the MW and M31 satellite galaxies

Argelander-Institut für Astronomie

Manuel Metz **Pavel Kroupa**

Argelander Institute for Astronomy

Abstract

Both large spirals of the Local Group, the Milky Way (MW) and Andromeda (M31) have about a dozen known bound satellite galaxies within their virial radii. The number of faint, possibly bound satellite galaxies steadily increased in the last few years, since very faint dwarf galaxies were detected with the help of the SDSS. We show that the satellite galaxies are anisotropically distributed - they are arranged in a great Disc-of-Satellites (DoS) - and that their kinematics show that some of them are orbiting within this DoS. This supports the idea that the satellite galaxies are causally connected and may be of tidal origin instead of being primordial dark-matter dominated sub-haloes.

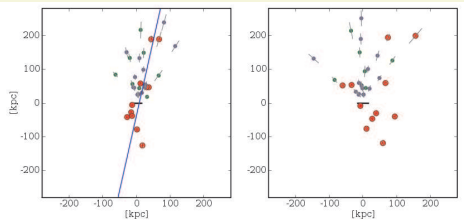

Fig 1: An edge-on view of the Disc-of-Satellites of the Milky Way from infinity and a view rotated by 90 degrees about the vertical axis. Red dots mark the 'classical eleven' satellite Galaxies, green dots mark new discoveries from recent years and blue dots mark new candidates in the SDSS that have to be confirmed (Jerjen, priv. comm.).

A Disc-of-Satellites

The spatial distribution of the satellite galaxies of the MW and M31 around their hosts shows asymmetric patterns and probable streams of galaxies [2,3,4,**5,**7]. We have used robust statistical methods to set constrains on the disc-like distribution of the satellite galaxies: a bootstrap method is used to investigate the robustness of the Disc-of-Satellites. Since statistics based on the apparent "thickness" are not adequate, the resulting data, the distribution of directions of normal vectors, is analysed using statistical methods of spherical data.

We find [**5**] that the spatial distribution of the most luminous MW satellite galaxies is inconsistent with being randomly drawn from spherical or mildly triaxial parent distributions as typically found in CDM cosmological simulations. They are distributed in a very pronounced planar-like distribution (Figure 1). The distribution of all M31 satellite galaxies however is consistent with being randomly drawn from a spherical parent distribution, while there are indications that a subset of the Andromeda satellite galaxies belong to a causal connected stream, however details depend on the distance data used [1,**5**].

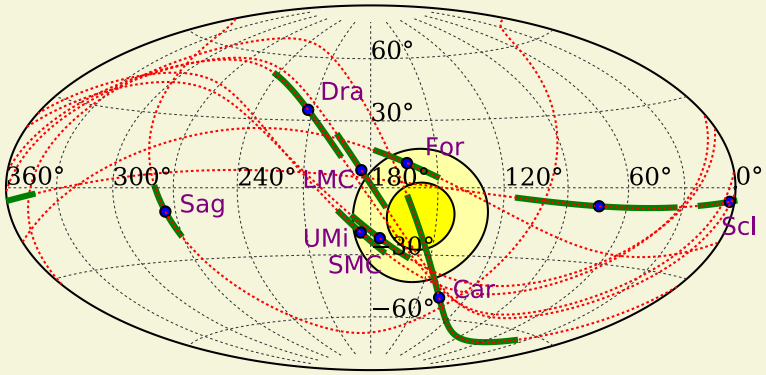

Fig. 2: Possible locations of the poles of the Angular Momentum vectors of Milky Way satellite galaxies that have measured proper motions. The dashed red lines mark the so called polar paths - all possible locations of the poles - while the blue dots and thick green lines give the directions of the Angular Momentum vector as derived from the measured proper motion and their 1-sigma uncertainties. The regions with 15 and 30 degrees distance from the pole of the DoS are marked by the yellow filled, closed loops. There is a clear concentration of the directions close to the pole of the Disc-of-Satellites.

Kinematics

We construct polar paths for the Milky Way and Andromeda satellite galaxies: polar path show all possible locations of the directions of the angular momentum vectors of satellite galaxies. Using measured proper motions for MW satellites, one can derive the directions of their angular momentum vectors, as well as their 1-sigma uncertainty arc-segments; these are shown in Figure 2. A clustering of orbital poles around the pole of the DoS is clearly visible and hints for a causal connection between these satellite galaxies - they have correlated angular momenta and orbit within the DoS, which is inconsistent with being primordial dark-matter dominated subhaloes, whose orbital moments are basically randomly distributed.

For Andromeda it is possible to restrict the plausible locations of polar paths based on geometrical arguments under the assumption that a satellite is bound to the Andromeda halo. Here we assumed an isothermal halo with circular velocity 250 km/s. The resulting polar paths and restricted polar paths are shown in Figure 3. The restricted polar paths indicate for example that And V and VI might have common orbital moments, while Pegasus has a different orbital momentum.

Concluding remarks and outlook

The highly anisotropic distribution of the MW satellite galaxies poses a challenge to explain them as pure primordial cosmological, dark-matter dominated subhaloes. If the Local Group satellite galaxies are, however, of tidal origin, - which is also consitent with their internat structure [6] - this would explain their highly anisotropic appearance [5] and correlated angular momenta.

References

[1] Koch A., Grebel. E.K., 2006, AJ, 131, 1405
[2] Kroupa P., Theis C., Boily C. M., 2005, A&A, 432, 517
[3] Lynden-Bell D., Lynden-Bell R. M., 1995, MNRAS, 275, 429
[4] McConnachie A. W., Irwin M. J., 2006, MNRAS, 365, 902
[5] Metz M., Kroupa P., Jerjen H., 2007, MNRAS, 374, 1125, astro-ph/0610933
[6] Metz M., Kroupa P., 2007, MNRAS, 376, 387, astro-ph/0701289
[7] Palma C., Majewski S. R., Johnston K. V., 2002, ApJ, 564, 736

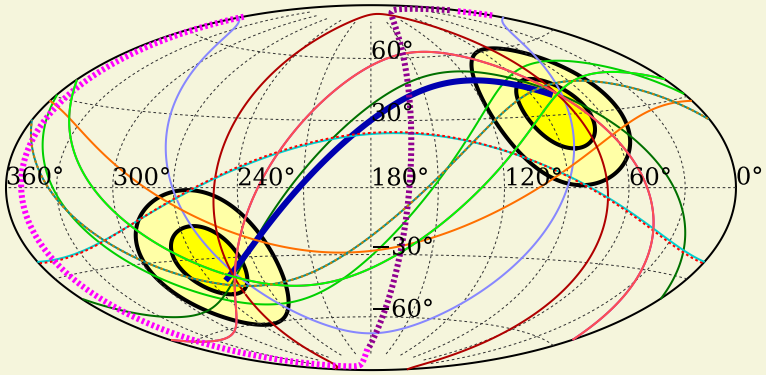

Fig. 3: As Figure 2, now for all satellite galaxies of Andromeda. Solid lines mark polar paths for satellite galaxies within its virial radius, dashed lines for those outside the virial radius. Polar paths for different satellites are colour coded. Thick lines mark restricted polar paths where the possible locations could be restricted based on pure geometrical arguments.