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ABSTRACT

The distribution of satellite galaxies relative to their host has been subject of debate among several authors. Some of them have found polar alignment in the satellite distribution in disk galaxies, while others have obtained a planar distribution (along the major axis of the disk seen in projection). We analyze the distribution of satellite galaxies in cosmological self-consistent hydrodynamical simulations. Our conclusions are that: (1) the three dimensional satellite orbits present a polar distribution, and (2) the satellite distribution as a function of the projected distance is, at short distances, planar for isolated systems and polar for rich systems.

INTRODUCTION

Satellite distribution: controversial observational results

- **Polar distribution** \Rightarrow satellite distribution perpendicular to the disc of the primary
 - Holmberg (1969): polar distribution in rich systems for distances $d_p < 50 \text{ kpc}$
 - Zaritsky *et al* (1997): polar alignment for $d_p > 250 \text{ kpc}$
 - Lynden-Bell (1982) and references thereafter: Satellites in the Milky Way in Great Circles perpendicular to the Galactic Plane
 - Koch & Grebel (2006): Satellites in M31 in orbits perpendicular to the disk
- **Planar distribution** \Rightarrow satellite distribution aligned with the disc of the primary
 - Sales & Lambas (2004): 3000 satellites of ~ 1500 isolated primaries in 2dFGRS
 - Brainerd (2005): planar distribution for satellites with $d_p < 100 \text{ kpc}$, in isolated primaries, isotropy for $250 < d_p < 500 \text{ kpc}$
- **Isotropy**
 - Azzaro *et al* (2006): 144 spiral and 193 satellites in SSDS

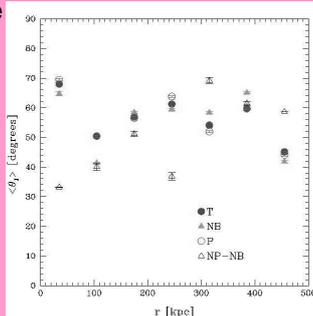
METHODOLOGY

- **Cosmological hydrodynamical simulations** using DEVA (Serna, Domínguez-Tenreiro & Sáiz 2003)
- We selected 29 isolated **disk galaxy+satellites** systems
- The systems of the *total* sample (T) are **classified** in:
 - *Binary* (B) systems (having massive satellites) and *Non-Binary* (NB) systems
 - *Non-Populated* (NP) systems (less than 4 satellites in projection) and *Populated* (P) systems.
- We **analyzed**:
 - the *three dimensional (3D) distribution* of the satellites: $\theta_j \Rightarrow$ angle between the orbital angular momentum of the satellite and the disk angular momentum ($45^\circ < \theta_j < 90^\circ$ polar trajectory)
 - the *projected distribution* of the satellites: $\phi \Rightarrow$ angle between the major axis of the disk in projection and the satellite projected position vector ($\phi > 45^\circ$: polar distribution, $\phi < 45^\circ$: planar distribution)

RESULTS

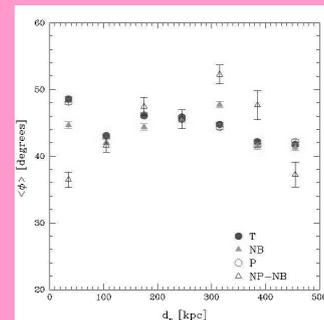
3D distribution of the satellites:

- **Polar orbits: more frequent**
- **Prograde orbits: more frequent in NP systems**
- As a function of the distance:
 - At $r > 150 \text{ kpc}$: polar orbits more frequent
 - At $r < 150 \text{ kpc}$: satellites in NP-NB systems more likely to be in non-polar orbits



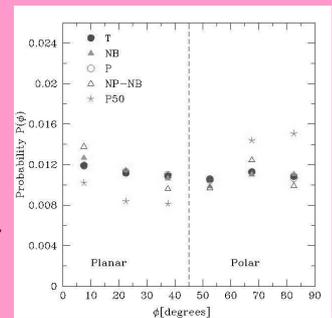
Projected distribution of the satellites:

- The **polar behavior** of the 3D distribution is **partially hidden by projection effects**



- More differences with an isotropic distribution for:
 - NP-NB sample: planar, mainly at $d_p < 50 \text{ kpc}$

- P50 sample (satellites with $d_p < 50 \text{ kpc}$ in P systems): polar distribution



CONCLUSIONS

- **3D distribution:**
 - Polar orbits
 - Satellite accretion along filaments
- **Projected distribution:**
 - Polar 3D distribution is softened in projection
 - Main differences at $d_p < 50 \text{ kpc}$
 - * P sample: polar distribution consistent with Holmberg (1969) findings for rich systems and the Milky Way and M31 satellites distribution \Rightarrow consequence of evolutive effects: prevalence of polar orbits at short distances in rich systems
 - * NP-NB sample: planar distribution consistent with Brainerd (2005) analysis of isolated systems \Rightarrow consequence of the assembly history in isolated systems (less filaments not isotropically distributed)

References

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