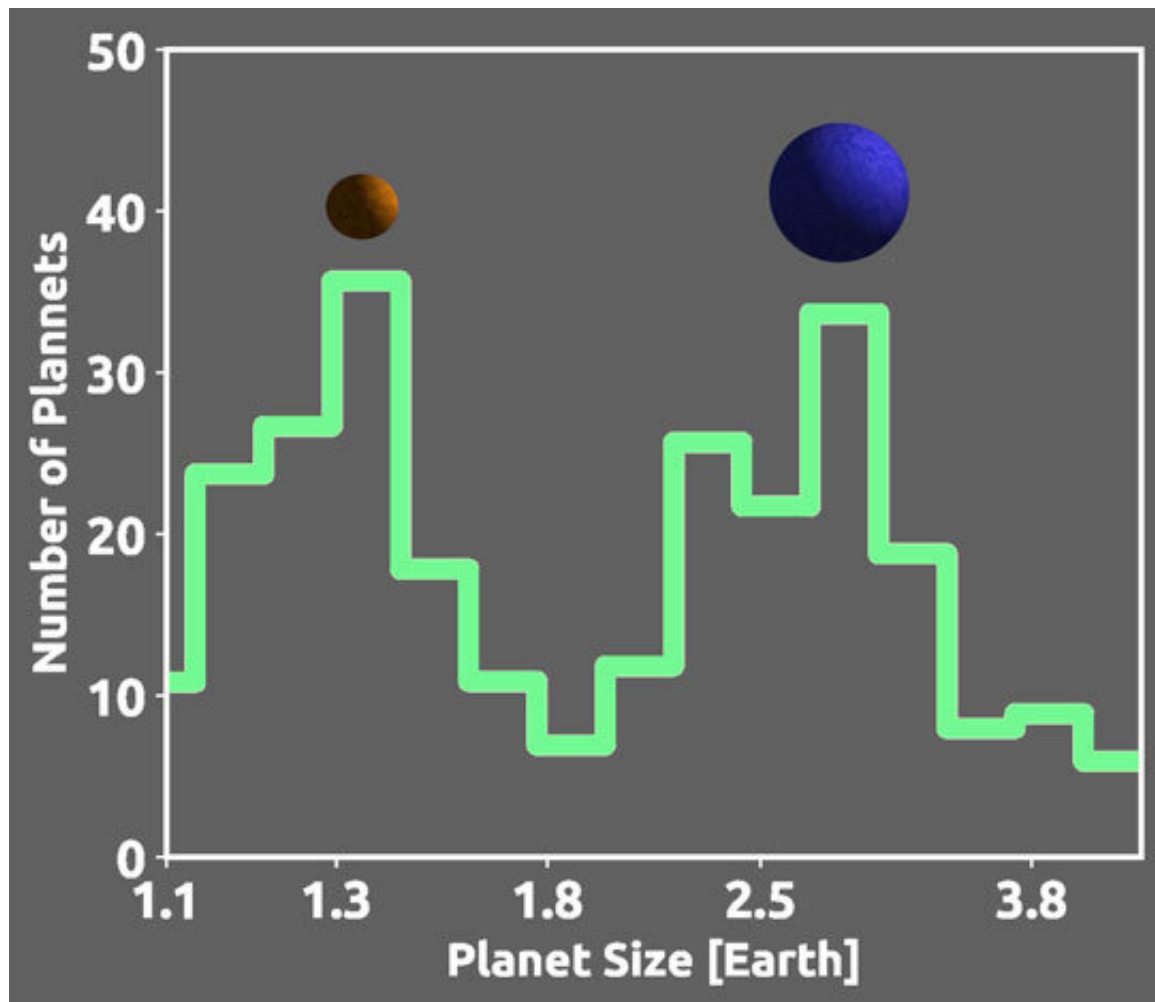


Early planetary migration can explain missing planets

November 7 2022, by Jade Boyd



An illustration depicting the scarcity of exoplanets about 1.8 times the size of Earth that were observed by NASA’s Kepler spacecraft. Credit: A. Izidoro/Rice University

A new model that accounts for the interplay of forces acting on newborn planets can explain two puzzling observations that have cropped up repeatedly among the more than 3,800 planetary systems cataloged to date.

One puzzle known as the "radius valley" refers to the rarity of exoplanets with a radius about 1.8 times that of Earth. NASA's Kepler spacecraft observed [planets](#) of this size about 2–3 times less frequently than it observed super-Earths with radii about 1.4 times that of Earth and mini-Neptunes with radii about 2.5 times Earth's. The second mystery, known as "peas in a pod," refers to neighboring planets of similar size that have been found in hundreds of planetary systems. Those include TRAPPIST-1 and Kepler-223, which also feature planetary orbits of near-musical harmony.

"I believe we are the first to explain the radius valley using a model of planet formation and dynamical evolution that self-consistently accounts for multiple constraints of observations," said Rice University's André Izidoro, corresponding author of a study published this week in *The Astrophysical Journal Letters*. "We're also able to show that a planet-formation model incorporating giant impacts is consistent with the peas-in-a-pod feature of exoplanets."



An illustration of the variations among the more than 5,000 known exoplanets discovered since the 1990s. Credit: NASA/JPL-Caltech

Izidoro, a Welch Postdoctoral Fellow at Rice's NASA-funded CLEVER Planets project, and co-authors used a supercomputer to simulate the first 50 million years of the development of planetary systems using a [planetary migration](#) model. In the model, protoplanetary disks of gas and dust that give rise to young planets also interact with them, pulling them closer to their parent stars and locking them in resonant orbital chains. The chains are broken within a few million years, when the disappearance of the protoplanetary disk causes orbital instabilities that lead two or more planets to slam into one another.

Planetary migration models have been used to study [planetary systems](#) that have retained their resonant orbital chains. For example, Izidoro and CLEVER Planets colleagues used a migration model in 2021 to calculate the maximum amount of disruption TRAPPIST-1's seven-planet system could have withstood during bombardment and still retained its

harmonious orbital structure.

In the new study, Izidoro partnered with CLEVER Planets' investigators Rajdeep Dasgupta and Andrea Isella, both of Rice, Hilke Schlichting of the University of California, Los Angeles, and Christian Zimmermann and Bertram Bitsch of the Max Planck Institute for Astronomy in Heidelberg, Germany.

"The migration of young planets towards their host stars creates overcrowding and frequently results in cataclysmic collisions that strip planets of their hydrogen-rich atmospheres," Izidoro said. "That means giant impacts, like the one that formed our moon, are probably a generic outcome of planet formation."

The research suggests planets come in two "flavors," super-Earths that are dry, rocky and 50% larger than Earth, and mini-Neptunes that are rich in water ice and about 2.5 times larger than Earth. Izidoro said new observations seem to support the results, which conflict with the traditional view that both super-Earths and mini-Neptunes are exclusively dry and rocky worlds.

Based on their findings, the researchers made predictions that can be tested by NASA's James Webb Space Telescope. They suggest, for instance, that a fraction of planets about twice Earth's size will both retain their primordial hydrogen-rich atmosphere and be rich in water.

More information: André Izidoro et al, The Exoplanet Radius Valley from Gas-driven Planet Migration and Breaking of Resonant Chains, *The Astrophysical Journal Letters* (2022). [DOI: 10.3847/2041-8213/ac990d](https://doi.org/10.3847/2041-8213/ac990d)

Provided by Rice University

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