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Hidden exoplanets between the Neptunian desert and savanna

An international team, including UNIGE, unveiled the “Neptunian Ridge”, an overdensity of Neptunes nestled between the Neptunian Desert and the Neptunian Savanna.

Astronomers have uncovered the “Neptunian Ridge”, a newly identified feature in the distribution of exoplanets. This discovery, led by an international team including members of the University of Geneva, The NCCR PlanetS and the Centro de Astrobiología (CAB), highlights the complex dynamics within the Neptunian Desert, a region with a scarcity of hot Neptunes, and the Neptunian Savanna, where these planets are more commonly found. By understanding these critical zones, researchers gain valuable insights into the dynamic processes that influence the formation and evolution of close-in exoplanets. The discovery of the Neptunian Ridge is published in the journal *Astronomy & Astrophysics*.

To visualize the vast extent of exoplanetary systems, researchers often plot the distribution of planets as a function of their radius and orbital period. It reveals patterns and regions of exoplanets with similar properties that astronomers try to understand. One of the most puzzling regions is the “Neptunian Desert”, where Neptune-sized planets are surprisingly scarce. This dearth of Neptunes in the distribution of planets orbiting close to their host stars is thought to result from intense stellar radiation stripping away the atmospheres of planets, eroding them and turning them into smaller planets.

Beyond this harsh desert lies the “Neptunian Savanna”, a less severe zone where Neptune-sized planets are more commonly found. In this region, the conditions allow these planets to maintain their gaseous envelopes, resulting in an area that is more populated with Neptunes that have migrated to orbits where they can survive the star’s radiation. Understanding how the Neptunian Desert and Savanna are shaped has become a key question in exoplanet research.

Introducing the Neptunian Ridge

The new study focuses on the transition between the Neptunian Desert and the Savanna. The astronomers found an unexpected concentration of Neptune-sized planets at the edge of the Neptunian Desert—a feature now termed the “Neptunian Ridge”.

High resolution pictures

“We found an overdensity of planets in this region, indicating a sharp transition between the barren Neptunian Desert and the more populated Neptunian Savanna,” explains Dr. Vincent Bourrier, Assistant Professor at the Astronomy Department of the UNIGE Faculty of Science and co-author of the study. This newly identified ridge marks a critical zone where planets have managed to migrate inward while resisting the intense radiation near their stars.

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Uncovering the Ridge: Methods and Tools

The discovery was made possible by analyzing data from NASA's Kepler mission, corrected for observational biases using advanced statistical techniques. The researchers meticulously mapped the period-radius space of these exoplanets, revealing distinct regions that define the Neptunian landscape. The team's analysis identified the Neptunian Ridge at orbital periods between 3.2 and 5.7 days, nestled between the Neptunian Desert and the Neptunian Savanna. This comprehensive mapping highlights the intricate processes involved in the migration and survival of these planets in close proximity to their stars.

Implications for Planet Formation and Evolution

"The Neptunian Ridge stands tall above the Desert and Savanna. It provides us with a key to understanding the physical mechanisms shaping the Desert," points out Vincent Bourrier. Most Neptunes may be distributed over the Savanna and Desert early in their life by migrating within the disk in which they formed. The existence of the Ridge suggests that some Neptune-size planets are brought to this region by a type of migration called high-eccentricity migration, which occurs later in their life and allow them to survive erosion from the stars. These migration processes, coupled with photoevaporation, likely shapes the distinct features observed in the Neptunian landscape. The similarities between the Neptunian Ridge and another feature in the exoplanet distribution, the hot Jupiter pileup, suggests that similar evolutionary processes may influence both groups of planets.

An ambitious Observation Program

To further unravel the mysteries of the Neptunian Desert and Savanna, a team of researchers led by UNIGE has secured a large-scale observational program using the high resolution spectrograph ESPRESSO mounted on the Very Large Telescope of ESO. This program aims to conduct a comprehensive census of the orientation of planets' orbits within a sample of close-in Neptunes. This orientation depends on the migration process and will thus provide critical data on the formation and evolution of these planets, providing essential clues for understanding the particularities of the Neptune distribution.

"The Neptunian Ridge is just the beginning," concludes Amadeo Castro-González, Ph.D. student at the Center for Astrobiology in Madrid, and first author of the study. "With upcoming results from this observational program, we'll be able to test our hypotheses about the origins and evolution of these intriguing worlds, providing a more comprehensive view of the close-in Neptunian landscape."