CHARACTERIZING THE ORBITAL ECCENTRICITIES OF EARTH-SIZE PLANETS AND ARCHITECTURES OF PLANETARY SYSTEMS WITH KEPLER

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The discovery of over 400 extrasolar planets with the radial velocity technique revealed that many giant planets have large eccentricities, in striking contrast with most of the planets in the solar system and prior theories of planet formation. The realization that many giant planets have large eccentricities raises a fundamental question: ``Do terrestrial-size planets of other stars typically have significantly eccentric orbits or nearly circular orbits like the Earth?'' Theorists have proposed numerous mechanisms that could excite orbital eccentricities which make different predictions for the eccentricities for low-mass planets (as well as their mutual inclinations and frequency of multiple planet systems). We propose to use Kepler data (and follow-up observations when available) to characterize the orbital eccentricities of the 1235 transiting planet candidates found by Kepler. We will improve upon our previous results during Cycle 1 of the Kepler Participating Scientist Program by: 1) incorporating more accurate stellar parameters based on high-resolution spectroscopy and (when possible) astroseismology; 2) analyzing planet candidates in and near the habitable zone (already 54, and likely to grow with increased time baseline); 3) obtaining more precise parameters thank to Kepler photometry spanning an order of magnitude more time; 4) analyzing short-cadence data for favorable cases than enable an accurate measurement of the impact parameter; and 5) incorporating dynamical stability constraints for multiple planet systems. One third of the Kepler planet candidates are in systems with multiple transiting planet candidates. In some cases, the planets can be confirmed based on transit timing variations (TTVs), without the need for expensive Doppler observations. Indeed, two systems (7 planets) have been confirmed based on transit timing variations. We identified over 60 candidates likely to have transit timing variations based on the first four months of Kepler data. With increasing timespan of observations of these and other systems, we expect roughly five times as many systems to exhibit measurable TTVs, as well as much stronger constraints on masses and orbital eccentricities. We propose to continue our critical roles in the identification, analysis and interpretation of these systems. The relative frequency of multiply transiting systems (along with orbital separations and stellar radii) constrains the distribution of mutual orbital inclinations and rates of multiplicity. Multiplicity, eccentricity and inclination are all linked to the formation history. We will combine analyses of individual systems and the ensemble of systems with theoretical models and simulations to improve our understanding the origin and history of solar systems, and particularly Earth-size planets. Since a significant eccentricity will cause the incident stellar flux to vary, a planet's eccentricity affects its climate and potentially its habitability. Thus, this research would contribute to NASA's goal of searching for Earth-like planets and the results could influence the design of future space missions that will attempt to characterize Earth-like planets and search for signs of life.