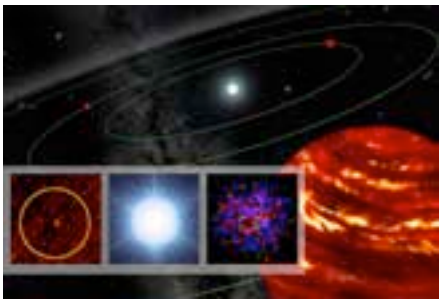
Major Breakthrough: First Photos of Planets Around Other Stars



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Astronomers have taken what they say are the first-ever direct images of planets outside of our solar system, including a visible-light snapshot of a single-planet system and an infrared picture of a multiple-planet system.

Earth-like worlds might also exist in the three-planet system, but if so they are too dim to photograph. The other newfound planet orbits a star called Fomalhaut, which is visible without the aid of a telescope. It is the 18th brightest star in the sky.

The massive worlds, each much heftier than Jupiter (at least for the three-planet system), could change how astronomers define the term "planet," one planet-hunter said.

Breakthrough technology

Until now, scientists have inferred the presence of planets mainly by detecting an unseen world's gravitational tug on its host star or waiting for the planet to transit in front of its star and then detecting a dip in the star's light. While these methods have helped to identify more than 300 extrasolar planets to date, astronomers have struggled to actually directly image and see such inferred planets.

The four photographed exoplanets are discussed in two research papers published online today by the journal *Science*.

"Every extrasolar planet detected so far has been a wobble on a graph. These are the first pictures of an entire system," said Bruce Macintosh, an astrophysicist from Lawrence Livermore National Laboratory in California, and part of the team that photographed the multi-planet system in infrared light. "We've been trying to image planets for eight years with no luck and now we have pictures of three planets at once."

Astronomers have claimed previously to have directly imaged a planet, with at least two such objects, though not everybody agreed the objects were planets. Instead, they may be dim, failed stars known as brown dwarfs.

Multi-planet snapshots

Macintosh, lead researcher Christian Marois of the NRC Herzberg Institute of Astrophysics in Canada, and colleagues used the Gemini North telescope and W.M. Keck Observatory on Hawaii's Mauna Kea to obtain infrared images. Infrared radiation represents heat and, along with everything from radio waves to

visible light and X-rays, is part of the electromagnetic spectrum.

The trio of worlds orbits a star named HR 8799, which is about 130 light-years away in the constellation Pegasus and about 1.5 times as massive as the sun. The planets are located at distances from their star of 24, 38 and 68 astronomical units (AU). (An astronomical unit equals the average Earth-sun distance of 93 million miles, or about 150 million km.) Other planet-finding techniques work out to only about 5 AU from a star.

The planet closest to the star weighs in at 10 times the mass of Jupiter, followed by another 10 Jupiter-mass planet and then, farther out, a world seven times the heft of Jupiter.

By astronomical standards, the planets are fresh out of the oven, forming about 60 million years ago. That means the orbs are still glowing from heat leftover from their formation. Earth, by comparison, is about 4.5 billion years old.

The most distant planet orbits just inside a disk of dusty debris, similar to that produced by the icy objects of the solar system's Kuiper belt, which lies just beyond the orbit of Neptune.

The setup of this planetary system, along with its dusty belt, suggests it is a scaled-up version of our solar system, Macintosh said. That means other planets closer in to the host star could be waiting for discovery.

"I think there's a very high probability that there are more planets in the system that we can't detect yet," Macintosh said. "One of the things that distinguishes this system from most of the extrasolar planets that are already known is that HR 8799 has its giant planets in the outer parts — like our solar system does — and so has 'room' for smaller terrestrial planets, far beyond our current ability to see, in the inner parts."

Hubble's discovery

University of California, Berkeley, astronomer Paul Kalas led the team of astronomers who took the visible-light snapshot of the single-planet system. The exoplanet has been named Fomalhaut b, and is estimated to weigh no more than three Jupiter masses.

The Hubble Space Telescope's Advanced Camera for Surveys was used to make the image. The camera is equipped with a coronagraph that blocks out the light of the host star, allowing astronomers to view a much fainter planet.

"It's kind of like if driving into the sun and suddenly you flip down your visor, you can see the road easier," Kalas said during a telephone interview. In fact, Fomalhaut b is 1 billion times fainter than its star. "It's not easy to see. That kind of sensitivity has never been seen before," he added.

Fomalhaut b is about 25 light-years from Earth. Photos taken in 2004 and 2006

show the planet's movement over a 21-month period and suggest the planet likely orbits its star Fomalhaut every 872 years at a distance of 119 astronomical units (AU), or 11 billion miles (nearly 18 billion km). That's about four times the distance between Neptune and the sun.

Kalas suspected the planet's existence in 2004 (published in 2005) after Hubble images he had taken revealed a dusty belt that had a sharp inner edge around Fomalhaut. The sculpted nature of the ring suggested a planet in an elliptical orbit was shaping the belt's inner edge. And it was.

"The gravity of Fomalhaut b is the key reason that the vast dust belt surrounding Fomalhaut is cleanly sculpted into a ring and offset from the star," Kalas said. "We predicted this in 2005, and now we have the direct proof."

Kalas' team also suspects that the planet could be surrounded by a ring system with the dimensions of Jupiter's early rings, before the dust and debris coalesced into the four Galilean moons.

What's a planet?

The successful image results could change how planets are defined, said Sara Seager, an astrophysicist at MIT who was not involved in the discoveries.

Until now, mass has been one of the critical pieces of information that could place an object into or out of the planet club. Objects that are too massive, above about 13 Jupiter masses, are considered brown dwarfs. But now formation could also be part of the formula. Both of the new planetary systems revealed dusty disks and suggest the planets must have formed similar to how planets in our solar system and elsewhere are thought to have formed.

So, most astronomers would call the four objects planets, although their masses are only inferred from the luminosities seen in the images.

"Taken together, these discoveries are going to change what we call a planet," Seager told *SPACE.com*. "Until now people have been arguing about how big can an object be and still be a planet."

Seager added, referring to the multi-planet system, "People want to call the upper mass 12 Jupiter masses. I think it's going to force us to reconsider what a planet is, because even if they are more massive than what we want to call a planet, they're in a disk." In addition, she said, nobody has ever spotted three stars orbiting a host star, as would have to be the case if you were to call the three planets something other than planets.

Aiming for Earth-like planets

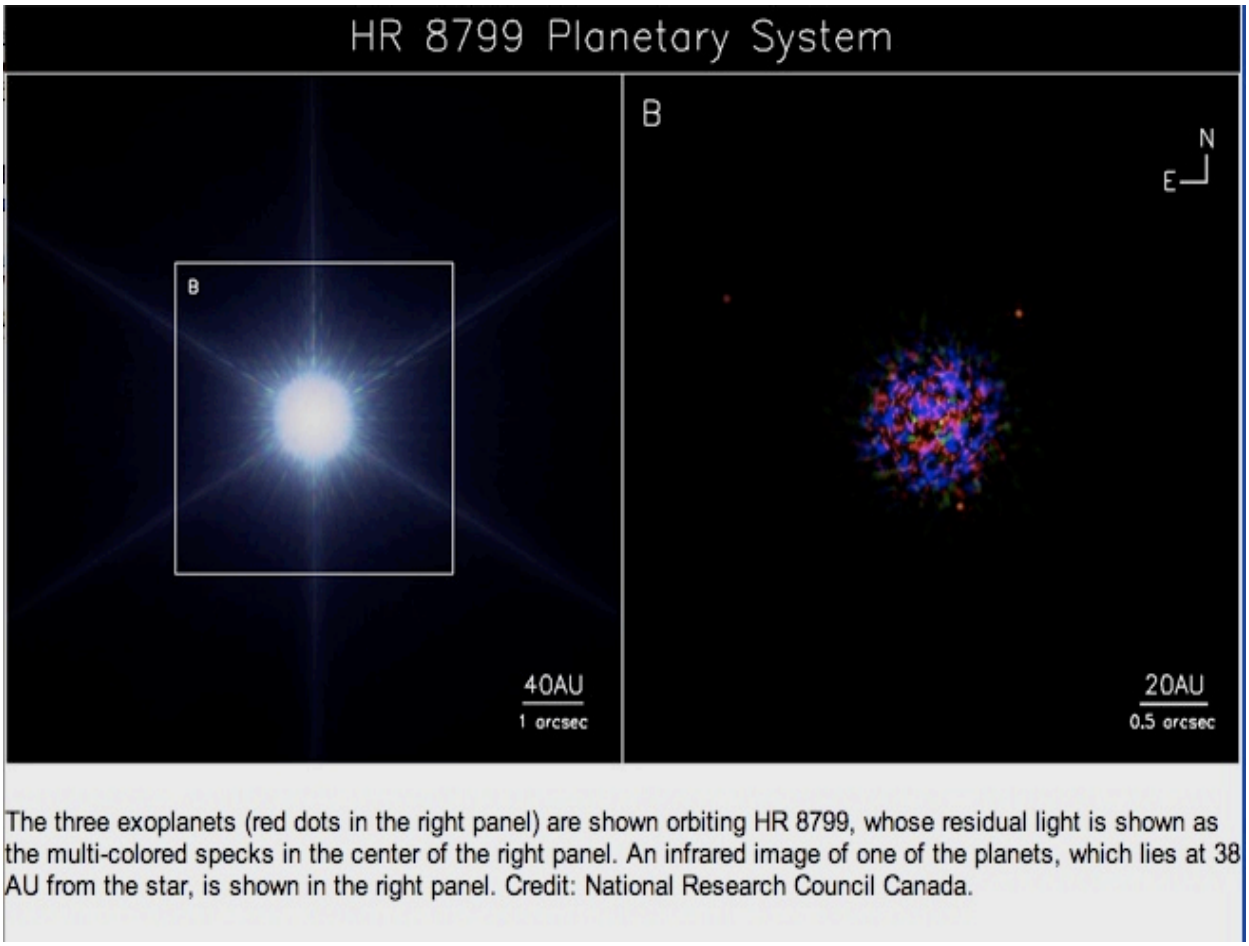
These recent direct images reveal giant, gaseous exoplanets in a new light for the first time, revealing not the effects of the planets but the planets themselves. The next goal would be direct images of an Earth-like planet, the astronomers say.

"The discovery of the HR 8799 system is a crucial step on the road to the ultimate detection of another Earth," Macintosh said.

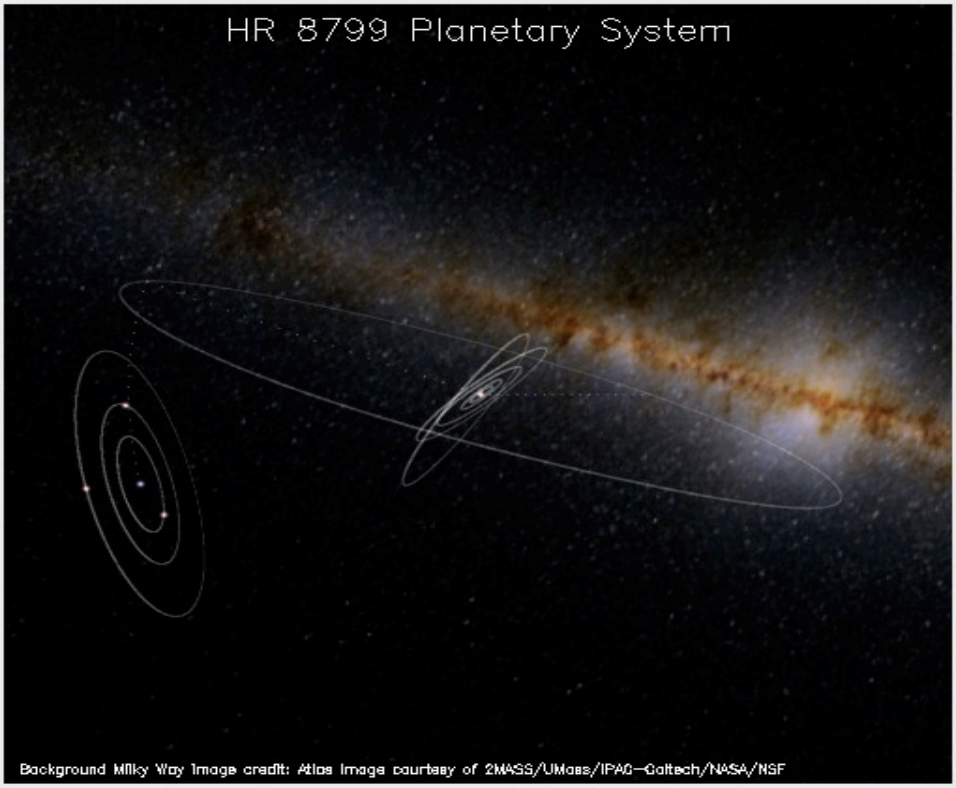
The problem is that terrestrial (Earth-like) planets are orders of magnitude fainter than the giant Jupiter-like worlds, and they are much closer in to their host stars. That means the glare from the star would be overwhelming with today's technology.

The pay-off could be big, though, as such rocky planets could orbit within their habitable zones (where temperatures would allow the existence of liquid water).

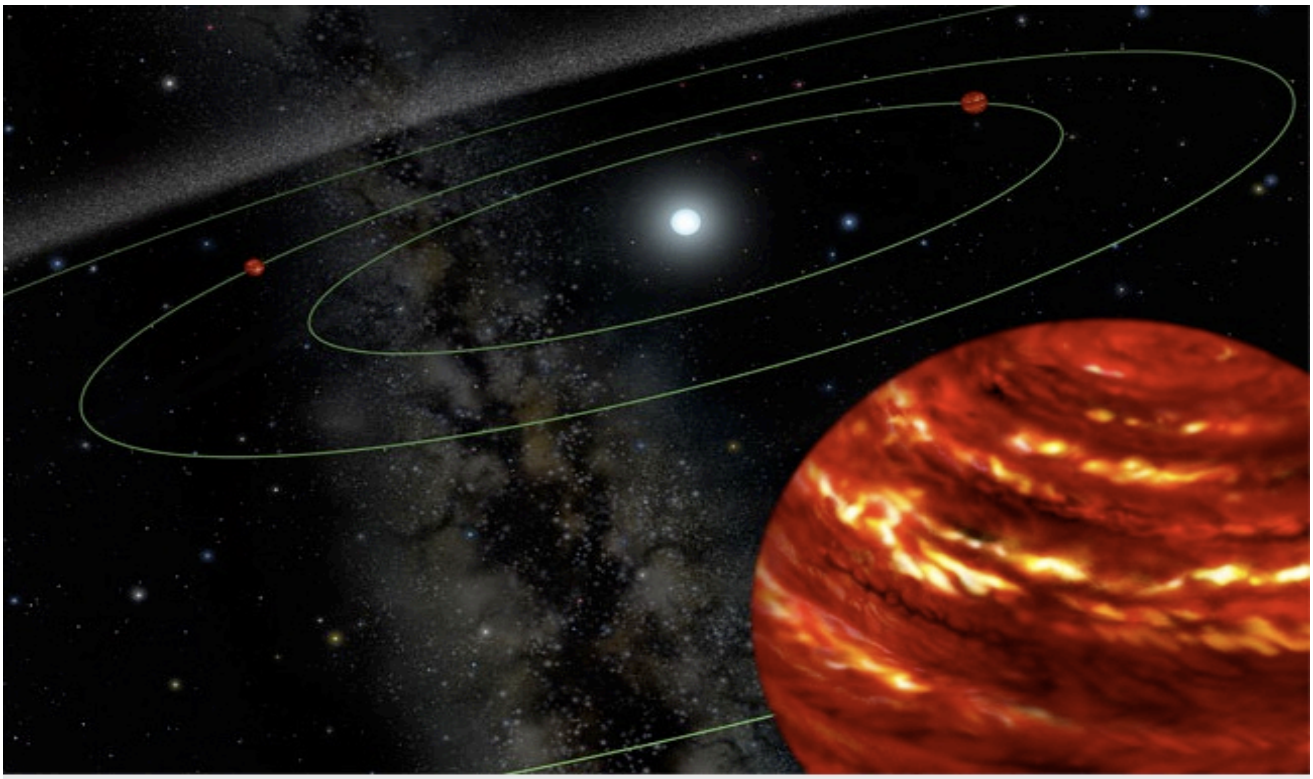
"There is plenty of empty space between Fomalhaut b and the star for other planets to happily reside in stable orbits," Kalas said. "We'll probably have to wait for the James Webb Space Telescope to give us a clear view of the region closer to the star where a planet could host liquid water on the surface."



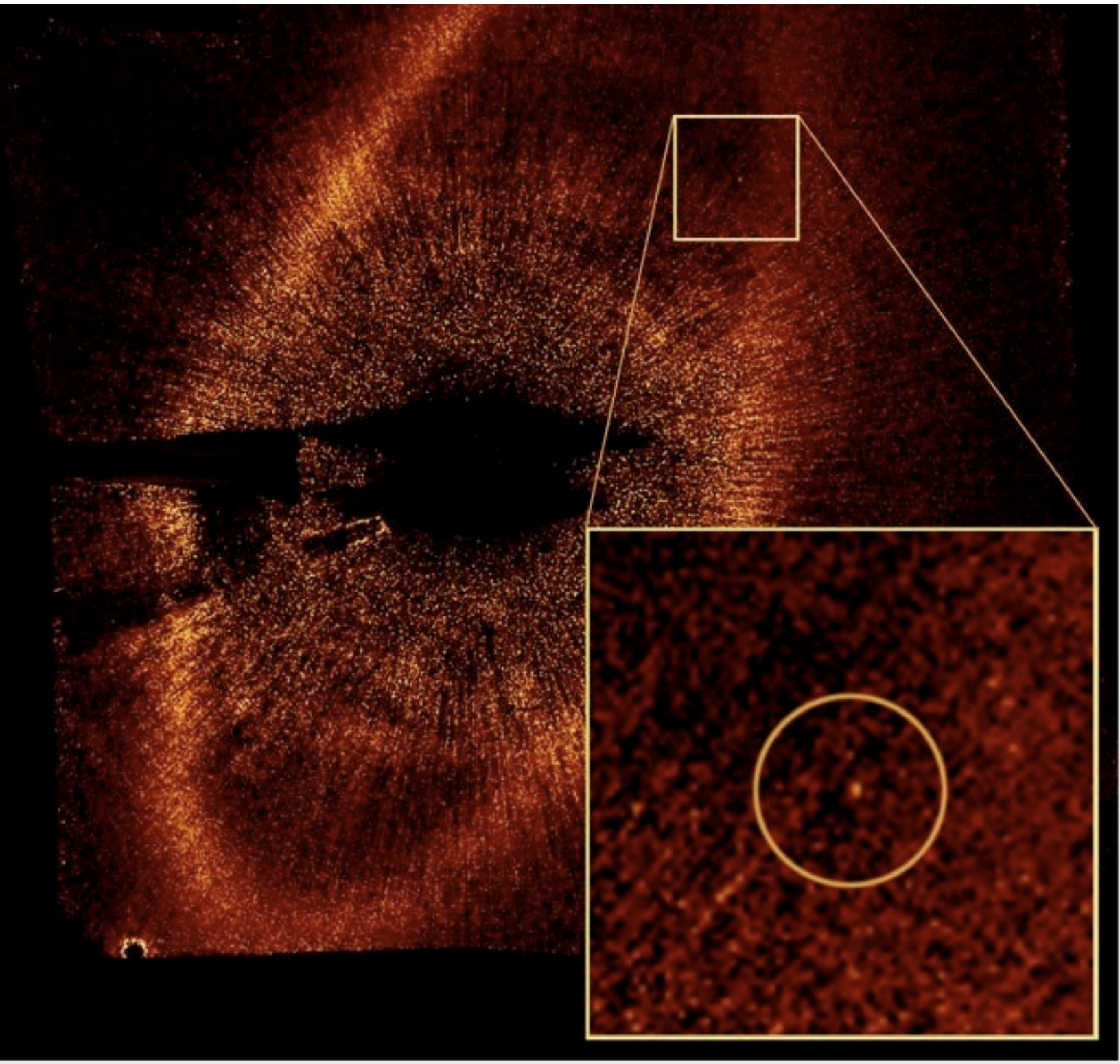
The three exoplanets (red dots in the right panel) are shown orbiting HR 8799, whose residual light is shown as the multi-colored specks in the center of the right panel. An infrared image of one of the planets, which lies at 38 AU from the star, is shown in the right panel. Credit: National Research Council Canada.



This 3D representation of the three planets orbiting the star HR 8799 shows the system is located 90 degrees away from the Milky Way galactic center, lower than the sun. (All orbital diameters are greatly exaggerated.) Credit: 2MASS/UMass/IPAC-Caltech/NASA/NSF



The HR 8799 planetary system (shown as an artist's conception) resembles a scaled-up version of the outer portion of the solar system, according to the researchers, who estimate the planets orbit their star at distances



This 2006 Hubble Space Telescope optical image shows the belt of dust and debris (bright oval) surrounding the star Fomalhaut and the planet (inset) that orbits the star every 872 years and sculpts the inner edge of the belt.
Credit: Paul Kalas/UC Berkeley; STScI