Stars and their variability observed from space
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KIC 10661783 – BINARY SYSTEM WITH A δ SCT TYPE COMPONENT

A. Miszuda[1], W. Szewczuk[1] and J. Daszyńska-Daszkiewicz[1]

Abstract. We present the analysis of KIC 10661783, an eclipsing binary system with a δ Scuti component. We use all available *Kepler* data from both short and long cadences to model the binary system and to subtract the calculated theoretical eclipsing light curve from the original data.

The Fourier analysis of the light curve corrected for the binarity effects shows a rich oscillation spectrum with most prominent peaks concentrated in the range of 20 - 30 d^{-1}. We find small-amplitude signals in the low-frequency range that can be a manifestation of high-radial order g-mode pulsations.

Keywords: stars: binaries: eclipsing, stars: binaries: spectroscopic, stars: low-mass, stars: oscillations

1 Introduction

KIC 10661783 (A5IV) is located in the original *Kepler* field of view and was found to be an eclipsing binary by Pigulski et al. (2009). Its *Kepler* light curve was analysed for the first time by Southworth et al. (2011). The authors found 55 independent pulsational frequencies from SC Q2.3 and LC Q0-1 *Kepler* data and assigned them to the primary component of the system.

Subsequently, Lehmann et al. (2013) obtained 85 spectra and derived atmospheric parameters for each component. Combining spectroscopic data and *Kepler* photometric observations (SC Q 2.3) they obtained an orbital solution of the system and found that KIC 10661783 is a post-mass transfer detached binary. The authors determined the masses and radii of both components to be $M_A = 2.100 \pm 0.028$ $\mathrm{M}_\odot$, $R_A = 2.575 \pm 0.015\,R_\odot$ for the primary and $M_B = 0.1913 \pm 0.0025$ $\mathrm{M}_\odot$, $R_B = 1.124 \pm 0.019\,R_\odot$ for the secondary.

2 Observations and binary modelling

KIC 10661783 was observed by the *Kepler* satellite for nearly 1500 days. The data have been collected in both SC mode (Q2.3, Q6.1-Q8.3 and Q10.1-Q10.3) and LC mode (Q0-Q17), resulting in over 470 000 (SC) and 58 000 (LC) observational points (see left panel of Fig. 1). Having a much longer time span of the observations, we were able to redetermine parameters of the system. Using the Wilson-Devinney (`WD`, see Wilson & Devinney 1971; Wilson 1979) code we derived a precise orbital period, $P = 1.2313632588 \pm 0.0000000326\,\mathrm{d}$ using all available LC observations. Then we modelled the system using SC data in a detached mode. This allowed us to correct the light curve for the variability caused by binarity.

3 Pulsational analysis

With the observations corrected for the binary orbit we performed a Fourier analysis. Periodograms (for SC data) calculated up to the Nyquist frequency ($\sim$680 d^{-1}) with the iterative pre-whitening procedure allowed us to find 750 frequencies with $S/N > 4.0$ (415 with $S/N > 5.0$); 167 of them seem to be independent frequencies. The most prominent frequency peaks are concentrated between $20 - 30\,\mathrm{d}^{-1}$ and no peaks were detected above 200 d^{-1} (see right panel of Fig. 1). Over 85 d^{-1} we observe only high harmonics of the orbital frequency. Moreover, in the case of the highest-amplitude peaks we found an amplitude modulation with the orbital period. Since this effect is also visible outside eclipses it cannot be caused by eclipsing of the stars.

[1] Astronomical Institute, University of Wrocław, ul. Kopernika 11, 51-662 Wrocław, Poland

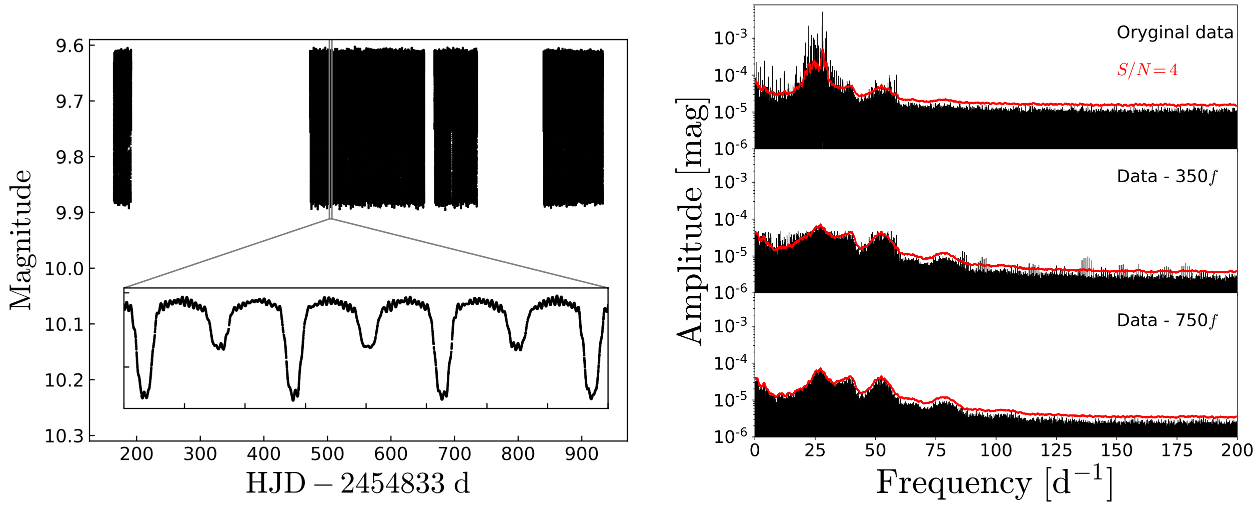

Fig. 1. Left panel: The full *Kepler* short-cadence light curve of KIC 10661783 covering over 473 000 observational points spanning over two years of observations. The inset shows the zoomed area covering 4 days in order to visualize both binary and pulsation variability. **Right panel:** Periodograms calculated for the *Kepler* SC observations corrected for the binary orbit. The amplitude spectra for the original data are shown in the top, after pre-whitening for 350 frequencies in the middle, while pre-whitened for all significant frequencies in the bottom panel. 4×S/N level is marked by red lines.

4 Conclusions

We present the analysis of all available *Kepler* photometric data of KIC 10661783. Using these data we redetermined the orbital elements of this system. Based on Fourier analysis we found 750 frequencies in the range of $0 - 200\,\mathrm{d}^{-1}$ from which 167 are independent. The highest-amplitude peaks concentrate in the range of $20 - 30\,\mathrm{d}^{-1}$. In addition to frequencies in the p-mode regime which are typical for δ Sct pulsators we found low frequency signals that can be interpreted as high-radial order g-modes.

We found that the amplitude of the most prominent frequencies is modulated with the orbital period. This can be caused by amplitude changes over the surface of the star.

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