

Proceedings of the International Astronomical Union

Date of delivery: 5 May 2016

Journal and vol/article ref: IAU 1600014

Number of pages (not including this page): 2

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Flares from Ultracool L Dwarfs with Kepler

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Abstract. We report on our search for L dwarf flares using NASA's Kepler mission. Spectroscopically confirmed flares were detected with the original Kepler mission from an L1 dwarf stars. We discuss the physical characteristics of these white light flares and compare them to M dwarf flares. For "habitable zone" planets, the apparent flare brightnesses would be comparable to the most powerful M dwarf flares. We are monitoring more L dwarfs with the Kepler K2 mission. We discuss the prospect for more detections during the remainder of the K2 mission.

Keywords. stars: activity, stars: flare, stars: low-mass, brown dwarfs

1. Introduction

As the many contributions to this symposium demonstrate, the *Kepler Mission's* precision photometry and comprehensive time coverage (Koch *et al.* 2000) has revolutionized the study of stellar flares (Walkowicz *et al.* 2011), from A dwarfs (Balona 2012) to G dwarfs (Maehara *et al.* 2012) to M dwarfs (Hawley *et al.* 2014). Here we summarize *Kepler* observations of flares in a nearby L1 dwarf, an ultracool ($T_{eff} \approx 2300\text{K}$), fully convective, very-low-mass star smaller than Jupiter.

WISEP J190648.47+401106.8 (W1906+40) was discovered in the original *Kepler* field midway through the original mission (Gizis *et al.* 2011). Gizis *et al.* (2013) summarize the flare observations; Gizis *et al.* (2015) give a update on the photometric variations over two years. The rotation period is 8.9 hours. W1906+40 is not particularly young; the kinematic and spectroscopic evidence supports an age of several billion years.

2. Flare Observations

W1906+40 was observed for one quarter (three months) by *Kepler* in short cadence mode. In the long-cadence, 30 minute observations, flares are difficult to detect, but the one minute observations allow the flare light curve to be temporally resolved. In all, 21 white light flares were detected; the strongest had an estimated energy of 1.6×10^{32} erg. Most show the usual fast-rise-exponential decay shape seen in M dwarf flares (Davenport *et al.* (2014)). Two show very long decays without a sharp peak; possibly these peaked while on the far hemisphere and then rotated into view, or are due to a more complex magnetic field geometry.

Fortunately, two of the flares occurred during optical spectroscopic monitoring with the Gemini GMOS spectrograph (see Gizis *et al.* 2013 for full details.) The dim, red photosphere allows the flare's white light continuum component to be clearly detected. A very broad H α component is also detected at the flare peak. The continuum and broad H α emission shows the exponential decay seen in the simultaneous *Kepler* photometry.

41 Kowalski *et al.*(2015) and Kowalski (2015, this volume) model the origins of the white
42 light in flares. Other emission lines, including a narrower H α component, peak later
43 and decay slowly. Evidently even at the cool temperatures of this L dwarf magnetic
44 reconnection and particle acceleration still occur, resulting in white light flares similar
45 to those in hotter flare stars.

46 3. Future Observations

47 W1906+40 is no longer observable by the *Kepler* spacecraft, but we are observing it
48 with *Chandra*. This will allow us to compare the X-Ray quiescent corona energy budget to
49 the white light energy budget. More generally, are the flares in W1906+40 representative
50 of all early L dwarfs? We have an approved program with the extended *Kepler/K2* mission
51 to monitor more ultracool dwarfs in short cadence. Our goal is to determine how the flare
52 rate depends on age, mass, rotation rate, effective temperature or other parameters.

53 References

- 54 Balona, L. A. 2012, MNRAS, 423, 3420
55 Davenport, J. R. A., Hawley, S. L., Hebb, L., *et al.* 2014, ApJ, 797, 122
56 Gizis, J. E., Troup, N. W., & Burgasser, A. J. 2011, ApJL, 736, L34
57 Gizis, J. E., Burgasser, A. J., Berger, E., *et al.* 2013, ApJ, 779, 172
58 Gizis, J. E., Dettman, K. G., Burgasser, A. J., *et al.* 2015, ApJ, 813, 104
59 Hawley, S. L., Davenport, J. R. A., Kowalski, A. F., *et al.* 2014, ApJ, 797, 121
60 Koch, D. G., Borucki, W. J., Basri, G., *et al.* 2010, ApJL, 713, L79
61 Kowalski, A. F., Hawley, S. L., Carlsson, M., *et al.* 2015, Solar Physics, 61
62 Maehara, H., Shibayama, T., Notsu, S., *et al.* 2012, Nature, 485, 478
63 Walkowicz, L. M., Basri, G., Batalha, N., *et al.* 2011, AJ, 141, 50