Solar and Stellar Flares and their Effects on Planets
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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 confirmedflares were detected with the original Kepler mission from an L1 dwarf stars. We discuss the physicalcharacteristics 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. Weare monitoring more L dwarfs with the Kepler K2 mission. We discussthe 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 ($T_{eff} \approx 2300$K), fully convective, very-low-mass star smaller then 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 Hα component is also detected at the flare peak. The continuum and broad Hα emission shows the exponential decay seen in the simultaneous *Kepler* photometry.

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

3. Future Observations

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

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