Analysis of photometry of luminous hot stars from BRITE

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The hot part of the Hertzsprung-Russell diagram contains many types of variable stars. The driving mechanisms are not yet understood. They can be pulsations, convection, stellar wind, granulation or other processes. The pulsations can be excited by different mechanisms. We will present here the results of the analysis of the BRITE-Constellation photometry of OB stars.

1 Introduction

Luminous hot stars are very interesting objects for which ground-based observations are not sufficient to understand all processes inside them. The atmosphere of the Earth influences the precision of the brightness measurements. Space photometry such as BRITE-Constellation allows us to avoid this kind of problems. High-precision photometry is needed to analyze trajectories of different types of modes inside the stars. It will allow us to locate convective regions and resolve one of the not yet understood aspects, i.e., convection in massive stars. We report here the first results of the photometric analyses of five OB stars observed with the BRITE satellites.

2 Before data analysis

The different instrumental effects of the BRITE satellites have different impact on the brightness measurements of stars. This causes that the data should be decorrelated before they will be analyzed. Magnitudes in the BRITE photometry mostly depend on four parameters: centroid position, instrument temperature and orbital phase. In most cases the strongest correlation is with respect to chip temperature because there is no cooling system onboard BRITE satellites. Decorrelation with orbital phase is also quite important. This dependence can cause not only a single peak at the orbital frequency but also at its harmonics. In such cases it can be difficult to remove all peaks even after multiple decorrelations. Figure 1 shows relations with respect to four parameters: raster position (x and y), chip temperature (T), orbital phase (φ). We used these four parameters to decorrelate data for all stars we analyzed. The process of decorrelation was as follows: we divided the data into few parts with respect to the parameter with which the data have to be decorrelated. Next, we calculated the mean values (anchor points) of residuals and x, y, T, φ parameters characterizing data intervals. Using the Akima method (i.e., continuously differentiable sub-spline interpolation) we interpolated a relation between anchor points and subtracted the fitted function from the light curve. An example of light curve after decorrelation is presented in the left panel of Fig. 2.

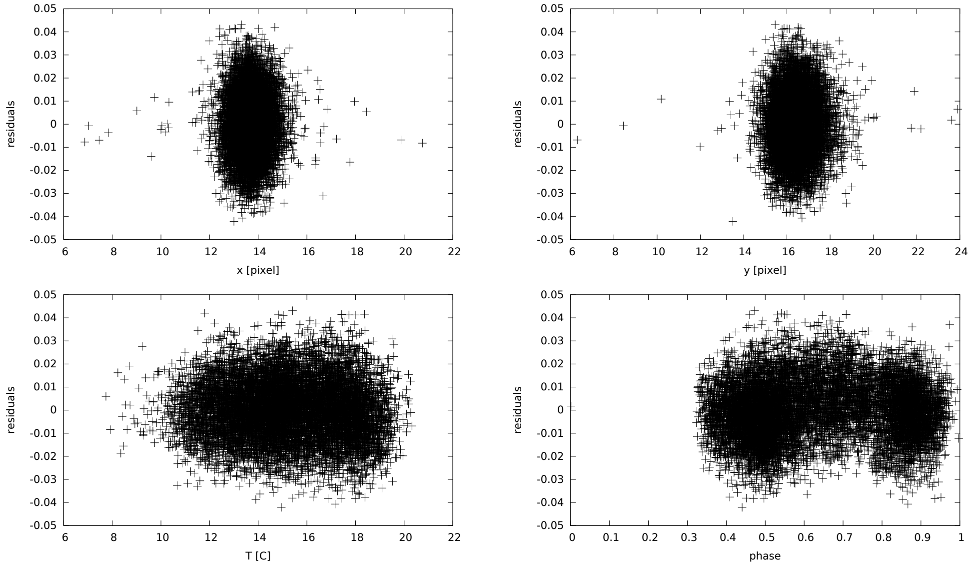

Fig. 1: 55 Cyg data: Relations between raster (x and y) positions, temperature, orbital phase and residuals.

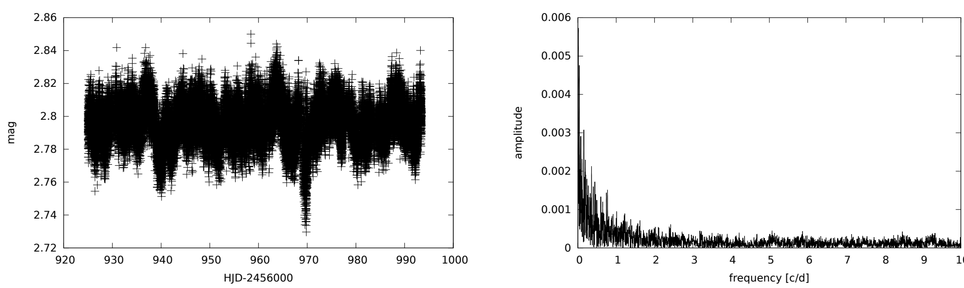

Fig. 2: Left panel: the light curve of HD 24398 based on UniBRITE data. Right panel: the periodogram of the HD 24398 data.

3 55 Cyg

55 Cyg is a B-type supergiant situated in the galactic bar. According to Kraus et al. (2015) it pulsates in pressure, gravity and mixed modes. The pulsation periods lie in the range between 2.7 hours and 22.5 days. It was observed by two BRITE satellites: Lem (16 days) and Toronto (116 days) in the first season. We collected more data in the subsequent season: four BRITE satellites (BLb, BTr, UBr, BAb) observed 55 Cyg total for almost 178 days. BRITE Toronto observed the object for most of this time. The Fourier analysis (Fig. 3, left panel) of the data of the first season shows that the star pulsates in eight frequencies (Table 1). Three of these frequencies were also found in the data of the second season and separately in the measurements of different BRITE satellites. Kraus et al. (2015) found 19 frequencies in the '$0.04-9$ d^{-1} interval, a range much wider than that of our results, i.e., eight frequencies in the $0.08-0.4$ d^{-1} interval.

	55 Cyg	HD 23180	HD 24398
F1	0.08572 (7)	0.45253 (1)	0.10923 (8)
F2	0.05709 (3)	0.11762 (7)	0.19922 (9)
F3	0.13036 (3)	0.03477 (2)	0.35516 (7)
F4	0.19864 (2)	0.81887 (2)	0.25652 (1)
F5	0.34495 (5)		
F6	0.30909 (1)		
F7	0.24177 (5)		
F8	0.40816 (1)		

Table 1: List of frequencies (in d^{-1} measure unit) found in the BRITE data of 55 Cyg, HD 23180 and HD 24398. Uncertainties on the last decimal figure are given between brackets.

4 HD 23180, HD 24398, HD 149038 and HD 2905

The other stars which we analyzed were HD 23180, HD 24398, HD 149038 and HD 2905. Table 1 lists the frequencies found in the data of HD 24398 and HD 23180, observed by UBr and BAb. The periodograms are shown in Fig. 2 (right panel) and Fig. 3 (right panel), respectively. The different amplitudes of the same frequency observed in the blue and red colours suggest changes in stars' temperatures, probably due to pulsations.

We collected not enough data of HD 149038 and HD 2905 for a reliable analysis.

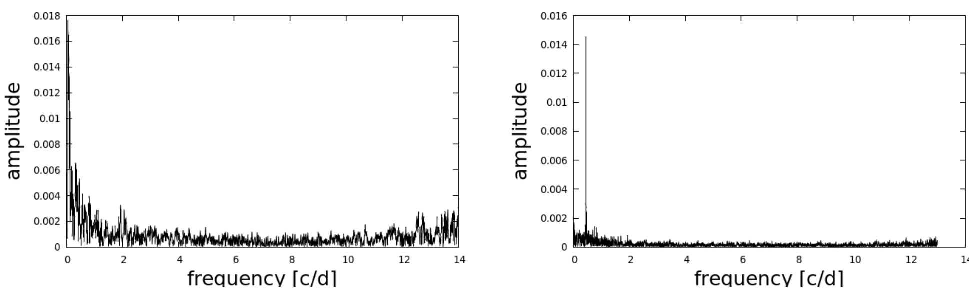

Fig. 3: The periodograms of the combined data of blue and red satellites (first season) of 55 Cyg (on the left) and of the data of HD 23180 (on the right).

5 Conclusions

We have analyzed data of five stars observed by BRITE-Constellation. We found clear variability in the data of 55 Cyg. The frequencies are different and confined in a narrow range with respect to those reported by Kraus et al. (2015). Changes in the photospheric temperatures of HD 23180 and HD 24398 are probably the cause of the different amplitudes observed in red and blue colours. This suggests that the observed variability is probably due to pulsations. More observations are needed in case of two objects: HD 149038 and HD 2905. Additional photometric as well as spectroscopic observations will be useful to confirm our results. Ground-based photometry should allow us to identify spurious frequencies due to instrumental effects in the BRITE photometry. On the other hand, spectroscopic data will be able to confirm and characterize the variability due to physical processes.

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References

Kraus, M., et al., *Interplay between pulsations and mass loss in the blue supergiant 55 Cygnus = HD 198 478*, A&A **581**, A75 (2015), 1507.01846