KOI-3158: An extremely compact system of five sub-Earth-size planets transiting a seismic K dwarf

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Abstract

Kepler's ultra-precise, long-duration photometry is ideal for detecting systems with multiple transiting planets. These systems provide important data for understanding the dynamics, formation, and evolution of planetary systems. Here, we present a detailed analysis of an extremely compact and old five-planet system around a seismic K dwarf (KOI-3158, HIP 94931). KOI-3158 is a bright, high-proper motion, main-sequence star of spectral type K0. Its overabundance of alpha elements and peculiar kinematics make it a member of the Galactic thick disk. Interestingly enough, it belongs to the Arcturus stellar stream, a moving group originally thought to be of extragalactic origin, but nowadays interpreted as arising from dynamical perturbations within the Galaxy. The detection of a bound M-dwarf pair means that KOI-3158 is part of a hierarchical triple system. The target star oscillates, being the densest star with detected solar-like oscillations found to date (i.e., having the highest large frequency separation). We provide precise stellar properties from grid-based modeling, including an asteroseismic age of _˜12 Gyr. The planetary system is fully validated and a transit analysis is presented. All five planets in the system are sub-Earth-sized, with the innermost planet being similar in size to Jupiter and the Solar System's largest moon, Ganymede. Remarkably, this is the most compact system ever found, being characterized by a concentration of dynamically packed planets below 0.1 AU with adjacent planet pairs lying close to strong 5:4, 4:3, 5:4, and 5:4 orbital resonances.

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