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Spectroscopic monitoring of eclipsing binaries at Ondřejov observatory

P. Gajdoš[1,2] **and Š. Parimucha**[2]

[1] *Astronomical Institute of the Czech Academy of Sciences*
251 65 Ondřejov, The Czech Republic

[2] *Institute of Physics, Faculty of Science, Šafárik University, Košice, Slovakia*

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Abstract. To date, a large number of variable stars have been classified as eclipsing binaries. Large photometric surveys such as Kepler, TESS or Plato are finding thousands of new candidates. However, only a few have been studied in detail. Moreover, photometric data provide no information about the masses of stars, which is the key information about the system. Spectroscopic observations and radial-velocity measurements are required for this purpose. Therefore, ground-based spectroscopy is a useful supplementary source of data for large photometric surveys. Additionally, a few interesting phenomena can be discovered using radial velocity curves, which are hardly detectable on the light curve. Binary orbits could be significantly eccentric, the system could have an unusually low mass ratio, or it would not have to be binary at all. Here, we present some interesting systems observed using the OES spectrograph attached at the Perek 2-meter telescope in Ondřejov together with their light curves obtained by the TESS mission.

Key words: eclipsing binaries – spectroscopy – radial velocities

1. Introduction

We used the Perek telescope at the Ondřejov observatory for spectroscopic monitoring of eclipsing binaries (EBs). We selected systems with orbital periods of less than 5 days, brighter than approximately 10 mag, and without any systematic spectroscopic observations and radial velocity (RV) measurements. Data from the *TESS* space mission were used to analyze the light curves (LCs) of the individual binaries. The main goal of this project is to use both sources of data (photometry and spectroscopy) to precisely determine the absolute physical parameters of the studied systems and their components.

This paper presents some initial results of a few systems in which spectroscopy and RV measurements reveal interesting features hidden for photometry-only analysis.

2. Ground-based spectroscopy

For the ground-based spectroscopic observations, we used a fibre-fed echelle spectrograph OES installed on a 2-m Perek telescope at the Ondřejov observatory (Kabáth et al., 2020). The spectral resolution was $R = 50\,000$ in the wavelength range 3600 − 9500 Å. A ThAr lamp was used for the spectral calibration.

The spectra were processed using the standard tools in IRAF. We used the spectrum with the highest SNR as the template spectrum to measure the RVs. For HD 247917, which is an SB2 binary, we created synthetic spectra as a template. The RVs were obtained using the cross-correlation function in ISPEC (Blanco-Cuaresma et al., 2014). It was impossible to correctly measure the RVs of HD 247917 for phases close to 0.0 and 0.5. Therefore, we adopted the KOREL code (Hadrava, 2004) to disentangle the spectra of both the components and precisely determine the RVs in these phases.

3. Discussions

KIC 7023917 is a short-period EB (0.7728 days). The depth and shape of the primary and secondary minima on the LC are very similar (see left panel of Fig. 1), suggesting comparable temperatures and radii of the stars. However, we could only detect the spectral lines of one component, and the amplitude of the RVs was surprisingly small. Further analysis (Gajdoš et al., 2024) showed that the mass ratio is only 0.1, which is unusual for stars with close spectral types (A7 & F6) and radii of 2 and 1 $R_\odot$.

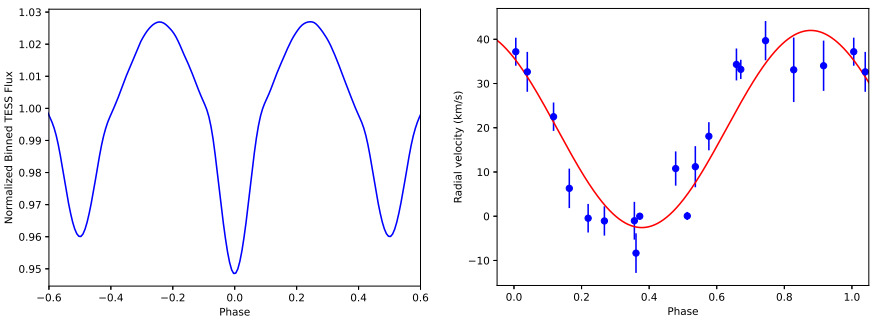

Figure 1. Normalized binned *TESS* LC (*left*) and measured RVs (*right*) of KIC 7023917.

Detached EB HD 247917 consists of two A-type stars with an orbital period of about 2.69 days. The LC looks similar to a normal Algol-type EB without any interesting features. However, the RV measurements classified it as an SB2

binary with a significantly eccentric orbit (upper right panel of Fig. 2). The eccentricity determined was 0.202 ± 0.014. However, the argument of the pericenter ($\omega = 93.2 \pm 0.9°$) causes the phase shift of the secondary minima to be 0.006. Both components have nearly the same masses - the mass ratio is about 0.94. Preliminary LC analysis suggests that they are both main-sequence stars of the later part of spectral type A (probably A8 or A9).

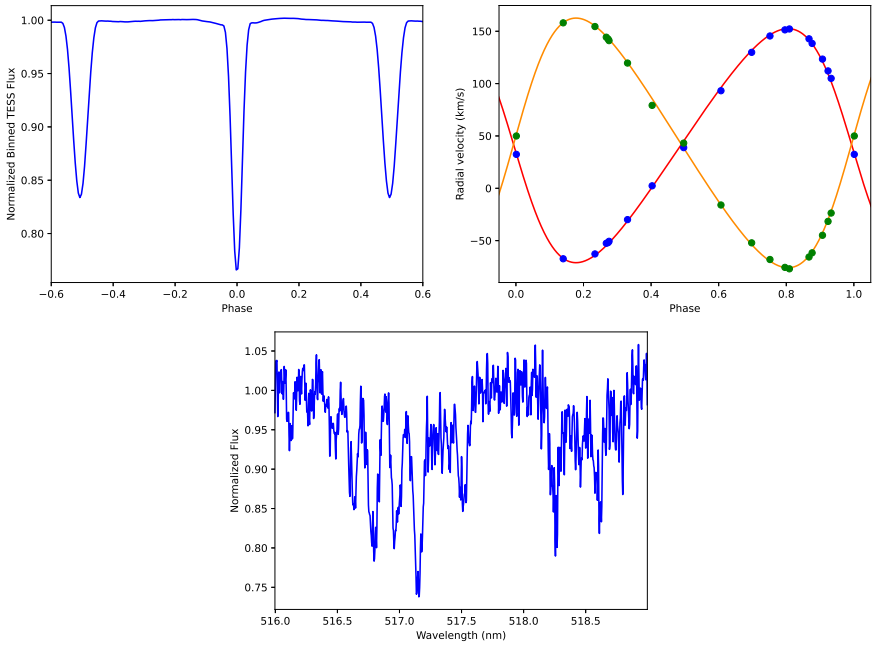

Figure 2. *TESS* LC (*left*) and obtained RVs (*right*) of HD 247917. Example of spectra of HD 247917 for the region of magnesium triplet, close to photometric phase 0.75 (*bottom*).

Star η UMi is classified as an Algol-type EB of spectral type F in the VSX catalogue with a period of 2.2 days. The classification was based on data from *TESS* sector 14 (Shi et al., 2022, highlighted in bold in the *left* panel of Fig. 3)). However, the LCs from the following sectors look weird and definitely differ from the LCs of any kind of EB. Moreover, we could not measure any changes in RVs (larger than 1km/s). Therefore, the system is not binary at all. The spectral lines of this target are extremely broad. We hypothesize that the star is the rotational variable.

A more detailed analysis of systems HD 247917 and η UMi is in preparation.

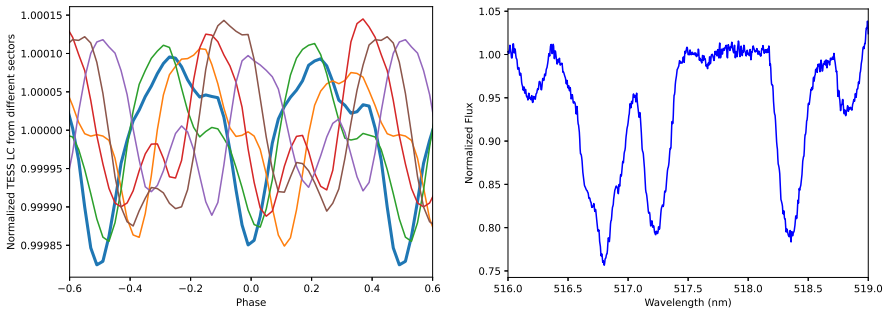

Figure 3. LCs from different *TESS* sectors (*left*) and example of spectra of η UMi (*right*).

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