

Robotically Discovering Earth's Nearest Neighbors

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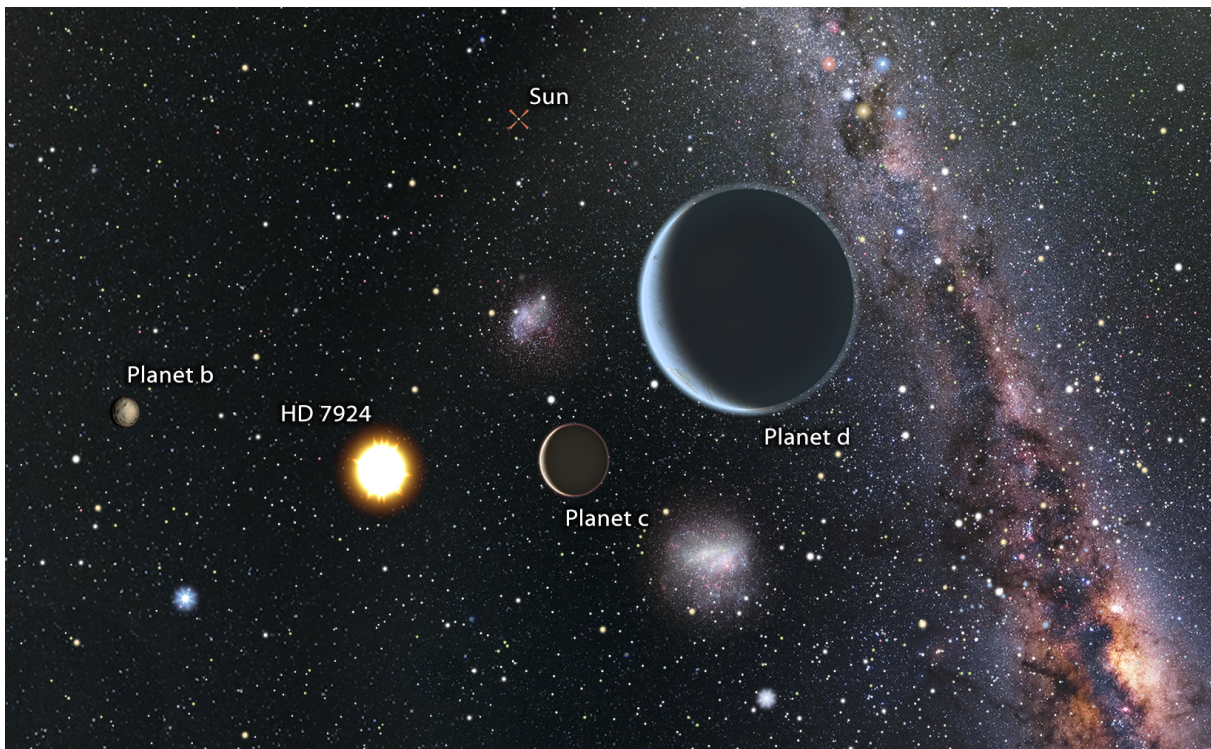
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A team of astronomers using ground-based telescopes in Arizona, California, and Hawaii recently discovered a planetary system orbiting a nearby star that is only 54 light-years away from our solar system. All three of its planets orbit their star at a distance closer than Mercury orbits the Sun, completing their orbits in just 5, 15, and 24 days.

Astronomers from the University of Hawaii at Manoa, the University of California, Berkeley, Tennessee State University in Nashville, and the University of California Lick Observatory found the planets using measurements from the Automated Planet Finder (APF) Telescope at Lick Observatory in California, the W. M. Keck Observatory on Mauna Kea, Hawaii, and the TSU Automatic Photometric Telescopes (APTs) at Fairborn Observatory in the Patagonia Mountains of southern Arizona.



Caption: Artist's impression of a view from the HD 7924 planetary system looking back toward our Sun, which would be easily visible to the naked eye. Since HD 7924 is in our northern sky, an observer looking back at the sun would see objects like the Southern Cross and the Magellanic Clouds close to our sun in their sky. Art by Karen Teramura & BJ Fulton, UH IfA.

The team discovered the new planets by detecting the wobble of the star HD 7924 as the planets orbited and pulled on the star gravitationally. The APF and Keck Observatory traced out the planets' orbits over many years using the Doppler technique that has successfully found hundreds of mostly larger planets orbiting nearby stars. In coordination with the APF and Keck Observations, the TSU APT made crucial brightness measurements of HD 7924 over 9 years to assure the validity of the planet discoveries.

The new APF facility offers a way to speed up the planet search. Planets can be discovered and their orbits traced much more quickly because APF is a dedicated facility that robotically searches for planets every clear night. Training computers to run the observatory all night, without human oversight, took years of effort by the University of California Observatory staff and graduate students on the discovery team.

TSU has also been developing and operating robotic telescopes for over 20 years. "The robotic telescopes are a wonderful advancement," says TSU astronomer Gregory Henry, who oversees the operation of seven robotic telescopes for his research. "They take away the tedium of all-night, manual observing sessions and produce far more and far superior data." One of the TSU robotic telescopes discovered the first transiting extrasolar planet in 1999, providing final proof of the existence of other planetary systems.



Caption: Tennessee State University's robotic telescopes in the mountains of southern Arizona prowl the night sky every clear night of the year studying Sun-like stars and searching for new planetary systems. (Moonlight image by Lou Boyd, Fairborn Obs.)

The Keck Observatory found the first evidence of planets orbiting HD 7924, discovering the innermost planet in 2009 using the HIRES instrument installed on the 10-meter Keck I telescope. This same combination was also used to find other super-Earths orbiting nearby stars in planet searches led by UH astronomer Andrew Howard and UC Berkeley Professor Geoffrey Marcy. It took five years of additional observations at Keck, a year-and-a-half campaign by the APF Telescope, and nine years of APT monitoring to find the two additional planets orbiting HD 7924.

“The APT measurements of the star's brightness allow us to determine whether or not star spots are mimicking the presence of false planets,” says Henry. “All three planets are strongly confirmed by the lack of brightness variability observed with the APTs.”

The Kepler Space Telescope has discovered thousands of extrasolar planets and demonstrated that they are common in our Milky Way galaxy. However, nearly all of these planets are far from our solar system. Most nearby stars have not been thoroughly searched for the small “super-Earth” planets (larger than Earth but smaller than Neptune) that Kepler found in great abundance.

This discovery shows the type of planetary system that astronomers expect to find around many nearby stars in the coming years. “The three planets are unlike anything in our solar system, with masses 7-8 times the mass of Earth and orbits that take them very close to their host star,” explains UC Berkeley graduate student Lauren Weiss.

“This level of automation is a game-changer in astronomy,” says Howard. “It’s a bit like owning a driver-less car that goes planet shopping.”

The robotic observations of HD 7924 are the start of a systematic survey for super-Earth planets orbiting nearby stars. University of Hawaii graduate student B. J. Fulton will lead this two-year search with the APF as part of his research for his doctoral dissertation. Henry will look for brightness changes in the same stars with the APTs. “When the survey is complete, we will have a census of small planets orbiting Sun-like stars within approximately 100 light-years of Earth,” says Fulton.

The paper presenting this work, “Three super-Earths orbiting HD 7924,” has been accepted for publication in the *Astrophysical Journal*. Other authors of the paper are Howard Isaacson (UC Berkeley), Evan Sinukoff (UH), and Bradford Holden and Robert Kibrick (UCO). The team acknowledges support of the Gloria and Ken Levy Foundation, NASA, NSF, the U.S. Naval Observatory, the University of California for its support of Lick Observatory and the State of Tennessee through its Centers of Excellence program.