M Dwarfs Search for Pulsations and Flare Studies Within Kepler GO Program

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Abstract.

We have done time-series analysis to search for pulsations in a sample of four M dwarfs -plus one M giant that seeped in our selection criteria - observed in short-cadence within Kepler (Koch et al. 2010) Guest Observer (GO) program. High-cadence sampling (Gilliland et al. 2010) is essential to detect the shortest pulsations predicted theoretically in the 20 min range and to enable high time-resolution analysis of flares. Three of the targets present stellar activity and two rotational modulation. We find that white light flares are present in the M dwarfs with rotational periods less than 20 days, and that their energy-frequency relations are comparable to traditional flare stars. The rapidly rotating M4 GJ 1243 shows the strongest and more frequent flares. Pulsations have not been found to a detection limit of several parts per million.

1. Pulsations Analysis

Kepler SAP short-cadence light curves of our targets (see Table .1)were detrended with a 3σ clipping to a point-to-point deviation of the two point difference function to remove outliers, following García et al. (2011). The SAP flux in e-/s was converted to relative flux in ppm and a 1-degree polynomial was fitted. Then, the light curves were appropriately binned to perform a cubic spline interpolation to remove the variations caused by activity and obtain a zero-centered flux.

The Fourier Transform analysis was performed with Period04 (Lenz & Breger 2005). A frequency was considered significant if its amplitude SNR ≥4 in a 2 c/d box around the considered peak.

Table .1: Targets

KIC ID	Other ID	KEP mag	Sp. Type Rot. Period (d)
002424191		11.880	M giant
004142913	GJ 4099	10.910	M1 ; 30 d
004743351		13.806	M0 ; 10 d
008607728	LP 230-6	13.410	M1 ; 30 d
009726699	GJ 1243	12.738	M4 ; 0.593 d

1.1 Results

Most of the frequencies found significant are matched to some of the artifacts described in Baran (2013) (see Table .2) or to the artifacts caused by the long cadence (LC) sampling. Frequencies found in the 320-500 c/d range, equivalently periods in the 3-5 min range, significantly change amplitude with time and thus cannot be attributable neither to pulsations, or to Solar-like oscillations as they lack their characteristic Gaussian profile. KIC 9726699, or GJ 1243, is a well known active M4 dwarf whose rotational period has been measured to be 0.593 d (Savanov & Dmitrienko 2011) and that we recover here, along with its 2 to 6 harmonics.

We encourage further searches for very low amplitude oscillations in M dwarfs, as supported by theory (Rodríguez-López et al. 2014). More short cadence high-precision photometry within Kepler K2 mission and spectroscopic variability searches as those carried out by the *Cool Tiny Beats Survey* (see Anglada-Escudé et al. (2014) and Berdiñas et al. (2014) in these proceedings) are essential to unveil M dwarfs pulsations.

1.2 Flares Analysis

Kepler's precision and broad filter allows hot white light flares to be detected in M dwarfs against the red photosphere. Figure 1 shows four days of data for the fully convective star GJ 1243. White light flares are frequent. We identify and measure the strength of the flares by subtracting a running median light curve consisting of five rotation periods. For the slower rotating stars, a simple polynomial suffices to model the underlying rotational light curve. Figure 2 shows the cumulative flare frequency for the three M dwarfs with meaningful numbers of detected flares. The much higher flare rate of the fully convective M4 GJ 1243 is due to its rapid rotation.

The main uncertainty in comparing the flare rates of the stars is systematic errors in the flare energy calibration. GJ 1243 is well studied with a trigonometric parallax (11.8 +/- 0.4 pc; Harrington & Dahn (1980)), but the other M dwarfs have uncertain distances and correspondingly uncertain energy calibrations. Gaia parallaxes and improved spectroscopy will allow the energy scale of the flares to be better constrained.

Table .2: Spurious frequencies

Freq. (c/d)	Artifact	KIC ID
8.48	0.5*16.98 (spurious)	2424191
19.92	'wide 20+ artifact'	2424191
31.42	'wide 20+ artifact'	2424191
31.68	'wide 20+ artifact'	8607728
153.46	'W artifact?'	4743351
293.63	6/LC	8607728
342.56	7/LC	4743351, 8607728
391.54	8/LC	2424191, 4142913, 8607728
440.48	9/LC	2424191, 4743351, 8607728
644.81	'U artifact' U17b	9726699
680.58	U18b	9726699
716.25	U19b	9726699

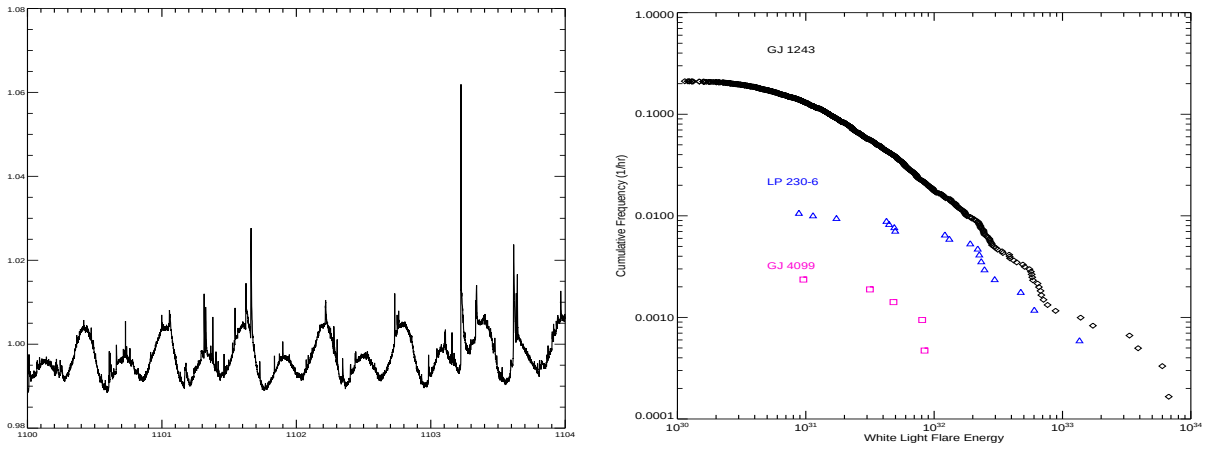

Figure .1: Left: A four day time series for GJ 1243. Note the white light flares and periodic spot rotation. Kepler short cadence photometry allows the flares to be resolved in time. Right: Frequency of observed white flares as a function of their energy for three M dwarfs.

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