Planet 'reared' by four parent stars

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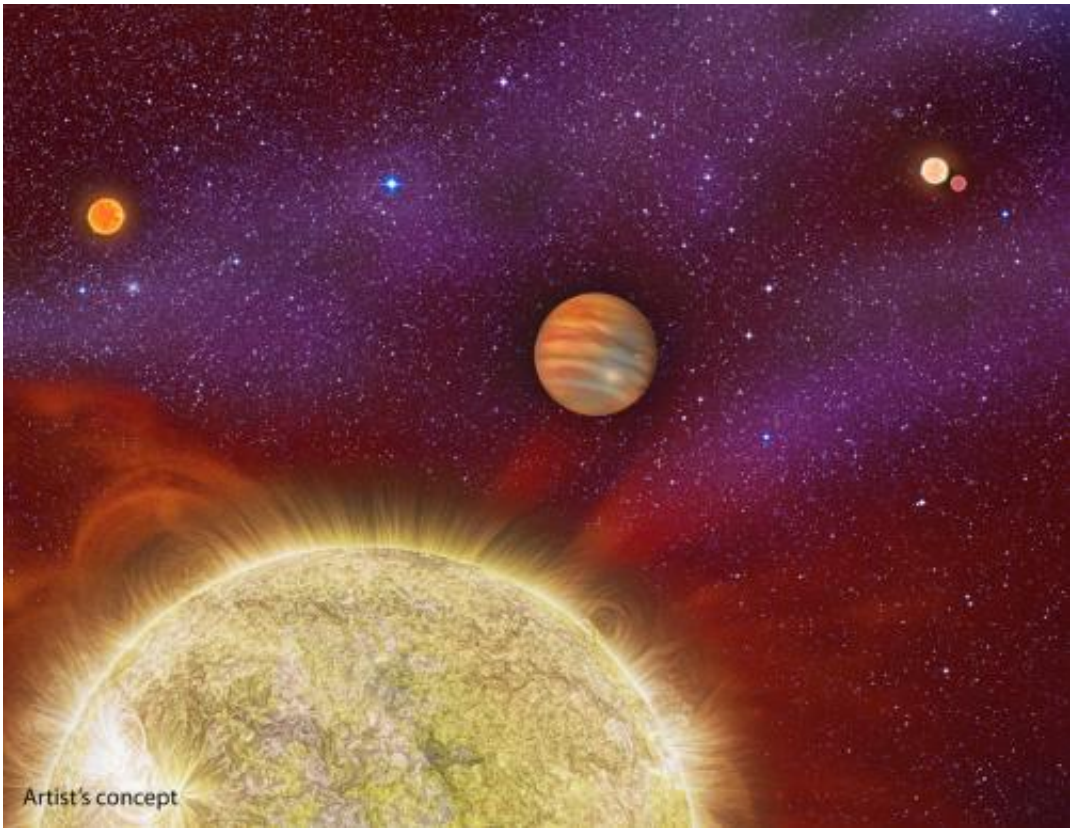


This artist's conception shows the 30 Ari system, which includes four stars and a planet. The planet, a gas giant, orbits its primary star (yellow) in about a year's time. The primary star, called 30 Ari B, has a companion -- the small "red dwarf" star shown at upper left. This pair of stars is itself locked in a long-distance orbit with another pair of stars (upper right), known as 30 Ari A. Researchers using instruments at the Palomar Observatory near San Diego, Calif., recently discovered the red star at upper left, bringing the total number of known stars in the system from three to four. Credit: Image copyright: Karen Teramura, UH IfA

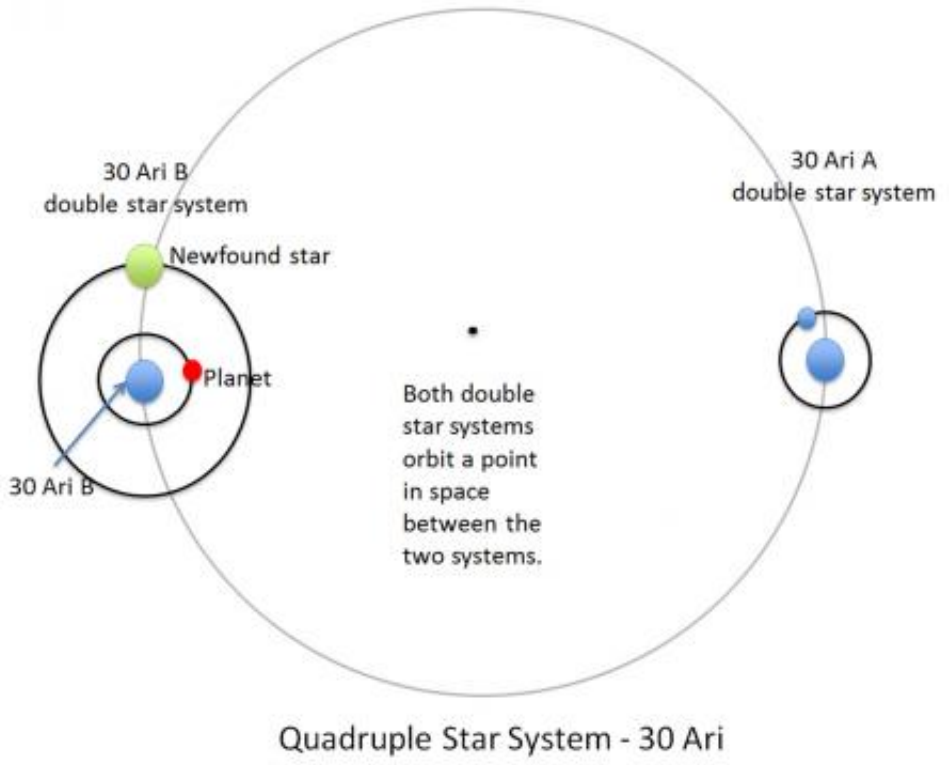
Growing up as a planet with more than one parent star has its challenges. Though the planets in our solar system circle just one star—our sun—other more distant planets, called exoplanets, can be reared in families with two or more stars. Researchers wanting to know more about the complex influences of multiple stars on planets have come up with two new case studies: a planet found to have three parents, and another with four.

The discoveries were made using instruments fitted to telescopes at the Palomar Observatory in San Diego: the Robo-AO adaptive optics system, developed by the Inter-University Center for Astronomy and Astrophysics in India and the California Institute of Technology in Pasadena, and the PALM-3000 adaptive optics system, developed by NASA's Jet Propulsion Laboratory in Pasadena, California, and Caltech.

This is only the second time a planet has been identified in a quadruple star system. While the planet was known before, it was thought to have only three stars, not four. The first four-star planet, KIC 4862625, was discovered in 2013 by citizen scientists using public data from NASA's Kepler mission.

The latest discovery suggests that planets in quadruple star systems might be less rare than once thought. In fact, recent research has shown that this type of star system, which usually consists of two pairs of twin stars slowly circling each other at great distances, is itself more common than previously believed.

"About four percent of solar-type stars are in quadruple systems, which is up from previous estimates because observational techniques are steadily improving," said co-author Andrei Tokovinin of the Cerro Tololo Inter-American Observatory in Chile.



The four stars and one planet of the 30 Ari system are illustrated in this diagram. This quadruple star system consists of two pairs of stars: 30 Ari B and 30 Ari A. A gas giant planet (red) orbits one of the stars in 30 Ari B about once a year. New observations led by NASA's Jet Propulsion Laboratory in Pasadena, California, identified the fourth star in the system (green); the three others stars and the planet were previously known. This is the second quadruple star system known to host a planet. The orbits shown are only approximations and are not as circular as they appear. Distances are not drawn to scale. Credit: NASA/JPL-Caltech

The newfound four-star planetary system, called 30 Ari, is located 136 light-years away in the constellation Aries. The system's gaseous planet is enormous, with 10 times the mass of Jupiter, and it orbits its primary star every 335 days. The primary star has a relatively close partner star, which the planet does not orbit. This pair, in turn, is locked in a long-

distance orbit with another pair of stars about 1,670 astronomical units away (an astronomical unit is the distance between Earth and the sun). Astronomers think it's highly unlikely that this planet, or any moons that might circle it, could sustain life.

Were it possible to see the skies from this world, the four parent stars would look like one small sun and two very bright stars that would be visible in daylight. One of those stars, if viewed with a large enough telescope, would be revealed to be a binary system, or two stars orbiting each other.

In recent years, dozens of planets with two or three parent stars have been found, including those with "Tatooine" sunsets reminiscent of the Star Wars movies. Finding planets with multiple parents isn't too much of a surprise, considering that binary stars are more common in our galaxy than single stars.

"Star systems come in myriad forms. There can be single stars, binary stars, triple stars, even quintuple star systems," said Lewis Roberts of JPL, lead author of the new findings appearing in the journal *Astronomical Journal*. "It's amazing the way nature puts these things together."

Roberts and his colleagues want to understand the effects that multiple parent stars can have on their developing youthful planets. Evidence suggests that stellar companions can influence the fate of planets by changing the planets' orbits and even triggering some to grow more massive. For example, the "hot Jupiters"—planets around the mass of Jupiter that whip closely around their stars in just days—might be gently nudged closer to their primary parent star by the gravitational hand of a stellar companion.

In the new study, the researchers describe using the automated Robo-AO

system on Palomar Observatory to scan the night skies, searching hundreds of stars each night for signs of stellar companions. They found two candidates hosting exoplanets: the four-star system 30 Ari, and a triple-star planetary system called HD 2638. The findings were confirmed using the higher-resolution PALM-3000 instrument, also at Palomar Observatory.

The new planet with a trio of stars is a hot Jupiter that circles its primary star tightly, completing one lap every three days. Scientists already knew this primary star was locked in a gravitational tango with another star, about 0.7 light-years away, or 44,000 astronomical units. That's relatively far apart for a pair of stellar companions. The latest discovery is of a third star in the system, which orbits the primary star from a distance of 28 astronomical units—close enough to have influenced the hot Jupiter's development and final orbit.

"This result strengthens the connection between multiple star systems and massive planets," said Roberts.

In the case of Ari 30, the discovery brought the number of known stars in the system from three to four. The fourth star lies at a distance of 23 astronomical units from the planet. While this stellar companion and its planet are closer to each other than those in the HD 2638 system, the newfound star does not appear to have impacted the orbit of the planet. The exact reason for this is uncertain, so the team is planning further observations to better understand the orbit of the star and its complicated family dynamics.

More information: *Astronomical Journal*, iopscience.iop.org/1538-3881/149/4/118/article

Provided by Jet Propulsion Laboratory