

Late-M and L Dwarfs in Kepler K2 Campaigns Two and Three

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Kepler K2 observations offer a unique opportunity to learn about substellar atmospheres that are not irradiated by a hot primary. An eighty day K2 campaign allows long, continuous coverage of hundreds ultracool dwarf rotation periods, a scale that is simply infeasible with ground-based telescopes. Following on our Kepler observations of the nearby L1 dwarf WISEP J190648.47+401106.8 (hereafter W1906+40; Gizis et al., 2013, ApJ, 779, 172), our approved Campaign 0 target, and our pending Campaign 1 proposal, we suggest new targets in Campaigns 2 and 3.

Campaign 2 is dominated by Upper Sco, which features numerous brown dwarfs from spectral type M6 to L2. Presumably these are already included in other proposals, or possibly will be within a large “postage stamp” as in the open cluster observations Campaign 0. We include this proposal to point out that even the faint objects should provide valuable data to Kepler K2. The figures below show the spectrum of the L1 dwarf W1906+40, as observed through the Kepler filter, and one quarter of phased data for it; Kepler essentially serves as a *i/z*-like filter yielding 0.5% photometry despite being $r = 20$. Thus, the late-M and even early-L dwarfs in Upper Sco are valuable, and we have provided all M6-L dwarfs known in the field of view; note that non-members are still valuable targets. We may expect variability due to starspots, condensate clouds, or accretion; probing these as a function of spectral type/mass is valuable; of course, brown dwarf or giant planet transits would have a large signal.

The Campaign 3 field includes the usual nearby sources that are found at random over the entire sky. Unfortunately, there are no bright L dwarfs published in this field, but there are several late-M dwarfs of interest and numerous faint M6 dwarfs confirmed by SDSS (West et al. 2008). Kepler photometry will allow the rotation periods to be determined and the amplitude and timescales of variability to be measured. M dwarfs may have magnetic starspots, but M7-M9 also form condensate clouds. L and T-type dwarfs show evidence of condensate cloud formation, a process also important in extrasolar planets. The rotational period of these objects are typically 3-10 hours. Periodic variations can be caused by rotationally modulated clouds, while non-periodic variations are attributed to cloud evolution (i.e., “weather”); K2 can sample both the rotation period and longer cloud evolution. The seven quarters of Kepler observations of the nearby W1906+40 revealed periodic variations tracing its 8.9 hour rotation period, stable over 600 days with no long-term or non-periodic evolution. An unusually stable dark cloud or bright cloud hole provides a natural explanation.

Although the probability of a transit is low, as the K2 mission continues many brown dwarfs may be observed. Disks are observed around very-low-mass stars and brown dwarfs, making the formation of planets likely and habitable planets possible (Belu et al. 2013, ApJ, 768, 125); furthermore, microlensing revealed a two jupiter-mass planet around a brown dwarf (Han et al. 2013, ApJ, 778, 38) demonstrating that giant planets can be formed. One young eclipsing double brown dwarf system is known (in Orion, Stassun et al. 2006, Nat. 440, 311), but no old ones, so even a double system would allow stringent tests of evolutionary models. Because the field targets are all roughly one jupiter radius, brown dwarf or gas giant companions produce $\sim 100\%$ eclipses, neptunes $\sim 10\%$, and earths $\sim 1\%$.

