VALIDATION OF SMALL KEPLER CANDIDATE TRANSITING PLANETS WITH BLENDER

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NASA'S Kepler Mission was launched with the goal of detecting extrasolar planets by the transit method, characterizing them, and determining the frequency of Earth-size planets in the habitable zone of their parent stars. A known challenge of transit searches is the fact that other phenomena unrelated to planets can produce photometric signals indistinguishable from those of a true planet. One example of such a false positive is a chance alignment with a background eclipsing binary (a "blend"), whose typically deep eclipses would then be diluted and reduced to planetary proportions. Confirming the true planetary nature of a candidate usually requires the measurement of the transiting object's mass. This can be done either by detecting the star's acceleration due to the planet, or by detecting departures from strict periodicity in the signals, caused by mutual interactions in systems with multiple planets. Confirmation by these means is not always possible or practical, either because the planetary masses are too small and/or the orbital periods too long to yield a detectable dynamical signal, or because the star is too faint to allow measurements with the requisite precision, or for other reasons. The only alternative is a probabilistic "validation" to demonstrate that the candidate is much more likely to be a transiting planet than a false positive. Without such validations we cannot be sure of the nature of the signals. This is the objective of this project, and the BLENDER procedure we propose to use is designed for that purpose. BLENDER is a sophisticated light-curve analysis technique developed by the PI that systematically explores the wide range of possible blend scenarios and places strict constraints on the kinds of configurations that might mimic the transit signal for a given candidate. It does this by making optimal use of the shape information contained in the Kepler light curve, comparing it with the detailed shapes of blend light curves. The procedure incorporates additional, complementary constraints from follow-up observations by the Kepler Project and the community such as high-resolution imaging, high-resolution spectroscopy, color information, and the analysis of the motion of the flux centroids from the Kepler images themselves. In this way BLENDER is able to rule out a majority of blends. The ones that remain viable will be quantified statistically in this project through a suite of Monte Carlo procedures and informed estimates of the number density of stars in the direction of the target, the known frequencies of background eclipsing binaries, and other stellar and planetary properties. We will then proceed to estimate the false positive probability, and validate the planet if this probability is small enough. Having concluded its 3.5-year nominal Mission, Kepler has entered its Extended phase in which the objectives are tightly focused on the smallest and most interesting planet candidates, those that are under 2.5 Earth radii in size. Because of their correspondingly small masses and the fact that most Kepler targets are faint, dynamical confirmation is currently not possible for the vast majority of these candidates. We propose to use BLENDER for their validation, with particular emphasis on the smallest ones most similar in size to the Earth that are in the habitable zone of their parent stars. These are among the most valuable of all of Kepler's candidates, but are also the most challenging to validate, and BLENDER is the only way to achieve this. The procedure has been used previously by the PI with great success to validate some of Kepler's most iconic results, including the first transiting Earth-size planets, and the first super-Earth-size planet in the habitable zone of a Sun-like star. This project relates directly to NASA's strategic goals and the science objectives of the Extended Kepler Mission to discover and study planets smaller than 2.5 times the size of the Earth.