ASTR 400B: Homework 3

Due on Feb 6, 2020

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2. Mass Breakdown

This is raw output from pandas.DataFrame.to_latex(), with rows sorted alphabetically:

Galaxy Name	Halo Mass	Disk Mass	Bulge Mass	Total	f_bar
M31	1.921	0.120	0.019	2.060	0.068
M33	0.187	0.009	0.000	0.196	0.047
MW	1.975	0.075	0.010	2.060	0.041
All	4.082	0.204	0.029	4.316	0.054

It looks better with a bit of manual formatting:

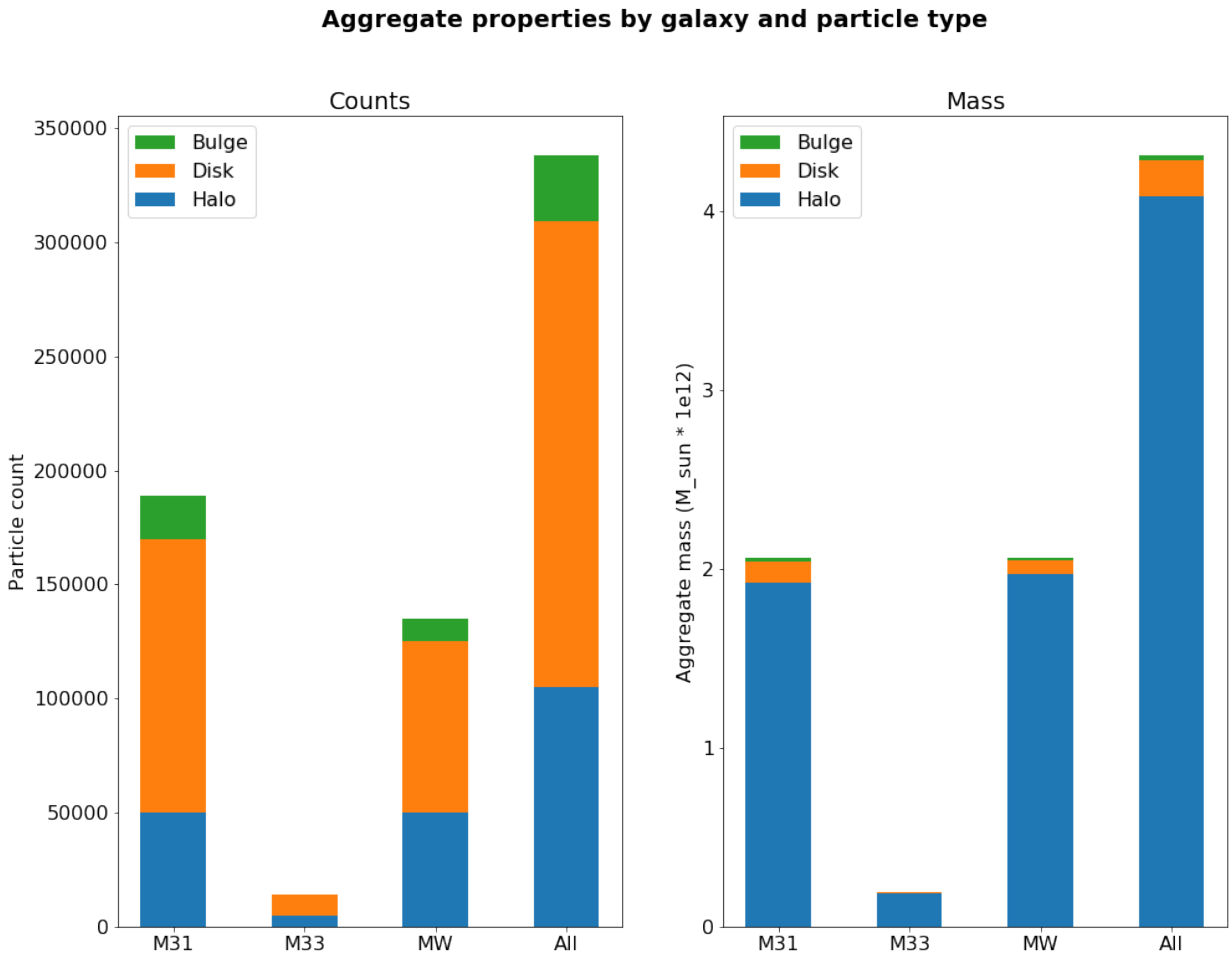
Galaxy Name	**Halo Mass** ($M_\odot \times 10^{12}$)	**Disk Mass** ($M_\odot \times 10^{12}$)	**Bulge Mass** ($M_\odot \times 10^{12}$)	**Total** ($M_\odot \times 10^{12}$)	$\mathbf{f_{bar}}$
MW	1.975	0.075	0.010	2.060	0.041
M31	1.921	0.120	0.019	2.060	0.068
M33	0.187	0.009	0.000	0.196	0.047
Local Group	4.082	0.204	0.029	4.316	0.054

Compare that with particle counts:

Galaxy Name	**Halo Count**	**Disk Count**	**Bulge Count**	**Total**
MW	50000	75000	10000	135000
M31	50000	120000	19000	189000
M33	5000	9300	0	14300
All	105000	204300	29000	338300

The DM halo contains fewer but more massive particles. Presumably this is just a matter of convenience in the sim, as we have little understanding of the underlying physics (to put it charitably).

This may be easier to see on stacked bar charts showing the distributions:



3. Questions

1. Total mass: M31 and the MW have the same total mass in this simulation. Dark matter in the halo dominates in most cases, but especially for the MW.

2. Stellar mass: Disk + bulge mass is about 60% higher for M31 than the MW. Assuming a roughly similar distribution of star types and ages, M31 is likely to be more luminous.

3. Dark matter mass: This is approximately the same in both the MW and M31, in contrast to the different stellar mass. Halo mass is the bulk of the galaxy, stellar mass is some minor froth on top (*except it's in the middle - analogies have limitations*).

4. Baryon fraction: This is in the $4-7\%$ range for each galaxy, well below the cosmological average of 16%.

One hypothesis is that this reflects the formation history of galaxies. Dark matter, because it is decoupled from radiation, can undergo gravitational collapse while baryonic matter is still too hot. This creates a gravitational well for baryons to fall into as they cool. Is f_{bar} higher in old galaxies than young ones?