ASTR 400B Homework 3

Due: Feb 2nd 2023 5 PM

In this assignment you will write Python code to compute the mass breakdown of the Local Group (SnapNumber 0) using its most massive members: the Milky Way (MW), M31 and M33.

1 Get the Data Files

You will need 3 files for this assignment: MW_000.txt, M31_000.txt, M33_000.txt . These files are located in the astr400b/ directory on nimoy.

You can either download these files directly onto your computer using sftp.
sftp username@nimoy.as.arizona.edu
navigate to the astr400b directory and use "get" to transfer the files.

Or if you are working in your home directory on nimoy, create a symbolic link to these files using the absolute path.
ln -s /home/astr400b/M31_000.txt ./M31_000.txt
or
ln -s /home/astr400b/M31_000.txt ./Homeworks/Homework3/M31_000.txt

If you run into issues like "no such file or directory", it probably means the symbolic link you created didn't point to the right targets (instead it points to a non-existing file).

2 Return Mass

1. Create a program called *GalaxyMass*. In that program, write a function called *ComponentMass* that will return **the total mass** of any desired galaxy component.

2. The function should take as input: a filename, the particle type. Recall that the particle types are: Halo type (1), Disk type (2), Bulge type (3).

3. You will need to utilize the *ReadFile* program you wrote in Homework 2. To do this, copy ReadFile.py into your working directory. Then add the below line at the start of your code (where you import modules):

   from ReadFile import Read

4. The Mass should be returned in units of 10^{12} $M_\odot$ rounded to three decimal places (*np.round*)

3 Mass Break Down of the Local Group

- Use *GalaxyMass* to compute the total mass of each component of each galaxy (MW, M31, M33) and **store the results in a Table**. Note that M33 does not possess a bulge.
- Columns of the table should be: *Galaxy Name, Halo Mass (units), Disk Mass (units), Bulge Mass (units), Total (units),* $f_{\rm bar}$. The rows should be for each galaxy.
- Input mass in units of 10^{12} $M_\odot$ in the table.
- Compute **the total mass of each galaxy** (all components combined) and add it to the Table.
- Compute the total mass of the Local Group in this simulation and add it to the Table.
- Compute the baryon fraction $f_{\rm bar}$ = total stellar mass / total mass (dark+stellar) for each galaxy and the whole Local Group.
- Save your Table as a PDF. BONUS POINTS if you create your table using LaTeX. If you don't know how to use LaTeX come to office hours or TA hours. Overleaf is a really useful online tex editors.

4 Questions

Save your answers to the above questions as a PDF.

1. How does the total mass of the MW and M31 compare in this simulation? What galaxy component dominates this total mass?
2. How does the stellar mass of the MW and M31 compare? Which galaxy do you expect to be more luminous?
3. How does the total dark matter mass of MW and M31 compare in this simulation (ratio)? Is this surprising, given their difference in stellar mass?
4. What is the ratio of stellar mass to total mass for each galaxy (i.e. the Baryon fraction)? In the Universe, Ω_b/Ω_m ~16% of all mass is locked up in baryons (gas & stars) vs. dark matter. How does this ratio compare to the baryon fraction you computed for each galaxy? Given that the total gas mass in the disks of these galaxies is negligible compared to the stellar mass, any ideas for why the universal baryon fraction might differ from that in these galaxies?

5 Homework Submission

- You must DOCUMENT your code . Explain each step.
- Create a directory called Homework3 in your GitHub Repository. Store your code and PDF with Table and answers to question 4 in this directory (along with the LaTeX file if you did this).