τ Ori and τ Lib: Two New Massive Heartbeat Binaries

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We report the discovery of two massive eccentric systems with BRITE data, τ Ori and τ Lib, showing heartbeat effects close to the periastron passage. τ Lib exhibits shallow eclipses that will soon vanish due to the apsidal motion in the system. In neither system, tidally excited oscillations were detected.

Following the discovery by Thompson et al. (2012) of 17 stars in highly eccentric systems that show heartbeat effect during periastron passage and sometimes tidally excited oscillations (TEOs), there is a growing interest in the study of such systems. The first massive heartbeat system, ι Ori, was recently discovered by Pablo et al. (2017). We announce the discovery of two more relatively massive eccentric binaries showing heartbeat signals, τ Ori and τ Lib.

τ Orionis (HD 34503, $V = 3.6$ mag) is a visual quadruple system, in which the brightest component A is an evolved mid B-type star classified as B5 III. Variability of the radial velocity of τ Ori A was found over a century ago (Frost, 1907), but up to now no orbital period was derived. In numerous studies, the star was used as an MK standard for spectral type B5 III. It was not known to be variable in brightness. τ Librae (HD 139365, $V = 3.6$ mag), a member of the Sco-Cen association, is a double-lined spectroscopic binary classified as B3 V + B5. The variability of the

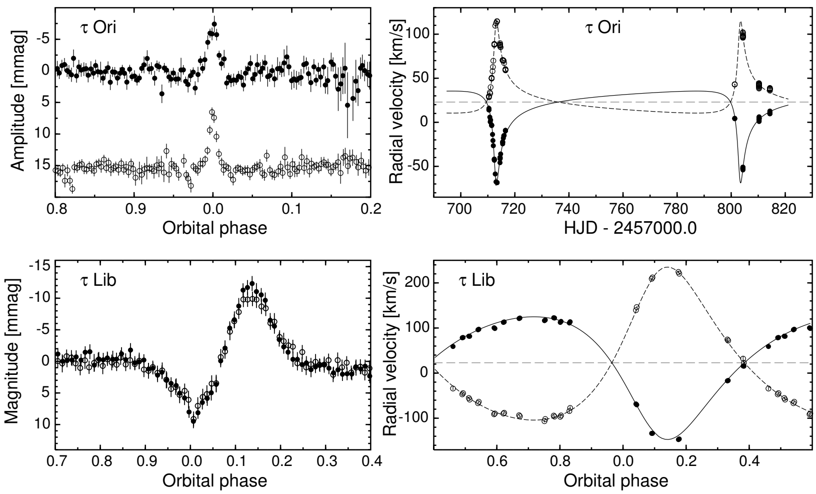

Fig. 1: Left panels: BRITE observations of τ Ori (top) and τ Lib (bottom) in the blue (filled circles) and red (open circles) bands phased with their orbital periods: 90.3 d and 3.4501 d, respectively. Note the shallow eclipse at phase 0.0 for τ Lib. Right panels: Radial-velocity curves for the primary (filled circles) and the secondary (open circles) components of τ Ori (top) and τ Lib (bottom). The solid- and dashed-line curves stand for the preliminary orbital solution for the primary and secondary components, respectively.

radial velocity of the star was found by Moore (1926). Similarly to τ Ori, the star was not known as photometrically variable prior to the BRITE observations.

The two stars were observed by BRITE-Constellation (Weiss et al., 2014; Pablo et al., 2016) in 2013−2016 (τ Ori) and in 2015 (τ Lib). The photometry, obtained by means of the pipeline presented by Popowicz et al. (2017), was subsequently corrected for instrumental effects and analyzed. For τ Ori, it revealed four short brightenings which we interpreted as a possible heartbeat signal in the vicinity of the periastron passage. The blue- and red-filter BRITE light curves of τ Ori phased with the derived orbital period of 90.3 d are shown in Fig. 1, top left panel. For τ Lib, the analysis revealed periodic variability with a period of 3.45 d, again showing a heartbeat shape, with a possibility of a very shallow ($\sim$3 mmag) eclipse (Fig. 1, bottom left panel). The eclipse was confirmed in the Solar Mass Ejection Imager (SMEI, Jackson et al. 2004) observations made between 2003 and 2010, in which it is much deeper (10–14 mmag) than in 2015. This changing shape of the eclipse can be interpreted in terms of apsidal motion.

The discovery of a heartbeat in τ Ori and τ Lib prompted us to organize a spectroscopic campaign. It resulted in over 260 spectra of τ Ori and 42 spectra of τ Lib. The radial-velocity curves (Fig. 1, right panels) show changes typical of eccentric systems. Both stars are double-lined spectroscopic binaries. τ Ori is a system consisting of two stars with practically the same mass (mass ratio $q = 0.997$) in a highly eccentric orbit. The preliminary solution of the radial-velocity curve resulted in $P_{\rm orb} = 90.29$ d, $e = 0.834$, and $\omega = 156^{\rm o}$. According to Thompson et al. (2012), the observed shape of the heartbeat corresponds to an inclination of about $30^{\rm o}$, which implies component masses of about 6 $M_{\odot}$, consistent with the spectral classification. The preliminary spectroscopic parameters derived from the fit shown in Fig. 1 are the following: $P_{\rm orb} = 3.4501$ d, $e = 0.276$, and $\omega = 155.4^{\rm o}$. The inclination estimated at about $66^{\rm o}$ allows to derive masses of 6.6 and 5.3 $M_{\odot}$. The difference between the BRITE and SMEI light curves can be explained by the change of the longitude of periastron. The estimated period of apsidal motion amounts to about 350 years. The eclipses will vanish in a few years. The star will become again eclipsing around 2050, when the secondary eclipse will start to be visible.

No tidally excited oscillations with amplitudes exceeding 0.35 mmag were found in the BRITE data of the two stars under consideration. A detailed analysis of the presented data will be published elsewhere.

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