Color Characteristics of Rapid Optical Oscillations in the Flare Star EV Lacertae

Irina A. Verlyuk
Main Astronomical Observatory - NAS, Kiev, Ukraine
irina@mao.kiev.ua

Abstract

First colorimetric analysis of rapid optical oscillations seen during flare events on EV Lac is presented. The analysis is based on the UBVRI light curves of the flare on September 11, 1998, 21:55:02 UT (max) obtained with the Crimean and Greek telescopes simultaneously during the course of cooperative observations in 1998. The digital filtering technique was used to evaluate the color characteristics of small oscillations and the main flare curve. It if found that the color indices of rapid oscillations differ significantly from those of the main outburst light curve.

Introduction

Many-site multichannel simultaneous monitoring of the red dwarf flare star EV Lac was carried out from four separate sites in September - October 1998 (Alekseev et al., 2000). These observations have confirmed the reality of rapid optical brightness oscillations during a significant part of a flare lifetime (Zhilyaev et al., 2000), as was discovered first by Rodono (1974) in the Hyades flare star HII 2411. These synchronous observations provide information of high quality on the colour indices of flare radiation, their dynamics and associated rapid optical oscillations. An estimation of the colour characteristics of the oscillations as well as a comparison with those of the main outburst light curve are the primary goals of this paper.

The digital filtering technique was used which makes possible the detecting of small-scale colour variations in flare events with limiting amplitude lower by a factor of $3 \div 5$ compared to ordinary observations (Zhilyaev et al., 1998).

1 Methods and Results

Observational data reported here were obtained during the above mentioned campaign of cooperative observations of EV Lac. Five distant telescopes were used from Ukraine, Russia, Bulgaria and Greece operating synchronously to an accuracy of 0.1 s. More than a dozen flare events were observed on EV Lac in UBVRI. To detect small oscillations we apply high-pass filtering (for more details see Zhilyaev, 2000, this volume).

Fig. 1 (upper panel) shows the simultaneous observations of the high-frequency oscillations (HFO) on EV Lac at the Crimean and at the Stephanion observatories. Lower panel shows the main flare curve in B band with sampling time of 1.2 s. Time variations in HFO were detected by subtraction of a moving average over 15 points (18 sec) and normalized to the quiescent intensity. A comparison between these two measurements obtained from synchronous observations at different sites shows obvious correlation significant at higher than 99 % confidence level. Period of 12.8 $\pm$ 0.7 s (0.078 Hz) was evaluated from the times of maxima and a mean amplitude of 0.025 mag was calculated. From these facts we can be assured that both, the atmospheric and the instrumental origin of the HFO can be ruled out with a high confidence.

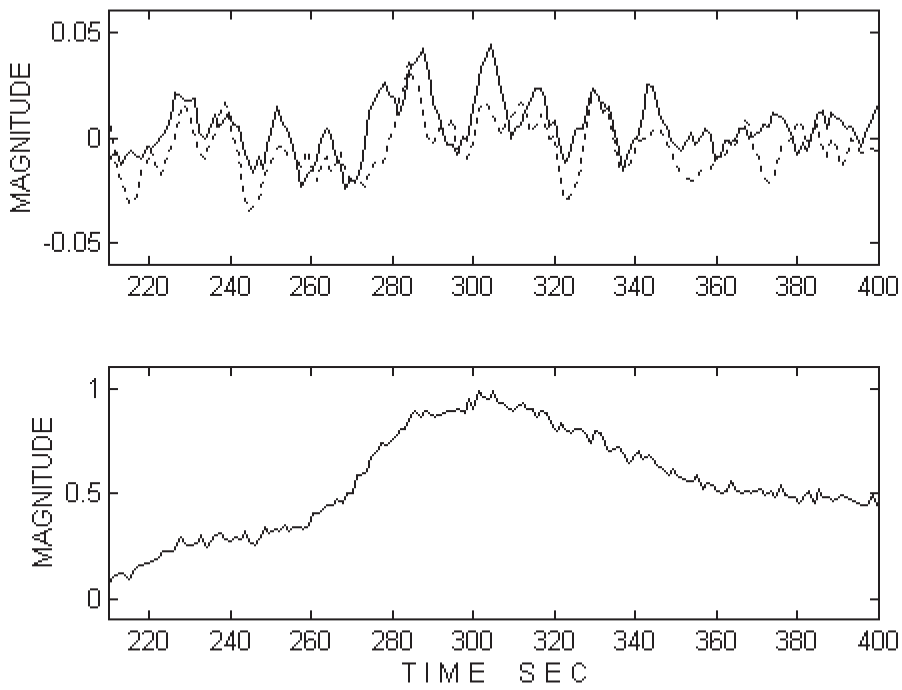

Figure 1: Portions of the main flare light curve and of the rapid B - band oscillations superimposed to it as seen simultaneously by the 1.25 m Crimean telescope AZT-11 (solid line) and the 30 inch Greek telescope in Stephanion (dotted line) in EV Lac on September 11, 1998, 21:55:02 UT (max).

Fig. 2 gives some insight into the way in which HFO arise and develop during the progress of the flare. A strong excitation of HFO is clearly seen from the upper panel. These oscillations first arise at the earliest stage of the flare development with a frequency of 0.039 Hz (the period = 25.7 $\pm$ 1.8 s). Some time later they transform into a wave of a twofold frequency. Their amplitude may reach 10 % of the quiescent intensity in the U light and about five times lower in the B light.This is an example of a highly-blue HFO's color. The expected dU/dB ratio between U and B fluxes, caused by the atmospheric scintillation, lies in the range from 1 to 1.2, depending on the aperture of the telescope (Stecklum, 1985). The result lends additional support to the reality of the HFO.

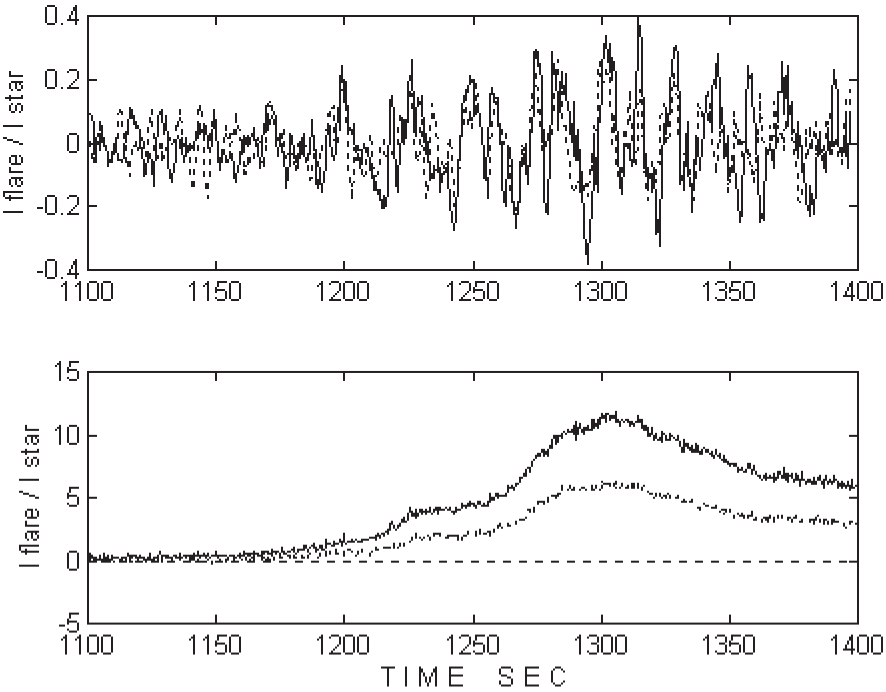

Figure 2: Portions of the main flare light curve and of the rapid B - band oscillations superimposed to it as seen simultaneously by the 1.25 m Crimean telescope AZT-11 (solid line) and the 30 inch Greek telescope in Stephanion (dotted line) in EV Lac on September 11, 1998, 21:55:02 UT (max).

The second important conclusion to emerge from the Fig. 2 is that the color characteristics of the HFO are different from those of the mean flare light curve. Really, the oscillation B flux, being magnified by a factor of 5, coincides practically with the U one. For the smoothed flare light curve similar factor is equal to 8.5.

In a similar manner the calculated values of the UBVRI oscillation amplitudes normalized with respect to U are the following : 1, 1/5, 1/9, 1/19 and 1/28. For the mean flare light curves these are : 1, 1/8.5, 1/25, 1/92 and 1/218.

Fig. 3 shows clearly that both the reduced oscillation VR remains and the mean outburst light curves coincide practically with the U ones to an accuracy of about 7%. An exceptional case occurs at the earliest and premaximum phases of the flare development (delimited by the star in Fig. 3) where a color's dynamics differs significantly from that at the later phase of the flare.

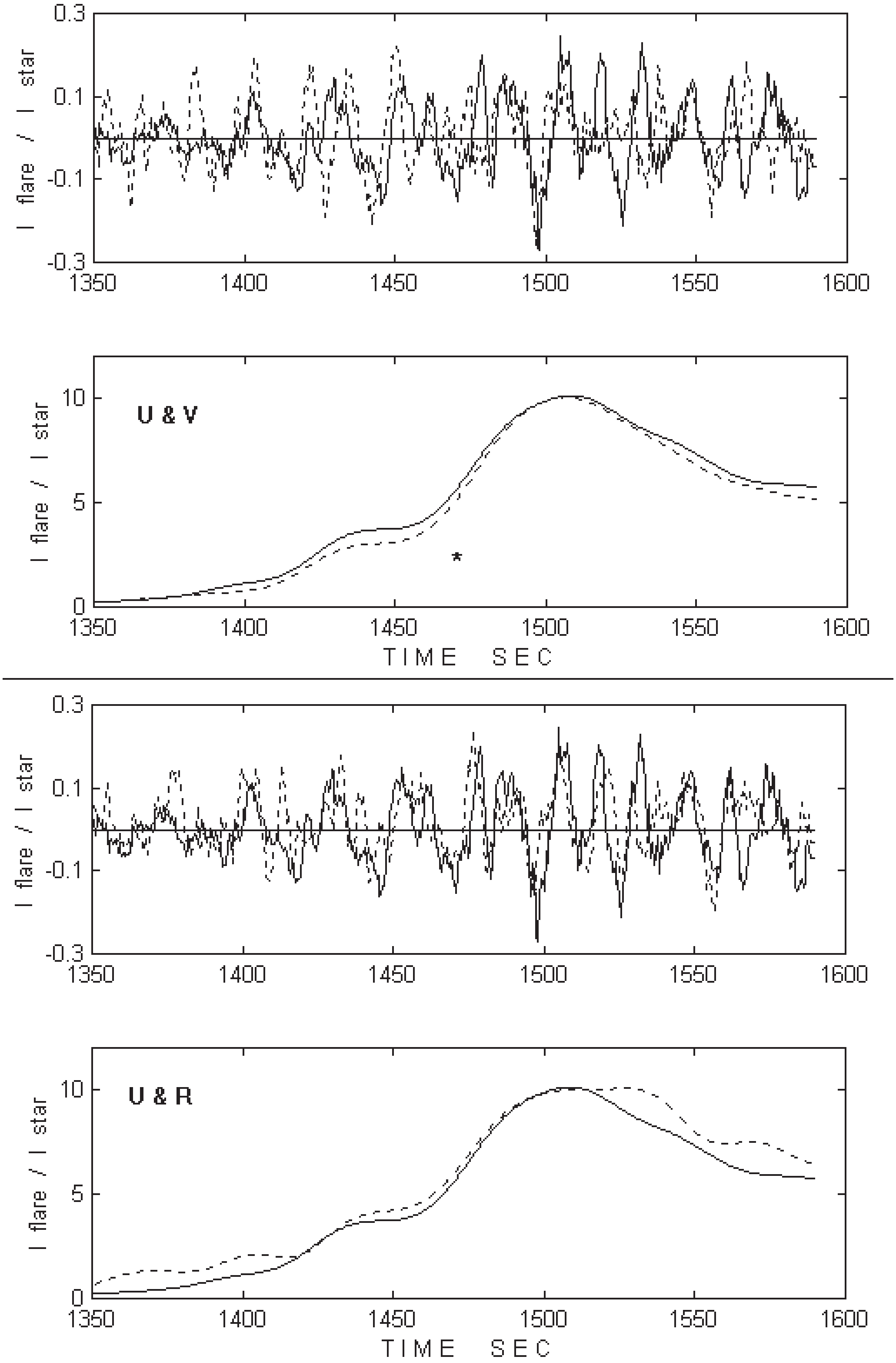

Figure 3: U (solid), V (dots) portions of the rapid oscillations (upper panel) and of the main flare light curve (lower panel) as seen by the 1.25 m Crimean telescope AZT-11 in EV Lac on September 11, 1998, 21:55:02 UT (max).

Conclusion

UBV color indices of the mean flare light curve differ significantly from those of the oscillations and are as follows : U-B $= -0.99 \pm 0.06$, B-V $= -0.46 \pm 0,07$ and U-B $= -0.42$, B-V $= 0.07$, respectively. The color indices show no variations with time in the vicinity of the brightness maximum and on the portion of the descending light curve to an accuracy of 0.07 mag.

References

[1] Alekseev I.Yu., Antov A.P., Avgoloupis S.J. et al., 2000, KFNT, (submitted)

[3] Rodono M., 1974, A&A 32, 337

[5] Stecklum B., 1985, Astron. Nachr., 306, 145

[4] Zhilyaev B.E., Verlyuk I.A., Romanyuk Ya.O. et al., 1998, A&A 334, 931

[2] Zhilyaev B.E., Romanyuk Ya.O., Verlyuk I.A. et al., 2000, A&A (accepted)