A SEARCH FOR MICROFLARING ACTIVITY ON DME FLARE STARS

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INTRODUCTION
It has long been suggested that coronal heating on the sun and other cool stars may be the result of numerous small, short duration, explosive events, often called microflares (e.g. Parker, 1989). If this is true, then the characteristics of the microflaring activity on a star should be associated with the amount of coronal heating, as measured by the "quiescent" soft X-ray flux. With this in mind we obtained time on the Hubble Space Telescope to take rapid, photometric time sequences of several dMe flare stars with known X-ray fluxes.

To date, only one of the target stars has been observed, CN Leo (Gl 406). This is a nearby (2.4 pc) flare star with a spectral type of dM8e and an X-ray luminosity of $5 \times 10^{26}$ erg s$^{-1}$. The observations consisted of four 30 minute time sequences and contain one large flare, two moderate sized events and 29 microflares. In this paper we describe the characteristics of these events.

OBSERVATIONS AND DATA REDUCTION
The observations were carried out on 1993 May 30 and consisted of rapid photometric time sequences taken with the High Speed Photometer aboard the Hubble Space Telescope. The experimental setup used a filter centered at 240 nm and with a bandwidth of 60 nm. Each of the 4 time sequences lasted for 30 minutes and had a sample time of 0.01s, with virtually no overhead between samples. At these wavelengths the quiescent emission from the star is small and the contribution from the flare is large, so that detectability of small events is maximized. Further, since the observations are not influenced by the atmosphere, the significance of an increase in the count rate will be determined primarily by the counting statistics of the data.

Microflare events were detected and analyzed by binning the time sequences by specified amounts and then searching the binned series for elements which have counts significantly higher than would be expected by chance, assuming...
FIGURE I  Results of analyzing a short section of one time sequence. The top panel shows the significance for event detection in terms of the probability that an observed count occurs by chance. Black, dark grey and light grey correspond to probabilities of $10^{-3}$, $10^{-4}$ and $10^{-5}$ respectively. The two lower panels show the same time series binned by different amounts. Lines show the average count and the threshold for event detection.

Poisson statistics. Strong events show up at small binning intervals over many adjacent bins, while weaker events sometimes required binning over the entire duration before a significant number of counts were accumulated. In analyzing the data we examined binning intervals ranging from 0.1s to 10s. In Figure I we show the results of the analysis for a short section of one time series. The upper plot shows the level of significance as a function of binning factor, where counts having a probability of $10^{-3}$ or less of occurring by chance are considered as the threshold for a positive detection. The two lower graphs show the time series binned by 2s and 6s. Note the fine structure in the later event.

RESULTS
We detected a total of 32 transient events during 2 hours of observing. 29 of these events had an integrated count (after background subtraction) of less than 100 and were designated to be microflares. Two moderate sized events had 203 and 483 integrated counts, while one large flare, which lasted for over 15 minutes, had more than 14,000 counts. In Figure II we plot the occurrence rate for the microflare events as a function of integrated counts. This has a power
law distribution, which is similar to that observed in ground-based observations for larger flare events (e.g. Shakhovskaya, 1989).

At present we have no flux calibration for these data, so we cannot directly compare the energy with ground-based observations. However, we note that extrapolating the fitted curve to flares with integrated counts of 300, which is representative of the moderate sized events seen, gives an occurrence rate of $7 \times 10^{-4}$ events h$^{-1}$, while the occurrence rate for the large flare is less than $10^{-226}$ events h$^{-1}$! Clearly the microflare events do not fit the same power law relation as the larger, more normal flares.

Examining the time history shows that microflares have durations ranging from 5 to approximately 30 seconds and often show a pronounced impulsive phase, sometimes with an abundant fine structure which resembles compact groups of smaller events. This fine structure occasionally showed variations with time scales as small as 0.1s.

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REFERENCES