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Question 3 table in latex

Galaxy	Halo Mass (10^{12})	Disk Mass (10^{12})	Bulge Mass (10^{12})	Total Mass (10^{12})	f_{bar}
MW	1.975	0.075	0.010	2.060	0.041
M31	1.921	0.120	0.019	2.060	0.067
M33	0.187	0.009	0.000	0.196	0.046
Local Group	-	-	-	4.316	0.054

Table 1: Galaxy mass components in units of $10^{12} M_{\odot}$.

Question 4

1. How does the total mass of the MW and M31 compare in this simulation? What galaxy component dominates this total mass?

   Answer:
   The total mass of the Milky Way (MW) and Andromeda (M31) is the same in this simulation, both being 2.060×10^{12} $M_{\odot}$. The dominant component in both galaxies is the **halo mass**, which is significantly larger than the combined mass of the disk and bulge.

   This confirms that the majority of the mass in both galaxies is **dark matter in the halo**.

2. How does the stellar mass of the MW and M31 compare? Which galaxy do you expect to be more luminous?

   Answer: M31 has a higher stellar mass than MW:

   MW Stellar Mass (Disk + Bulge) = $0.075 + 0.010 = 0.085 \times 10^{12}$ $M_{\odot}$
   M31 Stellar Mass (Disk + Bulge) = $0.120 + 0.019 = 0.139 \times 10^{12}$ $M_{\odot}$

   Since M31 has more stellar mass than the MW, it is expected to be **more luminous**. Luminosity is roughly proportional to stellar mass, and we assume similar stellar populations in order for this to work. This means M31 should be brighter than the MW.

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?

   Answer:

   The ratio of MW to M31 dark matter mass is:

   $$\frac{1.975}{1.921} \approx 1.028$$

   This means the MW and M31 have nearly the **same amount of dark matter**, with MW having slightly more. This is interesting because M31 has significantly **more stellar mass** than MW.

   Possible Explanation: M31 has undergone **more star formation**, converting more gas into stars, while the MW may have had **less efficient star formation** or lost gas due to interactions or feedback.

4. What is the ratio of stellar mass to total mass for each galaxy (i.e., the Baryon fraction)? In the Universe, $\Omega_b/\Omega_m \approx 16\%$ of all mass is locked up in baryons (gas & stars) vs. dark matter. How does this compare to the baryon fraction we computed? 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?

   Answer: The computed baryon fractions (f_{bar}) from the table are:

   MW: 0.041 (4.1%)
   M31: 0.067 (6.7%)
   M33: 0.046 (4.6%)
   Local Group Total: 0.054 (5.4%)

   Compared to the cosmic baryon fraction of 16%, the values in these galaxies are much lower.

   Possible Explanations for the Difference:

   Star Formation Efficiency: Not all baryons in a galaxy form stars; some remain in the intergalactic medium.
   Gas Loss from Supernovae and Feedback: Supernova explosions and stellar winds can **eject gas** out of the galaxy, reducing the baryon fraction.
   Dark Matter Overdensity in Galaxies: Galaxies form in **dark matter halos**, and dark matter dominates galaxy mass. The universal baryon fraction includes **diffuse gas in cosmic filaments**, but galaxies themselves are **more dark matter-dominated**.