White Dwarf Stars and the Age of the Milky Way

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Abstract

Our research objective is to determine the ages of the Milky Way's stellar populations using our derived velocities from thousands of white dwarf stars. Right ascension, declination, parallax, and proper motion values for known white dwarfs were taken from the Gaia Observatory database to calculate U, V, and W velocities relative to our position in the Galaxy. We wrote two codes —one in *Matlab* and one in *Python* — to assist with error propagation. Assuming that the input error distributions are Gaussian and that the transformations from the astrometric data to the U, V, and W velocities are sufficiently linear, we calculated the probability that each star belongs to the Galactic thin disk, thick disk, or halo. We are working on determining the ages of these star populations. The halo stars are the oldest of the three types; therefore, the average age of this population could give us an accurate estimate of the Milky Way's age.

Objective and Methods

Did you know that the average thin disk star can travel from Daytona Beach to Tampa in ***one second***? We found out that star velocities can help classify them into three groups: thin disk, thick disk, and halo. Using *Matlab,* we wrote a code to calculate the U, V, and W velocities of our sample. These velocities are perpendicular with respect to each other and to the plane of reference. The next step was to calculate the uncertainties and to display them for 1% of the data. Clearly, most velocities do not exceed 200 km/s and are not lower than -200 km/s.

Graphs

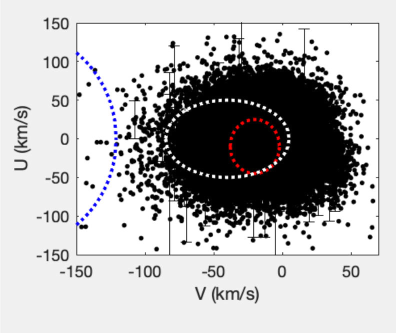


Figure 1 :The U-V velocity graph with error bars for 1% of the data points

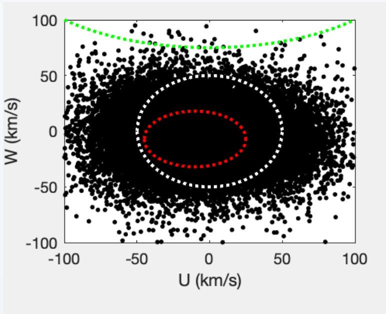


Figure 2: The W-U velocity graph with error bars for 1% of the data points.

An Explanation

- **Red ellipse** – the stars in this region are, most likely, thin disk stars. Their velocities are within one standard deviation from the mean
- **White ellipse** – the stars in this region , if they are also not in the red region, may well be thick disk stars
- **Green ellipse** - the stars in this region are, most likely, halo stars

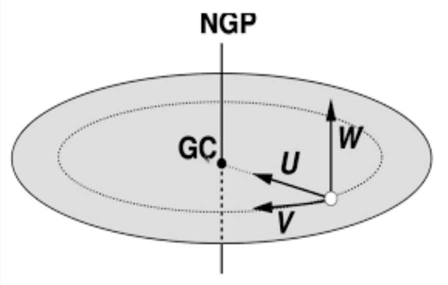
Velocities and Uncertainties

Variable	Thin disk (km/s)	Thick disk (km/s)	Halo (km/s)
U Velocity Mean	-10.0	0.00	0.00
U Velocity Standard Deviation	35.0	50.0	141
V Velocity Mean	-20.0	-40.0	-196
V Velocity Standard Deviation	18.0	45.0	75.0
W Velocity Mean	-7.00	0.00	160
W Velocity Standard Deviation	25.0	50.0	85.0

Definitions

- **A white dwarf star** – a star that is mostly composed of electron-degenerate matter. Its atoms no longer undergo fusion, which means that these stars are basically dead. Yes, space is a graveyard…
- **U, V, and W velocities** – the three velocity components of stars, perpendicular with respect to each other, the disk plane of the Milky Way Galaxy, and the orbital direction of the Sun.
- **The Gaia Observatory** – the source of our white dwarf data. This observatory is part of the European Space Agency

A Visual Representation of U, V, and W Velocities

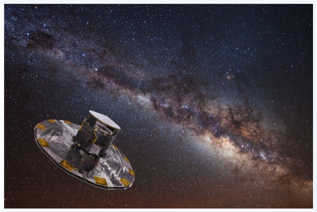


Source: Fellowship Program of India

Future Work

We know that the Big Bang started it all, but when were white dwarf stars born? After classifying these stars into their three categories, the next step will be to calculate the ages of the white dwarf stars.

The Gaia Observatory
Source: The European Space Agency



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