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Spotted eclipsing binary KIC 7023917 with δ-Scuti pulsations

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Abstract. Eclipsing binary KIC 7023917 is one of nearly three thousand other binaries in the well-known Kepler Eclipsing Binary Catalog. However, it has some uncommon features. We focused on this system because we detected fast anti-correlated changes on the O-C diagram which could suggest the presence of apsidal motion. However, these changes are very fast for apsidal motion and the orbit of this binary is circular. Detailed analysis of the Kepler and TESS light curves reveals deformation of the light curve by short-periodic pulsations and the O'Connell effect caused by stellar spot(s). Here, we present our initial study of this system and a possible explanation of the observed O-C diagram.

Key words: eclipsing binaries – pulsations – starspots

1. Introduction

KIC 7023917 is a short-period eclipsing binary (EB) discovered by mission *Kepler*. Its orbital period is only about 18 hours (0.7728 days). V magnitude is 10.1 and parallax measured by *Gaia* mission is 2.337 mas what gives distance ∼428 pc. *Gaia* also estimated temperature the whole system to 7460 K (spectral type A7; Gaia Collaboration, 2023). However, the temperature of the primary star should be nearly the same because of the big determined temperature and luminosity ratio between components.

This EB was observed by *Kepler* mission in long-cadence mode (30 minutes) and also by *TESS* in short-cadence mode (2 minutes) during sectors 14, 40, 41 and 54. In this paper, we use all available data collected by these two missions and analyse the light-curve (LC) of this EB and changes on it.

2. Light curve: analysing & modelling

The LC is significantly affected by stellar spots and also by the pulsations (see Fig. 1). The LCs covering about five orbital periods were phased and stacked together. After that the running mean and binning with a size in phase of

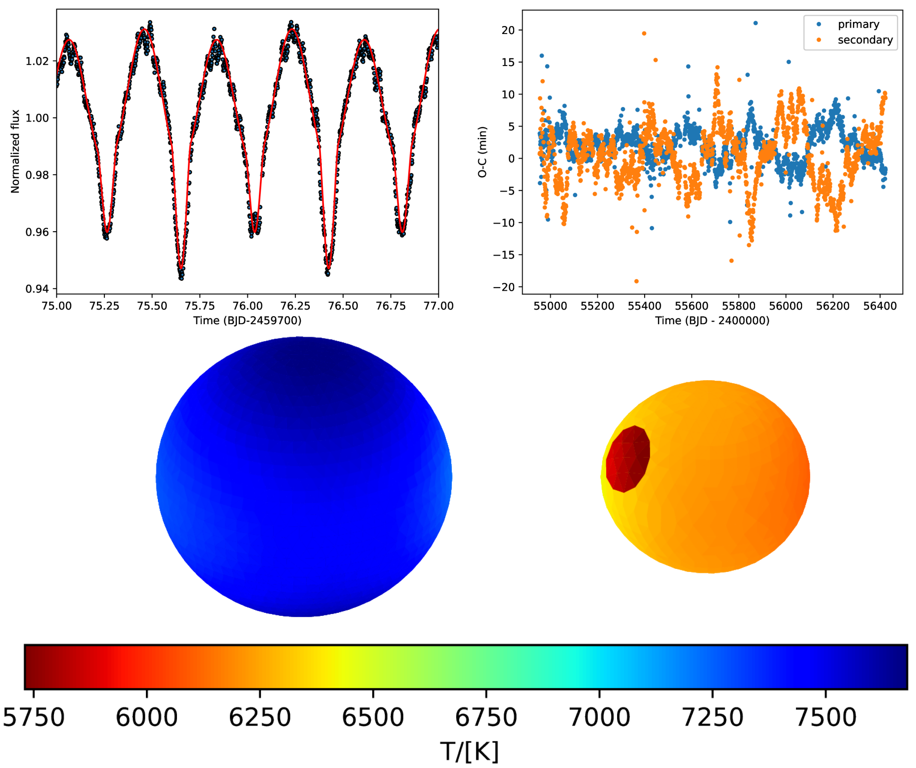

Figure 1. Part of LC obtained by *TESS* mission (*left*) and O-C diagram from *Kepler* data (*right*). Model of studied EB obtained by fitting in ELISa code (*bottom*).

0.01 were used. Because the pulsations were stacked in different phases, this procedure cleared their effect on the LC. Using a longer observing period could also clear out the stellar spots (see Sec. 3) which is undesirable at this step. We modelled the LC in the software package ELISa (Čokina et al., 2021) while assuming a cold spot on a secondary component.

From the model, the temperature of the secondary component is 6500 K (spectral type F6 - F7), the mass ratio is about 0.45 and the orbital inclination is 60°. The angular size of the spot is $\sim 20°$.

3. O-C diagram & O'Connell effect

O-C diagram based on data from *Kepler* (Fig. 1) shows anti-correlated changes which look very similar to that caused by apsidal motion (AM; e.g. Wolf et al., 2013). However, these changes are very fast (with a period of 200–300 days) for considered AM. Data from *TESS* shows similar behaviour.

We focused on the O'Connell effect caused by starspots which was already partially studied by Balaji et al. (2015). We determined the heights of maxima and the difference between them. We found a very strong correlation between heights of maxima and values of O-Cs which suggests that the observed O-C diagram is only the result of the present starspot.

4. Pulsations

Short-period pulsations were detected in the data from *TESS*. Their periods (∼50–100 minutes) are too short to be clearly visible also on *Kepler* data. Our hypothesis is that the primary component is a δ-Scuti pulsator as was already noted by different authors (Murphy et al., 2018; Shi et al., 2022).

5. Preliminary results and future plans

We have used *Kepler* and *TESS* data to study short-period EB KIC 7023917. This EB is a detached or semi-detached system consisting of the primary star of spectral type A7 and colder secondary one of spectral type F6 or F7.

The primary component is a δ-Scuti pulsator with pulsation in a period range of 50–100 minutes. The secondary one contains extensive cold starspot that deforms LC by the O'Connell effect and probably also caused observed changes on the O-C diagram. Both effects require further analysis.

In addition, we are performing ground-based spectroscopic and photometric follow-up observations. We use the OES spectrograph on Perek's 2-meter telescope in Ondřejov (Kabáth et al., 2020) to measure precise radial velocity caused by an orbital motion and to determine basic stellar parameters from spectra. We observe with the 15-cm Maksutov-Newton telescope at the Astronomical Observatory on the Kolonica saddle to obtain multicolour photometry (Sloan's filters g', r' and i' are used) for better characterization of this EB (mainly temperature ratio).

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