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Joint Satellite Distributions in the Milky Way and Andromeda

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ABSTRACT
We quantify the joint spatial distribution of satellites around the Milky way and Andromeda.

Key words: Galaxies: halos — Galaxies: high-redshift — Galaxies: statistics — Dark Matter — Methods: numerical

1 INTRODUCTION

2 OBSERVATIONAL DATA

3 LOCAL GROUP SATELLITES IN THE ILLUSTRIS SIMULATION

We use publicly available data from the Illustris Project (Vogelsberger et al. 2014). This suite of cosmological simulations, performed using the quasi-Lagrangian code AREPO (Springel 2010), followed the coupled evolution of dark matter and gas and includes parametrizations to account for the effects of gas cooling, photoionization, star formation, stellar feedback, black hole and super massive black hole feedback. The simulation volume is a cubic box of 75 $\mathrm{Mpc}\,h^{-1}$ on a side. The cosmological parameters correspond to a ΛCDM cosmology consistent with WMAP-9 measurements (Hinshaw et al. 2013).

We extract halo and galaxy information from the Illustris-1 simulation which has the highest resolution in the current release of the Illustris Project. Illustris-1 has 1820^3 dark matter particles and 1820^3 initial gas volumen elements. This corresponds to a dark matter particle mass of $6.3\times10^{6}\mathrm{M}_{\odot}$ and a minimum mass for the baryonic volume element of $8.0\times10^{7}\mathrm{M}_{\odot}$. The corresponding spatial resolution is 1.4 kpc for the dark matter gravitational softening and 0.7 kpc for the typical size of the smallest gas cell size.

The smallest satellites are barely resolved in stellar mass at magnitudes of $M_V = 9$, however its dark matter structure is sampled with at least 100 particles. We find that all considered halos have at least XX subhalos above a maximum circular velocity of 15km s^{-1}. For this reason we select the satellite galaxy samples from the DM subhalo population and not from the galaxies with photometry. We chose in two different ways the sub-halo samples. First, we rank the halos by decreasing order of its maximum circular velocity and select the first N_p halos in the list. Second, we select all satellites above maximum circular velocity of 20km $\mathrm{s}^{-1}$to randmbly subsample N_p subhalos.

We build a sample of Local Group Analgues (LGA) by performing a selection on the stellar mass and isolation properties of the galaxies in the simulation. The conditions to select LGA galaxies are the following.

- LGA galaxy pairs are composed by galaxies with stellar mass in the range $1\times10^{10}\mathrm{M}_{\odot} < M_{\star} < 1.5\times10^{11}\mathrm{M}_{\odot}$.
- For each galaxy A we find its closest galaxy B, if galaxy A is also the closest to halo B, the two halos are considered as a pair. Another way to phrase this selection is that pairs do not have neighbors closer than the pair's separation.
- The distance between the galaxies' center of mass must be in the range 500 kpc $< d_{AB} <$ 1500 kpc.
- For each galaxy in the pair there cannot be a galaxy more massive than the lightest galaxy in the pair within a radius of 2 Mpc.

We find 11 pairs with these conditions. Figure 1 shows the stellar masses, maximum circular velocities and the number of bright satellites for all the pairs in the sample.

4 SATELLITE SPATIAL DISTRIBUTION AND ALIGNMENT

We use the inertia tensor to characterize the satellites. This tensor is defined as

$$\bar{\mathbf{I}} = \sum_{k\in V}[(\mathbf{r_i}-\mathbf{r_0})^{\mathbf{2}}\cdot\mathbf{1}-(\mathbf{r_i}-\mathbf{r_0})\cdot(\mathbf{r_i}-\mathbf{r_0})^{\mathbf{T}}], \tag{1}$$

where k indexes the set of satellites of interest $\mathbf{r_k}$ are the satellites' positions, $\mathbf{r_0}$ is the positions pof the host DM halo, $\mathbf{1}$ is the unit matrix, and $\mathbf{r}^T$ is the transposed vector $\mathbf{r}$. We finally compute the eigenvalues, $a>b>c$, and corresponding eigenvectors, $\hat{I}_a$, $\hat{I}_b$, $\hat{I}_c$, of this tensor. In the

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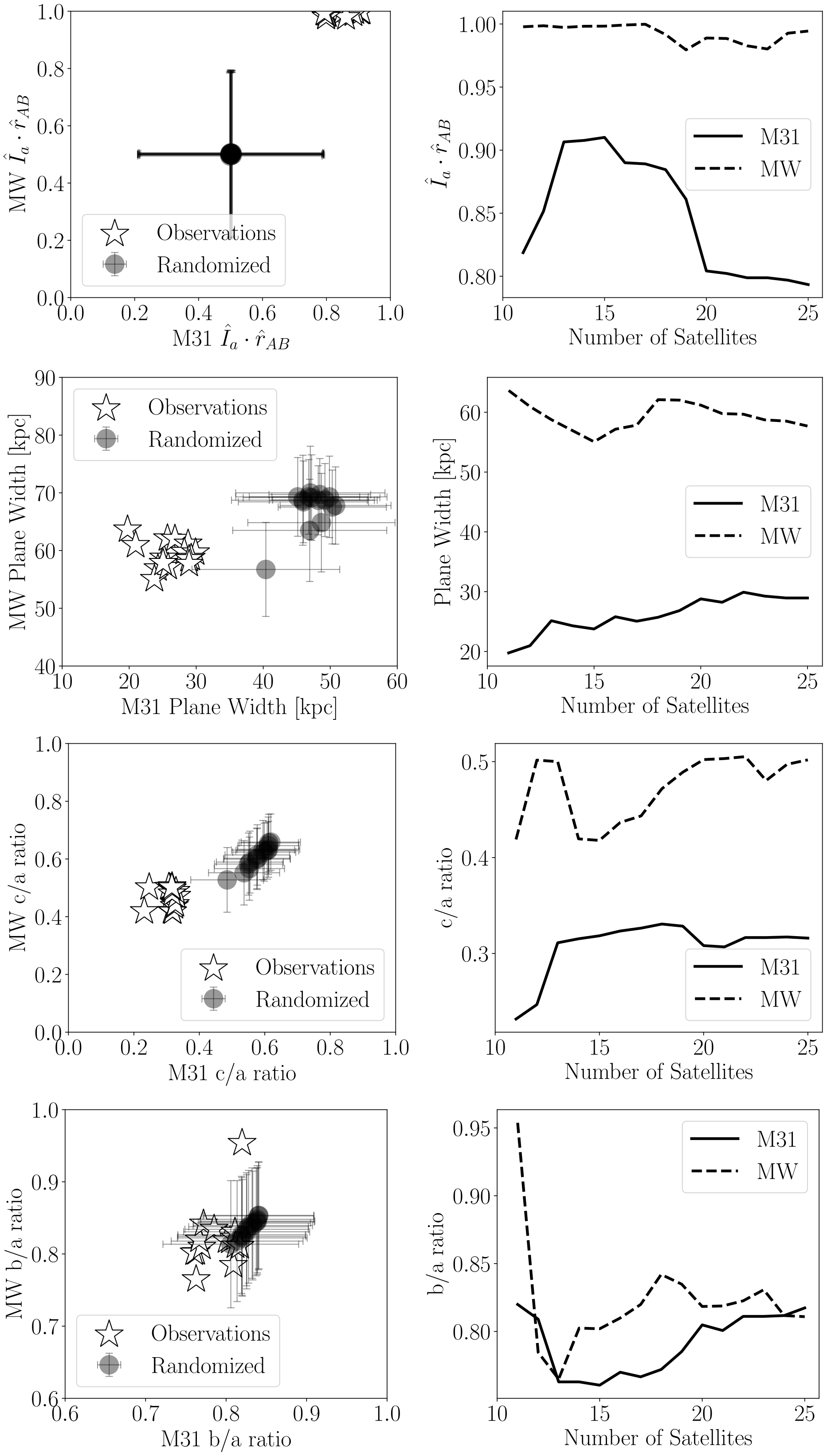

Figure 1. Basic characteristics for the MW and M31 satellite systems

case of a sheet-like configuration the vector perpendicular to the sheet would be signaled by, $\hat{I}_a$, the eigenvector of the largest eigenvalue. We measure the width of the satellite distribution as the standard deviation of all satellite distances to the plane defined by the vector $\hat{I}_a$.

5 RESULTS

REFERENCES

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Symbol	Units	Description
$\hat{r}_{AB}$		Unit vector along the direction connecting two dominant galaxies
N_s		Number of satellites
$a > b > c$		Inertia tensor eigenvalues.
$\hat{I}_a$, $\hat{I}_b$, $\hat{I}_c$		Inertia tensor eigenvectors.
σ_s	kpc	Ellipsoid width

Table 1. Overview of the parameters computed for each central galaxy and its satellite system.