AST424 Project proposal

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October 2025

1 Research proposal information

1.1 Topic chosen

General topic: Pulsating stars.
More specific topic: Comparing amplitudes and periods of various pulsating star types and modeling their light curves.
Possible extension: Conducting an analysis and categorization through a literature review.

1.2 Summary

We will be looking at pulsating transients, focusing primarily on pulsating stars. We hope to model the time-series data for three to four pulsating star types to determine the amplitudes and periods of the pulses. Then we will compare them with each other and draw inspiration from additional literature to conduct a more thorough analysis. In the end, we hope to use our model of the pulsating light curves to compare and possibly categorize different types of objects and find possible reasons why the discrepancies occur.
We were interested in this topic due to our curiosity about the underlying reasons for pulsating objects. We started from the topic of pulsars and found that there was no data on this in the MMU. Thus, decided to shift to pulsating stars in general, which is included in the MMU dataset. The first star type we have picked out is red oscillating giants due to their longer periods. In contrast, we have also selected Cepheid for shorter periods. We are still unsure about the last two star types we will choose. To ensure a strong analysis, we will take a set of 30 to 50 stars per star type and see how these star types have changing amplitudes, periods, and light-curves.

1.3 Planned deliverables and Approach

- **Literature and method review**: We will review several papers that describe core methods and research similar to our project. This will help us identify a range of possible implementation approaches and evaluate which are most suitable for our goals. For instance, to measure amplitude and period, we might compare the peak-to-peak method with the `find_peaks` function from `Scipy`. Each method has advantages and limitations that we will assess before finalizing our approach. (Chat 1)

- **MMU inspection and target selection**: We will examine the metadata from the MMU dataset to identify entries relevant to our study. After compiling all relevant data, we will select a representative subset of targets to test and use it to implement our chosen analysis methods. (Chat 1)
- **Data processing**: Using the selected subset, we will implement our chosen analysis methods to read the time-series data and extract key parameters such as amplitudes and periods for pulsating stars. (Chat 1)
- **Modeling**: We will fit light curves for individual stars and compile the derived parameters into tables and plots. We will also record metrics such as covariance and goodness-of-fit to evaluate which star types provide the least reliable results. (Chat 1)
- **Validation and sensitivity tests**: We will assess the accuracy of our results and estimate error rates. This includes comparing our measurements for a sample star with published values to confirm that our implementation is consistent with existing literature. We will also inspect residuals to evaluate the quality of our fits and identify potential systematic issues. (Chat 1)
- **Population analysis**: We will make an amplitude versus period plots to compare various star types. We will also compare light curves. Then we will try to find reasons for differences.(Chat 1)
- **Write up and optional extensions**: Once the analysis is complete, with the help of results from the literature (as listed in the "Relevant Papers" section) and other resources that will be used, we will attempt to draw conclusions based on our observations. If time permits, we may also pursue additional extensions, such as refining fitting techniques or expanding the dataset. (Chat 1)

1.4 Gantt Chart

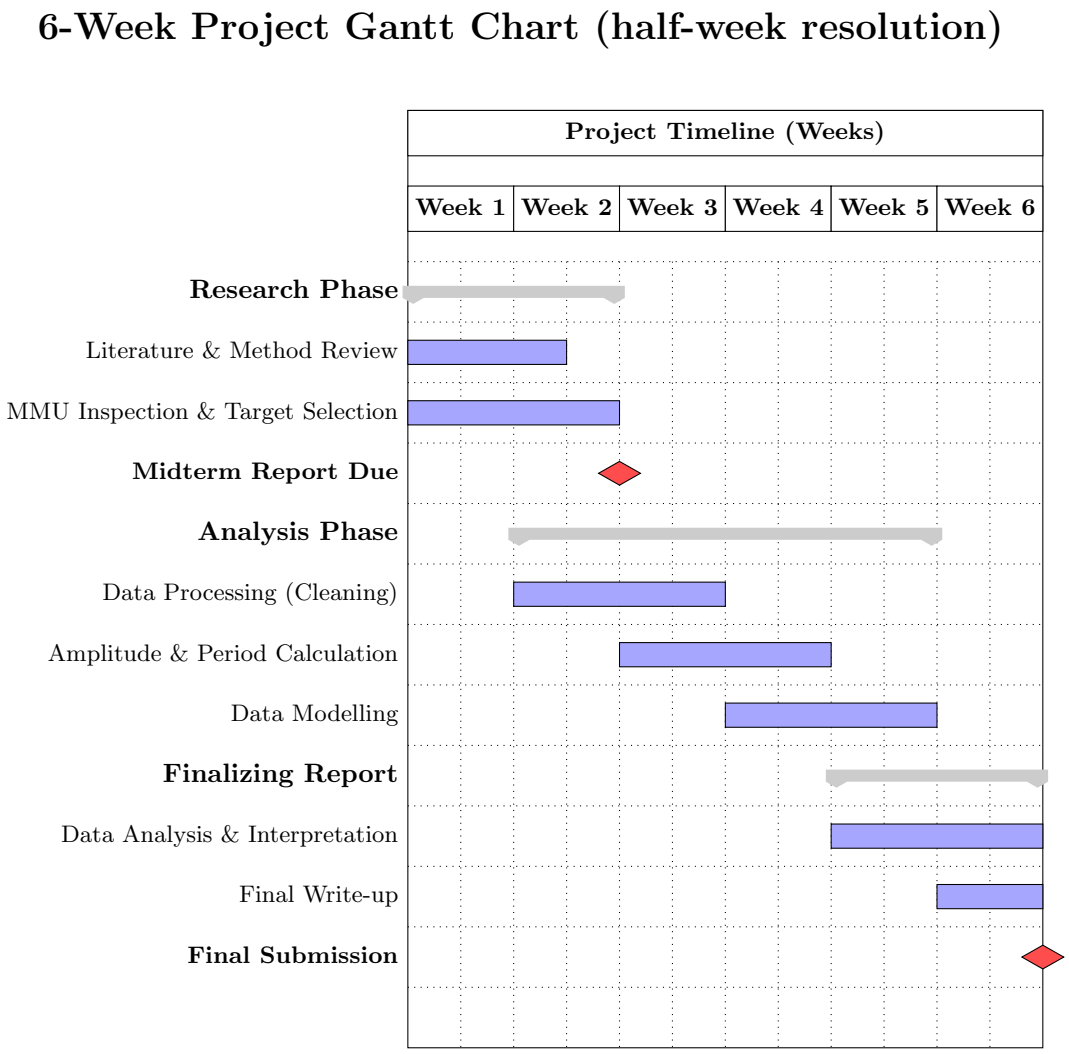

Figure 1: Six-week project Gantt chart outlining when deliverables are expected to be completed. (Chat 2)

2 Contributions

Name	Main Responsibilities	Specific Tasks
Adrien Bonansea	Lead programmer and data analyst	• Implement data extraction, period and amplitude computation, modeling. • Generate figures needed for analysis • Assists in interpretation of results by making new figures related to text • Assist proof reading and in final report assembly.
Dusan Iskic	Data selection and Results overview	• Assist in data selection and cleaning from the MMU dataset • Assist in programming or literature reviews • Draw conclusions and explanations from our data/ results
Amitai Hey	Literature review and writing	• Conduct background research on pulsating stars • Find and Understand various papers published on or similar to our research topic • Help interpret and perform "Sanity checks" of data. • Assist in proofreading and final report assembly
All Members	Collaboration	• Participate in discussions • Report and check up writing

Table 1: Division of responsibilities among group members

3 Relevant papers

3.1 General books/ paper on Pulsating Stars

- The book describes pulsation theory and then describes how to apply them to stellar objects that pulsate. (Cox)
- The book describes many topics related to pulsating stellar objects that will be useful for our research: fundamentals of Stellar Variability, classification of variable stars, pulsating super giant stars, stellar pulsation theory, specific pulsating stars.(Catelan)
- From this paper we will use its information on: radial pulsations of red giants, period–luminosity (P–L) relations and stellar parameters (mass, luminosity, chemical composition). (David)
- The study examines NGC 4559 X7 an ultraluminous X-ray source (ULX), this means it is very luminous, it is an intergalactic x-ray emitter and above the Eddington limit. . The study used XMM-Newton and Swift/XRT data to look at the spectral and temporal evolution of NGC 4559 X7. (Pintore et al)
- Goes into detail on white dwarfs' impotence in astrophysical research such as traces of planetary system evolution, cosmic clocks. (Córsico)

3.2 More specific papers: Pulsating red giants

- The study uses "long-term AAVSO visual observations and Fourier and wavelet analysis" for several semiregular (SR) pulsating red giants and long secondary periods (LSPs). They measure and compare the pulsation periods and amplitudes among each star. (Percy)
- The study proposes a new "pulsation code" for red giants. They then go further and perform exploratory calculations using the said code and find: turbulent energy transport has little effect of pulsation properties and sharp luminosity spikes. (Olivier)

4 References

4.1 Use of AI

AI was used to check english and for Latex formatting
Chat 1: English checker
Chat 2: Gantt graph creation

4.2 Paper references

Cox, J. P. (1974). Pulsating stars. Reports on Progress in Physics, 37(5), 563–678. link

Catelan, M., & Smith, H. A. (Eds.). (2015). Pulsating Stars. John Wiley & Sons.link

Pintore, F., Pinto, C., Rodriguez-Castillo, G., Israel, G. L., Pinciroli Vago, N. O., Motta, S., Barra, F., Walton, D. J., Fürst, F., Kosec, P., Salvaggio, C., Del Santo, M., Wolter, A., D'Aì, A., Ambrosi, E., Burderi, L., Imbrogno, M., Salvaterra, R., Robba, A., ... & (2025). A new pulsating neutron star in the Ultraluminous X-ray source NGC 4559 X7? link

Córsico, A. H., Althaus, L. G., Miller Bertolami, M. M., & S. O. Kepler. (2019). Pulsating white dwarfs: new insights. The Astronomy and Astrophysics Review, 27, Article 7. link

Percy, J. R., & Abachi, R. (2013). *Amplitude Variations in Pulsating Red Giants. JAAVSO, 41*(2), 193–213. Retrieved from link

Olivier, E. A., Wood, P. R., & Sebo, K. M. (2005). Non-linear pulsation models of red giants. *Monthly Notices of the Royal Astronomical Society, 362*(4), 1396–1412. Link