CIRCUMBINARY HABITABLE ZONE PLANETS

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The P.I proposes to continue to discover and measure the properties of circumbinary planets (those orbiting a pair of stars) with emphasis on the detection of smaller (R<2.5 Re) planets. The P.I. has an outstanding record as a Kepler Participating Scientist, having generated a range of products that have been used in key discovery papers (e.g. Kepler-9 and Kepler-11), and most importantly, leading much of the effort to detect and characterize circumbinary planets. The P.I. was the lead author of three significant Kepler discovery papers (ellipsoidal variations in HAT-P-7; the remarkable tidally pulsating binary KOI-54; and the discovery of the circumbinary planets Kepler-34 and Kepler-35). The latter paper appeared in the prestigious journal Nature, generating significant positive international press attention for the Kepler Mission. The proposed work is more tightly focused than the P.I.'s previous Kepler research, dealing exclusively with the detection and subsequent characterization of circumbinary planets. In particular, the search for the larger planets will continue, using tools already in place that rely heavily on visual inspection and pattern-recognition. Because circumbinary planet transits are neither periodic nor of the same duration, simple automatic detection algorithms (such as the ones used in the Kepler pipeline) will not suffice for finding these planets. Visual scrutiny, however, has been very successful thus far, with all 7 known circumbinary planets having been found in this way. The proposed refinement of the tools that assist our visual search method will allow easier and more complete detection of small planets (~3 Re). For even smaller planets (< 2.5 Re), visual inspection will generally not work. Thus we are developing automated tools that take the binary system's geometry and kinematics into account and allow for detection at thresholds far below what the eye can detect as a single event. The powerful eclipse and transit modeling software ``ELC'' will be modified to carry out this search. ELC will be used to measure properties of both the binary system and the planets in it. As part of this project, ELC will be improved and enhanced and will be made available to members of the Kepler Working Groups. The P.I. of this proposal is experienced and well versed in the skills relevant to this research, as evidenced by the Kepler papers he has led and contributed to, and the Working Groups he actively participates in. As the proposed investigation is directly related to the objectives of the Kepler Mission and to NASA's interests as a whole, the work will help Kepler achieve its primary goals of the Extended Mission. In particular, this proposed research is relevant due to the tendancy of circumbinary planets to be placed near the habitable zones of their parent stars (two out eight or 25% of the cases so far). This is because of the combination of observational bias and planet migration. The detection and characterization of circumbinary planets is therefore not only important for a complete census of exoplanets, but also for the determination of Eta-Earth itself, which is the fraction of planets that are sufficiently Earth-like to potentially harbor life.