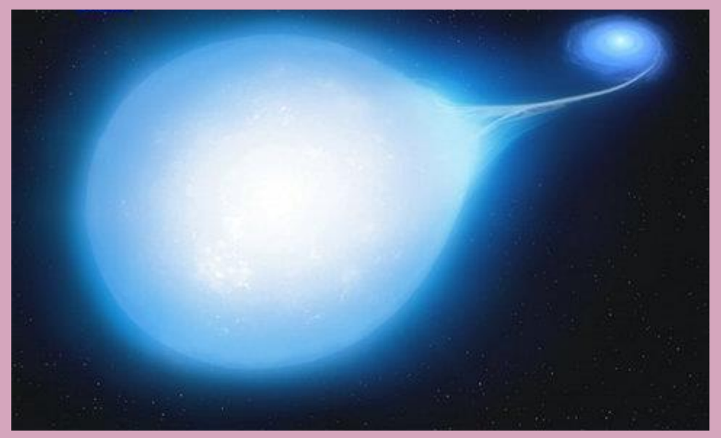
Searching for Binary Systems to Investigate the Formation of Subdwarf B Stars



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Abstract

Subdwarf B (sdB) stars are extreme horizontal branch stars with high temperature and gravity. The explanation for the formation of sdBs is widely unknown. A common theory is that they are the result of interactions in a binary system. About 30% of the sdB stars experience pulsations, and the brightness of the star varies in a cycle. Observing the timing of the pulsation's frequency will determine if the sdB star is a single star or a part of a binary system. This method is called the pulsation timing method. The NASA Transiting Exoplanet Survey Satellite (TESS) telescope can observe the same star continuously for an extended period of time, so the data is perfect for this method, which requires many observations. Using the data from TESS, the objective of this work are to verify that the pulsation timing method is effective in finding binary star systems.

Introduction

- Subdwarf B (sdB) stars are much hotter and brighter than others
- Little is known about their formation, but could be from binary systems
- Some variable sdBs have stable pulsations
  - Pulsation timing variation can be caused by periods of binary systems. To investigate the pulsation timing variation, we can search for the existence of binary systems (pulsation timing method.)

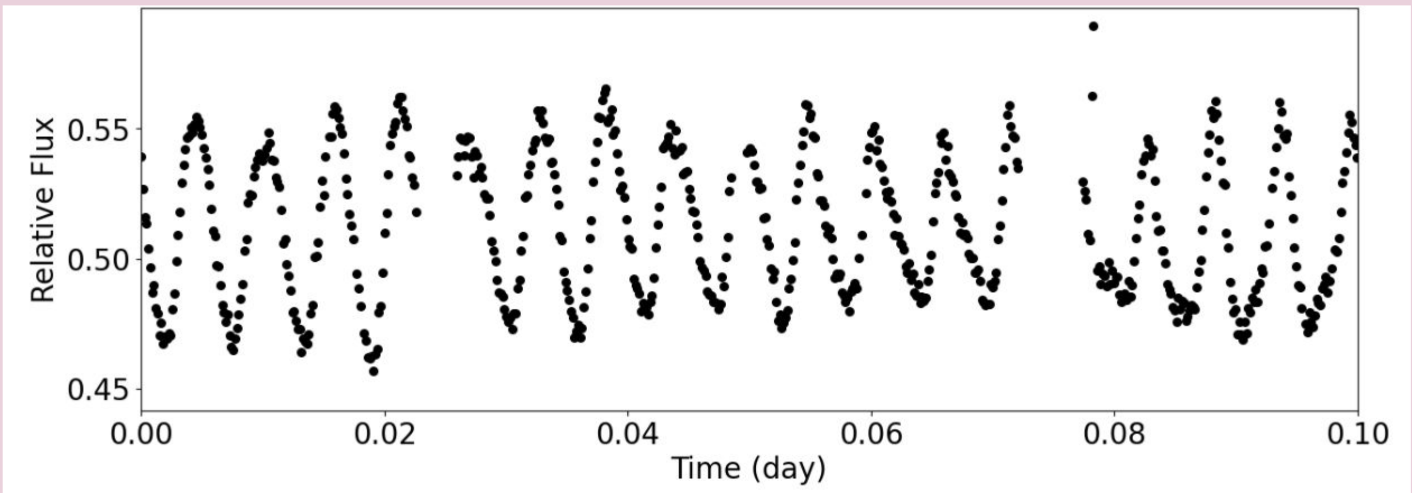

Figure 1. Light Curve of a sdB star, PG1605+072

- NASA Transiting Exoplanet Survey Satellite (TESS) telescope
  - Continuous observing, good for long period sdBs

Methodology

- Using TESS light curves, pulsation timing method was tested for its validity (BPM 36430)
- Data analysis
  - Divide one sector of TESS data (~27 days) into half day sections
  - Determine the pulsation phase for each section. If this is a binary system, the pulsation timing variations should be sinusoidal

Results

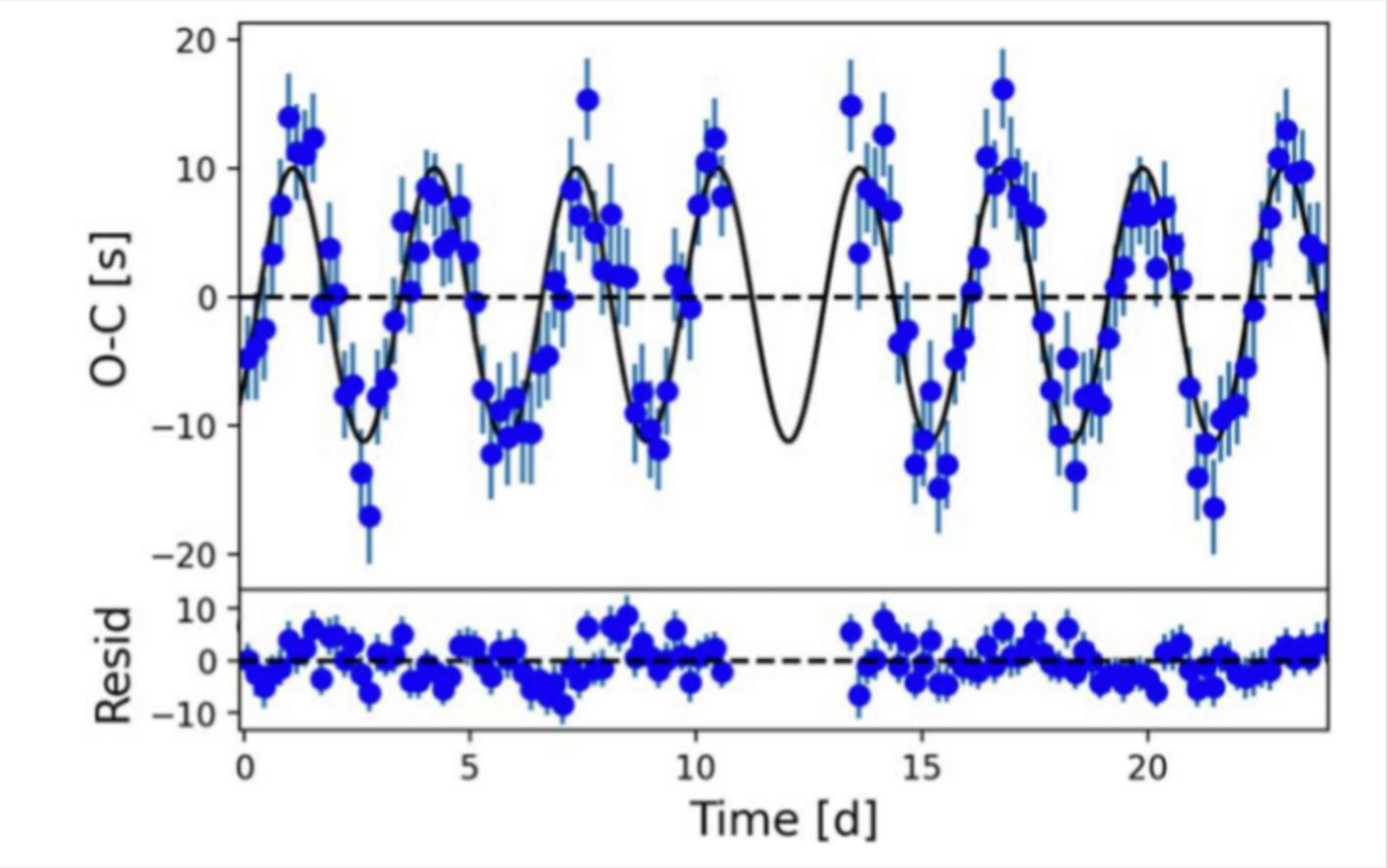

Figure 2. Published results of Smith et al. (2022). Top: The pulsation timing variations (It is also called "Observed minus calculated (O-C)" of published results (Smith et al. 2022). Bottom: residuals after subtracting the best-fitting sinusoid from the data. This shows that BPM 36430 is a binary system with an orbital period of 3.1 days.

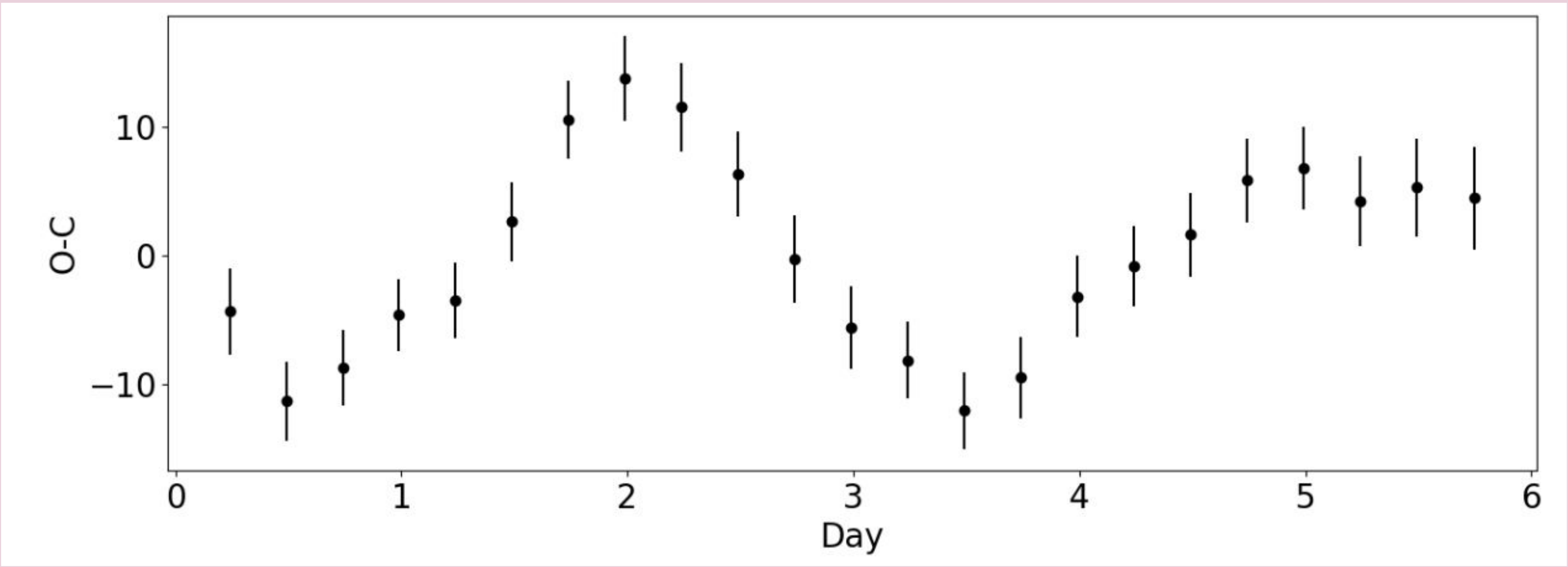

Figure 3. The pulsation timing variations (O-C) that were obtained from our results. Our method could replicate the published results of Smith et al. (2022).

Conclusions

- A frequency of 252.872946 Hz was found
  - This translates to a period of 341.67356 s
- BPM36430 is a part of a binary system
- OC method replicates data from Smith (2022) effectively
  - Same period was calculated as in paper
- Repetition of this method with other sdB targets from TESS
  - Currently working on TESS data of TIC 60985176
- Improve splitting of data to see if a better curve can be created
- Use SARA to compare our own observations with TESS data

References

- Smith, Bryce A., et al. "Pulse Timing Discovery of a Three-Day Companion to the Hot Subdwarf BPM 36430." ArXiv.org, 20 Sept. 2022, ApJ, 939, 57.

Acknowledgements

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