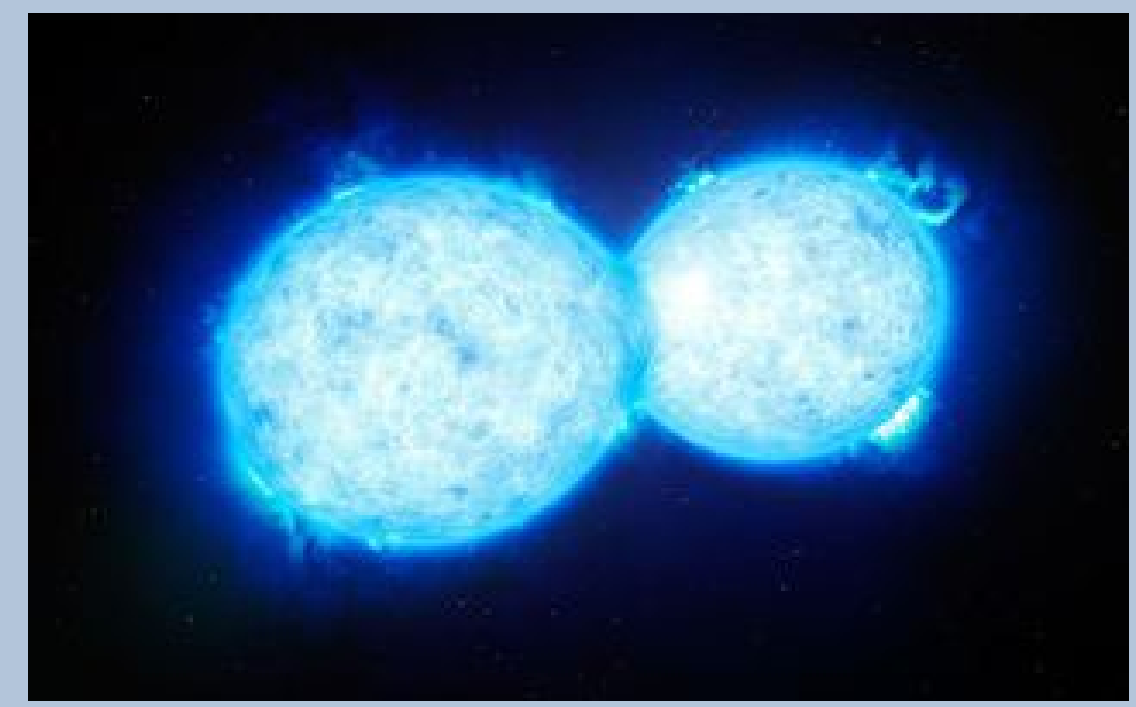




Automating the Subdwarf B Binary Search

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Abstract

Subdwarf B (sdB) stars are extreme horizontal branch stars with high temperature and gravity. The most promising formation scenarios involve close binary star evolution with three different channels, (a) Common Envelope (CE) channel, which can produce short period ($P = 0.1 - 10$ d) sdB + white dwarf (WD) or main sequence (MS) binary systems, (b) Roche lobe overflow (RLOF) channel, which results in long period ($450 < P < 1400$ d) sdB + MS binary systems, and (c) white-dwarf merger channel, which can produce single sdB stars. Unlike other types of stars, sdB types have a myriad of data; however, there is lack of automation code in the RLOF channel due to long-term efforts. This Python program aims to aid these missing areas in sdB binary research by automating the pulsation timing process. This Python program has been proven to shorten the analysis time down to a couple of minutes and has been tested with the target TIC 273218137 (BPM 36430) for accuracy due to the known binary status of the target. This program will be able to decrease the amount of time needed to analyze data and increase the number of discoveries that are able to be made.

Introduction

- A possible method for detecting subdwarf pulsating B (sdB) binaries is the pulsation timing method. [Otani et al. 2018, 2022]
- About 30% of sdB stars show stable pulsations. Detection of unresolved companions and orbital solutions can be obtained by timing the pulsations. Pulse arrival times change periodically as the star's reflex motion is manifested by the changing distance along the line of sight. This is called the pulsation timing method and the same principle used in the late 17th century by Rømer, who used apparent periodic errors in the observed times of mutual events of Jupiter's Galilean moons to estimate the speed of light
- The method we use is called O-C which stands for Observed minus Calculated. This method is performed by taking the observed light curve maxima timing and subtracting the calculated maxima timing that is predicted from theory
- We automated the code we previously built for Transiting Exoplanet Survey Satellite (TESS) photometry data (Clark, Spence, Otani 2023)

Python Script Details

- Requires user to enter Target number (TIC designation)
- Asks users multiple yes/no questions to determine data analysis techniques and figure formatting
- Saves all calculated data to a csv file and saves all figures as a png
- Takes only a couple of seconds to a few minutes per sector to produce requested information

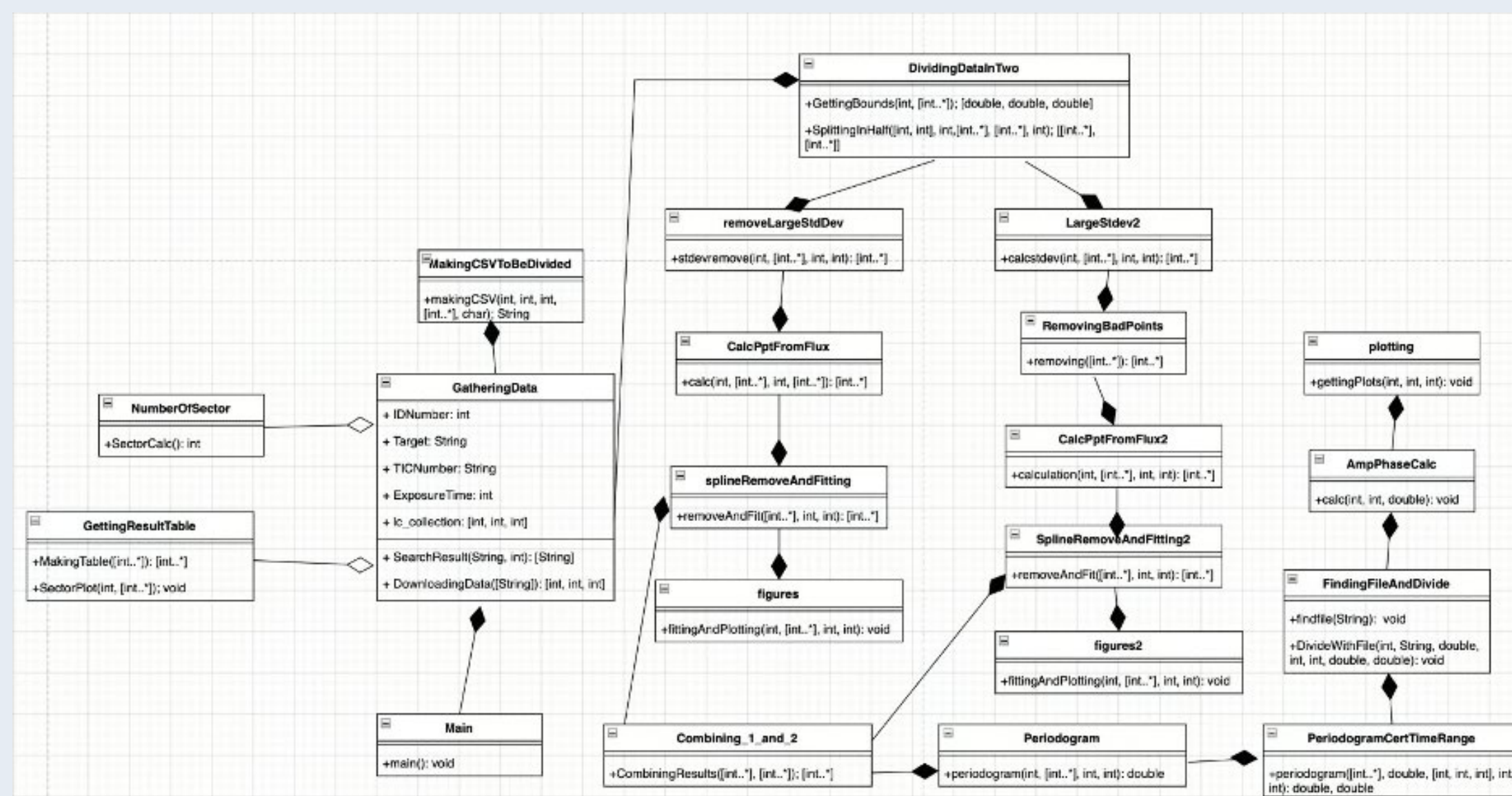


Figure 1: UML Diagram of the Python scripts

Results

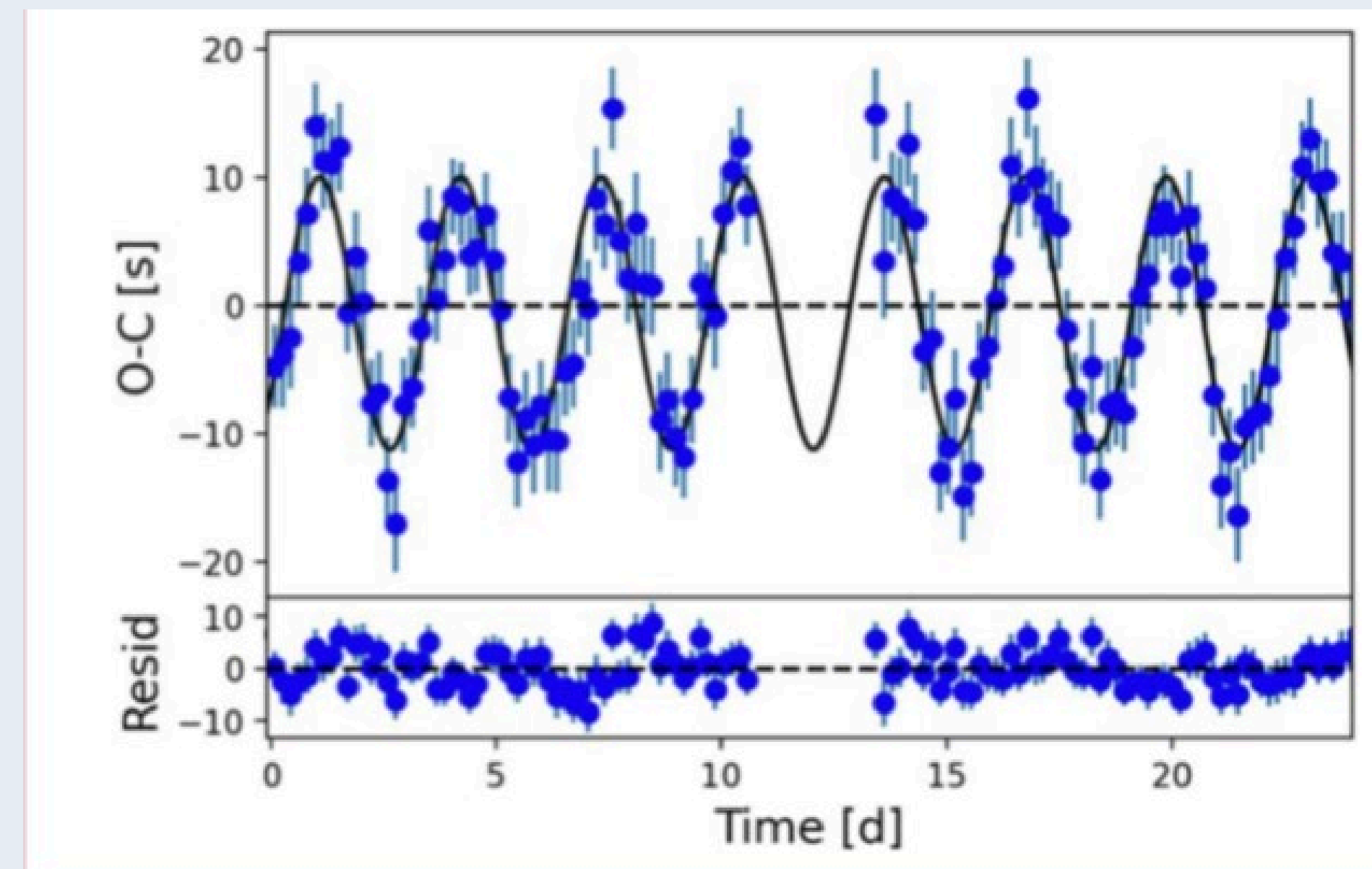


Figure 2: O-C Diagram of TIC 273218137 in Smith et al. 2022 [1]

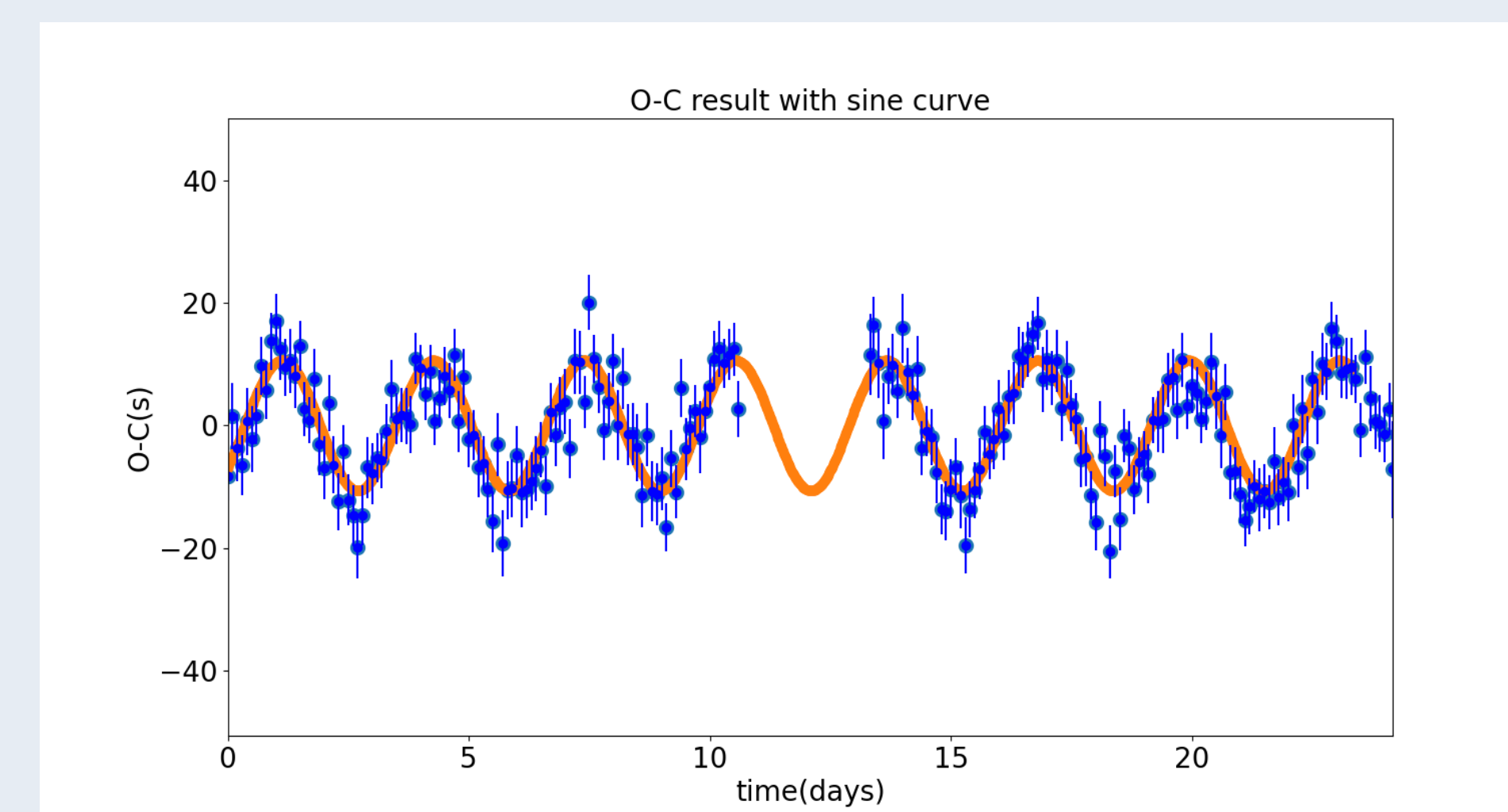


Figure 3: O-C Diagram of TIC 273218137 sector 37 generated from the Python program. Divided by 0.1 days

Conclusions

- From Smith et al. 2022 [1], the phase oscillation period was 3.132 ± 0.009 days
- From the Python program, the phase oscillation period of sector 37 was 3.1324 ± 0.0086 days which is the same as the published results within the uncertainty
- Since all the phase oscillation periods agree, the Python automation program can be considered a success.

Future Work

- Working on adding feature to plot amplitude magnitude variation to eliminate possible false positives
- Adding a functionality to determine if amplitude plot is shifted by 90 degrees
- Providing the user with an option to plot all sectors in one O-C diagram

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Acknowledgements

- L.S and T.O. acknowledges research support from the National Science Foundation (NSF) under grant No. AST-2108975.
- T.O. acknowledge research support from the National Aeronautics and Space Administration (NASA) under grant No. 80NSSC24K0494.