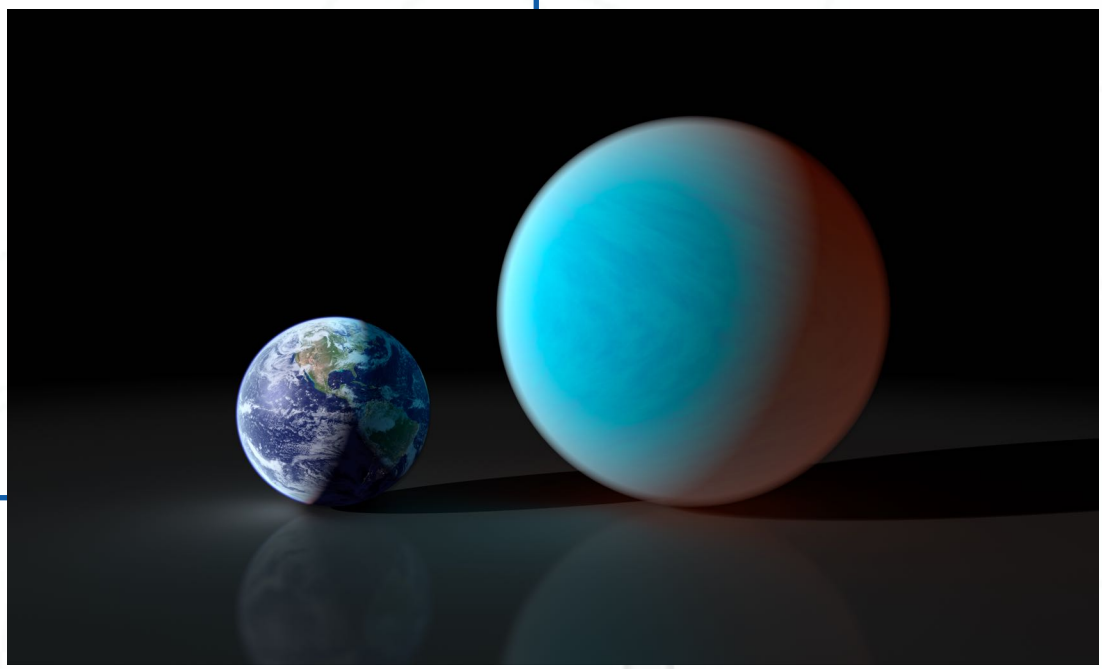
Uncovering the origin of super-Earths and mini-Neptunes

Our Galaxy abounds with super-Earths and min-Neptunes up to four times the size of our own planet. Super-Earths were thought to be the remnant rocky cores of mini-Neptunes whose gassy atmospheres were blown away by radiation from host stars. This theory predicts that our Galaxy has very few Earth-sized and smaller exoplanets. However, recent observations show this may not be the case.

A new study led by Prof. Eve Lee and undergraduate Nicholas Connors shows that some of these exoplanets never had gaseous atmospheres to begin with, shedding new light on their mysterious origins. Using analytic and numerical calculations that track thermal evolution of planets based on how massive their rocky cores are, how far they are from their host stars, and how hot the surrounding gas is, Lee & Connors demonstrate that not all super-Earths are remnants of mini-Neptunes. Rather, the exoplanets were formed by a single distribution of rocks, born in a spinning disk of gas and dust around host stars.

Rocks larger than the moon can gravitationally attract surrounding gas to form a shell around themselves. Over time this shell of gas cools down and shrinks, creating space for more surrounding gas to be pulled in, and causing the exoplanet to grow. Once the entire shell cools down to the same temperature as the surrounding nebular gas, the shell can no longer shrink and growth stops.

For cores smaller than the Earth, this shell is so tiny that they practically remain rocky exoplanets. The distinction between super-Earths and mini-Neptunes comes about from the ability of these rocks to grow and retain gas shells. "Our findings help explain the origin of the two populations of exoplanets, and furthermore, it opens up the possibility that rocky Earths and mini-Earths may be just as common as their larger counterparts," says Lee.



Artist's concept image of super-Earth shown next to Earth. Source: NASA/JPL-Caltech/R. Hurt (SSC)

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Why this is important

Super-Earths and mini-Neptunes do not exist in the solar system yet they are the most common outside of our own. Our study probes the origin of these planets and provides a theory that can predict how common Earths and mini-Earths are in our Galaxy that is testable with upcoming telescopes.

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