HIGH TIME RESOLUTION PHOTOMETRY OF RED DWARF FLARE STARS
I. A SEARCH FOR FINE STRUCTURES ON THE OPTICAL LIGHT CURVES OF FLARES


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ABSTRACT. A detailed analysis of 73 flares on UV Cet type stars observed at the 6-m telescope of the Special Astrophysical Observatory with $3\times10^{-7}$ s time resolution shows no fine structures on flare light curves with time scales from $10^{-3}$ to $10^{-1}$ s.

In 1982-85 we used the 6m telescope of the Special Astrophysical Observatory of the Academy of Sciences of USSR to search for rapid variability during flares on 8 UV Cet type flare stars. In 35 hours of monitoring with the MANIA system (Neizvestnyj and Pimonov, 1978; Pimonov, 1979) we recorded 118 flares, primarily on CN Leo, Wolf 424, V 577 Mon and UV Cet. In the standard regime of observations, the arrival time of each photon was recorded with a precision of $5\times10^{-6}$ s. The temporal resolution of the system was $3\times10^{-7}$ s and the largest flux, which could be recorded without distortion, was 15,000 counts/s. For larger fluxes we could record each k-th photon, "k" being selected by the observer.

Seventy-five flares were analyzed in detail. In carrying out our statistical analysis, we considered two types of brightness variations: bursts with triangular shape and time filling factor - the ratio of the mean event duration to the mean event separation - of $10^2$ and smooth sinusoidal fluctuations with a time filling factor of 0.5.

In order to search for brightness variability on time scales longer than the mean time interval between consecutive readings, i.e., on time scales within the range $10^{-3}$ - $10^{-1}$ s, the following methods were applied:

a) the statistical deviation method, which is the most sensitive to search for bursts;

b) the dispersion analysis, which is optimal to search for
The search for brightness variability, within the time scale ranges (a) $10^{-1}$ - 1 s, and (b) $10^{-2}$ - 10$^{-1}$ s, during the Wolf 424 flare on March 19, 1983 at 19h 58m UT.
smooth brightness fluctuations;

c) the $d_2$-function method, which is based on the analysis of the
dependence of the light curve dispersion on the time window
width; its sensitivity is comparable with the dispersion
analysis sensitivity (Shvartsman, 1977; Plakhotnichenko, 1983).

To search for brightness variability of flares within the range
$10^{-6} - 10^{-3}$ s, we used:

d) the $y_2$-function method, which is based on the statistical
analysis of the time intervals between arrival times
(Shvartsman, 1977; Plakhotnichenko, 1983).

The first two methods were employed to analyze all 73 flares.

Sequences of normalized deviations

$$\delta I(t) = \frac{[I(t)-\langle I(t) \rangle]}{\sigma[I(t)-\langle I(t) \rangle]}$$

where $\sigma[I(t)-\langle I(t) \rangle]$ is the standard deviation, $I(t)$ and $\langle I(t) \rangle$
are the original and smoothed light curves, were analyzed using
these methods. In Fig. 1a we present our results on one of the
Wolf 424 flares to search for brightness variability within the
range of time scales $10^{-2} - 1$ s. In Fig. 1b we present similar
data for the range of time scales $10^{-2} - 10^{-1}$ s.

The $y_2$-function and $d_2$-function methods were used to analyze
a rather small set of readings - about 20,000 - close to the
brightness maxima of 28 flares.

Our statistical analysis shows that for all detected flares,
significant brightness variations on time scales $10^{-6} - 10^{-1}$ s
are absent everywhere with a 99% confidence probability. Thus,
while the light curves of many flares are not smooth and have
rather complex structures, the lifetimes of individual details
exceed $0.2 - 0.3$ s in all cases. The upper limits for the
relative power of burst type brightness variations in the time
scales $10^{-6} - 10^{-1}$ s are from 20% to 0.5%; the upper limits for
the brightness variations on a smooth fluctuation, with time
scales $10^{-9} - 10^{-1}$ s, are from 75% to 8%. These results indicate
that the optical radiation of flares on UV Cet type stars is
thermal in nature.

The complete version of this study is published in the Letters to

REFERENCES

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