DETECTING ADDITIONAL PLANETS IN TRANSITING SYSTEMS USING TRANSIT TIMING VARIATIONS

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Each transiting planet identified by Kepler brings an opportunity to discover additional, nontransiting planets in that system. This is accomplished by identifying and analyzing variations in the time between transits---variations caused by planet-planet interactions. These transit timing variations are particularly large near mean-motion resonances and are capable for probing for planets with masses less than the mass of the Earth; as shown in the only published analyzes of this effect for TrES-1 (Steffen & Agol 2005) and HD 209458 (Agol & Steffen 2007). This proposal addresses: 1) developing the software necessary to analyze the transit times of Kepler planets in effort to detect additional planets in those systems and to infer their orbital elements; 2) testing that software on simulated data to determine how efficiently one can identify secondary planets in the system; and 3) work with the Kepler science team to implement that software and to analyze Kepler data when they are available. Some advantages that the proposed work brings to the Kepler mission include: 1) detecting nontransiting, terrestrial planets in the habitable zone by analyzing the transits of planets that are interior to the habitable zone; 2) identifying planetary and stellar masses and radii from the transit times of doubly transiting systems (see proposal by Eric Agol); 3) providing information that constrains planet formation theories which make predictions regarding the number and distribution of planets that are too small to detect by other means; and 4) constraining the evolution of planetary systems by identifying the orbital elements (including inclinations) of multi-planet systems.