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Active Late-Type Stellar Coronae: Hints for Flare Heating?

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Abstract. The *Extreme Ultraviolet Explorer* data archive has been used to study flare energy distributions and infer the role of flares in coronal heating. We have constructed flare number distributions as a function of observed EUV and X-ray emitted thermal energy. We find cumulative flare distributions of the form $N(>E) \propto E^{-\alpha+1}$ with $\alpha \approx 1.5$–2.6. We present results in the context of spectral type classification.

To explain coronal temperatures (1–30 MK), it has been proposed that flares play a crucial role (e.g., Parker 1988). Flares have been found to be distributed in energy according to a power law, i.e., $\mathrm{d}N/\mathrm{d}E \propto E^{-\alpha}$, with α around 2. Hudson (1991) argued that, if $\alpha > 2$ for solar microflares, an extrapolation to lower energies may provide the energy necessary to heat the whole corona. We have initiated a project in which we analyze data from the EUVE archive to study coronal heating on active late-type stars. Audard, Güdel, & Guinan (1999) found indices α for two young, active solar analogs that suggest that their coronae could be heated by flares. Here, we present an extension to 10 additional data sets.

First method: We reduced stellar data from the EUVE archive. A flare identification method based on the count distribution of "quiescent" radiation and the probability of Poisson occurrence was then applied (see Audard et al. 1999; 2000). Using fits to the light curves, we derived the flare durations and emitted energies. Finally, flare number distributions in emitted thermal energy (0.01–10 keV) were constructed and fitted (Figure 1, Table 1; Audard et al. 2000).

Second method: Another method was applied to the data of the active binary FK Aqr (dM2e+dM2e). The pattern of observed photon arrival times is compared with model photon events (Drake et al., in preparation). The derived index $\alpha \approx 2.4$ suggests that FK Aqr's flares follow a steep distribution.

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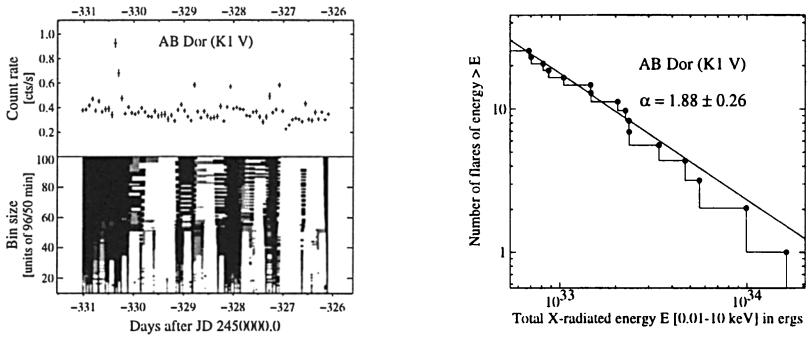

Figure 1. An example of our procedure results (for AB Dor).

Furthermore, a possible trend was discovered in which M-type stars have lower power-law indices α than F- and G-type stars, suggesting that the latter could have their coronae heated by flares. Further studies will be presented in Audard et al. (2000).

Table 1. Results of the different fitting methods.

Type	α^a	Star Name	α^b	$\log(E_0)^c$ [ergs]		
F+G	2.28 (2.03,2.57)	HD 2726 08/95	2.61 ± 0.38	31.7	(29.7,	32.3)
		47 Cas	2.19 ± 0.34	29.7	(⋯ ,	31.6)
		EK Dra	2.08 ± 0.34	30.2	(⋯ ,	32.0)
		κ Cet 1994	2.18 ± 0.89	27.2	(⋯ ,	31.0)
		κ Cet 1995	2.29 ± 0.51	29.5	(⋯ ,	31.1)
K	1.87 (1.50,2.39)	ϵ Eri 09/95	2.40 ± 0.81	29.1	(⋯ ,	30.7)
		AB Dor 1994	1.88 ± 0.26	⋯	(⋯ ,	28.8)
M	1.84 (1.63,2.06)	AD Leo 1996	2.02 ± 0.28	26.2	(⋯ ,	29. 8)
		EV Lac	1.76 ± 0.33	⋯	(⋯ ,	29.1)
		CN Leo 1994	2.21 ± 0.30	29.3	(27.0,	29.8)
		CN Leo 1995	1.46 ± 0.39	⋯	(⋯ ,	⋯)
		GJ 411	1.63 ± 0.29	⋯	(⋯ ,	⋯)

[a] For differential distributions with 68% confidence ranges for 1 parameter.
[b] For cumulative distributions, from an adapted version of Crawford, Jauncey, & Murdoch (1970).
[c] Minimum energy required to explain the total observed radiative energy loss.

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References

Audard, M., Güdel, M., Drake, J. J., & Kashyap, V. L. 2000, ApJ, submitted
Audard, M., Güdel, M., & Guinan, E. F. 1999, ApJ, 513, L53
Crawford, D. F., Jauncey, D. L., & Murdoch, H. S., 1970, ApJ, 162, 405
Drake, J. J., Kashyap, V., Audard, M., & Güdel, M., in preparation
Hudson, H. S. 1991, Solar Phys., 133, 357
Parker, E. N. 1988, ApJ, 330, 474