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PRESS RELEASE

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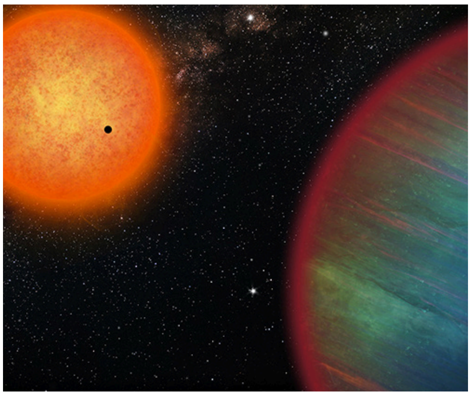
Not all Hot Jupiters orbit solo

A UNIGE study shows that Hot Jupiters do not systematically eject their planetary neighbours during migration. This discovery overturns our perception of the architecture of planetary systems.



The WASP-132 system was know to harbour WASP-132b, here in the foreground, a Hot Jupiter planet orbiting around a K-type star in 7.1 days. New data confirms the system has more planets, including an inner super-Earth, here seen transiting in front of the orange host-star. Visible as a pale blue dot near the top right corner is also the giant planet WASP-132d discovered in the outskirts of the system.

High resolution pictures

Hot Jupiters are giant planets initially known to orbit alone close to their star. During their migration towards their star, these planets were thought to accrete or eject any other planets present. However, this paradigm has been overturned by recent observations, and the final blow could come from a new study led by the University of Geneva (UNIGE). A team including the National Centre of Competence in Research (NCCR) PlanetS, the Universities of Bern (UNIBE) and Zurich (UZH) and several foreign universities has just announced the existence of a planetary system, WASP-132, with an unexpected architecture. It contains not only a Hot Jupiter but also an inner Super-Earth and an icy giant planet. These results are published in *Astronomy & Astrophysics*.

Hot Jupiters are planets with masses similar to that of Jupiter, but orbit close to their star, at a much smaller distance than Mercury is to the Sun. It is difficult for these giant planets to form where they are observed, because there is not enough gas and dust close to the star. They must therefore form far from it and migrate as the planetary system evolves.

Until recently, astronomers observed that Hot Jupiters were isolated around their star, with no other planets in their vicinity. This observation seemed all the more solid as there was a theory to explain it. The processes involved in the migration of giant planets towards their star lead to the accretion or ejection of any planets in an inner orbit. But recent observations suggest other scenarios.

A team led by the Astronomy Department of the UNIGE Faculty of Science, in partnership with UNIBE and UZH, as part of the NCCR PlanetS, and with other international institutions such as the University of Warwick, has just confirmed this trend. The scientists have discovered the existence of a multi-planetary system made up of a Hot Jupiter, an inner Super-Earth (even closer to the star than the hot Jupiter) and an outer massive giant planet (much further away from the star than the Hot Jupiter). If Hot Jupiters are not always alone in their planetary system, then their migration process must be different in order to preserve the architecture of the system.

A unique multi-planetary system

The WASP-132 system is a unique multi-planetary system. It contains a Hot Jupiter that orbits its star in 7 days and 3 hours; a Super-Earth (a rocky planet 6 times the mass of the Earth) that orbits the star in just 24 hours and 17 minutes; and a giant planet (5 times the mass of Jupiter) that orbits the host star in 5 years. In addition, a much more massive companion, probably a brown dwarf (a celestial body whose mass is between that of a planet and that of a star), orbits at a very long distance.

"The WASP-132 system is a remarkable laboratory for studying the formation and evolution of multi-planetary systems. The discovery of a Hot Jupiter alongside an inner Super-Earth and a distant giant planet calls into question our understanding of the formation and evolution of these systems," says François Bouchy, associate professor in the Department of Astronomy at the UNIGE Faculty of Science and co-author of the study. "This is the first time we have observed such a configuration!," adds Solène Ulmer-Moll, a postdoctoral researcher at UNIGE and UNIBE at the time of the study and co-author of the paper.

Eighteen years of observation

For exoplanetologists, the story of the star WASP-132 began in 2006, as part of the Wide-Angle Search for Planets (WASP) program. In 2012, the accumulation of more than 23,000 photometric measurements made it possible to identify a planetary candidate, WASP-132b, with a radius of 0.87 times Jupiter's and an orbital period of 7.1 days. In 2014, the CORALIE spectrograph, installed on the Swiss Euler telescope and led by the UNIGE, began a campaign to monitor this candidate. In 2016, WASP-132b was confirmed and its mass was measured to be equal to 0.41 Jupiter masses. Furthermore the CORALIE measurements indicate the presence of another giant planet with a very long period.

Around the same star, at the end of 2021, the TESS space telescope revealed the signal from a transiting Super-Earth with a diameter of 1.8 Earth radii and a period of only 1.01 days. In the first half of 2022, the HARPS spectrograph at the La Silla observatory measured the mass of this Super-Earth, which is six times the mass of Earth, as part of a program led by David Armstrong from the University of Warwick.

"The detection of the inner Super-Earth was particularly exciting," explains Nolan Grieves, a postdoctoral researcher in the Department of Astronomy at the UNIGE Faculty of Science at the time of the study, and first author of the paper. "We had to carry out an intensive campaign using HARPS and optimised signal processing to characterise its mass, density and composition, revealing a planet with a density similar to that of the Earth".

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Observations of WASP-132 are not over yet, however, as ESA's Gaia satellite has been measuring the minute variations in the positions of stars since 2014, with an aim to reveal their planetary companions and outer brown dwarfs.

A new understanding of planet formation

The discovery of an outer cold giant planet and an inner Super-Earth adds another layer of complexity to the WASP-132 system. The standard hypothesis of migration by dynamical perturbation of the Hot Jupiter towards the interior does not hold, as this would have destabilised the orbits of the other two planets. Instead, their presence suggests a more stable and dynamically "cool" migration path in a proto-planetary disc for the hot Jupiter, preserving its neighbours.

The combination of precise radius and mass measurements has also made it possible to determine the density and internal composition of the planets. The Hot Jupiter WASP-132b reveals a heavy element enrichment of around 17 Earth masses, in agreement with models of gas giant formation. The Super-Earth has a composition dominated by metals and silicates that is fairly similar to that of the Earth.

"The combination of a Hot Jupiter, an inner Super-Earth and an outer giant planet in the same system provides important constraints on theories of planet formation and in particular their migration processes," concludes Ravit Helled, professor at the UZH and co-author of the study. "WASP-132 demonstrates the diversity and complexity of multi-planetary systems, underlining the need for very long-term, high-precision observations."

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