First images taken of extrasolar planets

Hector Cordon
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In the last month, two teams of astronomers have for the first time directly imaged planets orbiting stars outside the solar system. This breakthrough is expected to foster further discoveries and deepen our understanding of what constitutes a planet and how they are formed.

While more than 300 planets have been found using indirect methods—either by a Doppler shift of the star's light as the gravitational interaction with a massive planet alters its orbit, referred to as a "wobble," or by a dip in light output as the planet moves in front of the star—directly imaging a planet has had to wait for the development of the necessary technology and improved data analysis.

A team of astronomers, led by Paul Kalas of the University of California, Berkeley, using the Hubble Space Telescope Advanced Camera for Surveys' coronagraph, optically imaged a planet circling the star Fomalhaut, located approximately 25 light years from Earth.

From analyses of Hubble observations in 2004, Kalas and his colleagues proposed in 2005 that Fomalhaut—located in the constellation Pisces Australis and one of the brightest stars in the night sky—may harbor a planet. The evidence cited was a sharply defined inner edge of the large dust ring, similar to our solar system's Kuiper Belt, surrounding the star.

The planet, named Fomalhaut b, is estimated by researchers to have a mass less than three times that of Jupiter. Mark S. Marley, a research scientist for NASA, explained in *ScienceExpress*, the online version of the journal *Science*, that, pending confirmation, "this object will be the coolest and lowest-mass body imaged outside of the solar system."

According to NASA's web site, "Fomalhaut has been a candidate for planet hunting ever since an excess of dust was discovered around the star in the early 1980's."

The web site quotes Kalas. "Our Hubble observations were incredibly demanding. Fomalhaut b is 1 billion times fainter than the star. We began this program in 2001, and our persistence has finally paid off."

Fomalhaut b is estimated to be 10.7 billion miles from its star—about 10 times the distance from Saturn to the Sun—and to take 872 years to complete its orbit.

A second group of astronomers imaged a group of planets orbiting the star HR 8799, located 129 light years from Earth in the constellation Pegasus.

Led by Christian Marois of Canada's Herzberg Institute of Astrophysics, the team announced the direct observation of a multi-planet system using the Keck and Gemini telescopes in Hawaii. A series of images of the three planets dating back to 2004—showing their orbital movement—was made using the infrared section of the spectrum.

Bruce McIntosh, an astrophysicist from Lawrence Livermore National Laboratory in California and a member of Dr. Marois's team, told to the *New York Times*, "Every extrasolar planet detected so far has been a wobble on a graph. These are the first pictures of an entire system."

These newly found planets have masses roughly 10, 9 and 6 times the mass of Jupiter and have orbital periods of 450, 180 and 100 years, respectively. A mass of 10 is near the upper limit of the planet class size of 13 Jupiter masses. At 13 masses and above, a planet would be capable of deuterium fusion and would be considered a brown dwarf, or failed star.

Since HR 8799 is a young star, about 60 million years old, its planets are still emitting residual heat left over from its formation. Marois's group took advantage of this

heat to allow imaging in the infrared. A coronagraph was attached to the telescopes to block out the direct light from the star. Additionally, the Keck and Gemini telescopes employed adaptive optics—rapid deformation of the mirror surface—to counteract air turbulence and produce a clearer image.

Last September, astronomers from the University of Toronto, led by David Lafreniere, submitted an infrared image of what appears to be a planet at a great distance from the star 1RXS J160929.1-210524 in Scorpius. The distance involved—330 times the Earth/Sun separation—challenges the current model of planetary formation. Lafreniere and his colleagues are allowing for two years of additional research to confirm that the object is indeed a planet orbiting the star.

Prior to 1995, there existed no physical evidence that our solar system was not unique. In October 1995, the first extrasolar planet was discovered orbiting the star 51 Pegasi in the constellation Pegasus. Astronomers Michel Mayou and Didier Quesloz at the Observatoire de Haute-Provence in France used the Doppler method to infer its existence.

NASA plans to launch a replacement for the aging Hubble with much-improved capabilities in 2013. Among other projects, the new telescope would be used to find evidence of Earthlike planets in the inner portion of Fomalhaut's ring.

Directly imaging planets will allow scientists to use other instruments, such as spectroscopes, that can measure the temperature, composition of the atmosphere and other qualities. This will add tremendously to our knowledge of how planets, including ours, are formed.