FLARE ACTIVITY LEVELS FOR FULLY CONVECTIVE RED DWARFS

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ABSTRACT. Current stellar models predict fully convective structures for masses less than about 0.3 Mo. We have monitored low luminosity dMe and dM stars for flare activity with the 2.1 m telescope at McDonald Observatory. The dMe stars produced 2-5 detectable U-filter flares per hour while none were seen in the dM stars. Typically, 15-30% of the U-filter flux received from the dMe stars is due to flares. The flare activity level of dMe stars (on an absolute scale) decreases as one approaches the lower end of the main sequence. Non-linear frequency distributions of flare energy are seen in some binary flare stars, suggesting that both stars contribute to the ensemble of flares observed from the binary. Upper limits for the dM stars suggest activity levels about one thousand times smaller than in the dMe stars.

1. INTRODUCTION

Flare stars on the lower main sequence may be separated into at least two types of structures. The brightest stars ($0.3<M/Mo<1$) have radiative cores and convective envelopes, while those fainter than $\log L/Lo=-2.2$ (corresponding to $M/Mo<0.3$) are fully convective from the center to the photosphere. It is unclear what consequences, if any, this structural difference may have on generation of magnetic fields and the phenomena of stellar activity. We have monitored some low luminosity dMe and dM stars for flare activity, and report here some results of that observing program.

2. OBSERVATIONS

Photometry with a time resolution of 1-5 seconds was done through a U-filter, using the 2.1 m telescope at McDonald Observatory. Data were taken on 18 nights distributed over 6 runs between 19 November 1979 and 10 December 1983. Table 1 contains a summary of the results for each star. For the dMe stars we detected 2-5 flares per hour, while none were seen in the dM stars.

L. V. Mirzoyan et al. (eds.), Flare Stars in Star Clusters, Associations and the Solar Vicinity, 49–52.

Table 1. Flare summary for some fully convective red dwarfs.

Star	Giclas	M_V(A)	M_V(B)	U(AB)	σ/I_o	T(h)	N	L_f(U)
FL Vir	G12-43	15.05	15.05	15.52	0.08	20.31	57	$8.0\ 10^{26}$
V780 Tau	G100-28	15.12	16.12	17.9	0.3	13.11	34	$6.0\ 10^{26}$
UV Cet	G272-61	15.45	15.95	14.90	0.07	38.55	154	$3.1\ 10^{26}$
EI Cnc	G9-38	15.47	16.33	16.7	0.08	4.47	24	$3.5\ 10^{26}$
DX Cnc	G51-15	17.00		19.0	0.3	6.70	17	$3.6\ 10^{25}$
HH And	G171-10	14.80		15.7	0.06	1.33	0	$< 4\ 10^{23}$
	G157-77	15.40		18.0	0.4	0.83	0	$< 6\ 10^{23}$

Notes: N is the number of flares detected during the monitoring time T. L_f(U) is the time averaged flare luminosity, in units of erg/s.

3. ANALYSIS AND DISCUSSION

We have integrated the flare lightcurves and calibrated the results to determine the amount of energy emitted over the U-filter bandpass for each flare. The total energy for all the observed flares on a star was then divided by the monitoring time to determine the time averaged flare luminosity in erg/s, given in the last column of Table 1, where the upper part contains data for dMe stars and the lower part for dM. The discriminating feature is the hydrogen Balmer lines in emission. The numbers correspond to 15-30% of the U-filter flux being due to flares. The largest proportions are seen at the lower end of the main sequence. On an absolute scale the flare luminosity of the dMe stars in Table 1 decreases as one moves towards fainter stars. This trend is confirmed if a wider range of stellar luminosity is considered (Fig. 1). It is also evident from Table 1 and Fig. 1 that dM stars are about 1000 times less active than their dMe counterparts, but we caution that this number is based on very limited sets of observations.

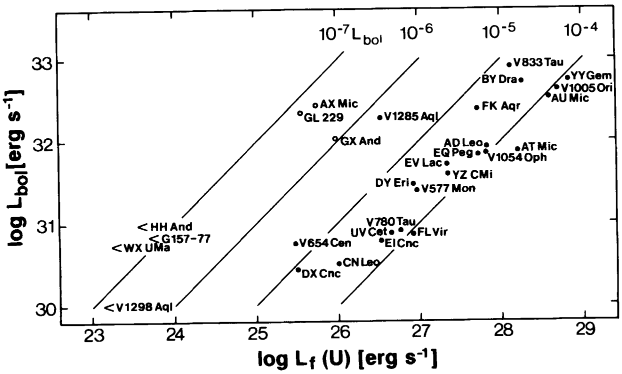

Figure 1. The flare activity for dM (open circles) and dMe (filled circles) stars. Upper limits are shown as $<$.

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In Fig. 2 we have plotted the cumulative frequency distributions of flare energy for the dMe stars in Table 1. Each is the result of two or more observing runs and therefore represents some average in time. We note that the binaries have non-linear distributions, perhaps reflecting that both stars have contributed to the flare sample in accordance with their intrinsic luminosity. The slopes above 10**30 erg are close to unity, while for smaller energies they are 2-3 times steeper. This causes considerable uncertainties when trying to determine if all flare stars are characterized by the same slope in this diagram.

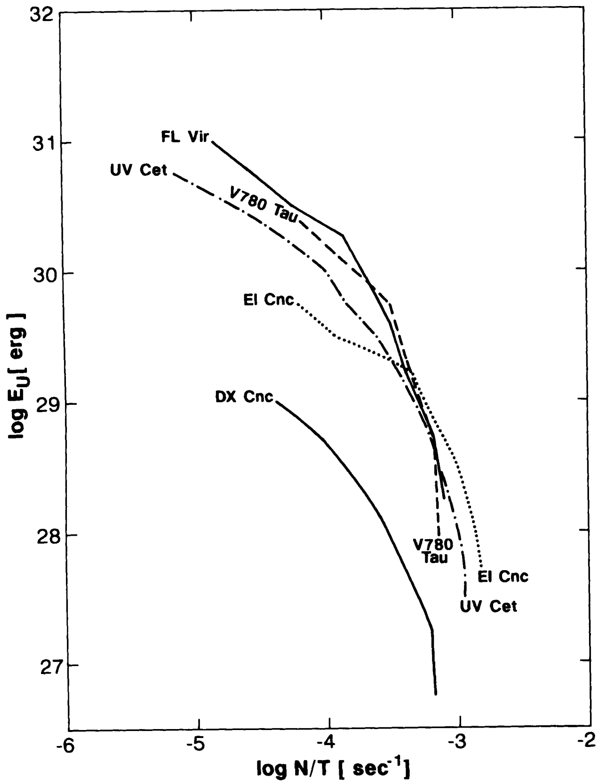

Figure 2. Cumulative flare energy distributions for four late type flaring binaries and one single flare star (DX Cnc).

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MONTMERLE: Is flare activity linked with binarity? In other words, is anything known about the possible connection between rotation and activity in dMe and dM stars?

PETTERSEN: Many flare stars are members of binary systems. Indeed, all but one in the sample discussed here are binaries. G 51-15 is believed to be single, but should be investigated in more detail. For the fully convective flare stars we do not have rotation information. Very high spectral resolution is difficult for these very faint stars (to determine v sin i), and photometric periodic variability due to spots on a rotating star has not been detected yet, despite many attempts on fully convective stars.