White Dwarf Stars and the Age of the Milky Way

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Abstract

The goal of this paper is to develop a technique to determine the age of formation of the Galactic thin and thick disks. To achieve this goal, we calculated the U, V, and W velocity components for thousands of Gaia white dwarfs and ran the BASE-9 Astro statistics software modules single PopMcmc and sample WDMass. Classifying the white dwarf stars into three Galactic populations was another important part of the study. We classified 101418 thin disk stars, 3158 thick disk stars, and six halo stars. The findings suggest that one out of the six halo stars —star 4108—is a white dwarf star that we can model. Its age is 5.62 Gyr, which is inconsistent with the age of the Galactic halo and thus this star is probably a velocity interloper. To further investigate stellar populations, we will apply the same method for the thick disk population candidates. The age of the thick disk would help broaden our knowledge of this star population and place it more fully into the history of the formation of the Milky Way.

$$\begin{bmatrix} u \\ v \\ w \end{bmatrix} = B \begin{bmatrix} \rho \\ \frac{k\mu_{\alpha}}{\pi} \\ \frac{k\mu_{\delta}}{\pi} \end{bmatrix} \quad \text{eq. 1}$$

Equation 1: UVW Velocities

Explanation: we used this equation to calculate the UVW velocities

Methods

1. We used the Gaia DR3 astrometry to calculate the U, V, and W velocities for all WDs that passed certain astrometric and photometric cuts (Johnson & Soderblom, 1987).
2. Unfortunately, we do not have radial velocities for any of these stars, so we need to estimate their space motions based on two of the three velocity components (Pasetto, Grebel, Zwitter et al, 2012).
3. We calculated the probability and the uncertainty of the probability that each star belongs to thin disk, thick disk, or halo populations.
4. We plotted the halo candidates in a color-absolute magnitude diagram and found that five out of six halo candidates are consistent with being white dwarfs.

Table 1: Average Galactic Velocities of Stars by Stellar Population (km/s)

velocity component	U			V			W		
population	thin	thick	halo	thin	thick	halo	thin	thick	halo
mean	0	0	0	0	-40	-196	0	0	0
standard deviation	35	50	141	18	45	75	25	50	85

Source: Pasetto, Greber, Zwitter et al. 2012

Table 1: The UVW Velocities of the GAIA Stars

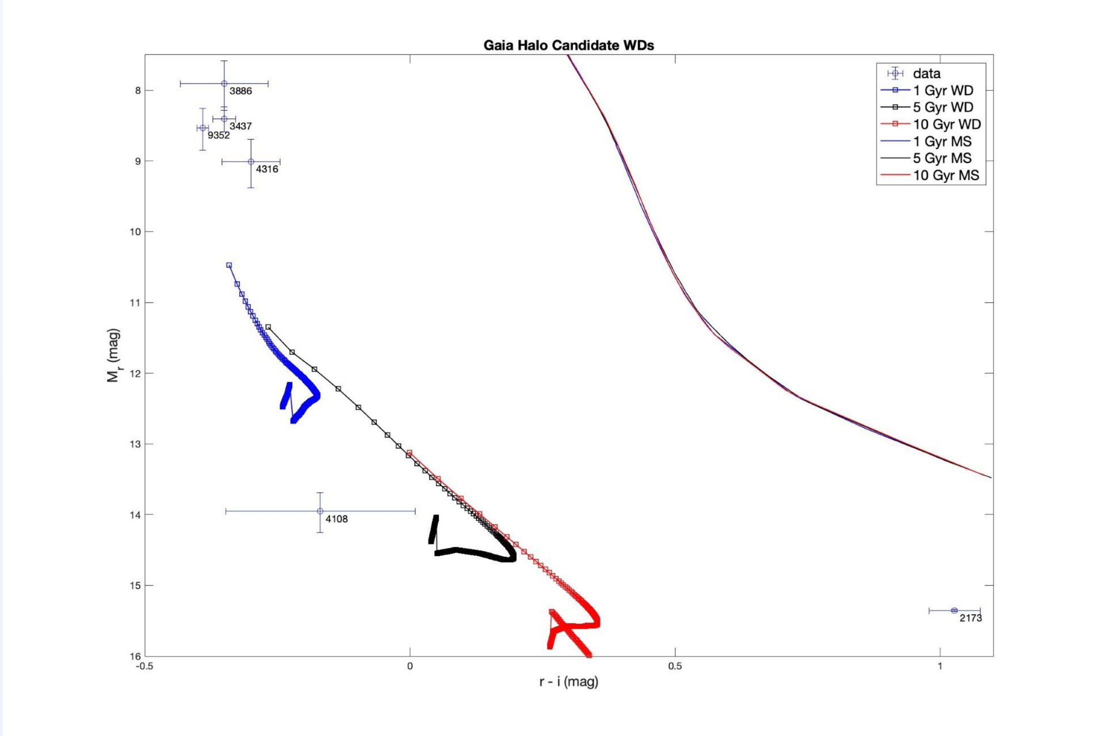
Findings

Star type	Probability used	Number of stars
Thin disk	P1>0.5	101418
Thick disk	P2>0.5	3153
Halo	P3>(P1+P2)	6
Total	-------------------------------	104577

Table 1: The UVW Velocities of the Stars

Having taken these six stars' positions on the CMD and their stellar characteristics into consideration, we can conclude that all these stars, with the likely exception of star 2173, are white dwarfs.

Figure 1: The HR Diagram of the Six Halo Candidates



Explanation: The HR diagram above shows the approximate locations of the white dwarf stars

Future Work

We have not yet derived ages for the hottest white dwarfs because BASE-9 does not yet incorporate models for these stars. These hot white dwarfs have spent the majority of their evolution in earlier stages, particularly the main sequence, and therefore their total ages will be uncertain due to uncertainties in the Initial-Final Mass Relation. More halo white dwarfs are required to derive a halo field star age. To further investigate stellar population ages, we will apply the same method to the thick disk candidates. Their ages are expected to offer insight into the formation of the thick disk, for which currently there is little age information.

Works Cited

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