Research and Creative Experience for Undergraduates (RCEU) Program 2024

Using Pulsating White Dwarfs as Accelerometers

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Overview

- Pulsating White Dwarfs(PWDs) are white dwarfs that, when they cool to certain temperatures, incite convection zones. These drive the pulsations of the star causing it to increase and decrease in luminosity.
- Using these pulsations, we used methods previously used on binary pulsars to determine if it is possible to use these stars as accelerometers(a device, or PWD in this case, that can measure acceleration).
- Applying those methods on these PWDs we determined the stars': period of pulsation(P), observed change in pulsations($\dot{P}^{obs}$), change due to the shklovskii effect (Refers to a stars increase in period due to its proper motion across the sky. This can be seen in figure 6 below in which the proper motion(μ) leads to a change in distance to the source.)shown here as $\dot{P}^{shk}$, and finally other effects shown as $\dot{P}^{obs} - \dot{P}^{shk}$.
- The next step after determining the feasibility was to check if there were any other influences that could affect the period such as the release of axions(theoretic dark matter particles that could increase the cooling rate of the PWDs upon there release from the core). Finally, we determined the physical parameters of a star that affect the measurement of galactic acceleration using this method(Table 1).

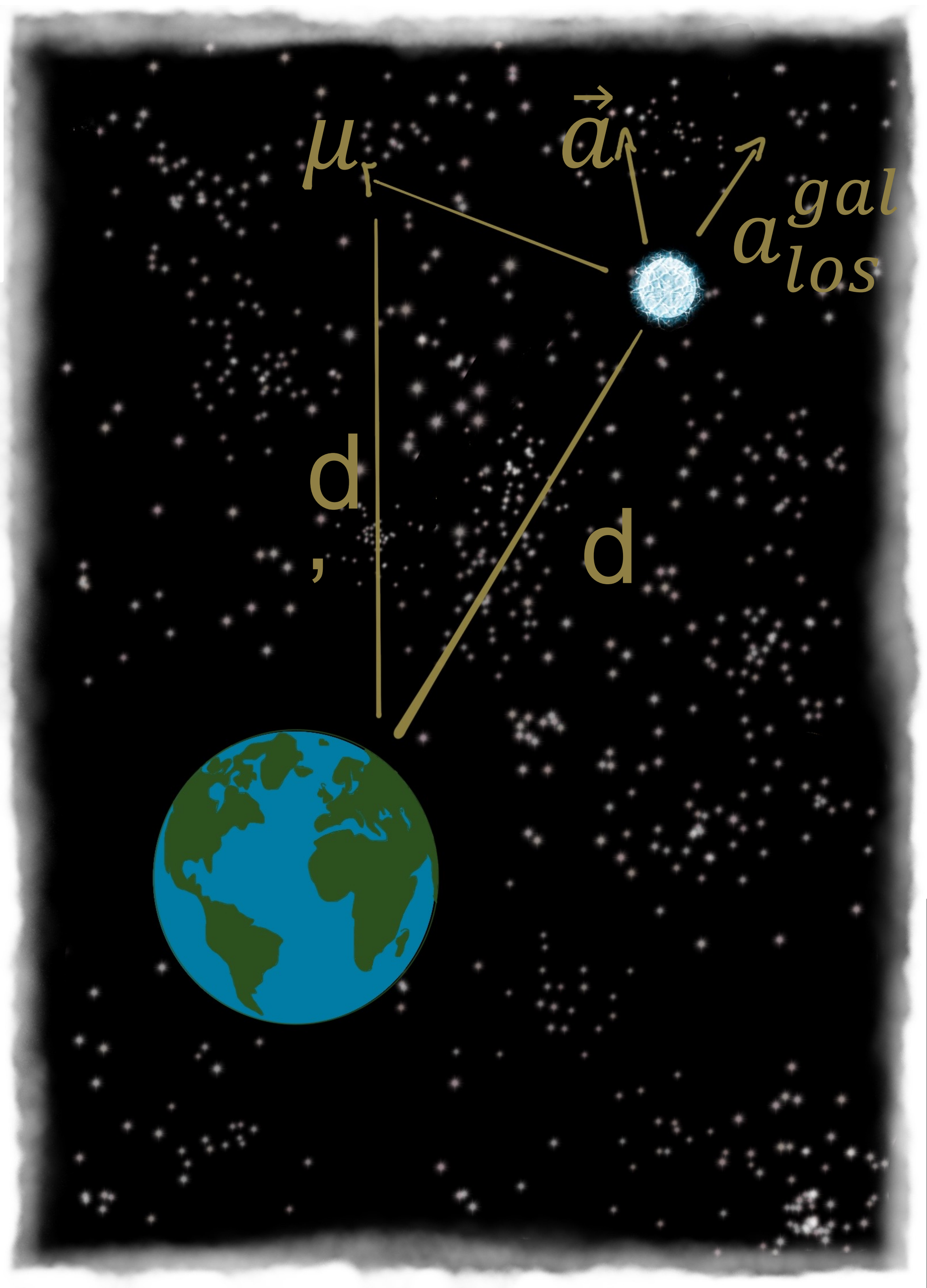

Figure 4
Author's own Illustration

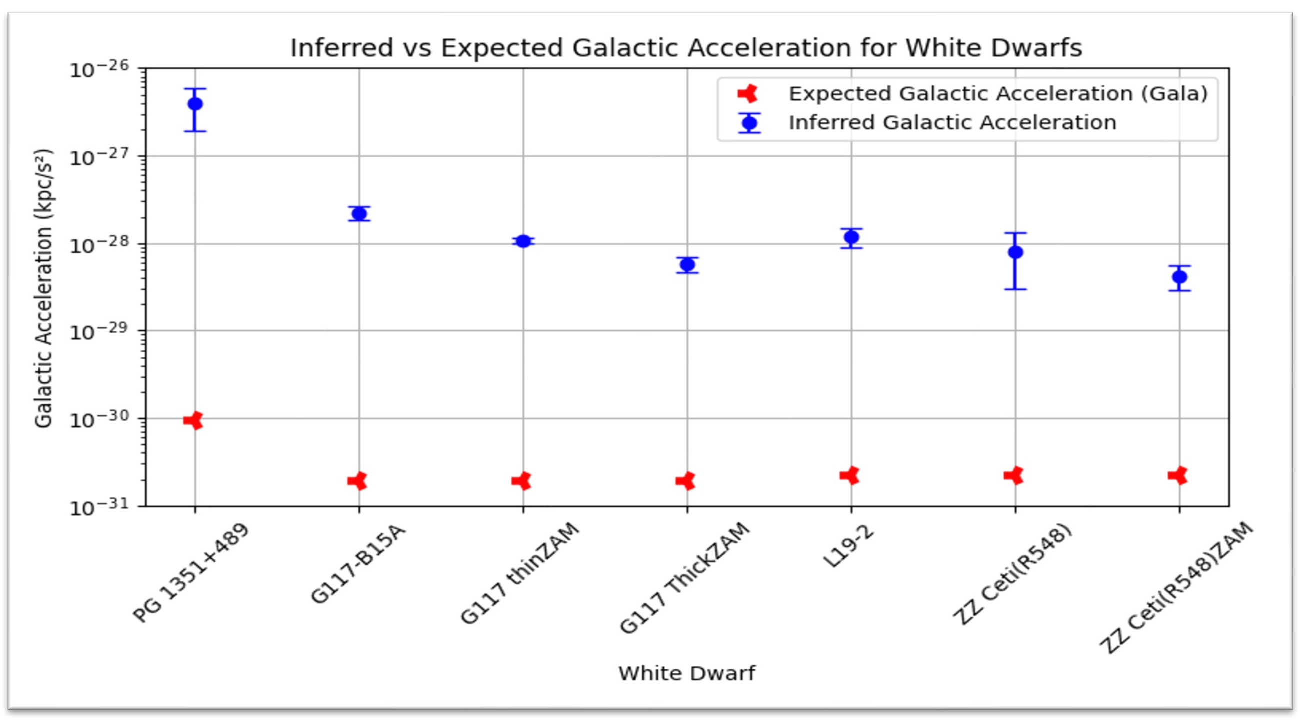

Fig. 1. In this figure the inferred galactic acceleration is compared to the expected galactic acceleration in that location.

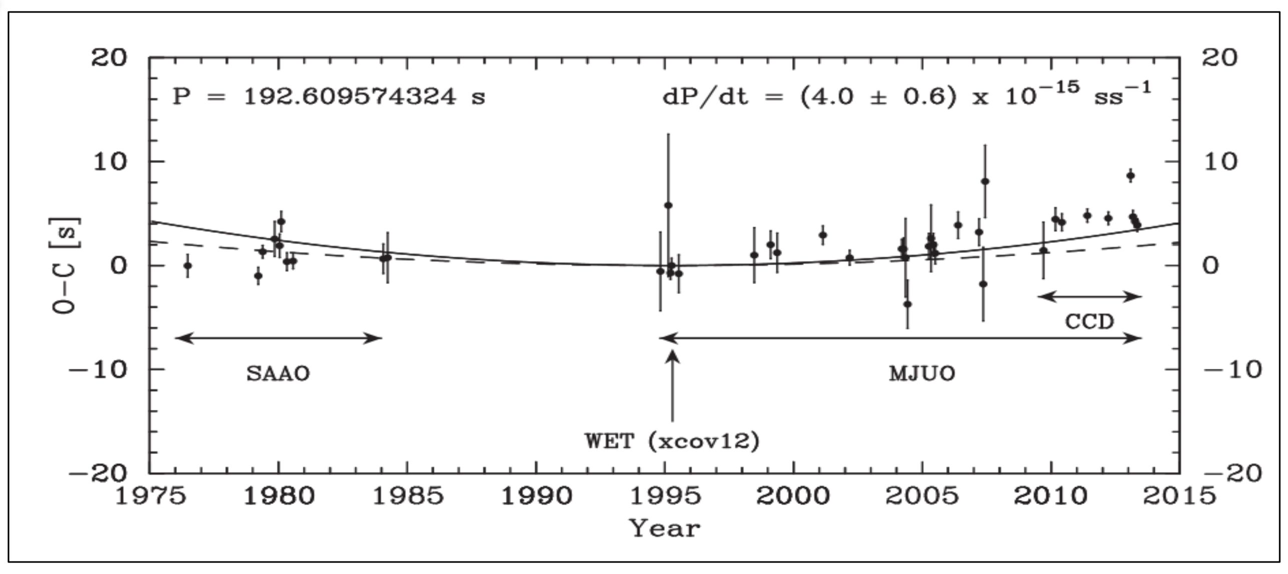

Fig. 2 This is a O-C or observed minus calculated chart of the PWD L19-2. This chart allows us to see the difference between the observed time of an event and the calculated time. (Sullivan)

Methods

- The first step in the project was to determine the shklovskii effect and the line-of-sight acceleration(a_{los}^{gal}) using standard formulas
- After finding the a_{los}^{gal}, the next step was to compare the inferred value with that of the expected value (Figure 1).
- The next step was to check and see if axions were affecting the $\dot{P}^{obs}$ and could give us a better inferred value of the a_{los}^{gal}. The result of this research showed us they had little to no effect. However, we were able to see the effects of the Zero Axion Model(ZAM) (the effect of cooling due to only photons) (Figure 1).
- Finally, the parameters of a good candidate for use of a PWD were checked(Table 1). These values show us the parameters that are describe the best white dwarfs that can be used as accelerometers given more research and observation.

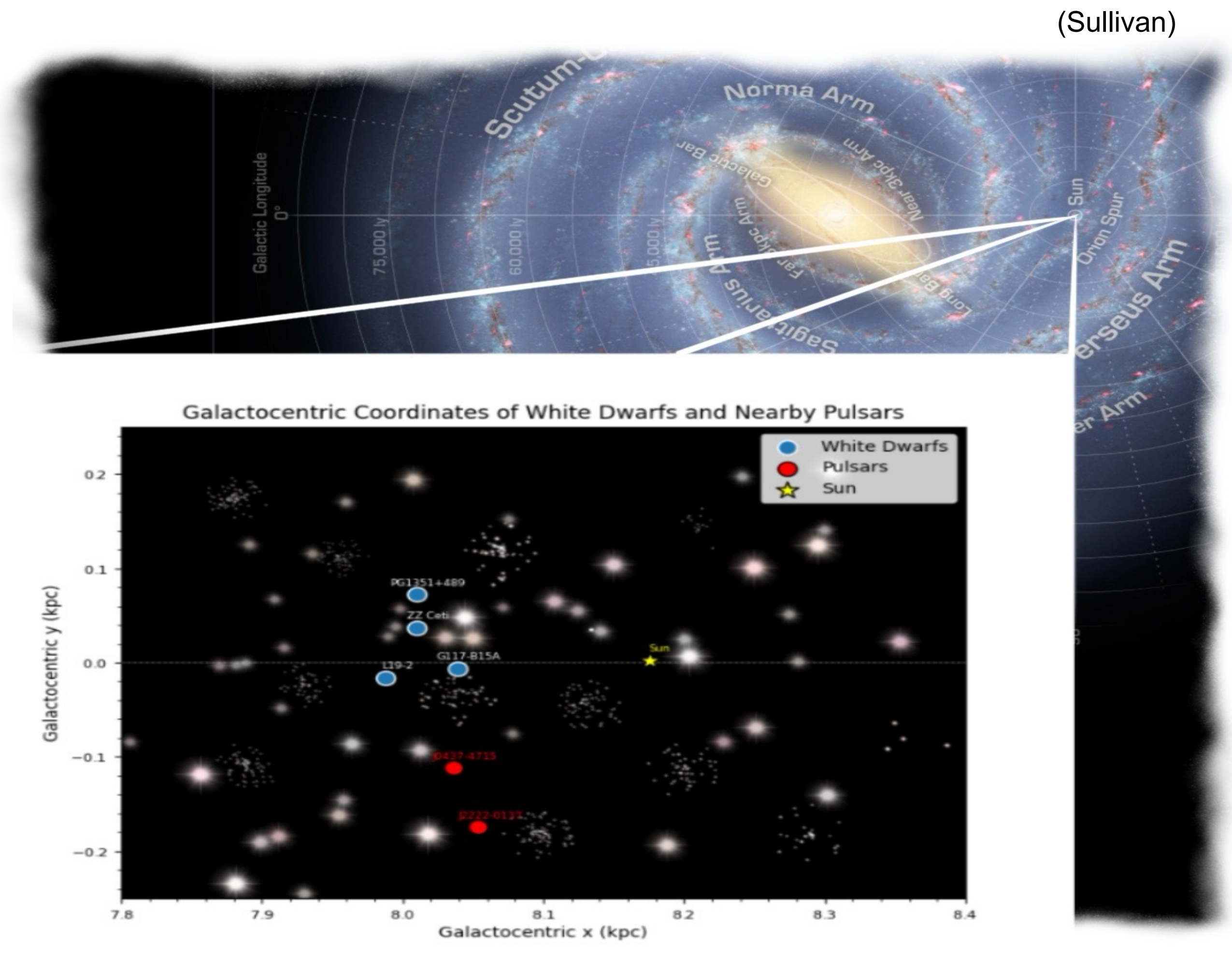

Fig. 3 In this figure the galactocentric coordinates of the white dwarfs are plotted and compared to nearby pulsars

Key Findings/Conclusion

- The inferred galactic acceleration that was found (Figure 1) ranged from 1-2 orders of magnitude away from the expected outcome.
- However, this research gave us insight on what would be required of the PWDs to be used, what information they can give if usable in the future, and what parameters allow for a good candidate.
- For the PWDs to be usable more research would be needed on the effect of cooling on the $\dot{P}^{obs}$ and simply the $\dot{P}^{obs}$ itself as an error of at most 20% is required for use in calculations.
- Most of the PWDs lie close to the galactic plane(Figure 3). In the future, PWDS can give us significant data regarding the galactic disk.
- Finally, the parameters for a good PWD candidate(Table 1) is that it needs to be a DA PWD.

	G117-B15A	R548	L19-2	PG1351+489
T_{eff}(K)	11599	11834	12147	26373
Log(g)	7.987	7.937	8.115	8.048
Cooling Time(Gyr)	0.4255	0.3735	0.446	0.0177
Radius($R_{\odot}$)	0.013	0.0134	0.0119	0.637
Luminosity ($L_{\odot}$)	0.00274	0.00315	0.00276	0.06767
Atmosphere Composition	H	H	H	He
Mass($M_{\odot}$)	0.597	0.569	0.675	0.665
Spectral Type	DA	DA	DA	DB

Table 1. In this figure the Effective temperature as well as other parameters of the listed white dwarfs are displayed. Green indicates the better candidates and red the worse.

References

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