Testing the role of a strong magnetic field in the production of flares from low mass stars

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Flares are seen on a range of stars including our Sun. However, flares from stars with a much lower mass than our Sun are more common. At the start of K2 we initiated a project to observe a range of late type stars to determine how the flare activity depended on mass and hence a better understanding of the underlying physics of flares. Our work will also have implications for determining how flares can effect the habitability of any exoplanets in the stellar system.

In Figure 1 we show the Kepler light curve of the M4V star KIC 5474065 made in Q16. Since these observations were made using 1 min sampling we were able to detect flares with durations of less than 10 mins and amplitudes δF/F>0.4. Kepler observations of another M4V star, KIC 9726699 (GJ 1243), which is 5 mag brighter than KIC 5474065, showed an extraordinary number of short duration flares (Figure 2) which indicates that given sufficient signal-to-noise, short duration flares can be very common on stars of such spectral type (Ramsay et al 2013 MNRAS 434 451).

An analysis of K2 engineering data on the flare star was published in Ramsay & Doyle (2014 MNRAS 442 2926) and a paper on K2 campaign 0 data on two M1 V stars has been published in Ramsay & Doyle (2015 MNRAS 449 3105). Both sources shows flares as energetic as observed from several M4V stars using both *Kepler* and ground based telescopes. We show in Figure 3 the cumulative energy distribution of flare from these two stars with other data taken from the literature. We find that the flare energy distribution of the sources shown here are very similar to the less active M3–M5 stars but are ~8 times less likely to produce a flare of a comparable energy to the more active M0–M5 stars, but their flaring rate is a factor of 8 lower. The K2 mission is allowing a wide range of late type dwarf stars to be targeted and assess their activity rates as a function of age and rotation period.

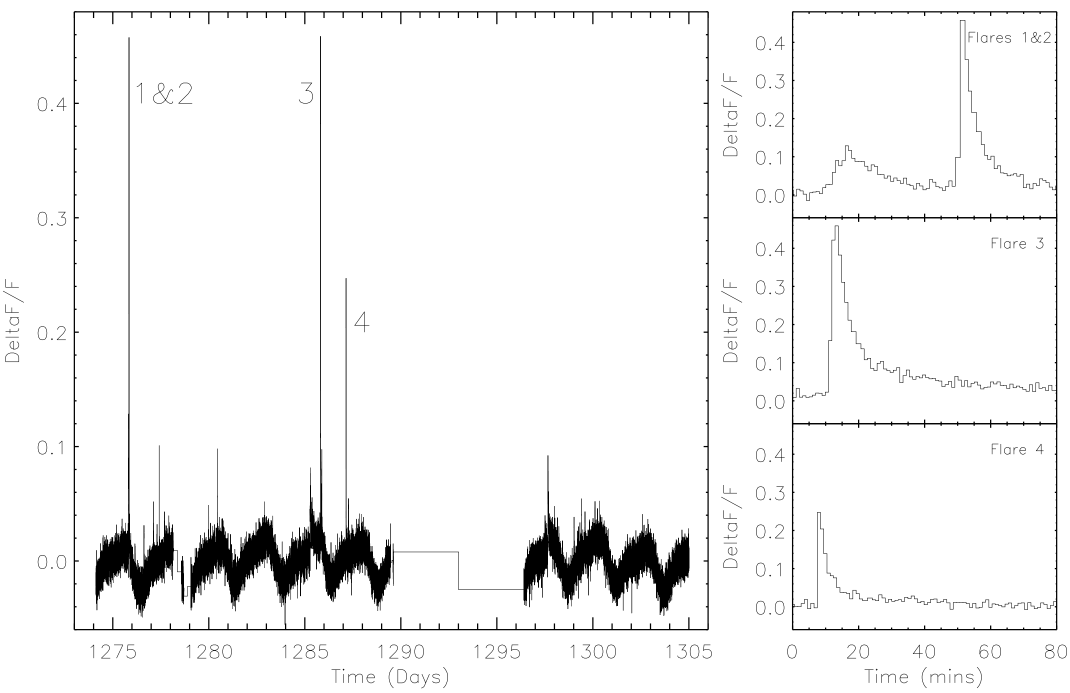

Figure 1: The *Kepler* light curve of the M4 V flare star KIC 5474065, g ~19.0, (Ramsay et al. 2013). Flares with energies up to $L = 7 \times 10^{32}$ ergs were detected.

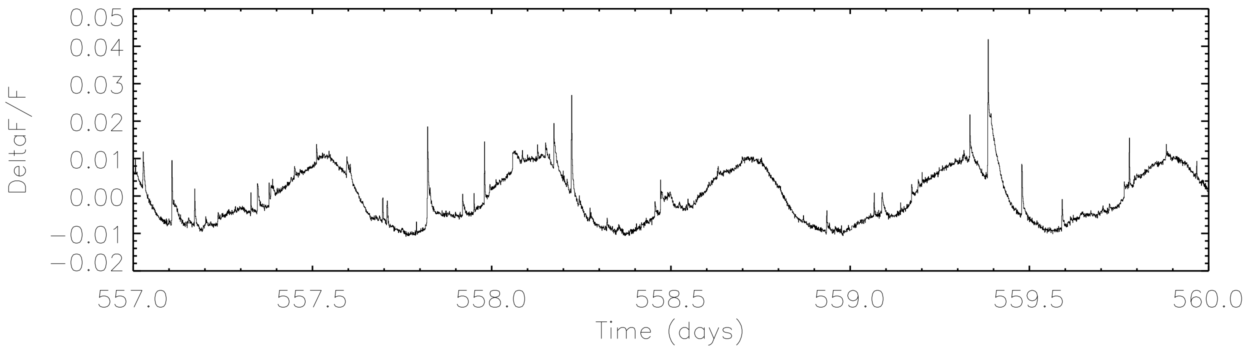

Figure 2: The *Kepler* light curve of the M4 V flare star KIC 9726699 (Ramsay et al. 2013) which is 5 mag brighter than KIC 5474065 at g ~13.9. With a higher signal-to-noise ratio many more flare were detected with the most luminous $L = 2 \times 10^{32}$ ergs.

Our target for Field 9 is GJ 1224 and is classified in `SIMBAD` as a known flare star (M4.5V). This together with its brightness (Kepmag=12.0) make it very suitable for short cadence mode data (short duration flares are likely to be missed in long cadence mode). Unlike other flare stars observed with *Kepler* or K2, there is a body of ground based optical data on this source which suggest it has a low vsini (<3 km/s) (indicating a slow rotation speed or low inclination) but also has evidence for a significant magnetic field (2.7 kG) (Reiners & Basri 2007 ApJ 656 1121). Morin et al (2010 MNRAS 407 2269) obtained spectra which also indicated a significant magnetic field and they inferred a strong dipole field. Our target is also a known X-ray source and has a high L_X/L_{bol} ratio (Delfosse et al 1998 A&A 331 581). Given that none of the M4V stars observed previously using *Kepler* and K2 have known magnetic fields, GJ 1224 is therefore an excellent target to examine the role that a strong magnetic field has on the rate and energy of stellar flares on low mass stars.

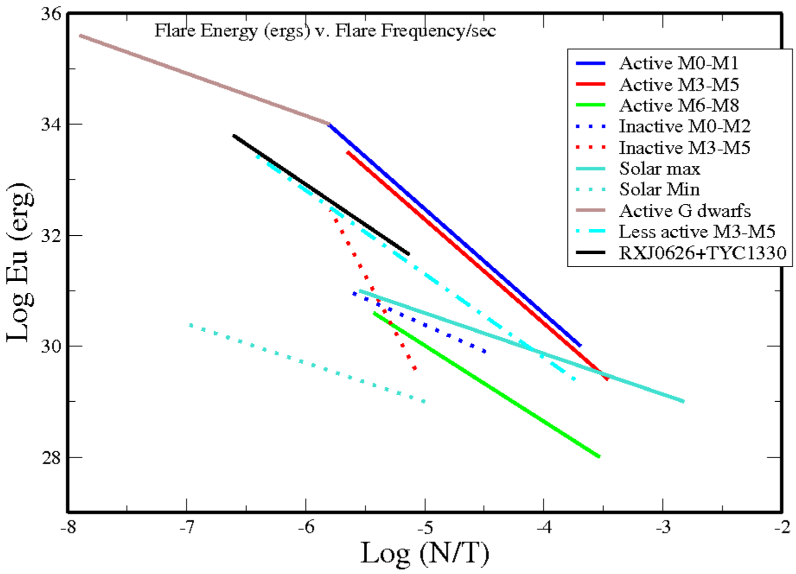

Figure 3: Observations of stars using *Kepler* and K2 allow us to determine the cumulative flare energy distribution and determine how this varies as a function of spectral type and how it various amongst the same spectral type.