

# The Milky Way Galaxy Homework

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Data files available here: <https://www.dropbox.com/sh/jthnnm29q9h5k76/AAAtMiwq4DuR9Hyv29c-dsh9a?dl=0>

Toy sample of 5000 halo stars drawn from a 3D Gaussian velocity distribution.

$$f(v) = \frac{1}{\pi^{1.5} \sigma_r \sigma_\theta \sigma_\phi} \exp\left(-\frac{v_r^2}{2\sigma_r^2}\right) \exp\left(-\frac{v_\theta^2}{2\sigma_\theta^2}\right) \exp\left(-\frac{(v_\phi - v_{\text{rot}})^2}{2\sigma_\phi^2}\right) \quad (1)$$

The stars are distributed randomly on the sky and follow a power-law radial profile with  $\rho \propto r^{-3.5}$ .

The data file (data.txt) gives observable parameters: ra, dec, D,  $v_{\text{los}}$ ,  $\mu_{\text{ra}}$ ,  $\mu_{\text{dec}}$ . The solar motion is given by:  $(v_{x_\odot}, v_{y_\odot}, v_{z_\odot}) = (11.1, 12.24 + 238, 7.25)$ .

- Write a program to convert the observable parameters to cartesian 6D phase-space coordinates  $(x, y, z, v_x, v_y, v_z)$ .
- Find  $\sigma_r$ ,  $\sigma_\theta$ ,  $\sigma_\phi$ ,  $v_{\text{rot}}$ . What is the velocity anisotropy of the system?
- How would you find these parameters if only 4D coordinates were given: ra, dec, D,  $v_{\text{los}}$ ?
- Now use the file data\_err.txt, which includes errors of 0.5 mas/yr in the proper motion coordinates. How would you find the velocity anisotropy and net rotation in this case?
- What does the net rotation and velocity anisotropy of halo stars tell us about the formation of the Milky Way halo?