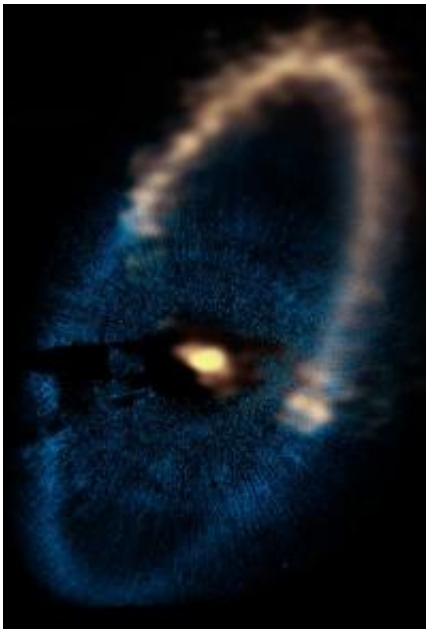


ALMA reveals workings of nearby planetary system

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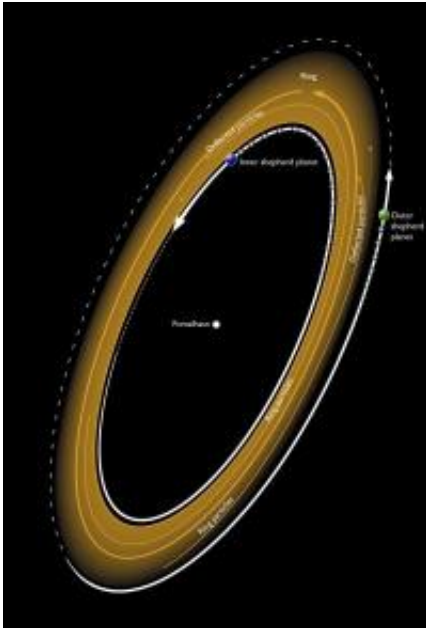
This image shows the narrow dust ring around Fomalhaut. Yellow at top is the ALMA image, and the blue at bottom is Hubble Space Telescope image. The star is at the location of the bright emission at the center of the ring. Credit: A.C. Boley (University of Florida, Sagan Fellow), M.J. Payne, E.B. Ford, MShabran (University of Florida), S. Corder (North American ALMA Science Center, National Radio Astronomy Observatory), and W. Dent (ALMA, Chile), NRAO/AUI/NSF; NASA, ESA, P. Kalas, J. Graham, E. Chiang, E. Kite (University of California, Berkeley), M. Clampin (NASA Goddard Space Flight Center), M. Fitzgerald (Lawrence Livermore National Laboratory), and K. Stapelfeldt and J. Krist (NASA Jet Propulsion Laboratory)

A new observatory still under construction has given astronomers a major breakthrough in understanding a nearby planetary system that can provide valuable clues about how such systems form and evolve. The scientists used the Atacama Large Millimeter/submillimeter Array (ALMA) to discover that planets orbiting the star Fomalhaut must be much smaller than originally thought.

The discovery, which helped resolve a controversy among earlier observers of the system, was made possible by high-resolution images of a disk, or ring, of dust orbiting the star, about 25 light-years from Earth. The ALMA images show that both the inner and outer edges of the thin, dusty disk have very sharp edges. That fact, combined with [computer simulations](#), led the scientists to conclude that the dust particles in the disk are kept within the disk by the gravitational effect of two planets -- one closer to the star than the disk and one more distant.

Their calculations also indicated the probable size of the planets -- larger than Mars but no larger than a few times the size of the Earth. This is much smaller than astronomers had previously thought. In 2008, a [Hubble Space Telescope](#) (HST) image had revealed the inner planet, then thought to be larger than Saturn, the second-largest planet in our Solar System. However, later observations with [infrared telescopes](#) failed to detect the planet.

That failure led some astronomers to doubt the existence of the planet in the HST image. Also, the HST visible-light image detected very small [dust grains](#) that are pushed outward by the star's radiation, thus blurring the structure of the [dusty disk](#). The ALMA observations, at wavelengths longer than those of visible light, traced larger dust grains -- about 1 millimeter in diameter -- that are not moved by the star's radiation. This clearly revealed the disk's sharp edges, which indicate the gravitational effect of the two planets.



Particles in dust ring are kept inside the ring by gravitational interaction with planets. Faster-moving inner planet transfers energy to dust particles, moving them outward, deeper into the ring. Slower-moving outer planet removes energy from the particles, causing them to drop inward. Credit: Bill Saxton, NRAO/AUI/NSF

"Combining ALMA observations of the ring's shape with computer models, we can place very tight limits on the mass and orbit of any planet near the ring," said Aaron Boley, a Sagan Fellow at the University of Florida, leader of the study. "The masses of these planets must be small; otherwise the planets would destroy the ring," he added. The small sizes of the planets explain why the earlier infrared observations failed to detect them, the scientists said.

The ALMA research shows that the ring's width is about 16 times the distance from the Sun to the Earth, and is only one-seventh as thick as it is wide. "The ring is even more narrow and thinner than previously

thought," said Matthew Payne, also of the University of Florida.

The ring is about 140 times the Sun-Earth distance from the star. In our own Solar System, Pluto is about 40 times more distant from the Sun than the Earth. "Because of the small size of the planets near this ring and their large distance from their host star, they are among the coldest planets yet found orbiting a normal star," Boley said.

The scientists observed the Fomalhaut system in September and October of 2011, when only about a quarter of ALMA's planned 66 antennas were available. When construction is completed next year, the full system will be much more capable. ALMA's new capabilities, however, revealed the telltale structure that had eluded earlier millimeter-wave observers.

"ALMA may still be under construction, but it already has proven to be the world's most powerful telescope for observing the Universe at millimeter and submillimeter wavelengths," said Stuartt Corder, of the National Radio Astronomy Observatory, a member of the observing team. The scientists will report their findings in an upcoming edition of the *Astrophysical Journal Letters*.

The effect of planets or moons in keeping a dust ring's edges sharp was first seen when the Voyager 1 spacecraft flew by Saturn in 1980 and made detailed images of that planet's ring system. One ring of the planet Uranus is confined sharply by the moons Cordelia and Ophelia, in exactly the manner the ALMA observers propose for the ring around Fomalhaut. The moons confining those planets' rings are dubbed "shepherding moons."

The moons or [planets](#) confining such dust rings do so through gravitational effects. A planet on the inside of the ring is orbiting the star more rapidly than the dust particles in the ring. Its gravity adds energy to

the particles, pushing them outward. A planet on the ring's outside is moving more slowly than the [dust particles](#), and its gravity decreases the energy of the particles, making them fall slightly inward.

Provided by National Radio Astronomy Observatory

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