HW3 Question 4

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Due: February 6th 2020

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

The total mass of the Milky way and M31 are nearly the same, with the mass of MW being 2.060x$10^{12} M_{\odot}$ and the total mass of M31 being 2.0601x$10^{12} M_{\odot}$. By far the largest component of both of these masses is the halo mass, or dark matter mass, of each galaxy. The dark matter in MW makes up a mass of 1.975x$10^{12} M_{\odot}$ and 1.921x$10^{12} M_{\odot}$ in M31. This masses again for the two galaxies are pretty similar, but the Milky way seems to have a slightly larger halo mass.

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

The stellar mass of a galaxy consists of the combined mass of the disk and the bulge of a galaxy. For the Milky way galaxy, this would add up to 0.085x$10^{12} M_{\odot}$, but for M31 this value is 0.1391x$10^{12} M_{\odot}$. The stellar mass of M31 is nearly twice that of the Milky Way, which would lead it to be the more luminous of the two galaxies.

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?

The total dark matter mass (the halo mass) of each galaxy as mentioned in question 1 are very similar to each other. This is surprising, because M31 has a much larger stellar mass than the milky way, so one might assume that dark matter would scale accordingly. Most surprising, M31 actually has a slightly smaller dark matter mass than the Milky Way galaxy. This shows us that the dark matter halo of a galaxy may not directly scale with the stellar mass of a galaxy.

4. What is the ratio of stellar mass to total mass for each galaxy?(i.e. the Baryon fraction)? In the Universe, 16% is locked up in baryons vs. dark matter. How does this ratio compare to the baryon fraction

that you computed for each galaxy? Given that the total gas mass in the disks of these galaxies is negligible to the stellar mass, any ideas for why the universal baryon fraction might differ from that in these galaxies?

For each galaxy, the dark matter mass was the largest component out of the total mass. For the Milky way galaxy, the baryonic matter only made up 4.1% of the total mass. M31 had a slightly larger amount with 6.8% baryonic matter, and M33 was in the middle with 4.7%. However, these are all much smaller than the universe value of 16%, with the local group coming in as a whole at 5.4% of matter coming from stellar mass. The baryonic matter to dark matter ratio of the local group is about 1/3 of the value that the universe as a whole seems to be.

One reason that these two values could be off would just be statistics. Some galaxies could have much larger fractions than our own local group, bringing the average of the universe to about 16% when in reality there is a wide range of different fractions of baryonic matter to dark matter

Additionally, we cannot see dark matter directly like we can with stars. The dark matter mass is measured/inferred based on the behavior of baryonic mass in the universe. Because we are very close to our own local group, we can make precise measurements of the different kinds of matter. When looking farther out into the universe, due to available light and observation techniques these measurements may not be nearly as accurate, which could affect the ratio value.