THE ARCHITECTURES OF EXTRASOLAR TERRESTRIAL SYSTEMS

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The field of extrasolar planets is now hitting close to home. The Doppler technique, having firmly established the statistical properties of gas giants, has made inroads to the sub-Neptune and super-Earth systems. The Kepler spacecraft has brought these latter populations into sharp focus. However, because many of these planets are thought to have a gas layer (with $R_p > 2.5\ R_E$) and most are at very short orbital periods, it remains unclear whether this population is analogous to the Solar System's terrestrial planets. We propose to determine whether their formation environment was similar, using the *architecture* of these systems. This term means the orbital distributions: absolute and relative spacings, eccentricities, and mutual inclinations. We propose to continue and advance our work with Kepler, using the architectural tools of transit timing, duration ratios and drifts, and stability analyses. Using transit timing, particularly the relative phases of transit timing variation (TTV) signals in the ~100 pairs of planets near resonance with each other, we will determine the degree of excitation of eccentricity, which indicates how much gas was present during the planet accretion epoch. Using duration ratios and drifts, we will determine both spatial components of the mutual inclinations of pairs of planets, which indicates if the planets formed in a disk which was flattened by gaseous dissipation processes. Using stability analyses, we will determine whether planets of small size are packed next to their neighbors due to gaseous dissipation, or whether planets grew by giant impacts in which case they would be more spread out. The new focus is to answer the vital question of whether the small planets from Kepler are "true" terrestrial planets, having the same dynamical properties as the four terrestrial planets of the Solar System. If they do not, then the Kepler sample is the statistical ensemble on which planet formation theory needs to be rebuilt from scratch. If they do, the theories of terrestrial planet formation built for the Solar System - in particular growth by giant impacts in the absence of gas -- can still serve as the paradigm of planet formation. This determination also impacts the interpretation of Kepler's central measurement, the fraction of Earth-sized planets, η_{Re}. To determine if this number represents $\eta_{terrestrial}$, i.e. the fraction of planets similar to Earth in history, chemistry, and even biology, we must first compare the dynamical record of Kepler-discovered planets to our terrestrial planets.