Targeting M dwarfs with K2

Ben Montet, Phil Muirhead, John Johnson, Jon Swift

One of the primary goals of the *Kepler* mission was to “Determine the abundance of terrestrial and larger planets in or near the habitable zone *of a wide variety of spectral types of stars.*” However, ~70% of *Kepler*'s target stars had masses within 20% of the Sun's, which restricts the variety of stars surveyed (Batalha et al. 2010; Brown et al. 2011). Of the 190,000 *Kepler* stars with at least one quarter of observations, only 5500 are M dwarfs; only 2400 of these were observed during all 16 *Kepler* observing quarters. Expanding the sample of M dwarfs will open up the possibility of studying planet occurrence and properties over an order of magnitude in stellar mass.

The *Kepler* science team has identified the potential of M dwarfs in the creation of the K2 mission. Two of the first three “science motivation” topics on the K2 website are to “provide a yield of small planets around bright and small stars in order to facilitate...follow-up measurements” and to “identify locations and characteristics of potentially-habitable planets around bright M dwarfs in the solar neighborhood.” Here, we provide a list of M dwarfs that could be observed in Field 0 to begin to accomplish these goals.

To identify potentially interesting targets, we begin with the 2MASS catalog of point sources. We use 2MASS because we expect it to have a nearly complete sample of M dwarfs. Moreover, it enables us to robustly separate M dwarfs from M giants by comparing their J-H and H-K colors (Bessell and Brett 1988, Figure 1 below). From our 2MASS sample, we first select only objects with “A” quality photometry in all three near-IR bandpasses. We then select those targets with J-H < 0.7 and H-K > 0.18 to isolate the M dwarfs in our sample. To ensure that a few M giants did not evade our best efforts to eliminate them, we then apply a proper motion cut: any reddened giants that have small J-H colors are likely at large distances and unlikely to have large proper motions. Therefore, we cross-correlate our sample with the UCAC4 catalog (Zacaharias et al. 2013) and eliminate those targets with proper motions smaller than 4 mas/yr and UCAC r – 2MASS J < 1.8.

Finally, we want to target only those stars bright enough for *Kepler* to detect small planets. We know the exoplanet radius distribution around small stars peaks around 1.3 Earth radii (Morton and Swift 2013), so we want to select those targets around which the planets are detectable. By injecting a simulated companion, we know we can detect a KOI 961.01 analogue in 4 quarters of *Kepler* observations around a star with Kp=18.9 (Figure 2). Here, we will have 1 quarter of observations and the instrumental noise is expected to be 4 times as large. However, a 1.3 Earth radius planet will have a transit depth three times as large as KOI 961.01. Therefore, we would expect to detect such planets around stars that are 64/9 brighter than Kp=19; i.e. stars brighter than Kp=16.7. Here we use *r* as a proxy for Kp when available; at other times we extrapolate from J and H-K, which, like r-J, follows a main sequence. Of course, we expect to detect all eclipsing binaries down to this magnitude, which will enable detailed analysis of these eclipsing targets' masses and radii to compare to theoretical models.

In total we submit 7495 targets. This may sound large, but the region described in the call for proposals is nearly 5 times Kepler's FOV, so we expect only 20-25% of these to fall on silicon.

References

Batalha, N. M. et al. 2013, ApJS, 204, 24

Bessell, M. S. and Brett, J. M. 1988, PASP, 100, 1134

Brown, T. et al. 2011, AJ, 142, 112

Morton and Swift, arXiv:1303.3013

Zacaharias, N. et al. 2013, AJ, 145, 44

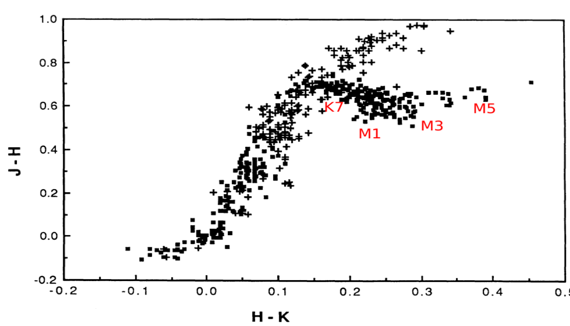

Figure 1: Bessell and Brett (1988) Figure 5, showing the separation between M dwarfs (labeled) and giants in a color-color diagram.

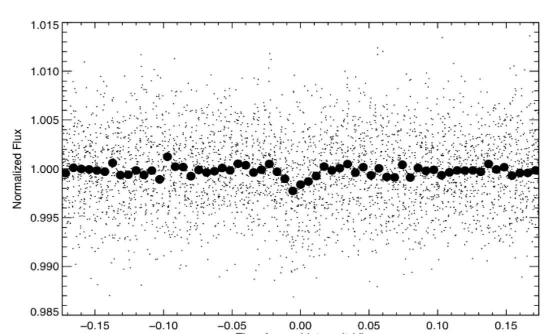

Figure 2: A simulation showing an example of a 7-sigma detection of KOI 961.01 around a star with Kp=18.9.