extra Solar Planets Encyclopaedia [2] now has clocked a total of 518 planets.

Kepler is continually monitoring the brightness of more than 145,000 stars, and it is expected that many more exoplanets will be discovered over the next year or so. As the data already downloaded is analysed for exoplanets with longer orbits than that of Kepler 10-b, the likelihood of finding planets that are similar to the earth increases.

Before the discovery of Kepler-10b the smallest exoplanet known was Corot-7b, found at the beginning of 2009, with a diameter 1.7 times the earth's and a mass five times bigger. It was found by the French-led Corot spacecraft and is even closer to its parent star than Kepler-10b, with a faster orbit. Corot-7b is also thought to be rocky and has a density somewhat less than if it were completely made of iron.

Last October, a team at NASA and the University of California, Berkeley, announced the result of a study of 166 stars over a five-year period at the Keck telescope in Hawaii [3], with exoplanets ranging from three to 1,000 times the mass of the earth. The exoplanets were all in

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orbits close to their stars, at a distance less than a quarter of the distance of the earth to the sun. Remarkably, it emerged that there was a distinctive trend in the distribution of exoplanet masses, with smaller planets outnumbering larger ones. Extrapolating from their data, the research team estimated that 23 percent of stars in our galaxy, or 46 billion stars, would have earth-sized planets orbiting the hot zone close to the star.

This result contradicts current theories on planet formation, which suggest that smaller planets would tend not to form in closer orbits. Nevertheless it gives support to the existence of large numbers of earth-size planets in more distant orbits and so possibly habitable. Andrew Howard of the University of California, Berkeley, lead author of the study explained, "During planet formation, small bodies similar to asteroids and comets stick together, eventually growing to Earth-size and beyond. Not all of the planets grow large enough to become giant planets like Saturn and Jupiter." Howard added, "It's natural for lots of these building blocks, the small planets, to be left over in this process."

A series of discoveries of exoplanets with fascinating properties have been made of recent months. In September researchers from the University of California, Santa Cruz, and the Carnegie Institution of Washington, announced they had found two exoplanets orbiting around the nearby red dwarf star Gliese 581. Their findings are based on 11 years of observations at the Keck Observatory. One of these planets, Gliese 581g, has a mass three to four times that of the Earth and an orbital period of fewer than 37 days. It is thought to be the first exoplanet discovered that lies in the habitable zone of the star, with temperatures in the range required for liquid water to exist on the planet's surface and to sustain an atmosphere.

In November, the first exoplanet from outside of our Milky Way galaxy was found. This Jupiter-sized planet orbits a star known as HIP 13044 that is part of the so-called Helmi stream. These are stars that originally belonged to a dwarf galaxy that was "eaten up" by our Milky Way some six to nine billion years ago.

Last month an exoplanet was discovered for the first time with an atmosphere that could be measured. The planet, GJ 1214b, is three times larger than earth and with a mass seven times greater. This study used near-infrared observations at the Very Large Telescope at Paranal Observatory in Chile. Although the planet has been shown to have an atmosphere, the chemical composition is still to be determined, with hydrogen, helium or water-steam all being possibilities.

Also in December a team of US and British scientists, using observations from NASA's Spitzer Space Telescope, discovered exoplanet Wasp 12b. This Jupiter-sized gas planet has been found to contain a high proportion of carbon, suggesting that rocky exoplanets made of diamond or graphite could exist.

Several observations over the last two years have produced visual images of exoplanets. The first such image was obtained in 2008, of three exoplanets orbiting a bright star called HR 8799, lying some 129 light years from Earth and faintly visible to the naked eye. Recently further analysis on HR 8799 has shown up a fourth exoplanet (see picture). Together with the fact that there are two belts of debris orbiting the star—small rocky or icy objects, as well as large amounts of tiny dust particles – the existence of four giant planets makes HR 8799 similar to our own solar system though on a much larger scale.

Our solar system has four giant planets—Jupiter, Saturn, Uranus and Neptune, and our debris belts include the asteroid belt between the orbits of Mars and Jupiter and the Kuiper Belt, beyond the orbit of Neptune. Christian Marois, an NRC astronomer and lead author of the research which is published in *Nature* [4] said, "The images of this new inner planet are the culmination of 10 years' worth of innovation, making steady progress to optimize every aspect of observation and analysis. This allows us to detect planets located ever closer to their stars and ever further from our own solar system."

[1] http://planetquest.jpl.nasa.gov/news/500planets.cfm
[2] http://exoplanet.eu/
[3] Science, Vol. 330, 29 October 2010, p. 556.
[4] Nature, Vol. 468, 23 December 2010, pp. 1080–1083.

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