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PRESS RELEASE

Astronomers Discover Rare Hierarchical Quadruple System: Pair of Cold Brown Dwarfs Orbiting Pair of Young Red Dwarf

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A revolutionary astronomical discovery.

Madrid / Nanjing / San Diego / La Serena, June 16, 2025 — An international team of astronomers has discovered an extraordinarily rare hierarchical quadruple star system composed of a pair of cold brown dwarfs orbiting a pair of young red dwarf stars. The system, named UPM J1040−3551, is located just 82 light-years from Earth in the constellation Antlia, and the discovery has been published in the prestigious journal Monthly Notices of the Royal Astronomical Society (MNRAS).

The research was led by **Professor Zenghua Zhang** of Nanjing University and includes **Dr. MariCruz Gálvez Ortiz and Dr. Patrica Cruz**, from the Centro de Astrobiología (CAB), CSIC-INTA, as co-authors.

A Unique Stellar System: UPM J1040−3551 AabBab

- **Aab:** two red dwarf stars (M-type), with temperatures around 3,200 K **(2900°C)** and masses of about 17% that of the Sun.

- **Bab:** two cold brown dwarfs (T-type), with much cooler temperatures of 820 K **(550°C)** and 690 K **(420°C)** , respectively, and estimated masses between 10 and 30 times that of Jupiter.

"What makes this system unique is its hierarchical structure, which ensures long-term orbital stability," explains Professor Zhang. "Each pair orbits internally over decades, and both pairs orbit each other over timescales exceeding 100,000 years."

The two pairs are separated by an impressive 1656 astronomical units (AU), where 1 AU equals the Earth-Sun distance. The brighter pair, UPM J1040−3551 Aab, consists of two nearly equal-mass red dwarf stars, which appear orange in colour when observed in visible wavelengths. With a visual magnitude of 14.6, this pair is approximately 100,000 times fainter than Polaris (the North Star) in visible wavelengths. The fainter pair, UPM J1040−3551 Bab, comprises two much cooler brown dwarfs that barely emit visible light, with Bab being about 1000 times fainter than the Aab in near-infrared wavelengths.

The close binary nature of UPM J1040−3551 Aab was initially suspected due to its wobbling photocentre during Gaia's observations and confirmed by its unusual brightness—approximately 0.7 magnitude brighter than a single star with the same temperature at the same distance, as the combined light from the nearly equal-mass pair effectively doubles the output. Similarly, UPM J1040−3551 Bab was identified as another close binary through its abnormally bright infrared measurements compared to typical brown dwarfs of its spectral type. Spectral fitting analysis strongly supported this conclusion, with binary templates providing a significantly better match than single-object templates.

Cold and Mysterious Objects

The spectroscopic observations that allowed the system to be characterized were led by Dr. Felipe Navarete of the Brazilian National Astrophysics Laboratory. Using the SOAR Telescope (Southern Astrophysical Research Telescope) at Cerro Tololo Inter-American Observatory in Chile—operated by NSF NOIRLab—the team obtained optical data for the brighter stellar pair and near-infrared spectra of the fainter brown dwarf pair.

“These observations were challenging due to the low brightness of the brown dwarfs,” said Dr. Navarete. “But SOAR’s capabilities allowed us to collect the spectroscopic data needed to understand the nature of these exotic objects.”

Brown dwarfs are small and dense low-mass objects, with the brown dwarfs in this system having sizes similar to the planet Jupiter but masses estimated to be 10-30 times greater. Indeed, at the low end of this range these objects could be considered "planetary mass" objects.

Dr. MariCruz Gálvez Ortiz emphasizes the unprecedented nature of this discovery:

“This is the first-ever quadruple system discovered containing a pair of T-type brown dwarfs orbiting two stars. Its discovery provides a unique cosmic laboratory for studying these mysterious objects.”

A Crucial Tool to Resolve the Age–Mass Degeneracy

Brown dwarfs are objects somewhere between planets and stars. Over time, they cool, which complicates determining their age and mass: a hot object can be young and light, or old and heavy. This dilemma, known as the age-mass degeneracy problem, has been a major obstacle in the study of these celestial bodies.

“UPM J1040−3551 is particularly valuable because H-alpha emission from the stars indicates the system is relatively young—between 300 million and 2 billion years old,” highlights **Professor Hugh Jones** of the University of Hertfordshire. “That makes it a critical benchmark for dating other brown dwarfs.”

A Natural Laboratory for Future Research

The team believes the system could be further studied with high-resolution imaging techniques, enabling precise measurements of the brown dwarfs' orbital motion and accurate dynamical mass determinations.

"This system offers a double opportunity for science: it can serve both as an age and a mass benchmark," adds Professor Adam Burgasser of the University of California, San Diego. "It will help refine models of evolution and atmospheric structure for these poorly understood objects."

The discovery of UPM J1040−3551 represents a major step forward in understanding brown dwarfs and reveals new pathways for the formation of multiple star systems in the solar neighborhood.

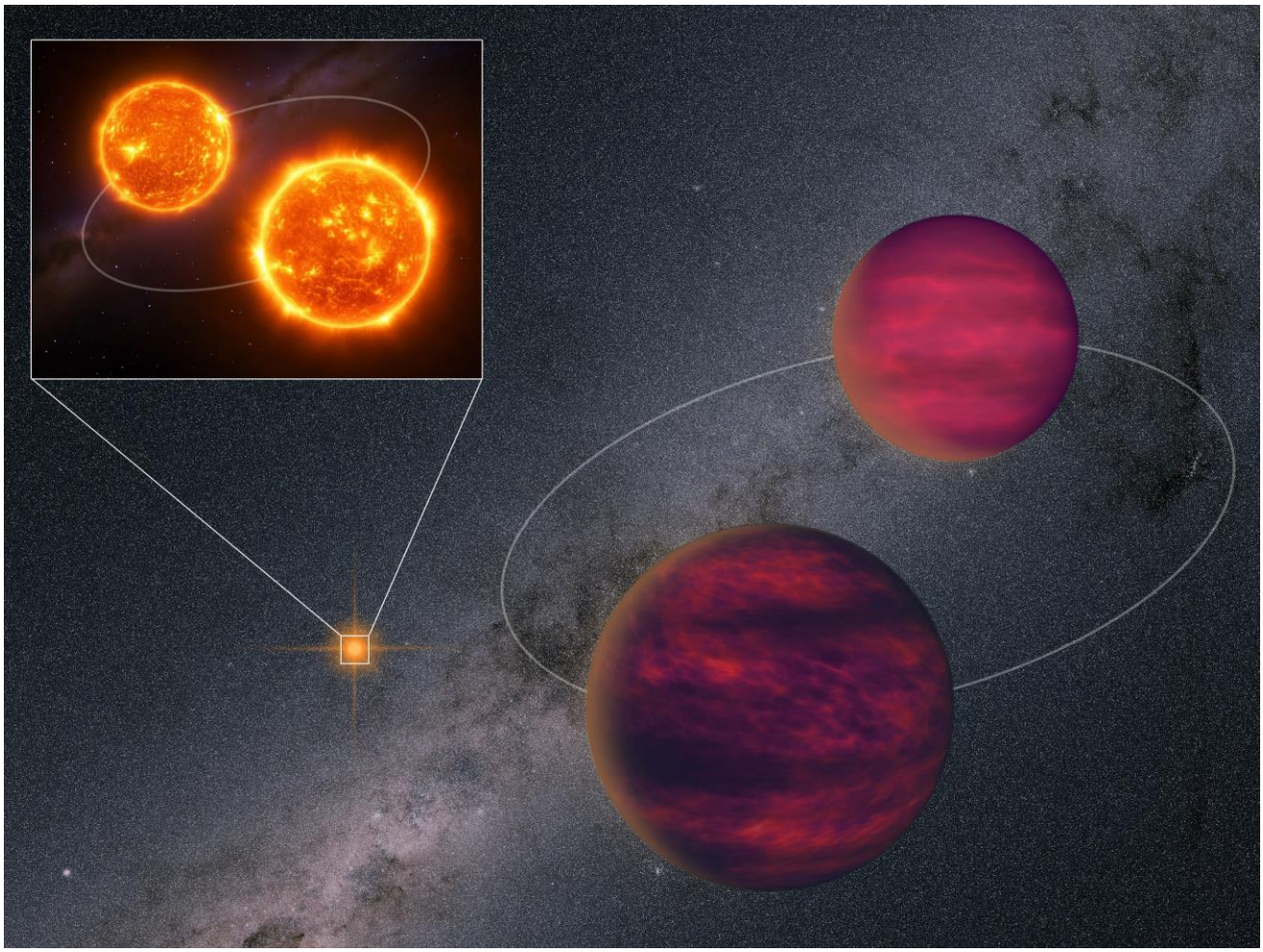
About CAB

Centro de Astrobiología (CAB) is a joint research center of the National Institute of Aerospace Technology (INTA) and the National Research Council (CSIC) of Spain. Created in 1999, it was the world's first center dedicated specifically to astrobiological research and the first non-US associate member of NASA's Astrobiology Institute (now the NASA Astrobiology Program). It is an interdisciplinary research center whose main objective is to study the origin, presence and influence of life in the universe from a transdisciplinary approach. In 2017, CAB was distinguished by the Ministry of Science and Innovation as "María de Maeztu Unit of Excellence".

CAB has led the development of the REMS, TWINS and MEDA instruments, all operational on Mars since August 2012, November 2018 and February 2021, respectively; as well as the science of the RLS and RAX Raman instruments, which will be launched in this decade on board of ExoMars and MMX missions. In addition, CAB develops the SOLID instrument, aimed at the search for life in planetary exploration. Likewise, CAB participates in different missions and instruments of great astrobiological relevance, such as CARMENES, CHEOPS, PLATO, BepiColombo, DART, Hera, the MIRI and NIRSpec instruments at JWST and the HARMONI instrument at ESO's Extremely Large Telescope (ELT).

More information

An image with good resolution and a short description



An artist's concept depicts the UPM J1040−3551 system against the backdrop of the Milky Way as observed by Gaia. On the left, UPM J1040−3551 Aa & Ab appears as a distant bright orange dot, with an inset revealing these two M-type stars in orbit. On the right, in the foreground, a pair of cold brown dwarfs—UPM J1040−3551 Ba & Bb—orbit each other for a period of decades while collectively circling UPM J1040−3551 Aab in a vast orbit that takes over 100,000 years to complete. Image Credits: Jiaxin Zhong, Zenghua Zhang.

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https://arxiv.org/abs/2505.24560

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