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Joint Satellite Distributions in the Milky Way and Andromeda

Jaime E. Forero-Romero [1] ⋆, Verónica Arias[1]
[1] *Departamento de Física, Universidad de los Andes, Cra. 1 No. 18A-10 Edificio Ip, CP 111711, Bogotá, Colombia*

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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 $6.3 \times 10^6 \mathrm{M}_\odot$ and a minimum mass for the baryonic volume element of $8.0 \times 10^7 \mathrm{M}_\odot$. 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 s^{-1}to randmbly subsample N_p subhalos.

We build a sample of Local Group Analgues (LGA) by selecting first all galaxies with an stellar mass in the range $1 \times 10^{10}\mathrm{M}_\odot < M_\star < 1.5 \times 10^{11}\mathrm{M}_\odot$. Then we consider the following criteria for all galaxies in that sample.

- For each galaxy A we find its closest galaxy B, if galaxy A is also the closest to halo B, the two are considered as a pair.
- With d_{AB} the distance between the two galaxies and $M_{\star,min}$ the lowest stellar mass in the two galaxies, we discard pairs that have any other galaxy C with stellar mas $M_\star > M_{\star,min}$ closer than $3 \times d_{AB}$ from any of the pair's members.
- The distance $d_{AB} > 700$ kpc.
- The radial velocity between the two galaxies is 120km s$^{-1} < V_{AB,radial} <$ 0km s^{-1}

We find XX pairs with these conditions.

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 case of a sheet-like configuration the vector perpendicular to the sheet would be signaled by, $\hat{I}_a$, the eigenvector of the

⋆ je.forero@uniandes.edu.co

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

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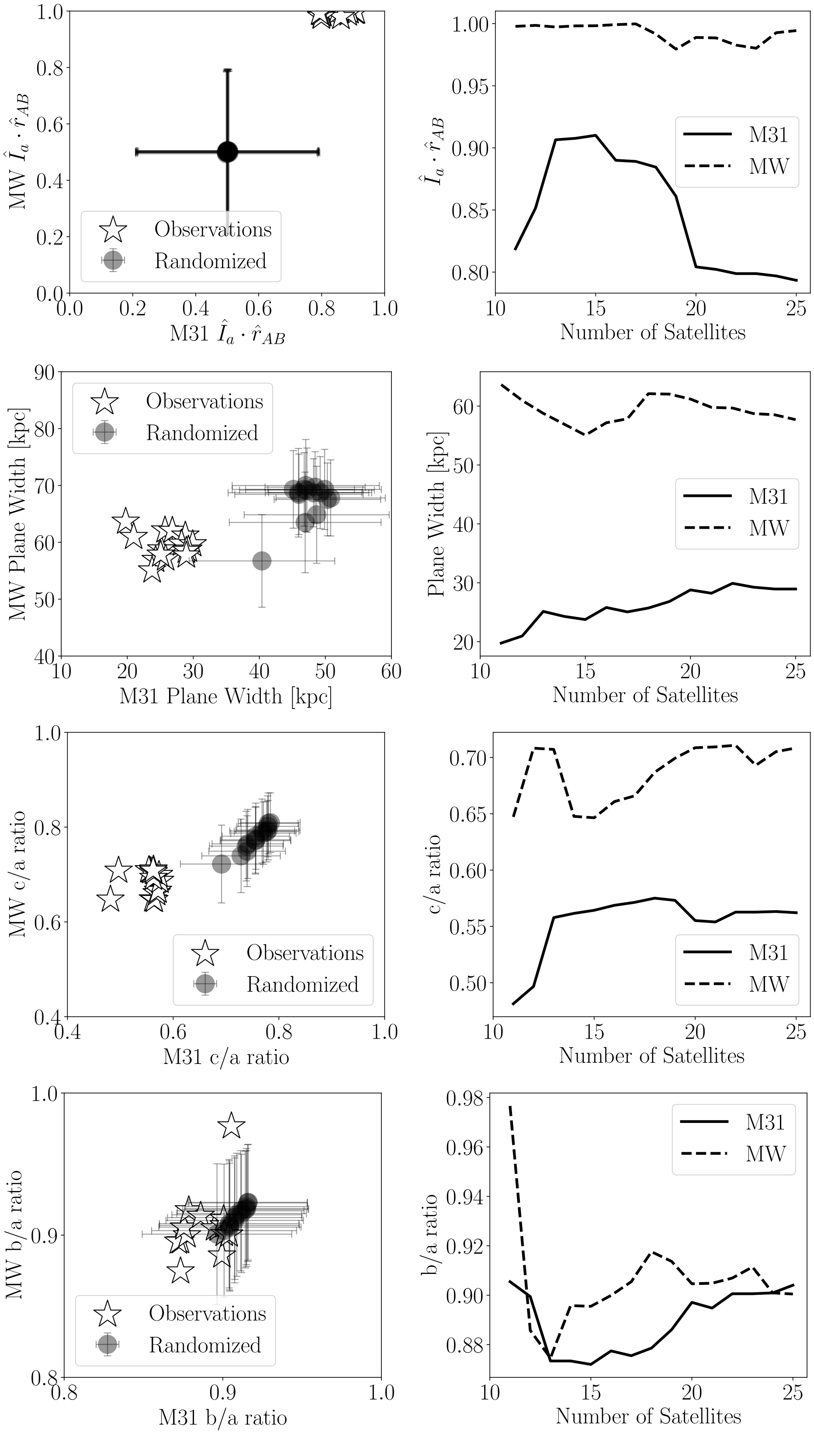

Figure 1. Basic characteristics for the MW and M31 satellite systems

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.