Analysis of RR Lyrae Variable Stars

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1 Introduction

RR Lyrae stars are pulsating stars that occupy the horizontal branch of the Hertzsprung-Russell diagram in the instability strip. They have already lived through their main sequences and red giant phases of life, and now burn helium in their cores [2]. RR Lyrae Variables are "standard candles" in measuring galactic distances and are more often found in globular clusters. There are three main classifications: "ab," "c," and "d." Some RR Lyrae stars experience the Blazhko effect, which observes a change in amplitude and frequency over time. Sergey Blazhko noted this effect in 1907, but the cause of the it has remained a mystery for 115 years. We are trying to better observe the changes from one Blazhko cycle to the next. My research being conducted this summer will focus on using data from the Transiting Exoplanet Survey Satellite (TESS) [3] to analyze and create models of these stars' pulsations in order to further understand why the Blazhko effect occurs, and what causes it to happen.

2 Procedure

The TESS data from six different RR Lyrae stars (type "c") will be used in our sample. Period 04 [5] will be used to analyze picked up frequencies (primary, harmonic, and sidebands). Models will then be created using the data from Period 04. We will also use the Fourier series, which assists in the relative analysis of the Blazhko period:

$$y(t) = Z + \sum A_i sin(\omega_i t + \phi_i) \tag{1}$$

where Z is the zero-point offset. The Blazhko period (P_B) shifts can be measured while keeping careful note of any amplitude changes. The scattered background light will also need to be subtracted when measuring these shifts. Using the Global Astrometric Interferometer for Astrophysics (GAIA) [4], we can make more observations and measurements on different stellar parameters of these variable stars, such as luminosity. We can do this because of GAIA's high-precision, which allows us to use parallax to compute said luminosity.

The research being done this summer will mostly involve data analysis, but there may be opportunities for observational work as well. This will be conducted using the MacAdam Student Observatory to obtain light curve data from the Blazhko sample stars. To reduce and analyze this data, we will use AstroImageJ [1]. This program is useful because it allows us to check for spacial resolution. TESS data uses very large pixels (about 21 arc seconds) so neighboring celestial objects fall on the data pixel. The MacAdam data (which has a spacial resolution of about 3 arc seconds) can be used to test the contribution of the neighboring objects to light curve variations because of the high spatial resolution.

References

[1] Karen Collins. *AstroImageJ ImageJ for Astronomy.* URL: `https://www.astro.louisville.edu/software/astroimagej/`.

[2] Paul A. Greer. "Characterisation Of The Blazhko Effect In RR Lyrae Stars Using SuperWASP Data". In: *PhD thesis The Open University.* (2018).

[3] MIT. *TESS.* 2022. URL: `https://tess.mit.edu/`.

[4] NASA. *Gaia.* 2019. URL: `https://solarsystem.nasa.gov/missions/gaia/in-depth/`.

[5] Period04. *Homepage of Period04.* 2022. URL: `https://www.univie.ac.at/tops/Period04/`.