Brown Dwarfs in Kepler K2 Campaign One

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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 of L and T 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) and our approved Campaign 0 target, seven L dwarfs and one T dwarf are observable with Kepler in Campaign 1. The Campaign 1 field is unusually favorable to brown dwarf science, because the major infrared sky surveys (DENIS, 2MASS, SDSS, UKIDSS and WISE) all scanned the celestial equator and intensively followed up brown dwarf candidates. Furthermore, unlike K2 Field 0, crowding is unimportant and none of our targets should be contaminated by background stars. This project will therefore demonstrate the feasibility of future K2 brown dwarf campaigns. The list of observable targets include four early L dwarfs, two mid-L dwarfs, a T dwarf, and an L subdwarf; we discard even fainter brown dwarfs. The subdwarf (sdL7) is believed to be a old, metal-poor (halo or thick disk) brown dwarf at 16 parsecs (Kirkpatrick et al. 2010, ApJS, 190, 100). For W1906+40, Kepler achieved 0.5% photometry in long cadence mode. Although each of these targets are fainter than W1906+40, we scale by the relative observed SDSS z magnitudes to find that each 30 minute observations should have noise in the range 1.5 to 3.5%. (Unlike typical targets, r is not useful to estimate count rates: L and T dwarfs will be dominated by counts at the reddest, $>$ 800 nm, edge of the filter). All targets are in EPIC but have proper motion, so we have updated the positions. We address two key science projects:

1. Weather in Substellar Atmospheres: 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 (or cloud holes), 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. The stability of W1906+40 would allow its 1.4% amplitude to be easily detected even with the lower signal-to-noise data we expect for our targets, and larger variations have been reported in other L dwarfs. The definite lack of the non-periodic variations at the 2-8% level claimed in ground-based observations of other early L dwarfs (Gelino et al. 2002, ApJ, 577, 433) implies that W1906+40 may not be representative of all early L dwarfs, making the need for a larger sample clear. The subdwarf is a particularly important target given the likelihood that cloud properties are a function of metallicity. The K2 data will provide rotation periods, cloud evolution timescales, and (model-dependent) cloud/hole filling factors.

2. Substellar Eclipses and Planetary Transits: 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 our targets are all roughly one jupiter radius, brown dwarf or gas giant companions produce $\sim$ 100% eclipses, neptunes $\sim$ 10%, and earths $\sim$ 1%.

In addition, white light flares were observed in Kepler L1 dwarf data, but they can be reliably detected only with short cadence data. Given the instruction to “diligently” compete for short cadence data, we are submitting a separate flare proposal for a subset of our targets.