Dark matter halo shapes in the Auriga simulations

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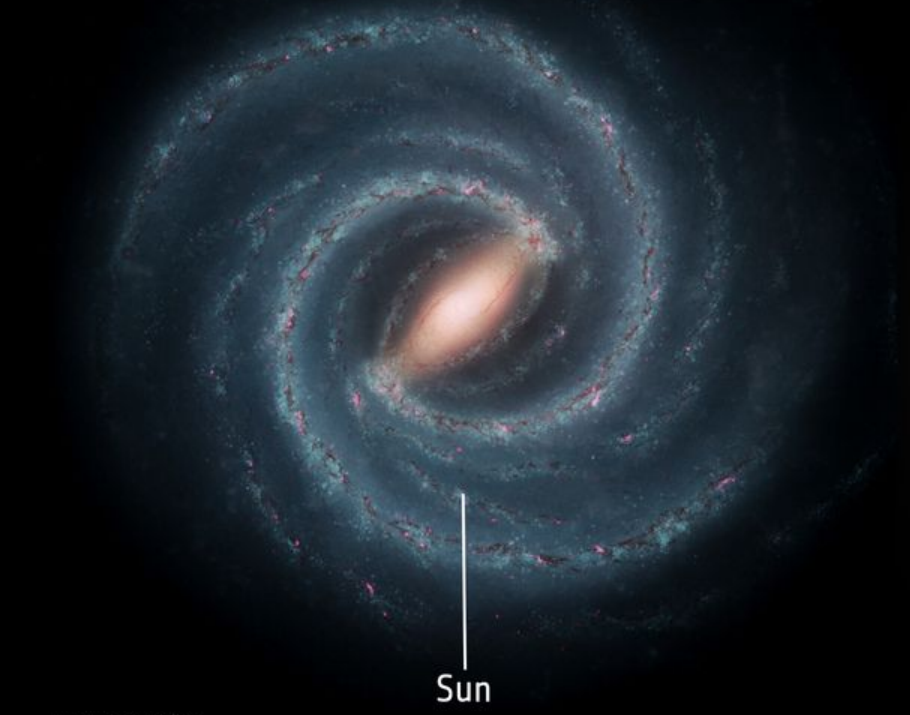
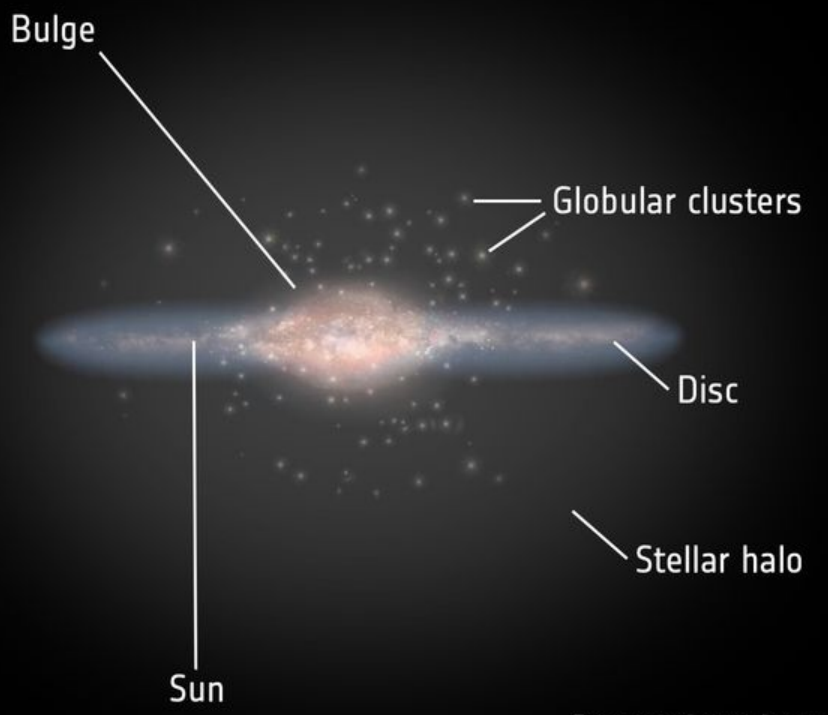
→ ANATOMY OF THE MILKY WAY





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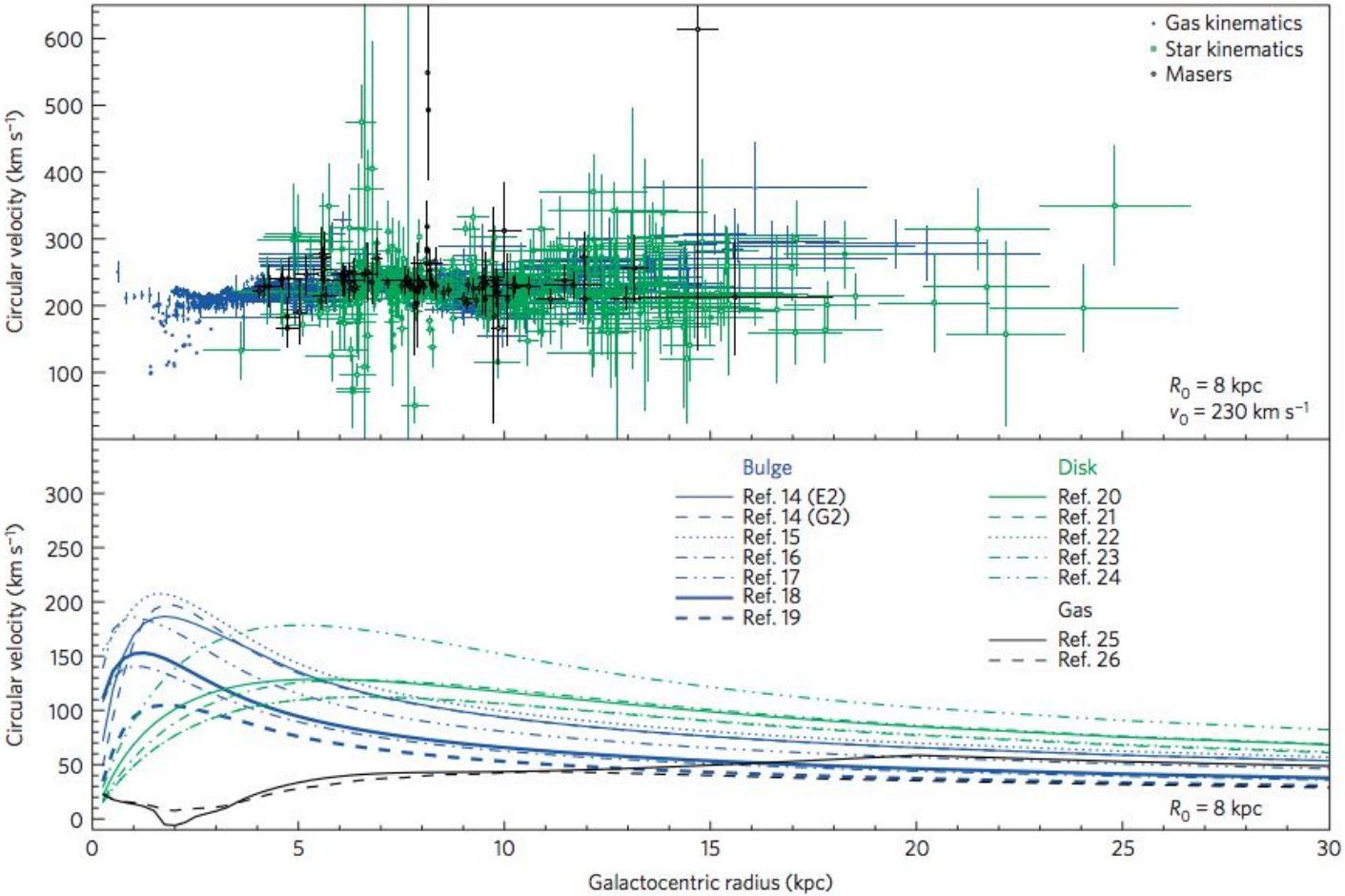
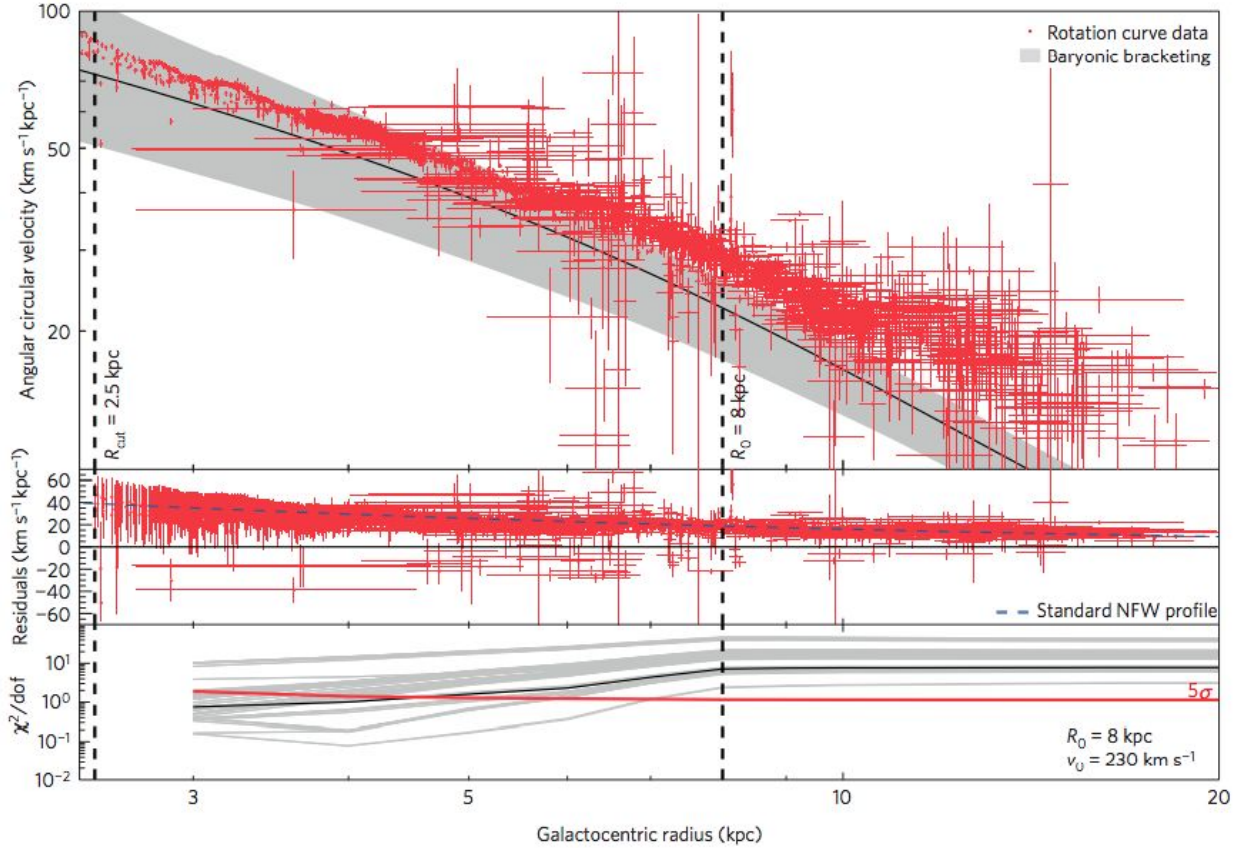


Iocco, Pato, Bertone (2015)

DM parameters are derived from global spherical averages

$$\rho_{\rm DM}(R) = \rho_0 \left(\frac{R_0}{R}\right)^{\gamma} \left(\frac{R_s + R_0}{R_s + R}\right)^{3-\gamma}$$



Iocco, Pato, Bertone (2015)

From observations we know that the MW potential is not spherical.

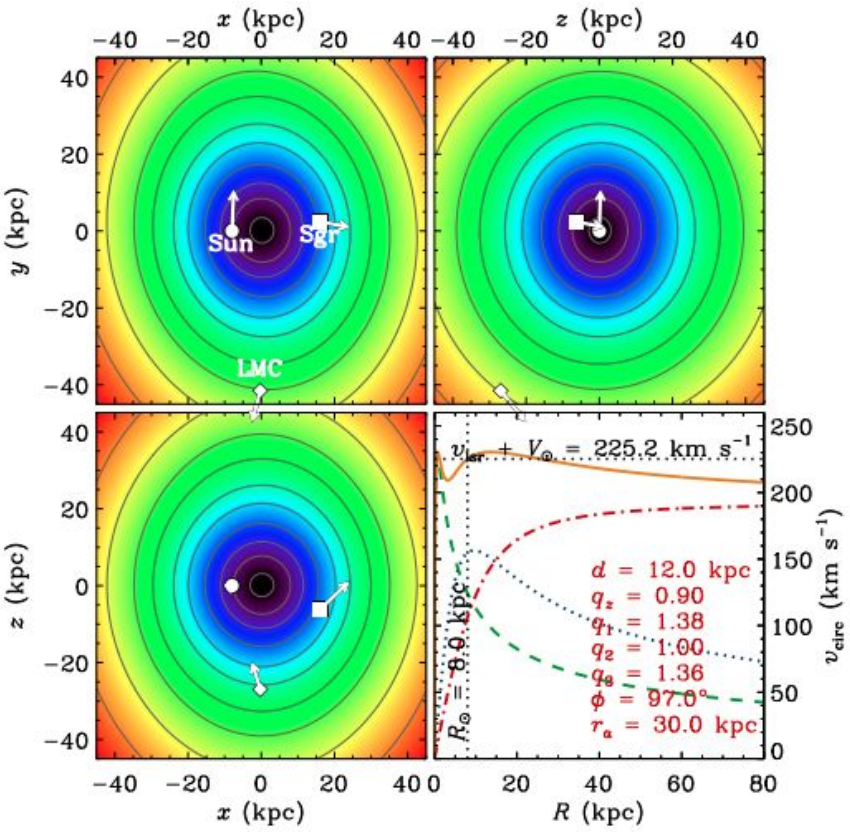
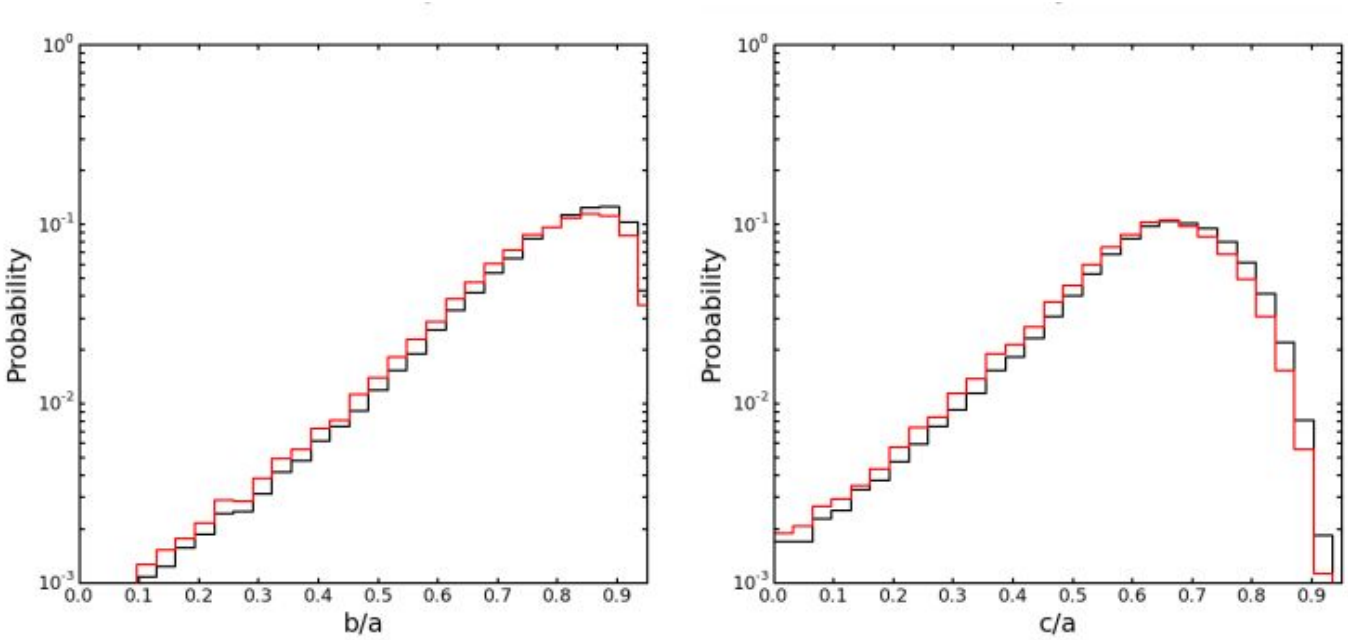


FIG. 1.— Dark halo potential isocontours on the plane $z = 0$ (top left), $y = 0$ (bottom left) and $x = 0$ (top right). For reference, we have included the positions and directions of motion for the Sun (circle), Sgr (square), and the LMC (diamond). The bottom right panel shows the circular velocity profile $v_{\rm circ}$ for the disk (dotted blue), bulge (dashed green), and halo (dash dotted red). The halo makes a transition from oblate to triaxial at $r_a = 30$ kpc.

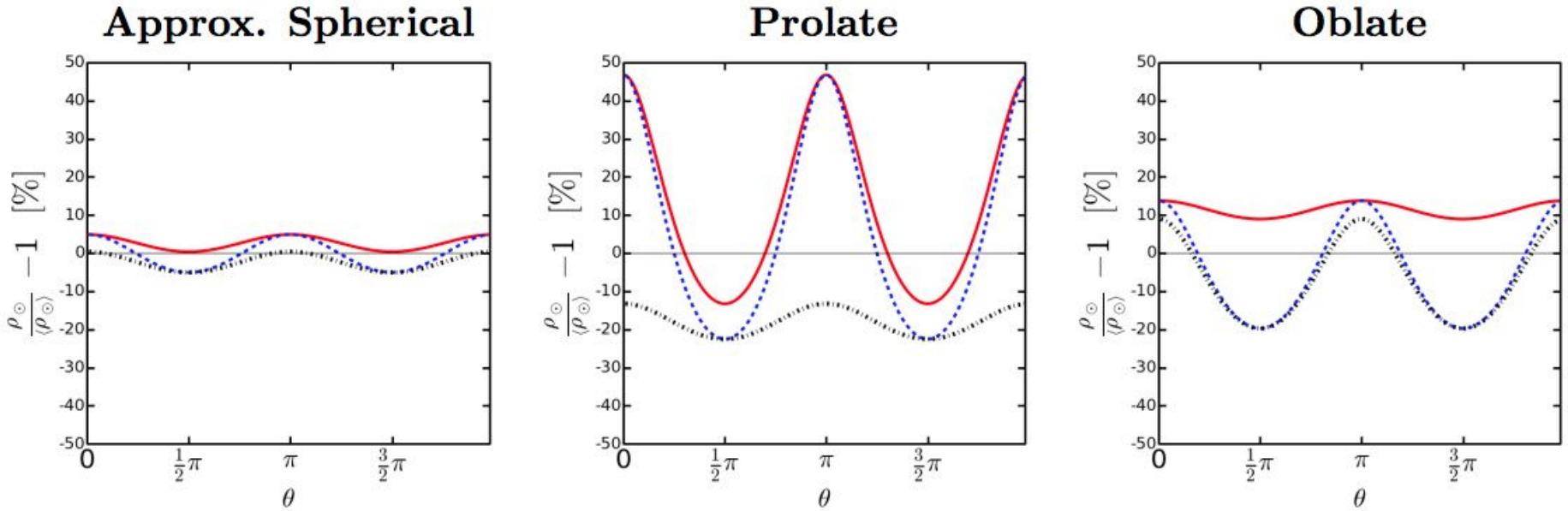
Vera-Ciro, Helmi (2013)

From simulations we know that DM halos are ellipsoidal



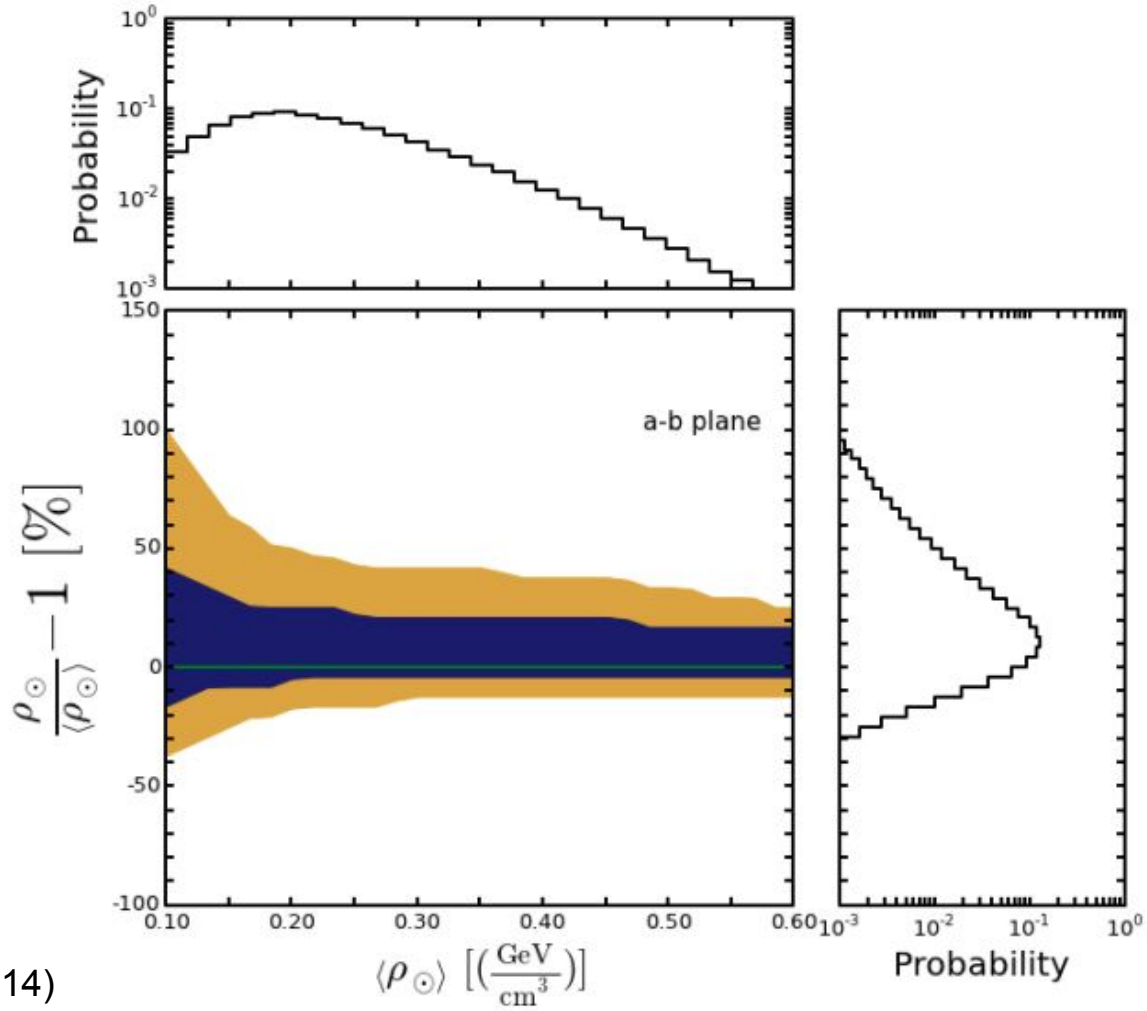
Bernal, FR, Garani, Palomares-Ruiz (2014)

Deviations from spherical symmetry are relevant for DM detection



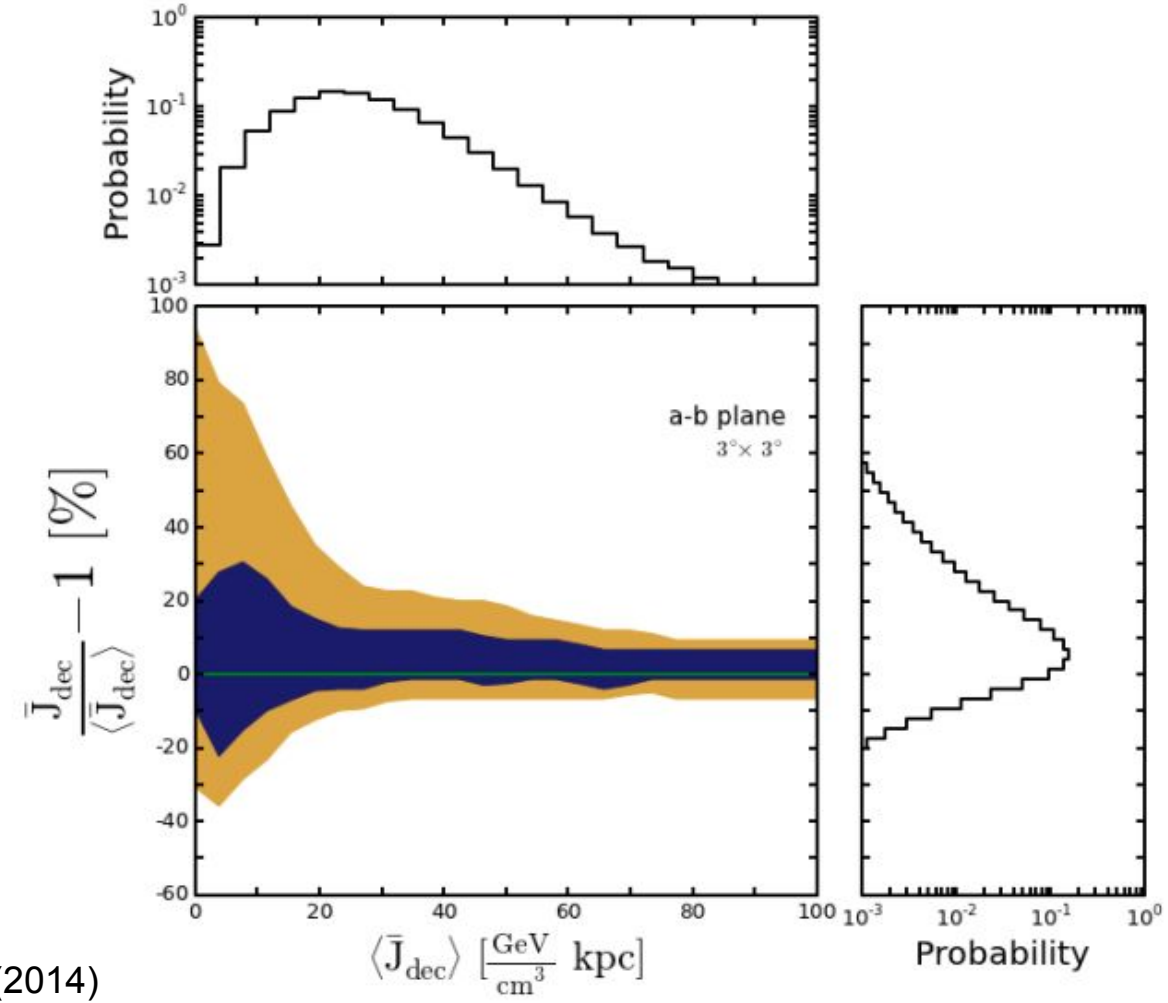
Bernal, FR, Garani, Palomares-Ruiz (2014)

Larger uncertainties on local DM density from asphericity.



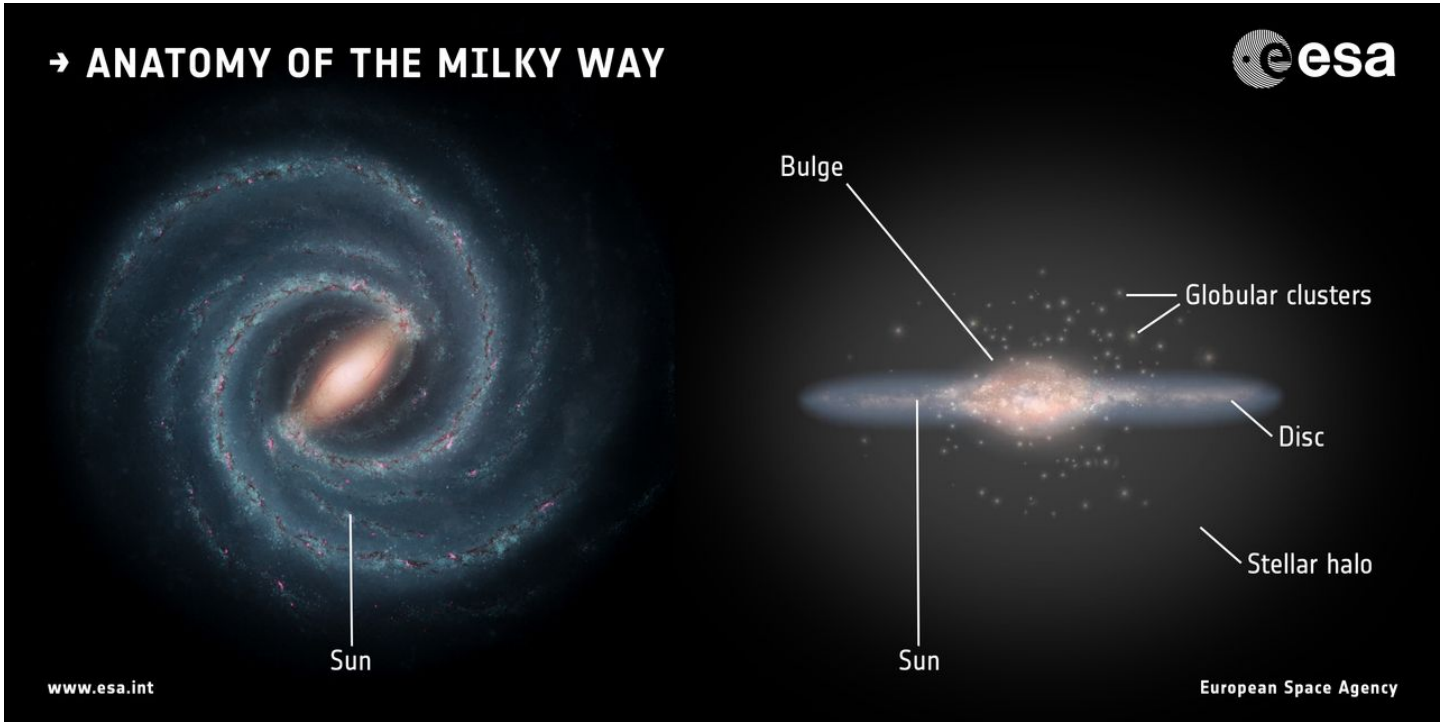
Bernal, FR, Garani, Palomares-Ruiz (2014)

Larger uncertainties on integrated squared density from asphericity.

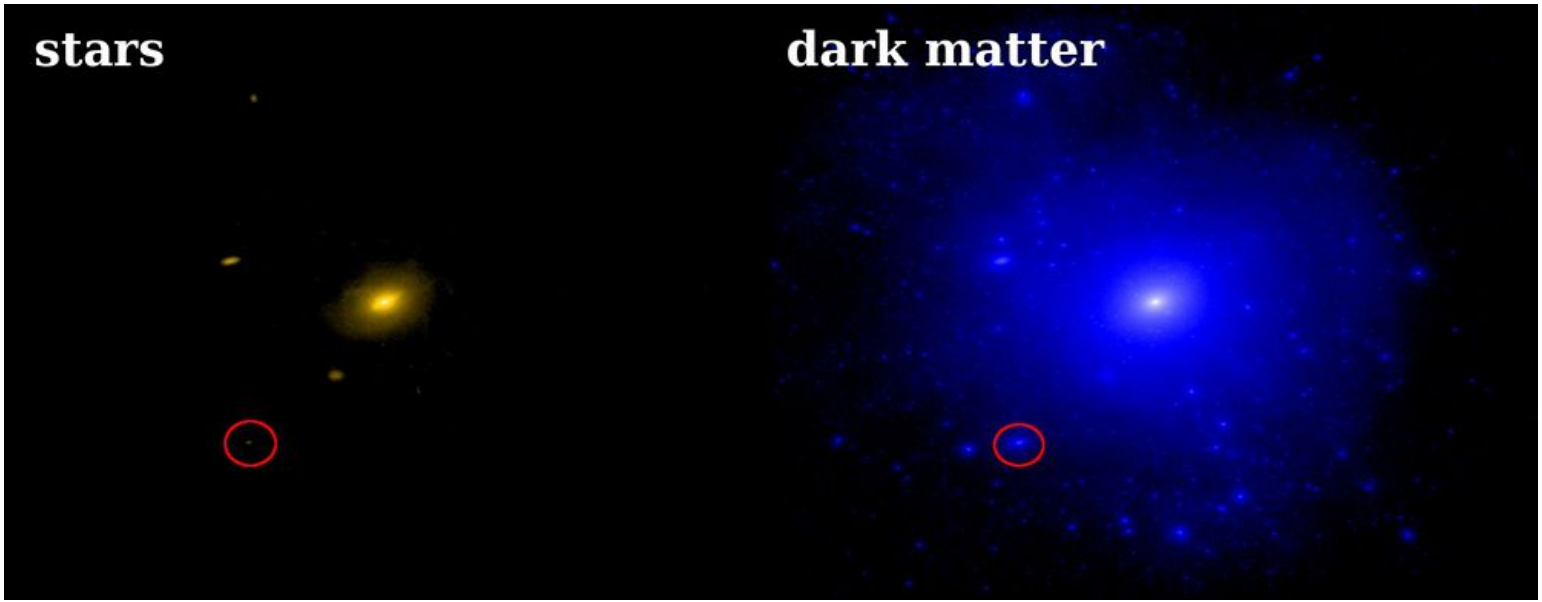


Bernal, FR, Garani, Palomares-Ruiz (2014)

What is the expected shape of the MW DM halo?



Main approach: use simulations of the MW and measure the DM halo shape



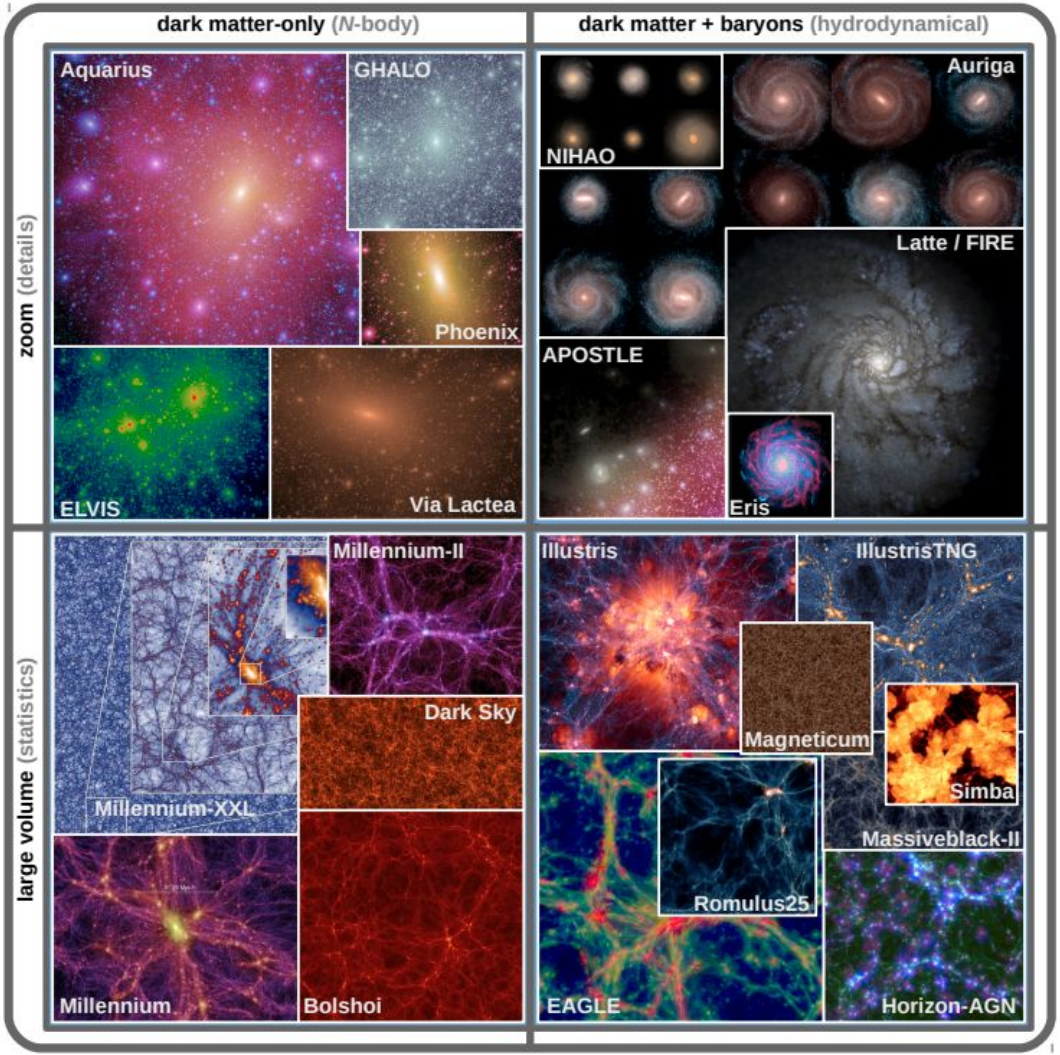
A. Wetzel + P. Hopkins

Cosmological Simulations of Galaxy Formation

Mark Vogelsberger (1), Federico Marinacci (2), Paul Torrey (3), Ewald Puchwein (4)

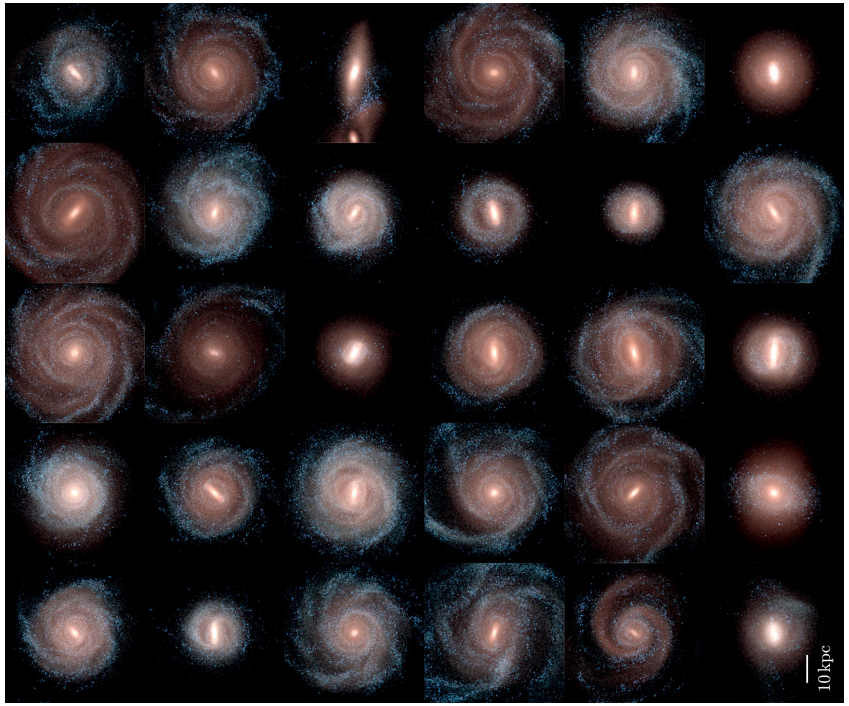
((1) MIT, (2) Unibo, (3) UFlorida, (4) AIP)

https://arxiv.org/abs/1909.07976



The Auriga Project produces realistic MW-type galaxies

Includes gas, star formation and magnetohydrodynamics (MHD). There are identical DM only simulations to compare.



DM halo: not spherical, not constant with radius

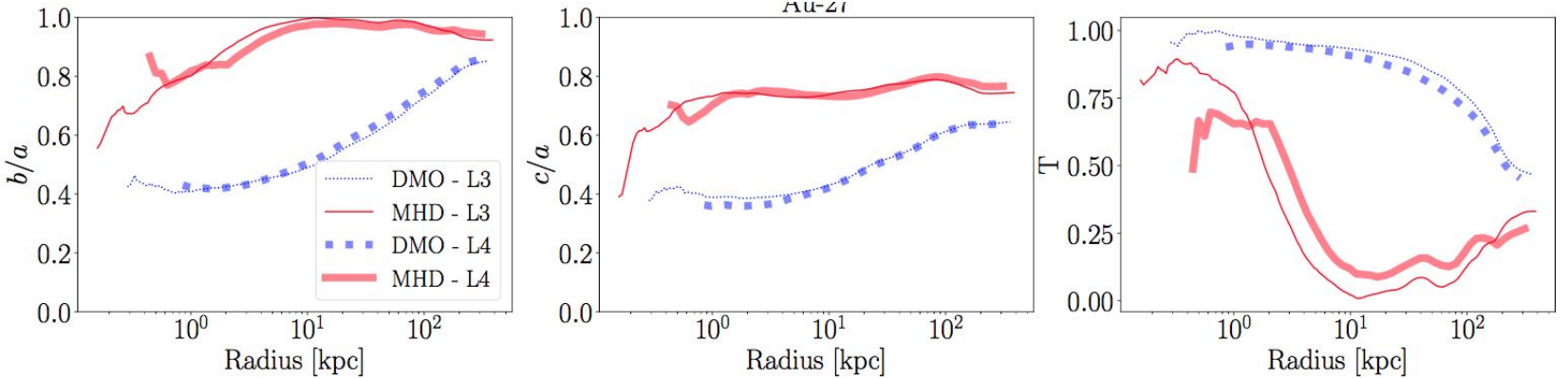
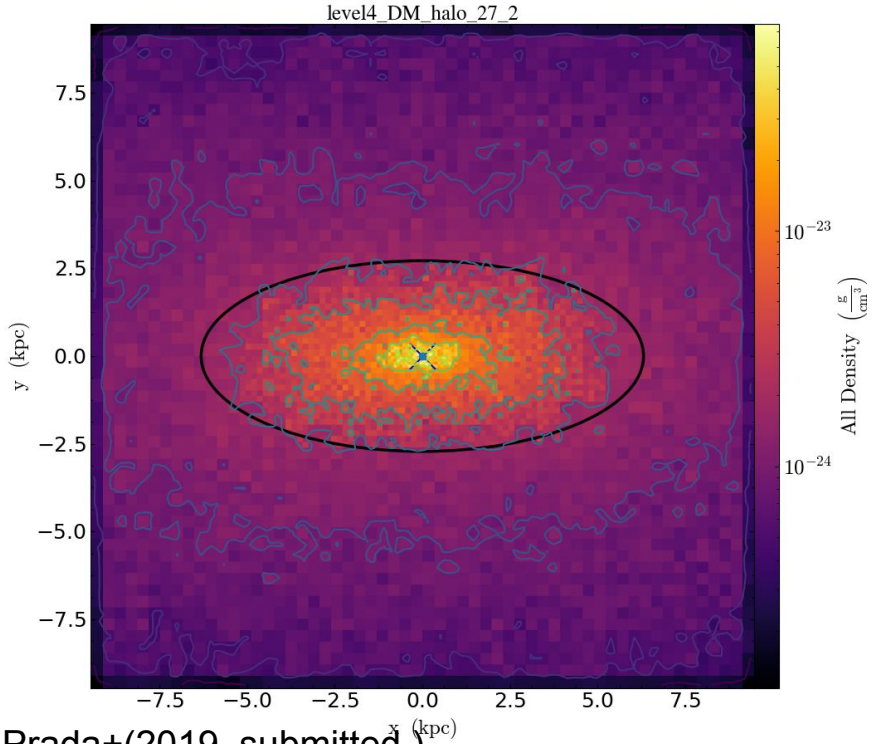
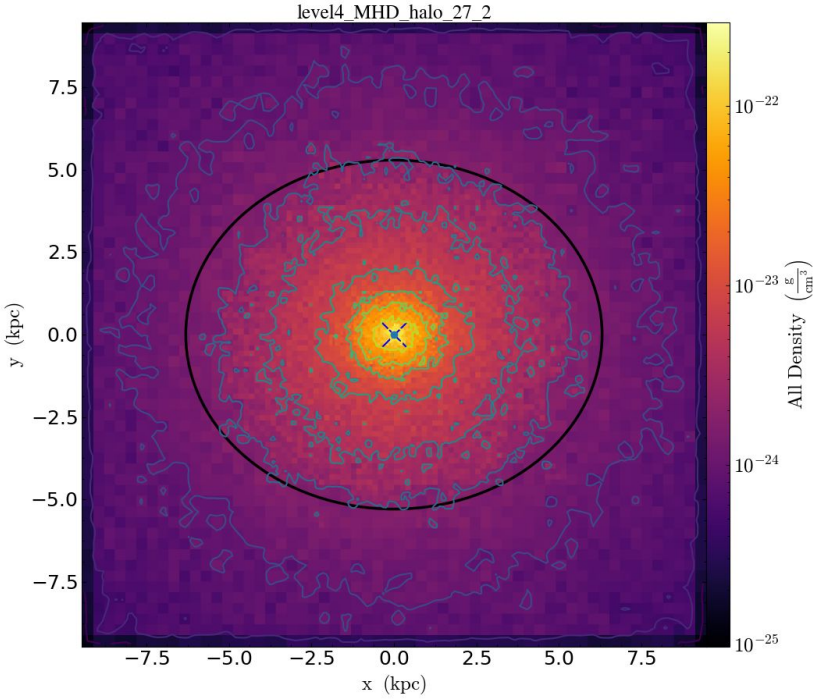


Figure 1. Axes ratios for the six halos simulated at two different resolutions with two different physical models (DMO and MHD). In DMO simulations there is good agreement between the two resolutions (L3 and L4) at all radii down to scales of ≈ 1 kpc from the center. In MHD simulations, there are noticeable differences at scales below ≈ 10 kpc. In this paper, we only report results at scales larger than ≈ 16 kpc ($R_{200}/16$).

J. Prada+(2019, submitted.)

MHD physics produces rounder halos





J. Prada+(2019, submitted.)

DM halo: shape can twist with radius

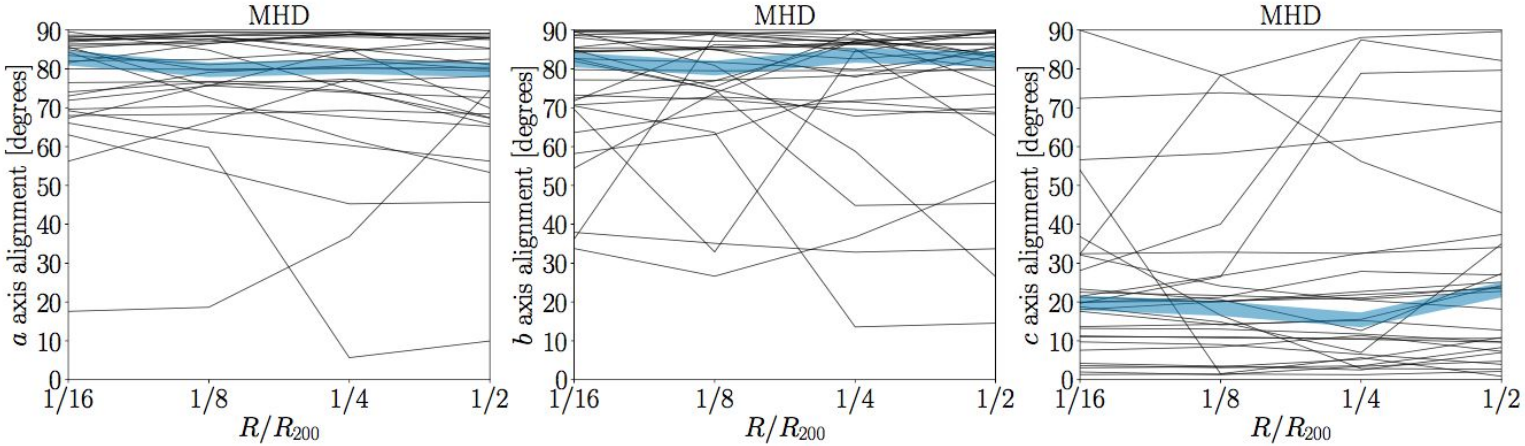


Figure 6. Angles between the principal axis of the dark matter halo shape and the angular momentum of the stellar disc as a function of the radius at which the halo shape directions are measured. Each panel compares the alignment of the corresponding major, middle, and minor axis in the halo. Thin lines correspond to each one of the thirty halos in the sample while the thick line traces the median value as a function of radius. The sample presents a good alignment of the angular momentum with the minor halo axis. This alignment is also constant in radius. However, the dark matter shells twist significantly in six halos of our sample making the alignment change.

J. Prada+(2019, submitted.)

Twisting is larger in the most recently formed halos

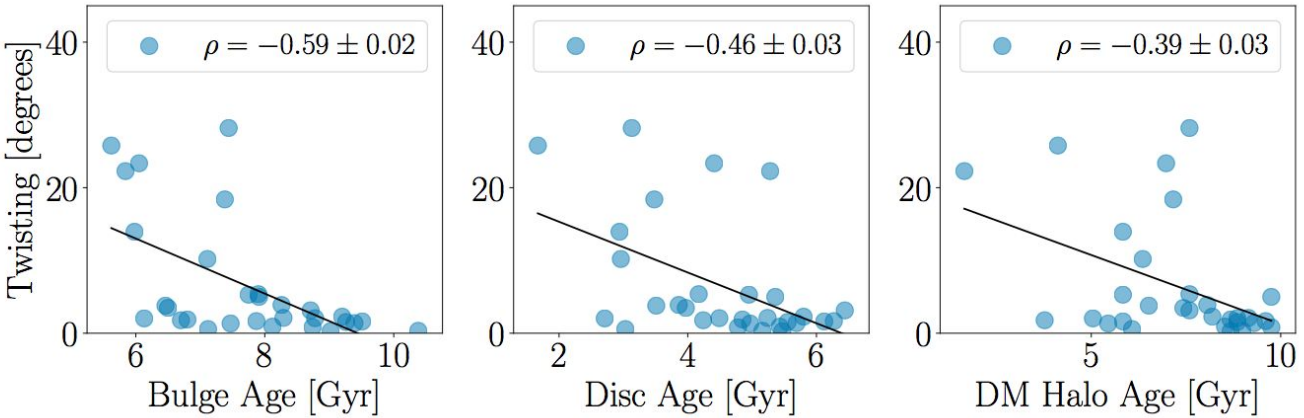
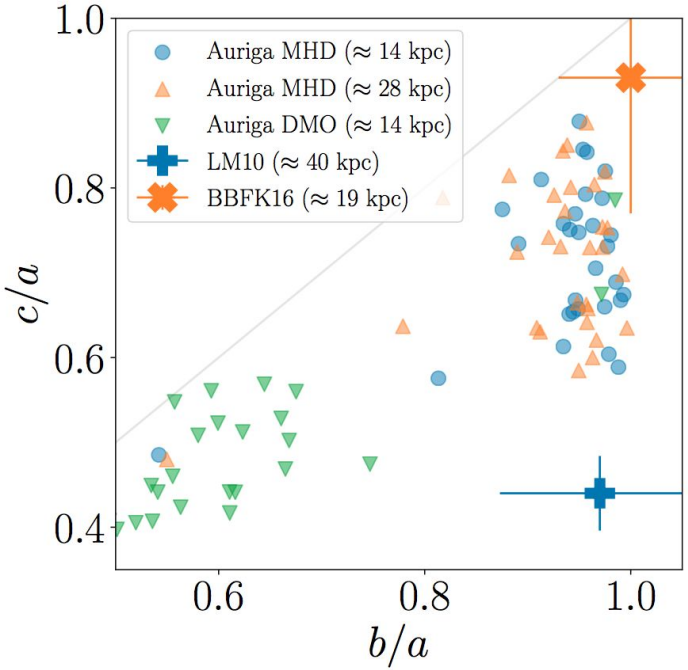


Figure 10. Twisting in the halo-disc alingment as a function of the mean stellar age in the bulge/disc and the lookback formation time of the dark matter halo (time at which half of its present mass has assembled). The label with the ρ value corresponds to the Spearman's rank correlation coefficient (mean value and uncertainty estimated via jackknife resampling). The line is the best minimum squares fit to a line.

J. Prada+(2019, submitted.)

Few systems consistent with an almost spherical halo



J. Prada+(2019, submitted.)

Conclusions

- Asphericity of DM halos has an impact on the interpretation of DM detection measurements in galaxies.
- In MW-type galaxies the DM halo: is **not spherical**, its shape is **not constant with radius** and is **not concentric**.
- DM halos in MW-type galaxies are close **spherical.**
- Is the MW a typical galaxy?