Wolfgang, Angie

Probabilistic Mass-Radius Relationship for Sub-Neptune-Sized Planets

The Kepler Mission has discovered thousands of planets with radii < 4 R_Earth, paving the way for the first statistical studies of the dynamics, formation, and evolution of these sub-Neptunes and super-Earths. Planetary masses are an important physical property for these studies, and yet the vast majority of Kepler planet candidates do not have theirs measured. A key concern is therefore how to map the measured radii to mass estimates in this Earth-to-Neptune size range where there are no Solar System analogs. Previous works have derived deterministic, one-to-one relationships between radius and mass. However, if these planets span a range of compositions as expected, then an intrinsic scatter about this relationship must exist in the population. Here we present a probabilistic mass-radius relationship (M-R relation) evaluated within a hierarchical Bayesian framework, which both quantifies this intrinsic dispersion and the uncertainties on the M-R relation parameters. We analyze how the details depend on the radius range of the sample, and on the method used to provide the mass measurements. Assuming that the M-R relation can be described as a power law with a dispersion that is constant and normally distributed, we find that M/M_Earth = 2.7 (R/R_Eearth)^{1.3} and a scatter in mass of 1.9 M_Earth is the "best-fit" probabilistic M-R relation for the sample of RV-measured transiting sub-Neptunes (R_pl < 4 R_Earth).