The effect of wide binaries on planet occurrence - Kepler K2 Campaign 1

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Recently Kaib et al. (2013) proposed a link between wide multiplicity and planet occurrence. In this theory, wide companions interact with field stars and are sent into elliptical orbits. This can bring them close to their primary star, possibly close enough to disrupt a planetary system. This mechanism could eject planets from the system or provide an instigator for planetary migration, moving giant planets closer to their parent stars. Wide binaries are also excellent calibrators for stellar age relations. Kepler's excellent photometric accuracy can be used to measure rotational periods of components of wide binaries. These rotation periods for pairs of stars with the same age can be used to calibrate and test gyrochronology relations.

Science Goal 1: Probe the effect of wide multiplicity on planet occurrence. Wide companions are common in the field; Raghavan et al (2010) found that >20% of solar-type stars have a companion wider than 100 AU. Any link between planet occurrence and wide multiplicity will have a significant effect on the number of habitable planets in the Galaxy. Kaib et al. (2013) proposed that wide binary companions will, due to interactions with the Galactic field, be sent into elliptical orbits, bringing them close to the planetary systems of their primaries. This leads to planets being either scattered inwards or outwards or even being ejected from the system all together. This scattering could also have an effect on closer planets in the systems. We propose to test this by observing ∼100 targets in wide binaries in each K2 field over the next two years. This will allow us to measure the frequency of planets on short orbits around these stars and to identify any deviation from that observed with field stars.

Science Goal 2: Provide benchmark gyrochronology systems. Wide binary systems contain stars which are physically isolated from each other yet share common metallicity and age. This means that the stars in these systems can be used to test age relations, which should give similar ages for both components. Kepler has already been used to accurately measure the rotation periods of thousands of stars. By including wide binary components as Kepler targets, we will produce a valuable legacy product to test and recalibrate gyrochronology relations allowing the ages of field stars to be more accurately determined.

Target Selection. We used the proper motion catalogue produced by Kraus et al. (2014) based on the methods of Kraus & Hillenbrand (2007). These data include not only proper motions, but also estimated spectral types and distance moduli from SED fitting. We selected objects by requiring that they had proper motions above 30 milliarcseconds per year, more significant than 5σ and with errors less than 7 milliarcseconds. We also required that the objects had proper motions which agreed within 5σ and which passed the proper motion test of Dupuy & Liu (2012) requiring that the fractional proper motion difference is below 20%. To ensure our proper motion fits were valid we required that these objects had at least five astrometric measurements and reduced χ^2 statistics less than 3. To select only objects with common distance as well as proper motion, we required that our pairs had distance moduli which did not differ by more than one magnitudes. This ensured that our sample consists only of widely separated objects with common proper motion and distance. We found that this analysis yielded such a large population of coincident pairing in Field 2 that we are unable to select wide binaries in this low-latitude area. Hence we only select targets in Field 3.

To remove contamination due to coincident pairings of unrelated field stars, we plotted a histogram of pair separations. Coincident pairings should scale with the separation. We have a significant excess of pairings closer than 60″ (see Figure 1). This indicates that these are likely to be physically associated pairs. Hence we set 60″ as our outer pairing radius. We also selected a higher proper motion sample (>50 millarcseconds/year) with a slightly wider upper pairing radius of 120″. We set a minimum pairing radius of 5″ to remove objects which would not be resolved due to Kepler's pixel scale. To ensure that our targets are bright enough for accurate planet detection, we selected objects for follow-up with $K_p < 16$. We visually inspected these targets to ensure they were stellar objects with apparent proper motion since the POSS I plates were taken. After all these cuts we identify 98 targets which the Kepler field of view tool identifies as lying on silicon in Field 3.

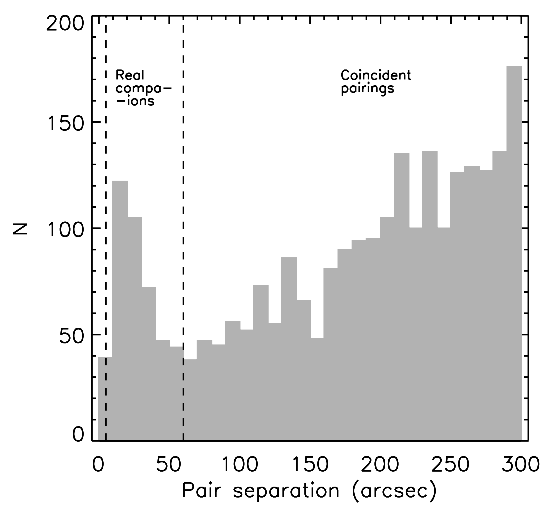

Figure 1: Distribution of candidates with consistent, reliable proper motions and distances. The dashed lines mark our separation boundaries.

Over the course of the next two years we will target approximately 1000 stars across the 10 K2 fields yielding approximately 20 planets. This will allow us to measure the occurrence of short period planets around stars in wide binaries and to test whether this deviates significantly from the field population.

References

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