11th Hel.A.S Conference
Athens, 8-12 September, 2013
CONTRIBUTED POSTER

Transient high frequency optical oscillations on red dwarfs

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Abstract: The results of the analysis of one colour (B, or U) observations of the Stephanion Observatory of different red dwarfs (EV Lac, AD Leo, YZ CMin,UV Cet)and the red flaring giant V 390 Auri at any stage of their activity (quiescence, weak flares, strong flares), indicate that transient high frequency oscillations occur during the flare event, no mater if the flare is strong or weak, and during the quiet-star phase as well.

1 Introduction

The scientific team of the Stephanion Observatory, University of Thessaloniki contributed to the research of high frequency optical oscillations on red dwarfs by participating in international programs for Multiwavelength observation of strong Flares of selected flare stars ([11]). These joined research shed plenty of light on the phenomenon of high frequency optical oscillations. Nevertheless a better understanding of the high-frequency oscillations demand a unified analysis of the flare light-curve for a wider time window covering pre-flare, flare and post flare and a broader band of frequencies. Thus in addition to the international campaign research the Stephanion Observatory group observe and analysis one colour (B, or U) observations of the Stephanion Observatory of different red dwarfs: EV Lac([1], [2] and [7]), AD Leo ([4] and [5]),YZ CMin ([3],[9]), V 390 Auri ([6],[10]), UV Cet([8]), at any stage of their activity (quiescence, weak flares, strong flares). In this review we present the result of this study.

2 The Observations

The observations were curried out with the help of the 30-inch Cassegrain telescope of the Stephanion Observatory ($\phi = 22^o49'45'', \lambda = 37^o45'09''$ and $h = 900m$) which is equipped with a Johnson photometer. The digitized recording system has a recording resolution of 0.108s. This facility allows the reliable analysis of the observational data for a wide range of frequencies (4.63Hz to 4.63×10^{-3} Hz i.e. periods 0.216s to 216s) and permits the reliable spectral analysis of small part of the light-curve. The observations were made mostly in B and occasionally in U color during the years 1999 to 2002 . All the Flares, irrespective of their magnitude, as well as parts of the quiescence state were analyzed in order to detect high frequency optical oscillations.

3 Analysis

The data consist of a sample of relative intensities i.e. $(I - I_o)/I_o$, where I is the flare intensity and I_o is the quiet star intensity. The extent, as well as the resolution, of the observational sample permit a reliable Discrete Fourier Transform analysis of sufficient light-curve parts for the determination of possible transient oscillations in the frequency domain and their approximate location in the time domain.So the analysis comprises the following steps: (1) With the help of DFT-analysis we deduce the power spectra and the logarithmic power spectra of the flares and the quiet state star deflection. The logarithmic power spectrum will enable us to separate the random part of the spectrum from the non random. (2) We isolate by filtering the random part of the spectrum and we estimate the standard deviation of the random noise σ_{BW}. (3) We identify the potential frequencies of star brightness oscillations from the power spectrum. To do this we use the Ho hypothesis test (see [1]) in which $\sigma = \sigma_{BW}$. (4) We filter out the identified frequencies from the star deflection. (5) We estimate the confidence level of those frequencies identifications comparing the amplitudes of the oscillations with the respective σ_{BW}.

4 Results

DFT-analysis and the use of the Brownian Walk noise notion enable us to estimate the proper random noise and to de-noise by filtering the observed light-curves. Thus we were able to detect possible weak transient optical oscillations and to isolate them by proper band filtering with a confidence level lower than 30% (Probability of proper identification higher than 70%).The results for all the program stars indicate that: (1) Transient high frequency oscillations occur during the flare event, no mater if the flare is strong or weak, and during the quiet-star phase as well. (2) The Observed frequencies range between 0.0083Hz (period 2min) and 0.3 Hz (period 3s) not rigorously bounded. The phenomenon is most pronounced during the flare state and is even more pronounced on the larger flare. (3) During the large flares:(a) Oscillations with period ranging from 2 to 1.5min, down to 11s, 7.5s and 4s appear during the pre-flare state and persist during the whole flare state, (b) from the flare maximum phase on, a progressive increase of oscillations with the shorter periods is markedly indicated and (c) At the end of the flare only the oscillation of the pre-flare state do remain.

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