Understanding the Behavior of RR Lyrae RRc Variable Stars by Modelling Stellar Pulsations

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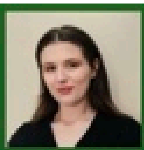


RR Lyrae Variables

RR Lyrae Stars are ancient-evolved, helium-core burning radial pulsators. An RR Lyrae star's outer hydrogen layer compresses under gravity. The star's temperature increases due to trapped energy, as the density of electrons in the gas obstructs energy escape. Eventually, the accumulated energy overcomes gravity, causing the layers to eject outward. This is called the κ - mechanism (Kolenberg, 2012).

In stars which pulsate predominantly in the first overtone, or RRc-type stars, the outer layer of hydrogen collides with the inner helium layer, triggering a flash of energy from ionization. This results in a noticeable light peak occurring well past the time of maximum radius. Observed modulations in the brightness of this compression hump are not fully understood.

Despite pulsations, the average luminosity of each RR Lyrae star is remarkably consistent, making them valuable tools for measuring distances and determining the ages of globular clusters. It is critical to understand these valuable distance markers.

Methodology

The Modules for Experiments in Stellar Astronomy software (MESA) allows for precise variations in many physical parameters, including helium abundance, metallicity, and temperature. Using this software, over 20 models were made with varied parameters in anticipation for comparison with Sx Uma, the chosen RRc-type pulsator.

TESS data of Sx Ursa Major was used for model comparison.

Conclusions

- Limitations of modelling constrain the investigation of the effects of temperature. Temperatures not set properly in MESA caused the model to behave as an RRab fundamental mode pulsitor, rather than the RRc-type selected.
- While data is not available yet, it is still believed that helium abundance may affect the compression hump behavior.
- Metallicity showed no direct effect to the ratios of harmoincs to the fundamental frequency. It is unclear if this is a factor for real compression hump variation.

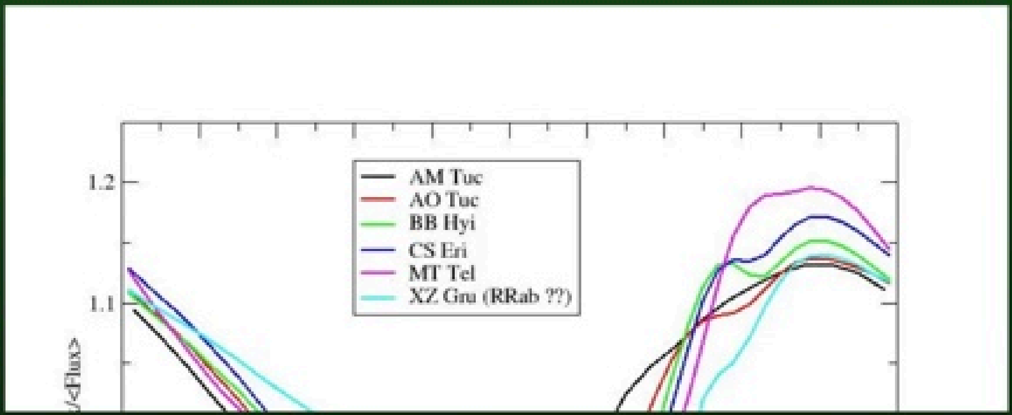
Further Investigation

- Modelling with varied helium abundances has not yet been achieved, but still holds great potential for a better understanding of pulsation features.
- Modelling with varied temperatures may still hold value. There are qualitative differences in the compression hump looking between two temperatures, but there were not enough consistent working models in each temperature to compare across temperature. Work will be done to define limits for temperature specification for different types of variable stars.
- Varying metallicity did not have an influence on the harmonic ratios. This rules out one avenue of exploration.

Effects of Parameters

Objective Question: Which parameters cause differences in an RRc variable's compression hump?

- Metallicity may affect the size of the inner layers, which could cause changes to the radial distance of recombination, changing the compression hump timing or magnitude. The ratio of harmonics to the fundamental frequency may also depend on metallicity.
- Helium abundance is responsible for the size of the helium layer. Different sized helium layers may cause variations in the radial distance of hydrogen recombination, changing the compression hump timing or magnitude.



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