

Possible habitable planet discovered: Extending the horizons of humanity

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A team of Swiss, French and Portuguese astronomers announced on April 24 the discovery of an “exoplanet” known as Gliese 581 c.

Planets that orbit around a star other than the Sun are known as extrasolar planets or exoplanets.

The team have published their findings in a paper entitled “The HARPS search for southern extra-solar planets: XI. An habitable super-Earth (5 MEarth) in a 3-planet system.” The paper is due to be published shortly in the scientific journal *Astronomy & Astrophysics*. It can be downloaded at: http://obswww.unige.ch/~udry/udry_preprint.pdf

The discovery is the most important yet in the rapidly developing field of exoplanetary science. Gliese 581 c appears to be the first exoplanet discovered in what is termed a habitable zone surrounding its parent star (Gliese 581). This means that the planet’s surface temperatures are similar to the Earth’s and may be able to maintain liquid water, and therefore could be suitable for life.

Gliese 581 c has been termed a “super-Earth” due to its radius being 50 percent larger, and its mass about five times greater, than that of the Earth. With an orbital period or “year” of 13 Earth days, it is the smallest Earth-sized exoplanet to be discovered. It is also relatively close to the Earth, in astronomical terms, at just 20.5 light years distance (about 120 trillion miles).

The parent star of the exoplanet is a lot cooler than the Sun, but because the planet is a lot closer to the star than the Earth is to the Sun it is in the so-called habitable zone.

Xavier Delfosse from Grenoble University in France, a member of the team, said of the remarkable discovery, “Because of its temperature and relative proximity, this planet will most probably be a very important target of the future space missions dedicated to the search for extra-terrestrial life. On the treasure map of the Universe, one would be tempted to mark this planet with an X.”

Until 15 years ago, no concrete proof existed that our solar system was not the only one to exist around an ordinary main sequence star, such as the Sun. In the past decade revolutionary developments in technique and new spectrographic telescope technology have enabled astronomers to detect and analyse exoplanets at an increasing rate.

The first exoplanet to be discovered around a main sequence star was in October 1995 by Michel Mayor and Didier Queloz, at the Observatoire de Haute-Provence in France. This planet was discovered to be orbiting the star 51 Pegasi in the constellation of Pegasus.

These first exoplanets were known as “Hot Jupiters” due to their mass being close to or exceeding the size of Jupiter—the largest planet in our solar system. Their massive size made them detectable, but they are unable to support life as we know it as they cannot maintain surface liquid water. This is because they orbit at a distance very close to their parent star.

Dozens more Hot Jupiters were discovered in the following years. As recently as 2002 the smallest confirmed exoplanet yet found was HD 49674 b, nearly 40 times the mass of the Earth (about half the mass of the

planet Saturn). It also orbited very closely to its parent star. To date, 237 exoplanets have been discovered, with more than 20 being discovered each year since 2002.

Detecting exoplanets

In comparison to their parent stars, planets are a very faint light source. They do not emit any light of their own. Viewed at visible wavelengths, an exoplanet will have less than a millionth of its parent star’s brightness. The overwhelming light of the parent star washes out the light of the planet, making detection very difficult. Finding an exoplanet orbiting a star has been compared to locating a firefly in the glare of a searchlight from a mile away.

Actual image detection of exoplanets can only be carried out under conditions where the planet is much larger than Jupiter and does not orbit close to the parent star. The planet must also be in the early stage of its evolution and be hot so as to emit detectable infrared radiation. The only direct image yet taken of an exoplanet is that of 2M1207b, discovered in 2005.

This infrared image of the parent star of 2M1207b and the planet itself can also be viewed at <http://apod.nasa.gov/apod/ap050510.html>. This site is one of the best for viewing photos and images relating to astronomy and can serve as a visually stimulating introduction to the subject. It is updated daily with a new image and maintains an archive of its previous images.

The main way to detect exoplanets is indirectly. Of the six methods available, the most productive—and the one used to detect Gliese 581 c—is known as the radial velocity or the “Doppler method.”

The radial velocity method is based on the detection of variations in the velocity of the central star, due to the changing direction of the gravitational pull from an (unseen) exoplanet as it orbits the star. These slight periodic shifts in a star’s spectrum are tell-tale signs that the star is moving to and fro at regular intervals to the tug of an orbiting planet. Astronomers are then able to measure these small variations in the star’s velocity to establish the planet’s orbit. From these observations, the period of the orbit of the planet, the distance from its star, and its minimum mass can also be deduced.

The present findings suggest that smaller Earth-sized planets may be far more common than previously thought. The parent star of Gliese 581 c is a red dwarf star. These types emit at least 50 times less light than the Sun and are also the most common type of star in the Milky Way.

Due to the fact that red dwarfs are much cooler than the sun, hence emitting less light, the habitable zone is much closer to them than it is around the Sun; planets in this zone such as Gliese 581 c are therefore more easily detected with the radial velocity method.

Another important factor in focussing on such stars in order to discover exoplanets is that of the 100 closest stars to the Sun, 80 belong to the red dwarf class.

HARPS

Gliese 581 c was discovered using the High Accuracy Radial Velocity for Planetary Searcher (HARPS) spectrograph. The spectrograph is located on the 3.6-m telescope at La Silla, Chile, and is controlled by the European Organisation for Astronomical Research in the Southern Hemisphere (ESO).

The HARPS spectrograph is dedicated to the discovery of extrasolar planets. It is incredibly accurate and is able to measure velocities with a precision better than one metre per second (or 3.6 km/h). According to a statement on the ESO web site, Gliese 581 c, for example, causes its parent star to move at a rate of around two to three meters per second—the speed of a briskly walking human.

In its April 25 press release ESO stated that, “Such tiny signals could not have been distinguished from ‘simple noise’ by most of today’s available spectrographs.”

The HARPS instrument is now by far the best available for detecting exoplanets. As well as discovering Gliese 581 c, in 2005 it detected another neighbouring planet orbiting Gliese 581. In their latest finding the team speculated that they had strong evidence suggesting a third planet orbiting Gliese. It is estimated that the Gliese 581 planetary system is around 4.3 billion years old. The solar system is similarly aged at 4.57 billion years old.

In 2006 HARPS found a further planetary system based on a trio of Neptune-sized planets orbiting the star HD 69830. One of these planets is also located in the “habitable zone” but is much larger than Earth. The latter planetary system most likely also hosts an asteroid belt, according to recent observations taken by the Spitzer Space Telescope.

Such discoveries are immeasurably broadening the understanding of planetary systems beyond our own.

An ESO May 2006 press release summarised the importance of such discoveries, “With three roughly equal-mass planets, one being in the habitable zone, and an asteroid belt, this planetary system shares many properties with our own solar system.”

HARPS is described by Michel Mayor, its principal investigator, as “a unique planet hunting machine. Given the incredible precision of HARPS, we have focused our effort on low-mass planets. And we can say without doubt that HARPS has been very successful: out of the 13 known planets with a mass below 20 Earth masses, 11 were discovered with HARPS!”

When HARPS commenced work, ESO stated that it had a “unique capability to detect big ‘telluric’ planets with only a few times the mass of the Earth.” With the discovery of Gliese 581 c this statement has been positively vindicated with the promise of more to come. From October 2003, the HARPS instrument has been offered to the research community and astronomers in the ESO member countries.

Announcing its latest discovery, ESO stated, “We are confident that, given the results obtained so far, finding a planet with the mass of the Earth around a red dwarf is within reach.”

Research under way on Earth and in space

Further research is now under way to establish more information and facts about Gliese 581 c and other newly discovered exoplanets. Scientists are seeking answers to questions such as: Is liquid water actually present? Are they rocky planets similar to our own? Is it a frozen ice-ball-type planet with liquid water on the surface? What is the make-up of the atmosphere on these planets?

Projected models of Gliese 581 c favour the theory that it should have an atmosphere. However if the atmosphere is too thick this could result in the surface temperature being too hot to support life.

Another issue that arises from the discovery of exoplanets in close orbit to their parent stars is that they are often “tidally locked.” This would mean that one hemisphere of Gliese 581 c would always be facing its star and be heated, whereas the other side would always face away and therefore be cold or even frozen. (While the Earth and the Moon are

tidally locked, the Earth and the Sun are not.)

The Geneva team has begun to use the MOST orbiting telescope operated in Canada to conduct follow-up work. The telescope orbits the Earth and is among the most sensitive in the world to subtle changes in starlight. It is able to provide ultra-high-precision photometry (i.e., measurement of brightness variations to a level of one part per million) of stars down to the naked-eye limit of visibility for up to two months, without major interruptions.

The search for planets and signs of extra-terrestrial life is to be accelerated over the next few years. On December 26 the Convection, Rotation & planetary Transits (COROT) space mission was launched. Led by the French Space Agency (CNES) and supported by the European Space Agency and other international partners, its aim is to find earth-sized terrestrial exoplanets. The mission will also measure the oscillations in stars which convect heat in their outer layers in the same way that the Sun does. COROT discovered its first exoplanet, a hot Jupiter type, in May.

Another important mission is the NASA Kepler mission. Set to launch in 2008, named after the famed German astronomer Johannes Kepler, the mission is for four years and can be extended to six. It will use the transit method to detect planets, which involves observing a planet as it passes directly in front of its star as seen from Earth. When transiting, the planet blocks some of the star’s light that would ordinarily reach Earth. By monitoring these falls in luminosity astronomers can calculate the planet’s size and orbit.

According to the NASA overview of the mission, Kepler is “specifically designed to survey our region of the Milky Way galaxy to detect and characterize hundreds of Earth-size and smaller planets in or near the habitable zone.”

NASA expects to find about 50 planets orbiting their parent star, which will have an orbit of about one year and are about the same size as the Earth. The organisation says of the Kepler mission, “In order to detect many planets one can not just look at a few stars for transits or even a few hundred. One must look at thousands of stars, even if Earth-like planets are common. If they are rare, then one needs to look at many thousands to find even a few. *Kepler* looks at 100,000 stars so that if Earths are rare, a null or near null result would still be significant. If Earth-size planets are common then *Kepler* should detect hundreds of them.”

Other missions due to be operational within 10 years are NASA’s Space Interferometry Mission, Terrestrial Planet Finder and the European Space Agency’s Darwin, Gaia and Eddington projects.

Another critical current project is the Super Wide Angle Search for Planets (SuperWASP), run by a consortium of mainly British universities. SuperWASP consists of two robotic observatories—one on La Palma, Canary Islands, and another at the South African Astronomical Observatory. Using the transit method of planetary detection the project is able to scan the entire sky in both hemispheres on a daily basis.

The SuperWASP observatories are equipped with an array of eight cameras, with a field of view 2,000 times greater than a conventional astronomical telescope. Each of the cameras is able to capture 50,000 stars per image. It is currently continuing its observations while the data collected from 2006 is processed.

It is estimated that there are 10 billion planetary systems in the Milky Way alone. From the evidence found thus far it must be assumed that many more exoplanets will be discovered by these missions and by ground-based detection over the coming months and years.

These discoveries will enable scientists for the first time to place the solar system within the context of other planetary solar systems that are in close proximity to ours—and perhaps establish conclusively that life exists elsewhere in our galaxy. The team that discovered Gliese 581 c and all the scientists and researchers involved in the HARPS and other projects are carrying out enormously valuable work, the historic importance of which

can only be fully realised in the coming years.



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