L Dwarf Flares in Kepler K2 Campaign One

John E. Gizis (U. Delaware), Peter K. G. Williams (CfA)

Besides coinciding with the hydrogen burning limit, early L dwarfs are a part of remarkable transition in which the familiar solar/stellar magnetic activity relations break down. Chromosphere emission lines become weak and coronae are usually undetectable but there is oofiten strong radio emission (e.g., Berger et al. 2010, ApJ, 709, 332). The objects are rotating rapidly ($P < 10$ hours) with little magnetic braking (Reiner & Basri, 2008, ApJ, 684, 1390). This transition is one of the key puzzles in very-low-mass stars and brown dwarfs. The neutrality of the atmospheres (Mohanty et al., 2002, 571, 469) and a changed dynamo (e.g., Cook et al., arXiv:1310.6758) are often invoked, preventing magnetic reconnection events. Nevertheless, when Kepler observed the nearby L1 dwarf W1906+40 in short cadence mode during Quarter 13, Gizis et al (2013, ApJ, 779, 172) observed 21 white light flares; fortunately, two of these occurred during Gemini spectroscopy (Figure 1) confirming that this early L dwarf is capable of generating flares similar to those on M dwarf flare stars, and as energetic as the most powerful known solar white light flares. Flares may play an important role in the heating of the chromosphere, and would affect "habitable" planets. Because of their proximity, such planets would experience the strongest W1906+40 flare as equivalent to the strongest AD Leo flare modeled in Segura et al. (2010, AstroBio, 10, 751). These are the only white light flares ever detected in any L dwarf. Indirect evidence suggests that W1906+40 is billions of years old (ia star, not a bona fide brown dwarf), suggesting the flare rate may not decay as rapidly with time as in GKM dwarfs. We need an expanded sample to investigate how flares depend on stellar properties, but ground-based monitoring with large telescopes is impractical at the rate of only ~ 1 flares per week even with 24 hour coverage.

K2 short cadence monitoring of the known early L dwarfs in the Campaign 1 field offers the opportunity to expand the sample of flaring L dwarfs. K2 monitoring will also yield precise substellar rotation period measurements, which are rare and have a poorly-understood relationship to magnetic activity in this regime (e.g., Cook et al. 2013). Furthermore, short-cadence observations of the four early L dwarfs will be able to detect white light flares similar to those in M dwarf flare stars, as observed (and confirmed spectroscopically) in W1906+40 during Quarter 13. *Flares are too diluted in long cadence observations to be reliably detected.* Scaling the relative brightness of W1906+40 to the four L0-L1 dwarfs, we estimate that the noise in short cadence K2 observations will be 6% for the brightest to 10% for the faintest; the cooler L dwarfs are too faint to detect flares. There were fifteen W1906+40 flares in Q13 whose peak would be reliably detected with these noise levels; all lasted several minutes up to hours, enhancing detectability. There are enough expected flares for each target to be meaningfully compared to W1906+40, providing the first statistical sample of flaring in L dwarfs. We will be able to answer questions such as: Are flare rates correlated with rotation rate, spot properties (both observable by Kepler K2), or quiescent Hα emission? Is the flare rate independent of age? How does the flare rate compare to hotter fully convective stars?

The detection rate of flares is comparable to that of field M dwarf stars. In our GO 030021 program, we observed a number of M dwarfs in short cadence. Although the dM4e GJ 1243 (Period 0.59 days) had over a thousand detected flares in one quarter, other objects with rotation rates ($10 < P < 30$ days) had fewer flares (GJ 4099, 19 in one month; LP230-6, 17), while the M dwarfs KIC 2424191 and LHS 6343 had no detected flares. Ramsay et al. (2013, MNRAS, 434, 2451) observed 27 flares in KIC 5474065 in one month.

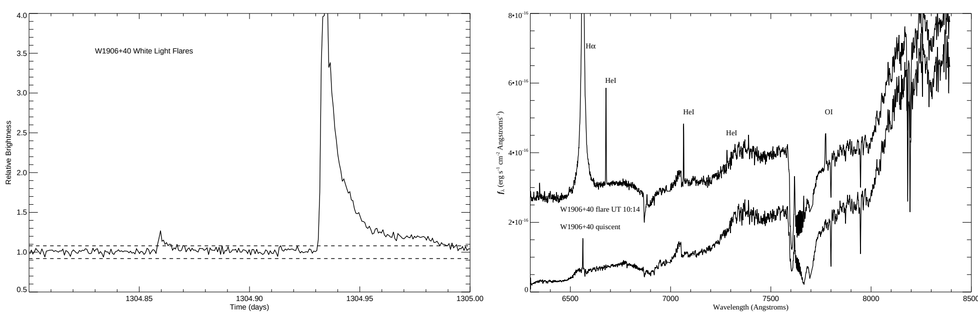

Figure 1: Left: Kepler photometry of L1 dwarf W1906+40 showing two flares. The expected noise level for the faintest of our targets is shown as a dotted line. Right: Gemini optical spectra taken outside the flare and at the peak of the strongest flare.