

Assignment 5:

0.1 The distribution of the Solar Siblings

The Sun was probably born in a star cluster, somewhere in the Galaxy. In this assignment we will adopt a semi-analytic galaxy model (actually a smooth potential) to integrate the equations of motion for the stars with which the sun was born in a cluster until we reach the current time. We are interested in the distribution of these solar siblings with respect to the current location of the Sun in the Milky Way Galaxy.

Write a script to integrate the Sun's current location in the Galaxy backward in time using your preferred galaxy model. Use a semi-analytic description of the potential of the Milky Way Galaxy, and a drifter code or an N -body code for integrating the location of the Sun in the Galactic potential

Start the Sun at it's current location of

$$\mathbf{x} = (-8400, 0.0, 17.0) \text{ pc} \quad (1)$$

$$\mathbf{v} = (-11.35, -232.1, -7.41) \text{ km/s} \quad (2)$$

What was the location and velocity of the Sun 4.56 Gyr ago?

How does the birth location of the Sun changes if you randomly select the Sun's position and velocity from a Gaussian distribution assuming a standard deviation in the observed values of 1%. Make a figure of the position and velocity where the Sun could possibly have born. Why is the shape of this figure funny?

Now initialize a star cluster on the location where the Sun was born and integrate all the stars forwards for 4.6 Gyr. Use star cluster parameters from [1], but adopt a softening length of 1 pc.

Integrate the cluster using `BHtree`, and bridge this with the Galactic background potential.

What goes wrong when you do not adopt a 1 pc softening length?

Plot the cumulative distribution of the distance between the sun and any of the stars in the cluster. What is the probability of finding a Solar Sibling within 100 pc from the current location of the Sun. What velocity would this star have with respect to the Sun. Do you think that 1I/2017 U1 originated from the Sun's birth cluster?

Perform the same calculation with 50, 100, 200, ..., 2000 stars. Make a plot of the number of stars you expect to find within 100 pc from the Sun as a function of the number of stars in the parental cluster. Is it obvious that with a richer cluster you expect a higher probability of a nearby Solar Sibling?

References

- [1] S. F. Portegies Zwart, *ApJL* **696**, L13 (2009).