Pulsations to the rescue!

TIC47377536 (PG1047+003) might harbor a planet

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Summary

Subdwarf B (sdB) stars are post-main-sequence stars of high temperature (22,000 to 40,000 K) and gravity (log g = 5.0 to 6.2). Their formation and evolution are still not well understood but the most promising formation scenarios involve close binary star evolution.
Approximately 30% of sdB stars show stable pulsations and we can use the pulsation timings to search for the existence and orbital solutions of the sdB binary systems. We used both TESS data and ground observation data to search for the orbital solutions of sdB stars. In this paper, we discuss the pulsation timing variation of a TIC 47377536.

Method

The observed pulse arrival times are compared to the expected arrival times calculated from the ephemeris:

$$BJD = BJD_0 + N\,P \qquad (1)$$

where BJD is the Barycentric Julian Date of a given maximum. BJD_0 is the Barycentric Julian Date of an arbitrarily chosen first maxima (the epoch, E), P is the assumed period of pulsation, and N is the number of cycles from the BJD_0 to any subsequent maximum of interest. When the period P is constant and correct, O-C = 0 for all observed times of maxima. If the assumed period P is incorrect, the O-C variations change linearly and a correct period can easily be computed. If the intrinsic period is changing linearly with time due to the evolution of the star, the O-C variations will exhibit a second-order secular curvature. Except in rare cases when the orbit is perpendicular to the line of sight, a companion in an orbit around a pulsating host star will impose sinusoidal-like variations on the O-C diagram due to the star's changing distance from the observer.

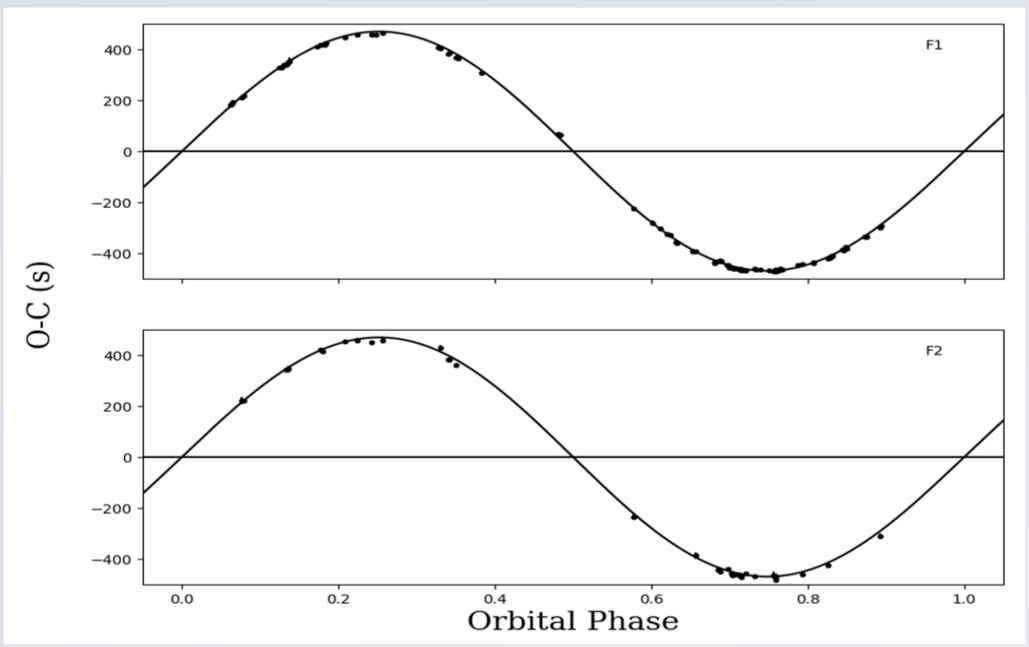

Figure 1. Phase-folded O-C curves for an pulsating sdB star EC 20117-4014 constructed from the largest and the second-largest amplitude pulsation modes (F1: 7.29 mHz at the top and F2: 7.04 mHz at the bottom) (Otani et al. 2018). From this diagram, the orbital parameters (P= 792 0.3 days, *e* = 0.004) was obtained.

Result of TIC0047377536

TIC47377536 (PG 1047+003) is a sdB star which was observed by TESS in 2018 (sector 9, 2-min cadence) and 2020 (sector 35, 20-s cadence). Among six pulsations detected in TESS data, two stable pulsations that have large and stable amplitudes (533.75 cycles/day and 595.04 cycles/day) were used for the O-C analysis. In addition to that, ground telescope data were obtained using SARA-KP and RM telescopes during 2010, 2011, and 2020 right after the TESS observation period.

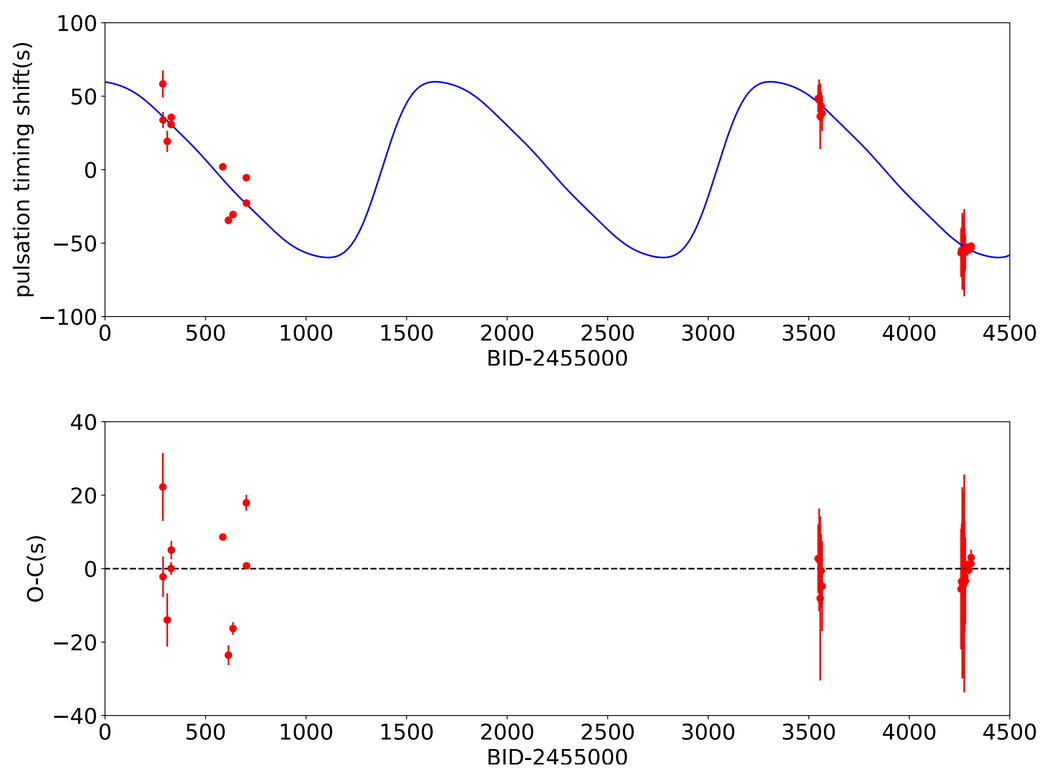

Figure 2. (Top) O-C diagram for a pulsating sdB star TIC 47377536 constructed using 595.04 cycles/day pulsation mode. (Bottom) The residual of the fitted curve (the blue curve in the top diagram, which is due to the existence of a companion). From this diagram, the orbital parameters (P= 1667 days, e = 0.51, mass function f = 0.0001) are estimated. The other pulsation mode (533.75 cycles/day) also shows the O-C variations with the same period and amplitude within the error.
TIC0047377536 is one of the first detected pulsating sdB stars, and it was considered as a single sdB star. Our results show a possibility that this star might have a planet or a companion star, however, more data is needed to confirm it.

References

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Acknowledgements

- This material is based upon work supported by NASA under Grant No. 80NSSC21K0245 and by the National Science Foundation under Grant No. AST-1910396.
- This paper includes data collected by the TESS mission, which are publicly available from the Mikulski Archive for Space Telescopes (MAST) and described in Jenkins2016.
- The SARA-KP 0.9 m and SARA-RM 1.0 m telescopes are owned and operated by the Southeastern Association for Research in Astronomy (saraobservatory.org).