On the Detection of (Habitable) Super-Earths Around Low-Mass Stars Using Kepler and Transit Timing Variation Method

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We present the results of an extensive study of the detectability of Earth-sized planets and super-Earths in the habitable zones of cool and low-mass stars using transit timing variation method. We have considered a system consisting of a star, a transiting giant planet, and a terrestrial-class perturber, and calculated TTVs for different values of the parameters of the system. To identify ranges of the parameters for which these variations would be detectable by Kepler, we considered the analysis presented by Ford et al. (2011, ArXiv:1102.0544) and assumed that a peak-to-peak variation of 20 seconds would be within the range of the photometric sensitivity of this telescope. We carried out simulations for resonant and non-resonant orbits, and identified ranges of the semimajor axes and eccentricities of the transiting and perturbing bodies for which an Earth-sized planet or a super-Earth in the habitable zone of a low-mass star would produce such TTVs. Results of our simulations indicate that in general, outer perturbers near first- and second-order resonances show a higher prospect for detection. Inner perturbers are potentially detectable only when near 1:2 and 1:3 mean-motion resonances. For a typical M star with a Jupiter-mass transiting planet, for instance, an Earth-mass perturber in the habitable zone can produce detectable TTVs when the orbit of the transiting planet is between 15 and 80 days. We present the details of our simulations and discuss the implication of the results for the detection of terrestrial planets around different low-mass stars.

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