THEORY AND OBSERVATIONS OF NEGATIVE PREFLARES IN UV CET STARS

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Negative preflares (NPFs) of UV Cet stars, which were first observed by Italian astronomers |1|, are a highly unusual type of preflare activity without direct analogy in solar flares. The rarity of these events in the visual region leads to difficulties in statistical investigations. At present one can consider as reliably established only that the mean NPF-amplitudes increase and the probability of their appearance decreases with a shift toward blue |2|. According to |3| NPFs are observed mainly before flares of smaller amplitudes. Beginning in 1974 at the Crimea and the Astronomical Institute of Tashkent a series of works on the theory and observation of NPFs was carried out. A short review of these is given below.

As shown in |4| the preflare depression of light below the quiescent level may be a consequence of a weak impulsive heating of the stellar atmosphere. This anomalous response is due to the strong temperature dependence of the ionization of metals, the main source of free electrons. As a result even a small heating leads to noticeable increase of the H^- opacity, that in turn leads to the temporary decrease of the flux. The mean duration of NPF is determined by the characteristic time of a temperature relaxation at optical depth $\tau \simeq 1$ and is of the order of a few tens of seconds; its amplitude is maximal in the center of the stellar disc and is negligible at the limb. More detailed calculations |5| accounting also for opacity variations due to molecular lines and bands, showed that this effect takes place in a wavelength region excluding the strong molecular bands of TiO (Fig. 1). Then the amplitude of NPF increases toward long wavelengths, which agrees with the observations. At the same time the observations of such fine effects are especially difficult in the U band due to the veiling of NPFs by the flare itself. In this respect the spectral region $\lambda \sim 1\mu$, free from the strong molecular bands, was proposed in |5| as the most suitable for the monitoring of NPFs.

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In 1975 synchronous photoelectric observations of flare stars in the visual and near IR-regions were initiated in the Crimea and then continued in Tashkent. Up to the present more than one hundred flares of UV Cet, EV Lac and AD Leo have been observed [6-8]. These observations fully confirmed the prediction of a sharp increase in the rate of occurrence of NPFs in the near IR-region: on average for two observational seasons, about 40% of flares observed in the i-filter (λ_{eff}=0.8μ) manifestes NPFs. Most of them are similar to the UV Cet flare 24.8.76 (Fig.2) when a single NPF just before the positive flare was observed. Sometimes the NPF and the following flare are separated by a time interval of up to 1/min. In a few cases more complicated preflare activity was observed. For example in the flare of UV Cet on 23.8.76 three successive NPFs were observed in i: one of them proceded the main flare, two others preceded two earlier bursts in U band [6].

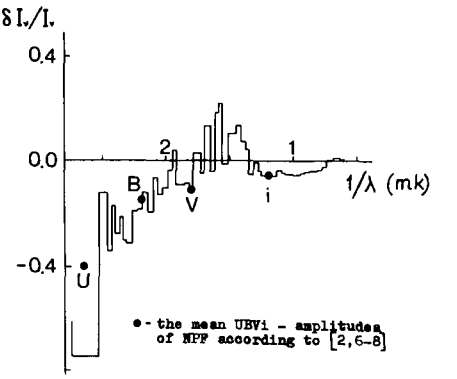

Figure 1. The amplitude of the intensity perturbation $\delta I_\nu/I_\nu$ in an atmosphere with T_{eff}=3500K, log g= 5 and $\delta T/T=\exp(-k\tau)$, k=5.

During these observations were obtained two new results related directly to flares themselves. 1) A correlation between the (U-i) colour at light maximum and flare amplitudes was found, which shows that the temperatures of flares increase with increasing amplitude. 2) The systematic reddening of the (U-i) colour was observed along the descending branch of the light curve of the flares [8] due to the relaxation of the heated atmosphere [4].

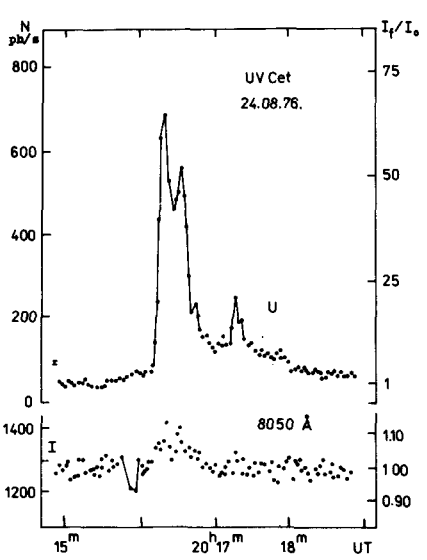

Figure 2. Simultaneous U and i observations of an UV Cet flare.

In total these observations confirm the proposed NPF model. However for the final test of this theory it is necessary to carry out photoelectric observations in the i band and in any narrow bandpass centered on TiO-bands. It follows from Fig.1 that the preflare variations of light in these two regions caused by opacity changes are expected

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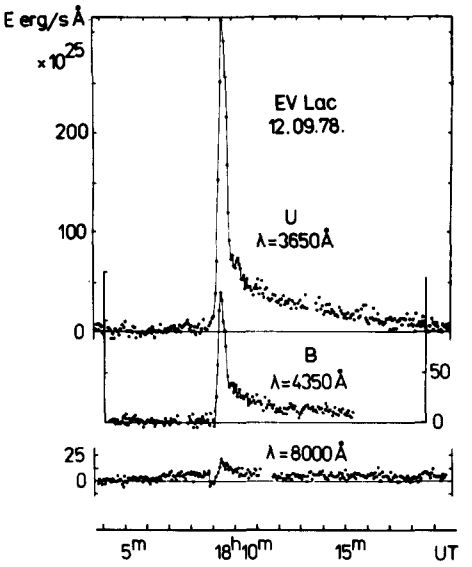

Figure 3. Simultaneous U,B and i observations of an EV Lac flare.

to be in antiphase.

Some other mechanism of NPFs were also briefly discussed in |9, 10|. One of them |9| is based on the assumption that the continuous emission from flare stars consists of two components: photospheric emission and continuous emission formed either in compact active regions or as a result of the superposition of a successive microflares. The decrease of this additional noise-emission related to the preflare variations of the magnetic field might be the reason for the observed preflare depression of light. This hypothesis might be confirmed if the relation between the NPF-amplitudes and the level of additional continuous emission were established. The EV Lac flare of 12.9. 78 (Fig.3) might serve as a hint to this relation. Some minutes before the flare the light in i band slowly increased. Then the following NPF reduced the excessive emission returning the light to its initial level.

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