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 3×10^{-7} s time resolution shows no fine structures on flare light curves with time scales from 10^{-6} 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 5×10^{-8} s. The temporal resolution of the system was 3×10^{-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-three 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 irterval 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

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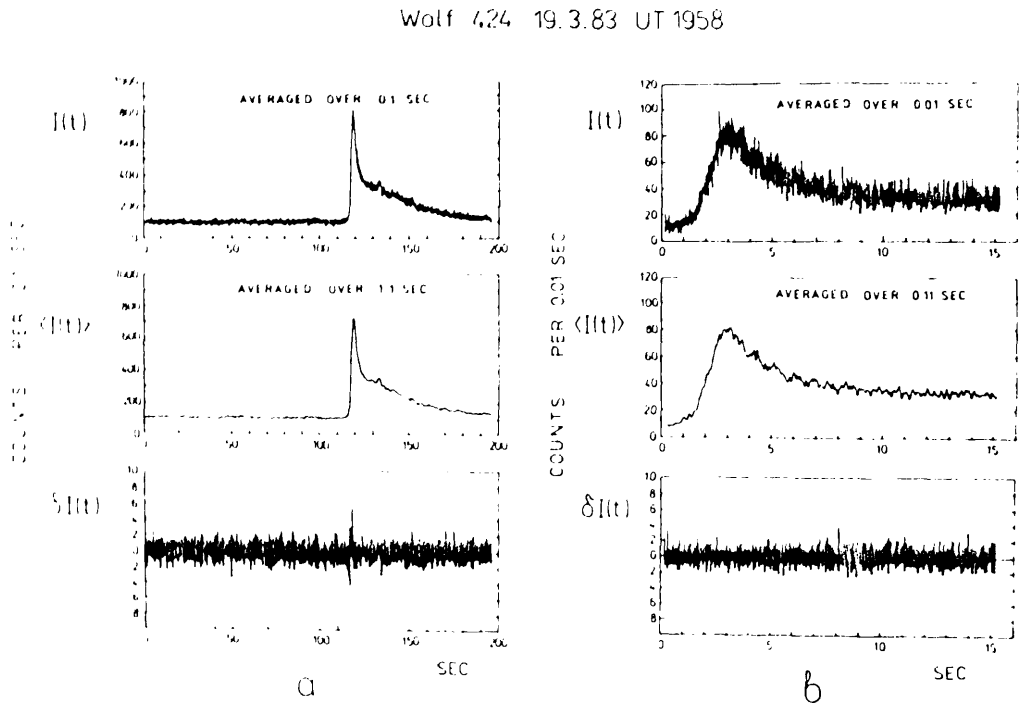

Figure 1. The search for brightness variability, within the time scale ranges (a) 10^{-1}– 1 s, and (b) 10^{-2}– 10^{-1} s, during the Wolf 424 flare on March 19, 1983 at 19h 58m UT.

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smooth brightness fluctuations;

c) the d_z-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^{-4} – 10^{-3} s, we used:

d) the y_z-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

$$\delta I(t) = [I(t)-\langle I(t)\rangle] \,/\, \sigma[I(t)-\langle I(t)\rangle]$$

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^{-1}– 1 s. In Fig. 1b we present similar data for the range of time scales 10^{-2}– 10^{-1} s.

The y_z-function and d_z-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^{-4}– 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^{-4} – 10^{-1} s are from 20% to 0.5%; the upper limits for the brightness variations on a smooth fluctuation, with time scales 10^{-3}– 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.

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