Finding Exoplanets by Assessing the Dynamical Packing of Kepler Three- and Four-Candidate Systems

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Barnes' and Raymond's Packed Planetary System (PPS) hypothesis postulates that planetary formation is efficient and creates dynamically packed planetary systems that cannot contain additional planets. Here I look for unpacked spaces in Kepler multi-candidate systems that should, according to a PPS corollary, contain planets. In doing so, a "roadmap" was created to find potential unidentified planets. Previous research suggests that a system's dynamical packedness can be quantified using the dynamical spacing Δ: the number of mutual Hill radii between adjacent planets (a "planet pair"). Using previously proposed values for minimum Δ (10, 12.3, and 21.7) required for planet pair orbital stability, I determine whether planet pairs in Kepler multi-candidate systems could host an intermediate body (an "unpacked pair"). For each Kepler unpacked pair, the maximum mass of an intermediate body that the pair could host while remaining in stable orbits ("mass capacity") and the semimajor axis at which this mass could be hosted were calculated. Next, the probable masses were determined. Known packed planet triplets were surveyed to determine the mass capacity each middle planet uses. The results suggest that there could be as many as 254 unidentified intermediate planets assuming a minimum $\Delta = 12.3$. Median mass efficiencies suggest 20% could be Earth-sized and 33% could be Super Earth-sized. The predicted mass and semimajor axis for these potential planets may facilitate detection by characterizing expected transit and radial velocity signals. Ultimately, such observation-based evidence could support or dispute PPS.

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