

## Probing M Dwarf Properties, Activity, and Planets with K2

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### Scientific Justification

M dwarfs are the most common stars in the Galaxy, and represent an exciting frontier for planet searches, studies of stellar structure, and studies of stellar activity, among other topics. We propose to observe the ~400 brightest M dwarfs in the K2 Field 0 (K2-F0), mostly in long cadence mode. The 75-day baseline will reveal close planetary or stellar companions that transit, and will provide an important time-series dataset for probing the rotation, radii, and photometric activity of low-mass stars. Our targets are selected so as to all be accessible for NIR RV follow-up.

**Planets:** Exoplanet searches have already discovered over 100 planets or candidates orbiting M dwarfs (Swift et al. 2013), despite most of these surveys working at optical wavelengths, where M dwarfs are relatively faint. The advantages of searching for planets around M dwarfs are compelling: the RV and transit signals for a given planet size are larger around lower-mass stars, and M dwarfs are the most common stars in the Solar neighborhood. Data from *Kepler* suggest that the frequency of small (0.5-4.0 Earth radii) short-period planets around M dwarfs is almost one planet per star (Dressing & Charbonneau 2013, Kopparapu 2013). The K2-F0 75 day baseline encompasses the period range expected for planets orbiting in the habitable zone of late M stars. *Kepler* was sensitive to terrestrial planets, and with a 75-day baseline K2-F0 will discover small habitable-zone planets transiting our M dwarf sample!

**Activity:** *Kepler*'s photometric precision has revolutionized the study of stellar magnetic activity (e.g. Bastien et al. 2013). However, our understanding of activity in M dwarfs—especially beyond M3—lags behind that of FGK stars. A survey of M stars with K2 will provide a wealth of insight into the activity of nearby M dwarfs, including rotation periods, flare frequency, spot lifetimes, differential rotation, and photometric variability, as well as better defining stellar radii, which have been shown to depart significantly from stellar models. Studying the few active M dwarfs in the *Kepler* short cadence data has produced the largest catalog of flares for any star besides the Sun, and is shedding new insight on the physics of flare cooling. We include the three most active M stars in K2-F0 from the SDSS DR7 M dwarf catalog (West et al. 2011) to observe on short cadence. These observations will significantly increase the population of well-measured active M-dwarfs, and test the dependence of flare physics on stellar parameters such as rotation. Another of our targets is in the HET/HRS M dwarf activity survey (Robertson et al. 2013). With 40 spectra over 10 years, we have already found its rotation period via spectral variability, allowing comparison of photometric and spectral activity tracers. Along with understanding stellar physics, our activity study will inform efforts to detect planets hidden by stellar noise, both with *Kepler* and RV campaigns.

**Follow-up:** There are multiple extant (e.g. HET-HRS, Keck-HIRES, SDSS-III APOGEE) and upcoming (e.g. HPF, CARMENES) resources in the community for RV follow-up of targets with possible planetary or stellar companions. The Co-Is have extensive experience carrying out such observations and are currently conducting binary characterization and KOI follow-up with HET-HRS and APOGEE. Targets with  $V \leq 12$  are amenable to immediate follow-up with HRS and HIRES. Moreover, upcoming M dwarf spectroscopic planet search surveys (HPF, CARMENES) will directly benefit from K2-F0 observations of M dwarfs that provide rotation rates or activity levels of possible RV targets, thereby identifying optimal planet search targets. The upcoming TESS mission will provide photometric follow-up of the brightest nearby M dwarfs, and K2 will add extra temporal coverage for targets common to the missions, providing additional transits for longer-period planets. Planet candidates with large transit depths will be immediately available for atmospheric characterization using transit spectroscopy and spectrophotometry with HST, and later with JWST, GMT, and TMT.

The M dwarf sample we propose here includes 58 targets being observed with the R~22500 H-band APOGEE spectrograph, which provides a typical RV precision of 100 – 200 m/s. These data provide a valuable, ready resource for characterizing stellar companions and will also enable a search for activity-sensitive features in the H-band. Many of the 58 targets already have 6-12 epochs of observation, which are available to our group now; the full APOGEE dataset will be public by Dec 2014.

**Technical Justification:** We draw the nearby M dwarf targets from established and new catalogs based on proper motion (Lepine & Shara 2005, Lepine & Gaidos 2011), which are estimated to be 90% complete in the K2-F0 region. These targets are supplemented with M stars observed serendipitously with APOGEE. The spectral types of our targets range from early to mid/late M dwarfs, as estimated through their optical-to-infrared (V-J) color. To select all low-mass stars with reasonable prospects for follow-up, we implement cuts at  $V-J > 2.5$  and  $J < 13$ . These cuts yield a range of V magnitudes (10-19), in which the faintest targets are also those with the latest types.

