Astronomy 400B Lab 1

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Due: Jan 31st 2023 by 5 PM

1 First Step

Make sure to have a cloned copy of your own repository on your computer (or nimoy if you are using nimoy for Jupyter). Create a directory Labs/Lab1.

From the command line git clone the class repository. If you have already done this, git pull to update the repository. There is a directory Labs/Lab1/ with a file Lab1.ipynb, which is the template for this exercise.

Copy this template to your own repository directory Labs/Lab1

2 Part A: Local Standard of Rest

The Proper motion of Sgr A* from Reid & Brunthaler 2004 $\mu = 6.379$ mas/yr

Peculiar motion of the sun, $v_\odot = 12.24$ km/s (Schonrich 2010)

$$v_{tan} = 4.74 \frac{\mu}{\text{mas/yr}} \frac{R_o}{\text{kpc}} = V_{LSR} + v_\odot \tag{1}$$

2.1

Create a function called VLSR to compute the local standard of res (V_{LSR}).

The function should take as input: the solar radius (R_o), the proper motion (mu) and the peculiar motion of the sun in the $v_\odot$ direction.

Compute V_{LSR} using three different values R_o:

1. Water Maser Distance for the Sun : $R_o = 8.34$ kpc (Reid 2014 ApJ 783)
2. GRAVITY Collaboration Distance for the Sun: $R_o = 8.178$ kpc (Abuter+2019 A&A 625)
3. Value for Distance to Sun listed in Sparke & Gallagher : $R_o = 7.9$ kpc

2.2

Compute the orbital period of the sun in Gyr using R_o from the GRAVITY Collaboration (assume circular orbit)

Note that 1 km/s $\sim$ 1kpc/Gyr

2.3

Compute the number of rotations the sun makes about the Galactic Center over the age of the universe (13.8 Gyr)

3 Dark Matter Profiles

3.1

Try out Fitting Rotation Curves:
http://wittman.physics.ucdavis.edu/Animations/RotationCurve/GalacticRotation.html

3.2

In the Isothermal Sphere model, what is the mass enclosed within the solar radius in units of $M_\odot$?
Where G = 4.4988e-6 kpc^3/Gyr^2/$M_\odot$
What about at 260 kpc (in units of $M_\odot$) ?

3.3

The Leo I satellite is one of the fastest moving Milky Way satellite galaxies we know.
Vtot = 196 km/s at a distance of 260 kpc (Sohn 2013 ApJ 768)
If we assume that Leo I is moving at the escape speed:

$$v_{esc}^2 = 2|\Phi| = 2\int G\frac{\rho(r)}{r}dV \tag{2}$$

and assuming the Milky Way is well modeled by a Hernquist Sphere with a scale radius of 30 kpc, what is the minimum mass of the Milky Way (in units $M_\odot$) ?

How does this compare to estimates of the mass assuming the Isothermal Sphere model at 260 kpc (from your answer above)?

4 Last Step

Git push your Lab1.ipynb file to your repo. Recall steps:

1. git add filename
2. git commit -m "COMMENTS"
3. git push