# Investigation of orbital period changes in 9 short-period eclipsing binaries


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## ABSTRACT


We present the results for orbital period analysis of 9 short period contact binaries (CBs). The photometric data analysed in this work is collected using 1.3-m Devasthal Fast Optical Telescope (DFOT) and multiple ground/space based photometric missions. The changes in the times of minimum brightness (TOMs) are calculated using O-C diagram. Out of these 9 CBs, 4 systems show no change in orbital period with time. Among remaining systems, 2 show decrease and 3 systems show increase in orbital period with time. The period variation in systems is expected to be due to mass transfer between the components. Such type of studies are helpful in order to understand the physical interaction between binary components, mass loss/transfer processes, magnetic activities and detect extra components in the system.


## INTRODUCTION

Eclipsing binaries (EB) are a type of binary systems in which flux variation occurs whenever one component eclipses another component depending on their specific alignment towards the observer. EBs are popular among astronomers as they are used for precise parameter determination and distance measurements. The number of EBs has increased tremendously due to recent ground and space based missions. A large fraction of the EBs observed in these missions have short period or categorised as contact binaries (CBs). The CBs are easier to detect as they show continuous flux variation and have period less than 1 day. The short period CB population covers more than 50% of the overall EB population detected by missions like CRTS, ASAS-SN, Kepler, etc. Apart from being a well known parameter and distance measurement tool, short period EBs provide a way to study component interaction (Kraft et al. 1962). Long term period analysis of such systems can be used to detect period variations and study responsible mechanisms such as mass transfer/loss, magnetic activity cycle, presence of extra component, etc.

This poster shows results from our orbital period analysis for 9 short period EBs. The sources are selected from the Catalina Surveys Periodic Variable Star Catalog. The systems are also mentioned in other surveys such as ASAS-SN, PTF, ZTF, Kepler/K2, TESS, etc. All these systems are classified as contact binaries and have orbital period less than 15 hrs (Drake et al. 2014).

## OBSERVATIONS

To study orbital period behaviour on a large time scale, we searched these targets in all previous photometric archives. The photometric quality of data and short cadence is important in order to determine precise TOMs. Although different targets are available in different catalogues (depending on brightness of target or availability of target due to specific location of observing facility), Kepler/K2 and TESS observations are more precise. Observing facilities used for data collection are listed below:

**SuperWASP**
**2004-2008**

**CRTS**
**~2005-**

**PTF/ZTF**
**2009-**

**TESS**
**2018-**

## METHODOLOGY

To study orbital period variation, we need to extract the observed and calculated (O-C) TOM for each EB at different orbital cycles (E) or times. The shape of O-C plot reveals the behaviour of the evolution of the orbital period of the system.

$$(JD_o^{Eth})_{cal} = JD_o^{0th} + period \times E$$

$$O\text{-}C = (JD_o^{Eth})_{obs} - (JD_o^{Eth})_{cal}$$

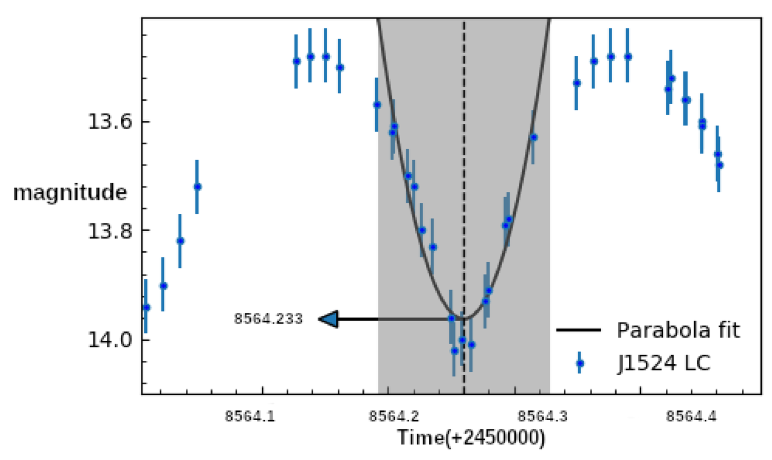



Figure: The Figure shows the parabola fitting (black continuous line) in minimum brightness region for one source.

## METHODOLOGY (Cont...)

The O-C determination involves mainly four steps. These steps are:

**Step-01**
- Observe EBs near primary or secondary eclipse

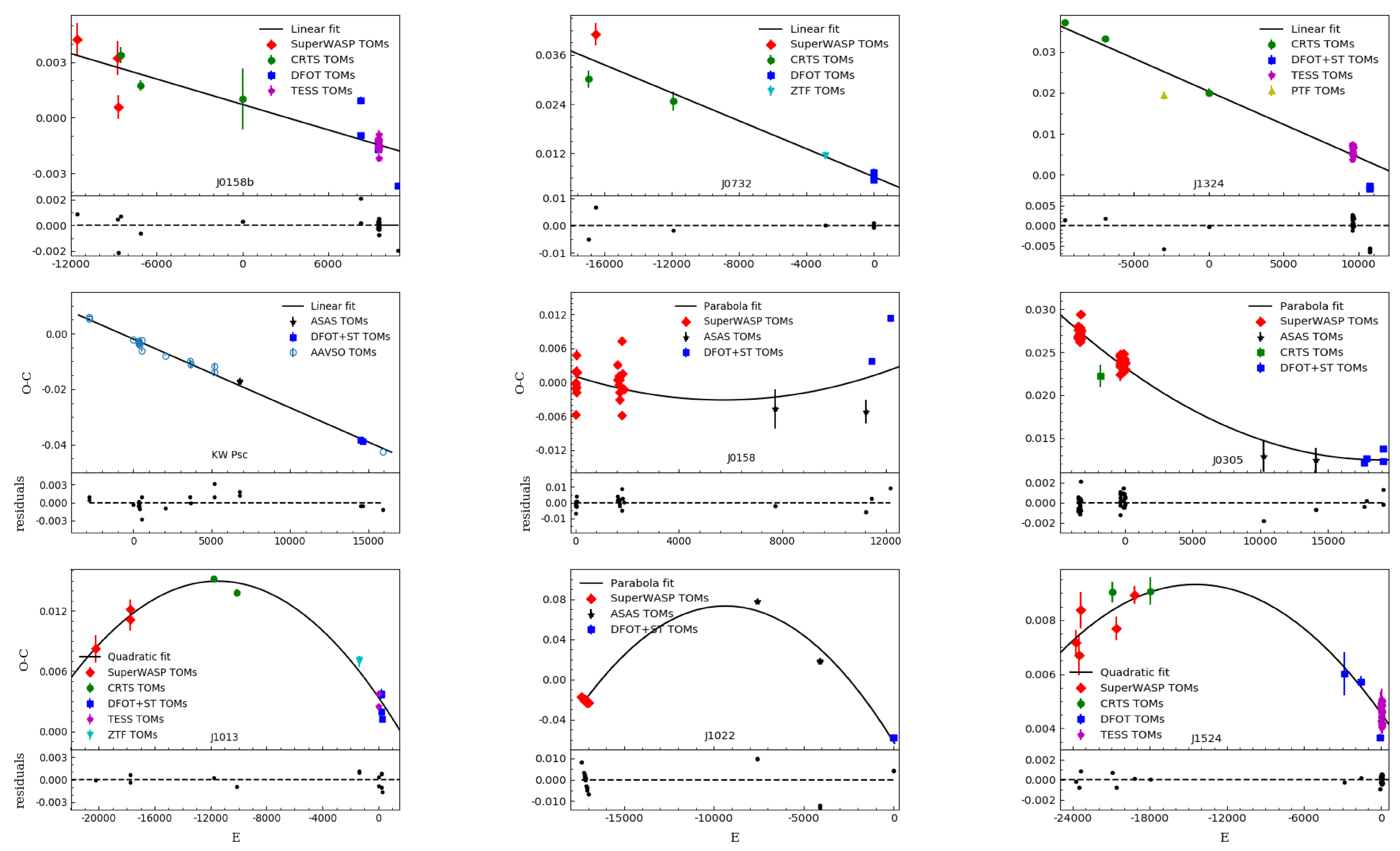
**Step-02**
- Fit parabola in minimum brightness region to get observed TOM.

**Step-03**
- Determine calculated TOM using average orbital period

**Step-04**
- Plot O-C with respect to different orbital cycles

## RESULTS & DISCUSSION

- TOMs determined from ASAS-SN, CRTS and ZTF have large error bars due to poor data quality
- In our orbital period analysis, we detected period variation in 5 systems
- 5 systems show parabolic variation in their O-C diagram which indicates non-variable period. The O-C diagram for each system are shown below:




- The above shown O-C diagrams follow following equations:

J0158b $O\text{-}C = 0.0007(\pm0.0002) - 2.2901(\pm0.2148) \times 10^{-7} \times E$
J0732 $O\text{-}C = 0.006(\pm0.002) - 1.7065(\pm0.1981) \times 10^{-6} \times E$
J1324 $O\text{-}C = 0.0204(\pm0.0009) - 1.611598(\pm0.103038) \times 10^{-6} \times E$
KWPsc $O\text{-}C = -0.00195(\pm0.00030) - 2.47017(\pm0.04911) \times E$
J0158 $O\text{-}C = -0.00104(\pm0.00118) - 1.467(\pm0.906) \times 10^{-6} \times E + 1.283(\pm0.772) \times 10^{-10} \times E^2$
J0305 $O\text{-}C = -0.0005(\pm0.0002) - 1.7986(\pm0.7301) \times 10^{-7} \times E + 3.004(\pm0.472) \times 10^{-11} \times E^2$
J1013 $O\text{-}C = 0.0034(\pm0.0004) - 2.0112(\pm0.1564) \times 10^{-6} \times E - 8.746(\pm0.852) \times {}^{10-11} \times E^2$
J1022 $O\text{-}C = -0.00028(\pm0.00044) + 1.901(\pm1.339) \times 10^{-7} \times E - 7.825(\pm0.678) \times 10^{-11} \times E^2$
J1524 $O\text{-}C = -0.00456(\pm0.00007) - 6.582(\pm0.701) \times 10^{-7} \times E - 2.2773(\pm0.3192) \times 10^{-11} \times E^2$

- The rate of period change are determined as follows:

J0305 $dp/dt = 5.261(\pm1.722) \times 10^{-7}$ days/year
J0305 $dp/dt = 8.881(\pm1.386) \times 10^{-8}$ days/year
J1013 $dp/dt = -2.552(\pm0.249) \times 10^{-8}$ days/year
J1022 $dp/dt = 2.211(\pm0.188) \times 10^{-8}$ days/year
J1524 $dp/dt = -6.792(\pm0.952) \times 10^{-8}$ days/year

- Using the mass-ratio and component masses information for these systems from Panchal & Joshi 2021 and Panchal et al. 2022, we calculated the mass-transfer rates for variable period systems with the help of mass-transfer relation by Kwee (1958).

J0158 $dM_1/dt = 9.8661 \times 10^{-7} M_\odot$ /year
J0305 $dM_1/dt = 3.9301 \times 10^{-8} M_\odot$ /year
J1013 $dM_1/dt = -2.2258 \times 10^{-7} M_\odot$ /year
J1022 $dM_1/dt = 1.1972 \times 10^{-7} M_\odot$ /year
J1524 $dM_1/dt = -6.1247 \times 10^{-8} M_\odot$ /year

The study of EBs is important in order to understand the stellar formation and evolution. As most of the EBs are expected to be a part of multiple system and may have low-brightness or wide orbit extra components, these systems can give clues about multiple stellar systems. Although complete characterization requires photometric and spectroscopic observations, photometric data alone is useful to understand their evolution by studying their period variation with time. In this work, we studied the orbital period behaviour of 9 contact binaries and revealed non-variable orbital period nature for 5 systems. The period change rates are converted into mass-transfer rates between components. Further observations for these systems will be helpful to detect any long term changes or long orbit extra components.

## REFERENCES


-Drake et al. 2014, ApJS, 213, 9
-Kraft et al. 1962, ApJ, 136, 312
-Kwee, K., K. 1958, BAN, 14, 131
-Panchal & Joshi, 2021, AJ, 121, 22
-Panchal et al. 2022, ApJ, 927, 12