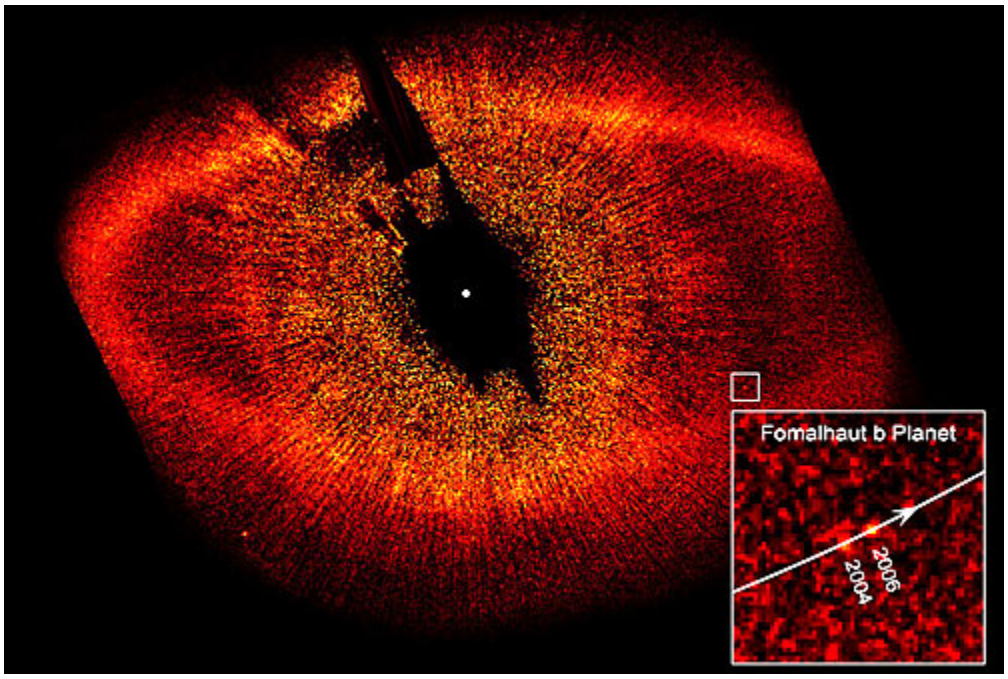
Scientists take first photos of planets orbiting other stars



NASA/ESA

The newly discovered planet Fomalhaut b sits inside the dust belt surrounding the star Fomalhaut. Scientists made the discovery after blocking out the glare from the star using special instruments on the Hubble Space Telescope.

A Berkeley team uses the Hubble telescope to take a picture of Fomalhaut b, a newly found exoplanet. Another second team in Hawaii snaps photos of three other planets orbiting a young star.

By John Johnson Jr.

12:03 PM PST, November 13, 2008

Marking a milestone in the search for Earth-like planets elsewhere in the universe, two teams of astronomers have parted the curtains of space to take the first pictures in history of planets orbiting stars other than our sun.

"This is amazing," said Eugene Chiang, an astronomer at UC Berkeley. "It's almost science fiction. I didn't think this day would occur until years from now."

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The first team, led by Berkeley researchers, used the Hubble Space Telescope to take a picture of a giant planet orbiting the star Fomalhaut, located 25 light-years from Earth.

Paul Kalas, the lead astronomer for the Berkeley team, said he "nearly had a heart attack" when he found the new planet, which he calls Fomalhaut b.

"It's a profound and overwhelming experience to lay eyes on a planet never before seen," he said.

The other effort relied on the giant Keck and Gemini telescopes in Hawaii to image three planets surrounding the young star HR8799, 130 light-years -- 700 trillion miles -- away. Benjamin Zuckerman, an astronomer at UCLA and a member of the Keck-Gemini team, noted that it's only been about a decade since the first exoplanet -- a planet orbiting another star -- was found. He said he never envisioned being able to take a picture of a planet orbiting another star so soon.

Both discoveries were released Thursday by the journal Science.

"These two papers will represent a milestone in the field that people will look back on years from now," he said.

Finding other Earths has been a dream of scientists and authors for centuries. The big problem for all planet hunters is that stars other than our sun are far away, so far that their light overwhelms the weak reflected light of any planets, just as a lightbulb overwhelms the light from a candle.

So far, more than 200 exoplanets have been discovered. But all of the previous ones were found indirectly, mostly from the wobble their gravity causes in their parent stars.

The two teams used different techniques to solve the problem. Berkeley's Kalas relied on Hubble's Advanced Camera for Surveys to tease out the Jupiter-sized planet Fomalhaut b. The planet's existence had been suspected since 2005, when Kalas studied a picture of a dust ring around the star.

He noticed the inner edge of the ring was sharply defined, raising his suspicions that there was something hiding in there that had a lot of gravity, like a planet. Planets tend to sweep their orbits clean, either by ejecting pretenders or smashing them to dust.

As Kalas studied the image, made with the assistance of a coronagraph that blotted out the star's light, he found a big chunk of something in the dust belt. A picture taken in 2006 showed it was indeed orbiting the star, located in the constellation Piscis Austrinus.

"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."

The planet would not be capable of supporting life as we know it. At 11 billion miles from its star, about three times as far from its sun as Pluto is from ours, it would be too frigid for life.

The huge amount of material in the dust ring, equivalent to three Earths, made the discovery possible by reflecting so much starlight.

The star is 16 times as bright as our sun. One reason it's so bright is because it's young, only 200 million years old. Our sun is 4.5 billion years old. But because Fomalhaut is burning so furiously, it will burn itself out long before our sun enters its dotage, in about 5 billion years.

The planet represents the lowest mass planet yet found outside our solar system, Chiang said, bringing the day closer when researchers might be able to find Earth-like planets.

The second team, which also included researchers from Lawrence Livermore National Laboratory in Northern California, and the NRC Herzberg Institute of Astrophysics in Canada, took its photographs 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," said Bruce MacIntosh, an astrophysicist at Lawrence Livermore and one of the lead authors of the research paper.

Two breakthroughs made this discovery possible. First is the use of adaptive optics -- a set of optical techniques that correct for the interference of the Earth's atmosphere, which bends and twists incoming light. In recent years, adaptive optics has become so sophisticated that ground telescopes can make pictures every bit as crisp and eye-popping as the Hubble Space Telescope. Because the mirrors of Gemini and Keck are so large, 26 and 32 feet across, they can gather even more light.

Scientists estimated that the three planets are roughly from seven to 10 times the size of Jupiter. Like Fomalhaut b, they are far from their parent star, ranging from 24 to 67 astronomical units. An astronomical unit is the distance of the Earth from the sun, about 93 million miles.

But this time it wasn't their distance from HR8799 that enabled the researchers to spot them. It was their youth. The central star is only about 100 million years old, making the planets even younger, about 65 million years old. That means they are still glowing with heat from their formation, generating enough heat that they can be seen in the infrared, even 130 light-years away.

"Seeing these planets directly -- separating their light from the star -- lets us study them as individuals, and use spectroscopy to study their properties, like temperature or composition," said MacIntosh.

It appears all three planets have complex atmospheres, with dusty clouds that trap radiating heat, scientists said.

These twin discoveries mean researchers have now found alien planets whose orbits are close to (the wobble technique) and far away (direct imaging studies) from stars outside our solar system. That still leaves a vast area in between, where any Earth-like planets would likely be residing.

Probing that territory will await at least one, and maybe more, leaps forward in technology. The first is a new and improved adaptive optics system called the Gemini Planet Imager. Expected to be 100 times more sensitive than the current instruments, it should be able to find planets the size of Jupiter around other stars.

It is expected to be in operation on the Gemini South telescope in Chile in 2011.

HR8799 will be a key target.

"I think there's a very high probability that there are more planets in the system that we can't detect yet," MacIntosh said.

Finding the next Earth could require a leap beyond that, perhaps with a space mission such as the Terrestrial Planet Finder. Proposed by NASA several years ago, it would include a suite of space-based observatories outfitted to search for Earth-like planets in our local neighborhood of space.

That mission has been deferred because of budget problems.

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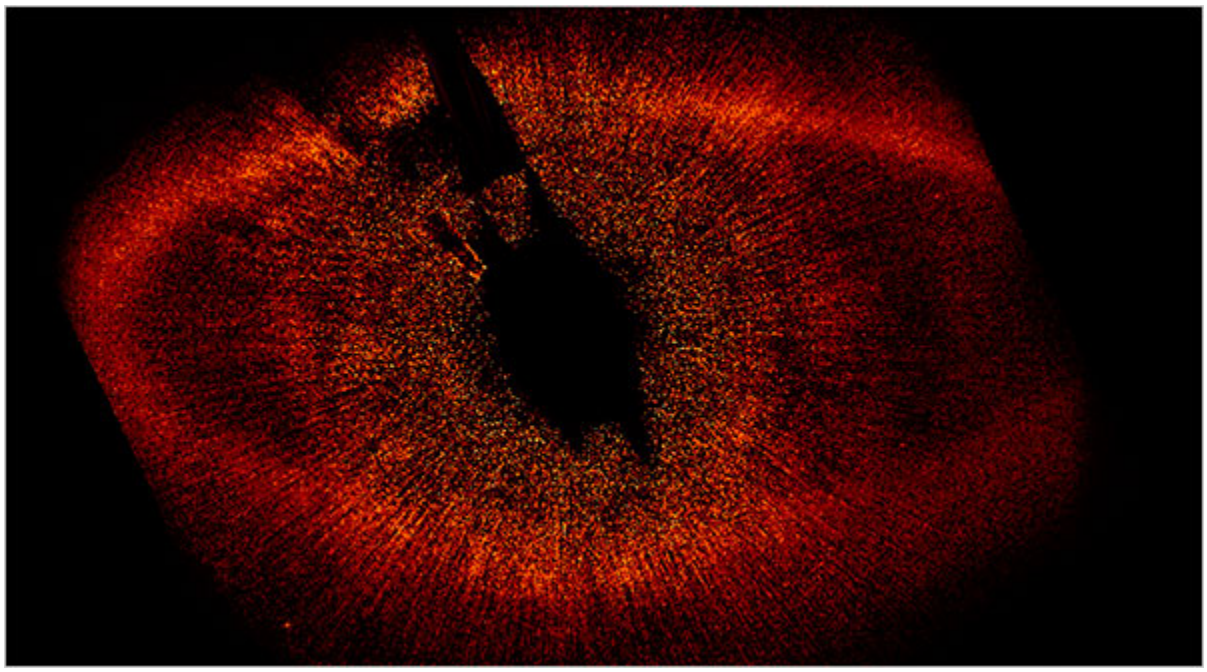
Now in Sight: Far-Off Planets



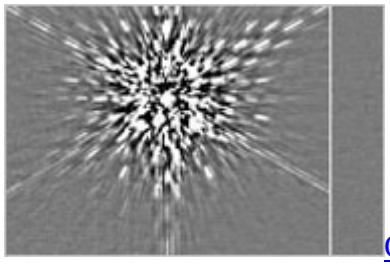
NASA, via Associated Press

A dust ring, seen in red, surrounds the star Fomalhaut, which is located at the center of the image, but is not visible. The Hubble Space Telescope captured a fuzzy image of the planet, known as Fomalhaut b, which is no more than a white speck in the dust ring that surrounds the star.

By DENNIS OVERBYE
Published: November 13, 2008

A little more of the universe has been pried out of the shadows. Two groups of astronomers have taken the first pictures of what they say — and other astronomers agree — are most likely planets going around other stars.

Multimedia



Graphic

New Extrasolar Planets

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The achievement, the result of years of effort on improved observational techniques and better data analysis, presages more such discoveries, the experts said, and will open the door to new investigations and discoveries of what planets are and how they came to be formed.

“It’s the tip of the iceberg,” said Christian Marois of the Herzberg Institute of Astrophysics in Victoria, British Columbia. “Now that we know they are there, there is going to be an explosion.”

Dr. Marois is the leader of a team that recorded three planets circling a star known as HR 8799 that is 130 light-years away in the constellation Pegasus. The other team, led by Paul Kalas of the University of California, Berkeley, found a planet orbiting the star Fomalhaut, only 25 light-years from Earth, in the constellation Piscis Austrinus.

In an interview by e-mail, Dr. Kalas said that when he finally confirmed his discovery last May, “I nearly had a heart attack.”

In scratchy telescope pictures released Thursday in Science Express, the online version of the journal Science, the planets appear as fuzzy dots that move slightly around their star from exposure to exposure. Astronomers who have seen the new images agreed that these looked like the real thing.

“I think Kepler himself would recognize these as planets orbiting a star following his laws of orbital motion,” Mark S. Marley of the Ames Research Center in Mountain View, Calif., wrote in an e-mail message elaborating on HR 8799.

More than 300 so-called extrasolar planets have been found circling distant stars, making their discovery the hottest and fastest-growing field in astronomy. But the observations have been made mostly indirectly, by dips in starlight as planets cross in front of their home star or by wobbles they induce going by it.

Astronomers being astronomers, they want to actually see these worlds, but a few recent claims of direct observations have been clouded by debates about whether the bodies were really planets or failed stars.

“Every extrasolar planet detected so far has been a wobble on a graph,” said Bruce Macintosh, an astrophysicist from Lawrence Livermore National Laboratory in California and a member of Dr. Marois’s team. “These are the first pictures of an entire system.”

The new planetary systems are anchored by young bright stars more massive than our own Sun and swaddled in large disks of dust, the raw material of worlds.

The three planets orbiting HR 8799 are roughly 10, 9 and 6 times the mass of Jupiter, and orbit their star in periods of 450, 180 and 100 years respectively, all counterclockwise.

The Fomalhaut planet is about three times as massive as Jupiter, according to Dr. Kalas's calculations, and is on the inner edge of a huge band of dust, taking roughly 872 years to complete a revolution of its star.

Both systems appear to be scaled-up versions of our own solar system, with giant planets in the outer reaches, leaving plenty of room for smaller planets to lurk undetected in the warmer inner regions. Dust rings lie even farther out, like the Kuiper belt of icy debris extending beyond the orbit of Neptune.

"This is a window into what our own solar system might have looked like when it was 60 million years old," Dr. Marois said.

Sara Seager, a planetary theorist at the Massachusetts Institute of Technology, said it was significant that the planets in both cases seemed to be associated with disks of dust, particularly Fomalhaut, one of the brightest and closest stars known to be host to a massive disk.

"Fomalhaut is like a Hollywood star to astronomers, so we have some personal excitement here," Dr. Seager said. "It feels like finding out that one of your four closest friends just won the lottery big time"

Alan Boss, a planetary theorist at the Carnegie Institution of Washington, said the triple-planet system in Pegasus was particularly promising, "as we expect planets to form in systems in general, whereas spurious background interlopers will generally appear as single 'planets.' " But he and others cautioned that much more study of these objects was necessary and that the masses imputed to them were still highly uncertain.

Being able to see planets directly opens the door to spectroscopic observations that can help determine the composition, temperature and other physical characteristics of planets and allow for comparisons with one another and with their parent stars. Dr. Macintosh said he hoped to train a spectroscope on his new planets as early as Monday.

The new images are the fruits of a long campaign by astronomers to see more and more of the unseeable. In particular, it is a triumph for the emerging technology of adaptive optics, in which telescope mirrors are jiggled and warped slightly many times a second to compensate for the atmospheric turbulence that blurs star images.

The problem in seeing other planets is picking them out of the glare of their parent stars, which are millions of times brighter, at least in visible light. As a result, planet hunters

usually look for infrared, or heat radiation, which is emitted copiously by planets still shedding heat from the process of formation.

For their observations, Dr. Marois and his colleagues used the 8-meter in diameter Gemini North and the 10-meter Keck telescopes on Mauna Kea in Hawaii, both of which had been fitted with adaptive optics. Then they processed the images with a special computer program, which Dr. Marois described as “a software coronagraph,” for processing the images.

The team first spied a pair of dots about four billion and six billion miles out from HR 8799 in October last year. Following up, they discovered a third planet closer in, at about two billion miles. Then they discovered an old observation from 2004, which also showed the planets and how far they had moved around the star in three years.

“Seeing the orbit is one of the coolest things,” Dr. Macintosh said.

Dr. Kalas did his work with the Hubble Space Telescope, which is immune to turbulence because it is in space. He used a coronagraph to block light from the actual star.

He said he had been driven to look for a planet around Fomalhaut after Hubble photographs in October 2004 showed that a dust ring around the star had a suspiciously sharp inner edge, often a clue that the ring is being sculpted by the gravity of some body orbiting nearby.

A second set of Hubble observations, in July 2006, revealed a dot moving counterclockwise around the star. “I basically held my breath for three days until I could confirm the existence of Fomalhaut in all of my data,” Dr. Kalas recalled.

Fomalhaut is also a young star, about 200 million years old, and its dust ring extends 11 billion to 20 billion miles from its planet, Dr. Kalas said. In order not to disturb or roil the dust ring, Fomalhaut’s planet must be less than three Jupiter masses, well within regulation planet size, Dr. Kalas and his collaborators calculated.

A more detailed analysis, with another team member, Eugene Chiang of the University of California, Berkeley, as lead author will appear in the Astrophysical Journal, Dr. Kalas said.

In an e-mail message, Dr. Kalas pointed out that Fomalhaut was the closest exoplanet yet discovered, “close enough to contemplate sending spacecraft there.”

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