宇宙学流体模拟中的盘星系形成

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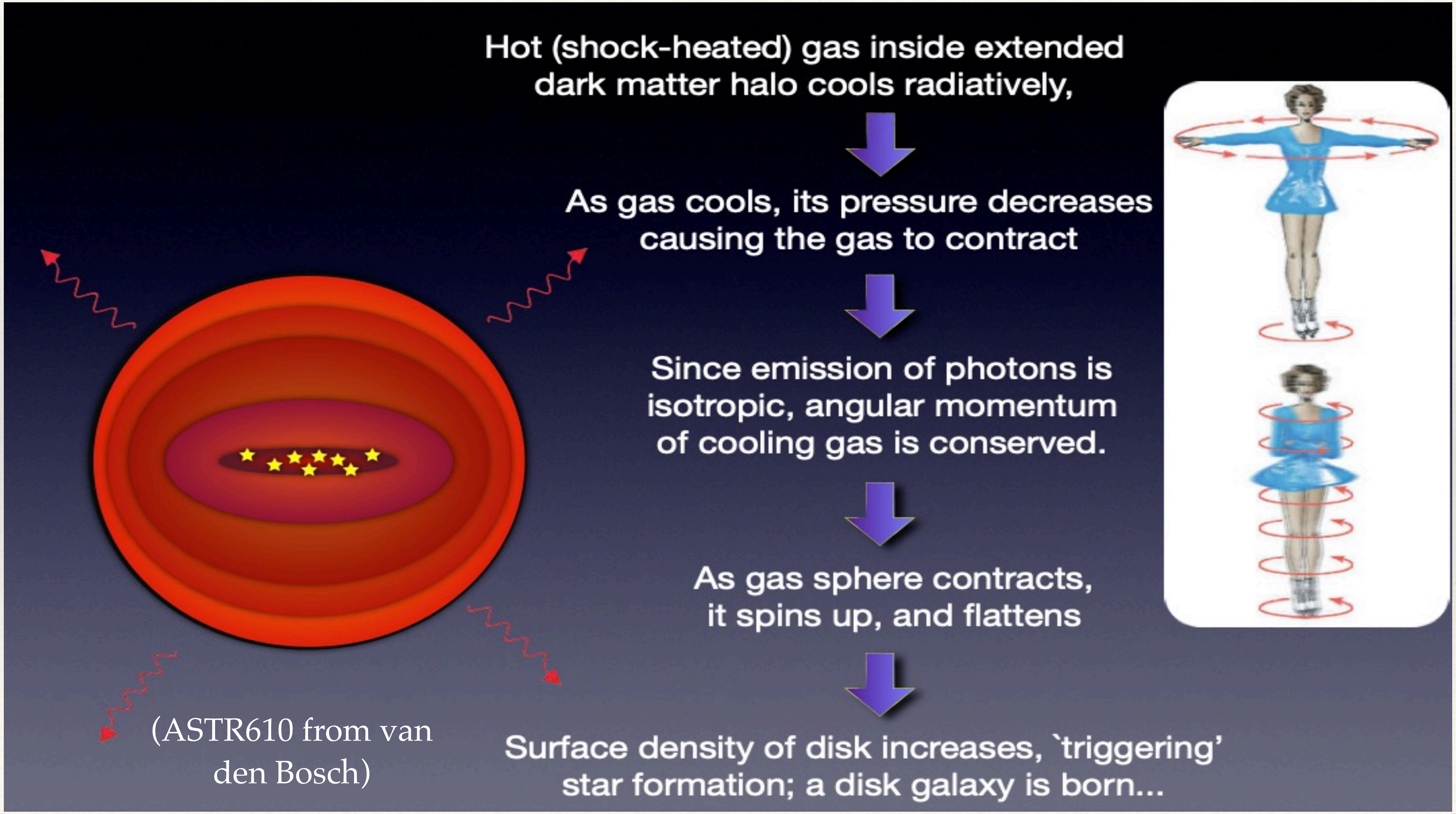
Contents

- Classical disk formation theory and size—halo spin relation in hydro-simulation.
- Effects of different sub-grid models on the evolution of angular momentum of disk galaxies.

Classical Picture of Disk Formation



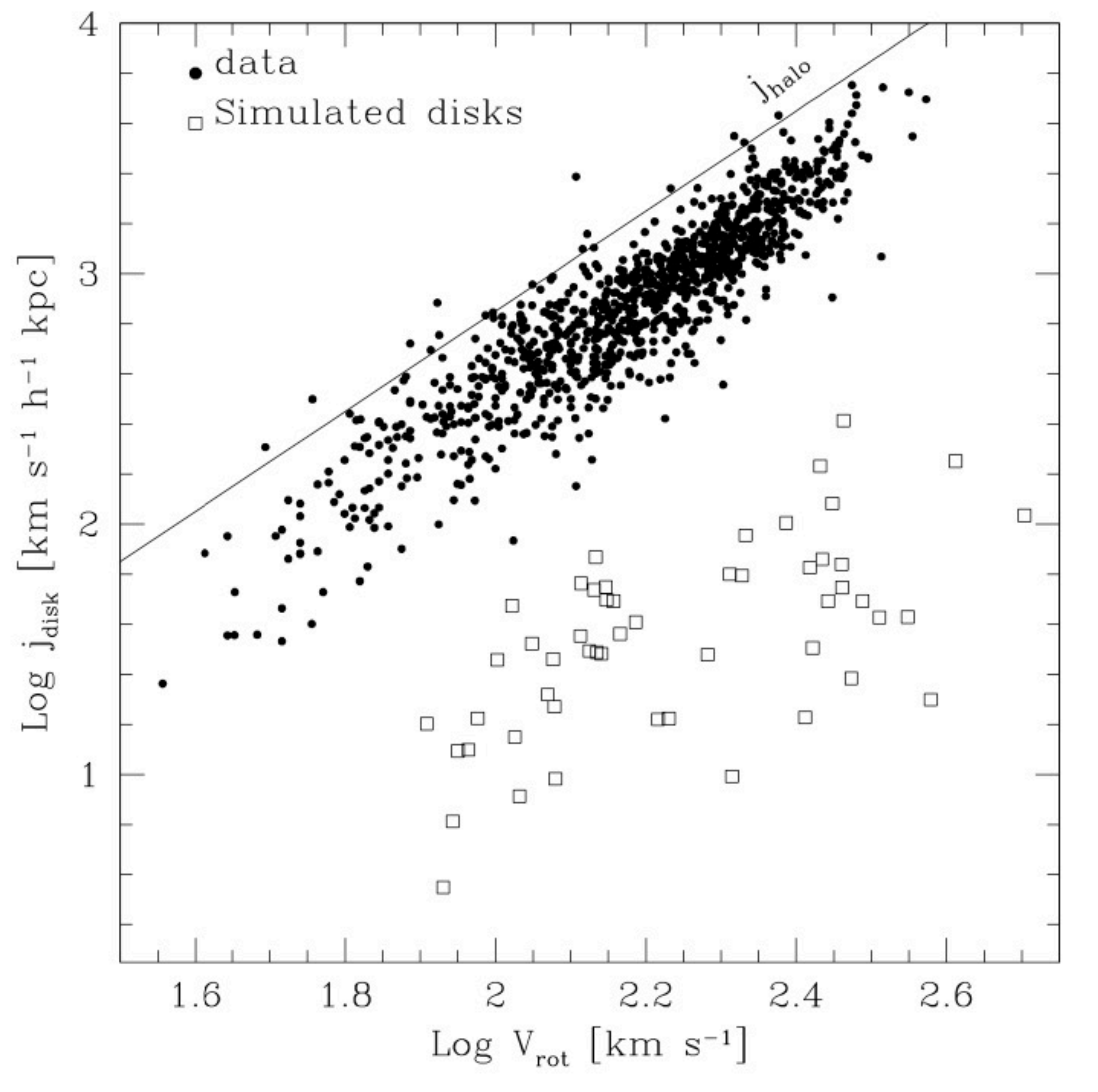
(ASTR610 from van den Bosch)

Stand picture suggest the sizes of galactic disks are tightly related to the halo spin (Fall+ 1980; Mo, Mao & White 1998). This model has been extremely successful to interpret a large body of observational data.

$$\lambda = \frac{j_h}{\sqrt{2} V_{200} R_{200}}.$$

$$\frac{r_{1/2}}{R_{200}} = \frac{1.68}{\sqrt{2}} f_j f_R \lambda$$

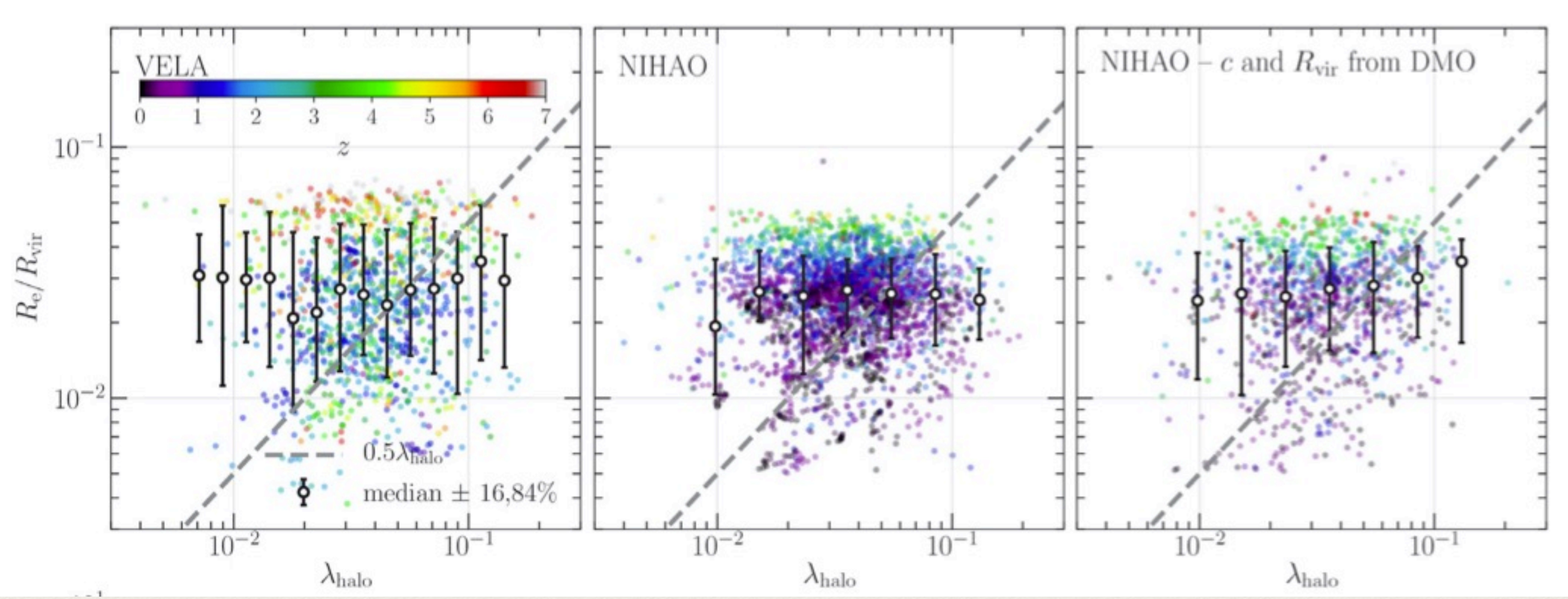
Angular Momentum Catastrophe in Simulation



(Steinmetz&Navarro, 1999)

- More drastic dynamical friction by low resolution.
- Overcooling by invalid feedback.

Size–Spin Relation in NIHAO and VELA



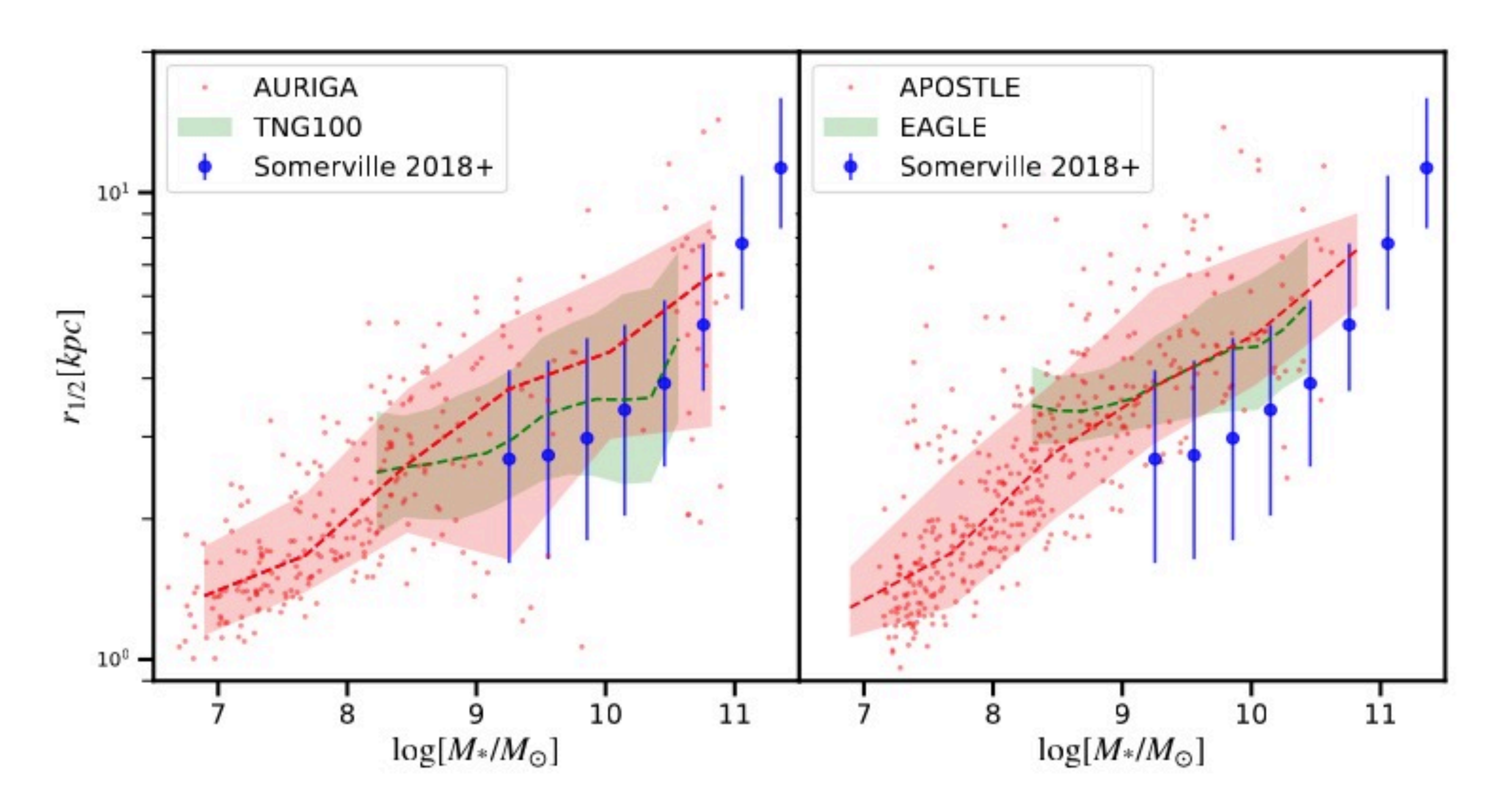
- Size—spin relation in two zoom-in simulations are inconsistent with the `standard' picture of disk formation. (Jiang+ 2019)

Size–Spin Relation in Eagle and TNG

Project	Sovler
Auriga	AREPO
IllustrisTNG	AREPO
Apostle	gadget-3
Eagle	gadget-3

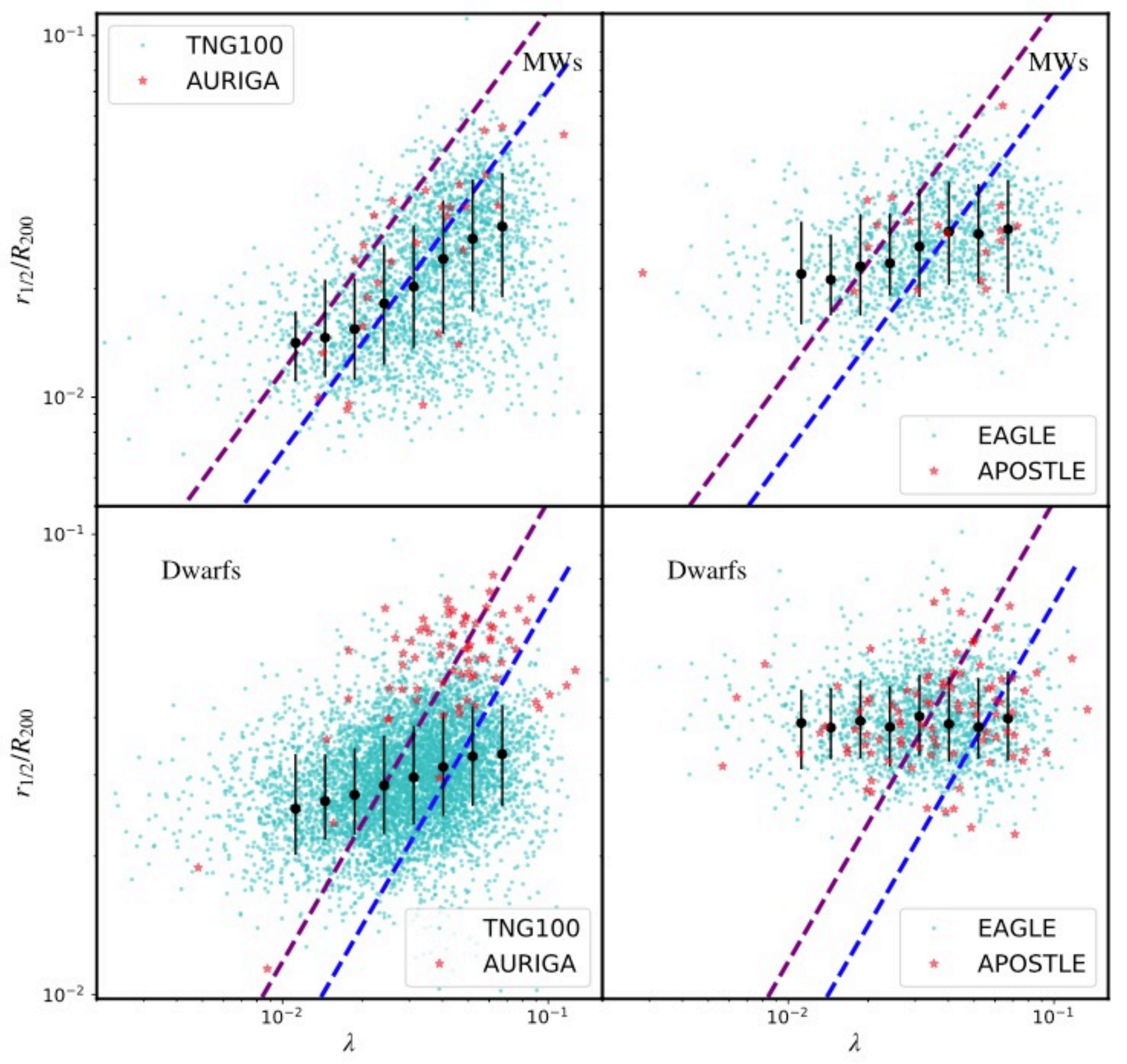
	$\epsilon\,[pc]$	$m_b\,[M_\odot]$	$m_{DM}\,[M_\odot]$
AURIGA	369	5×10^4	3×10^5
TNG100-1	740	1.4×10^6	7.5×10^6
APOSTLE-L2	216	1.2×10^5	5.8×10^5
EAGLE(RefL0100N1504)	700	1.8×10^6	9.7×10^6

$$\kappa = \frac{K_{rot}}{K} = \frac{\sum_i 1/2 m_i \{(\hat{\boldsymbol{L}} \times \hat{\boldsymbol{r}}_i) \cdot \boldsymbol{v}_i\}^2}{\sum_i 1/2 m_i v_i^2}$$

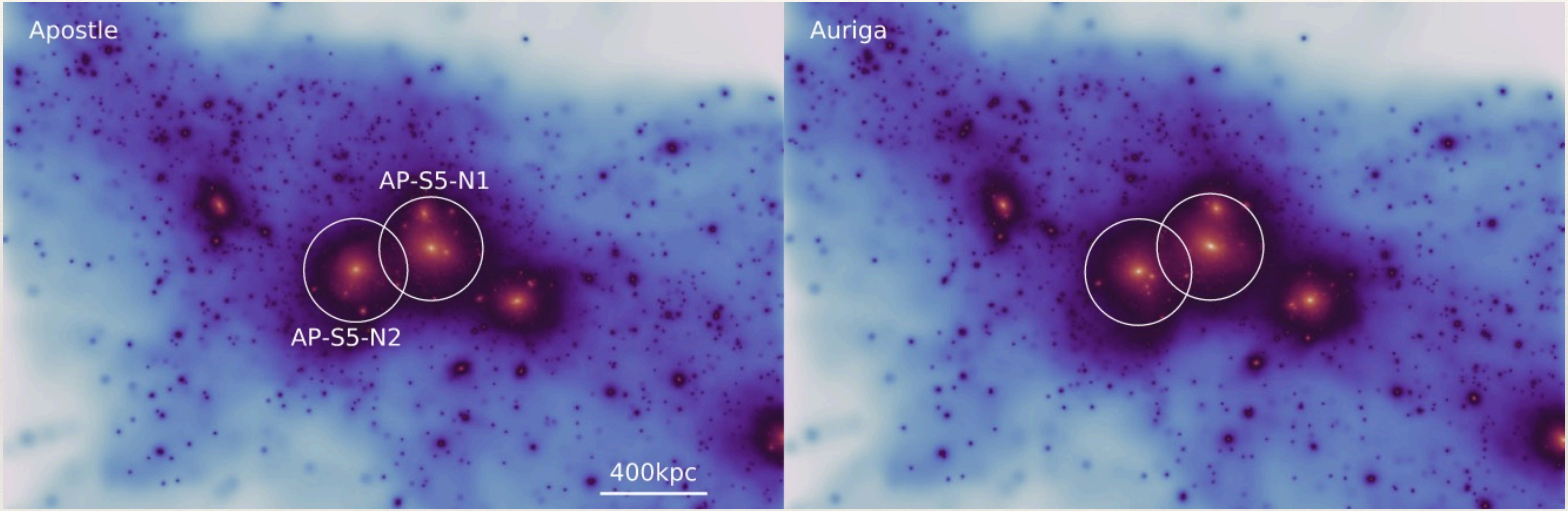


	MW-like	Dwarf
ρ(TNG100&Auriga)	0.50 ± 0.05	0.38 ± 0.05
ρ(Eagle&Apostle)	0.32 ± 0.07	0.02 ± 0.09

- There is also a size—spin correlation for the Milky way analogies in the Eagle and TNG simulations.
- For the dwarfs in the simulations from the Eagle collaboration, there is Null correlation

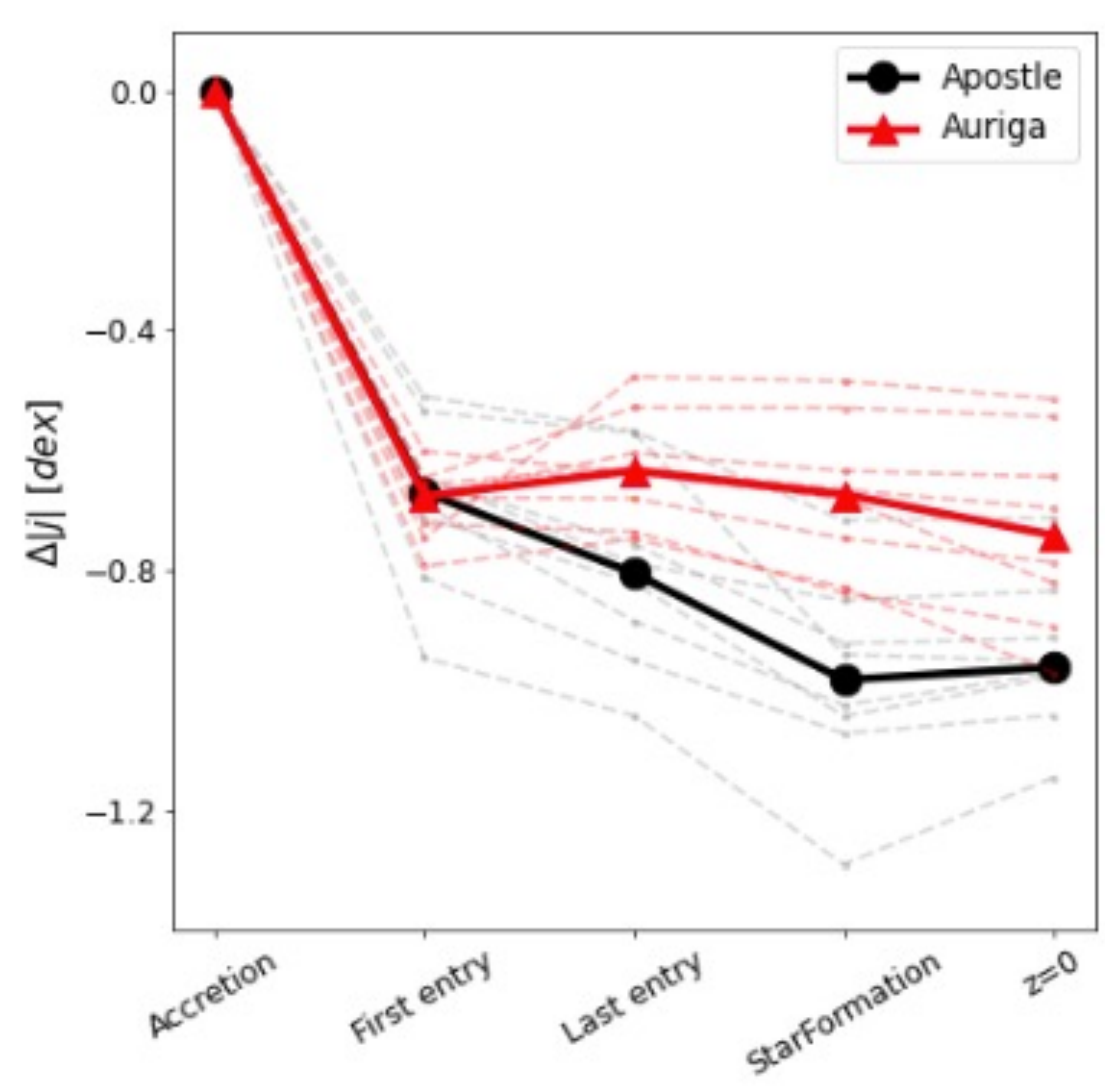


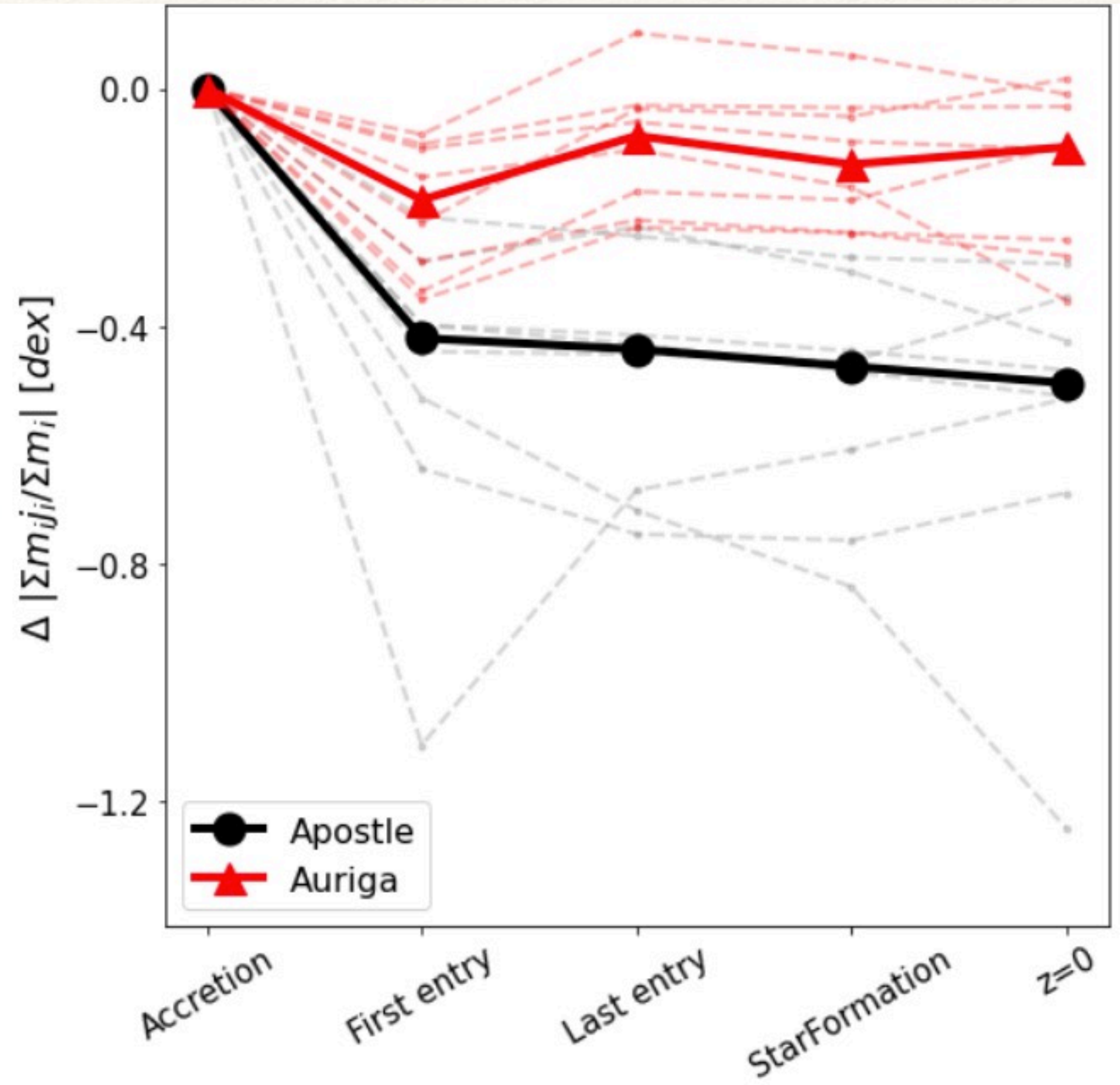
Zoom-in Simulation with Same ICs



- Both two simulations used the same initial conditions, but different code. (Kelly+, 2022)

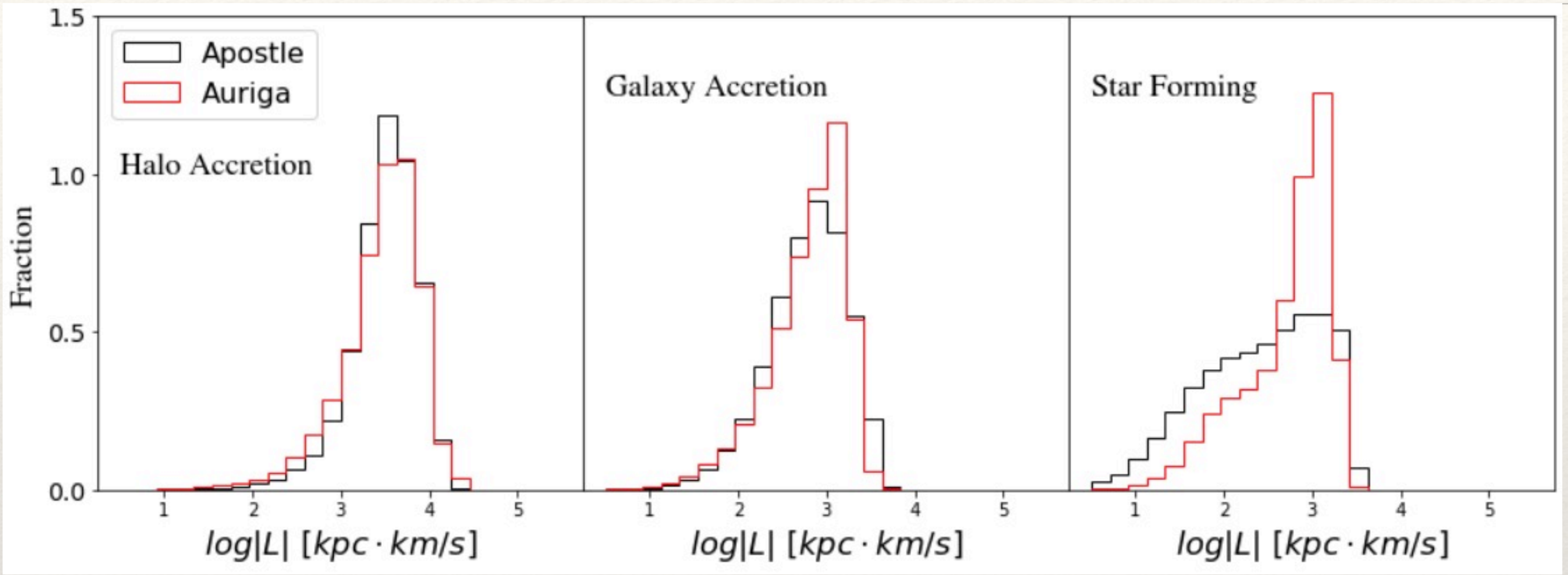
Angular Momentum Evolution in Two Simulations

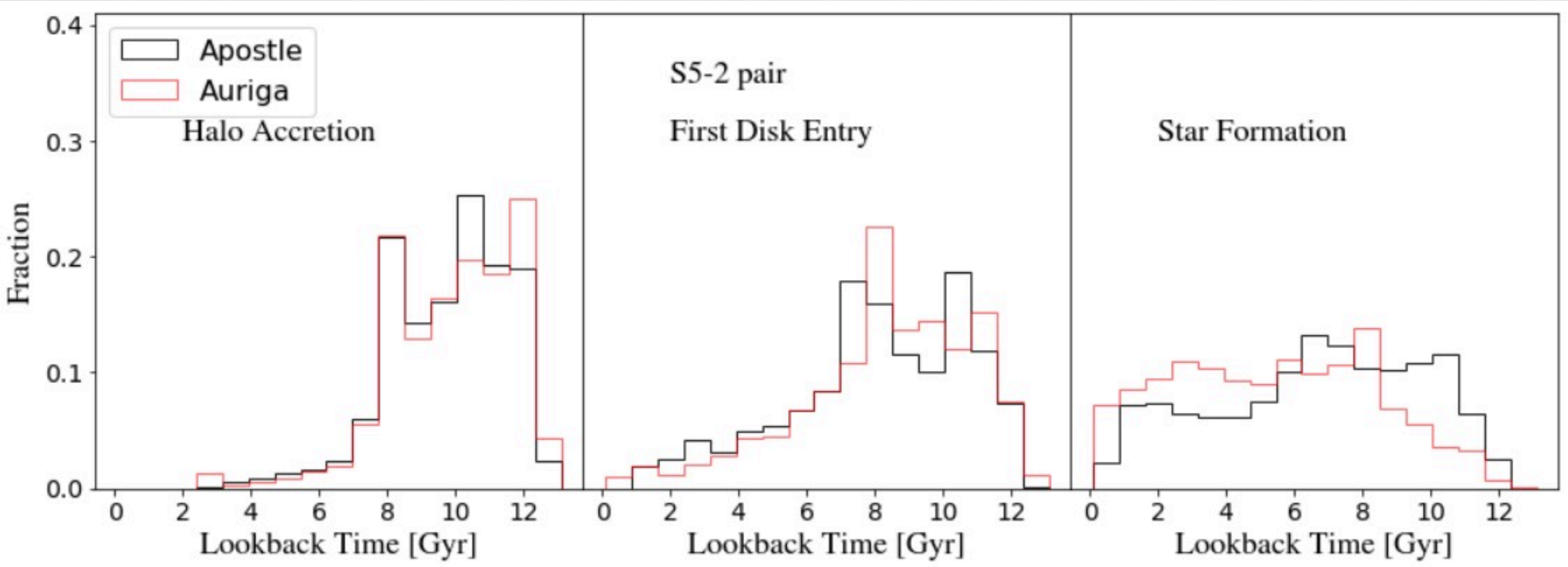




- magnitudes of specific AM of individual particle loss is about 0.7 (1.0) dex in Auriga(Apostle).
- magnitudes of specific total AM of those particles loss is about 0.1 (0.5) dex in Auriga(Apostle).

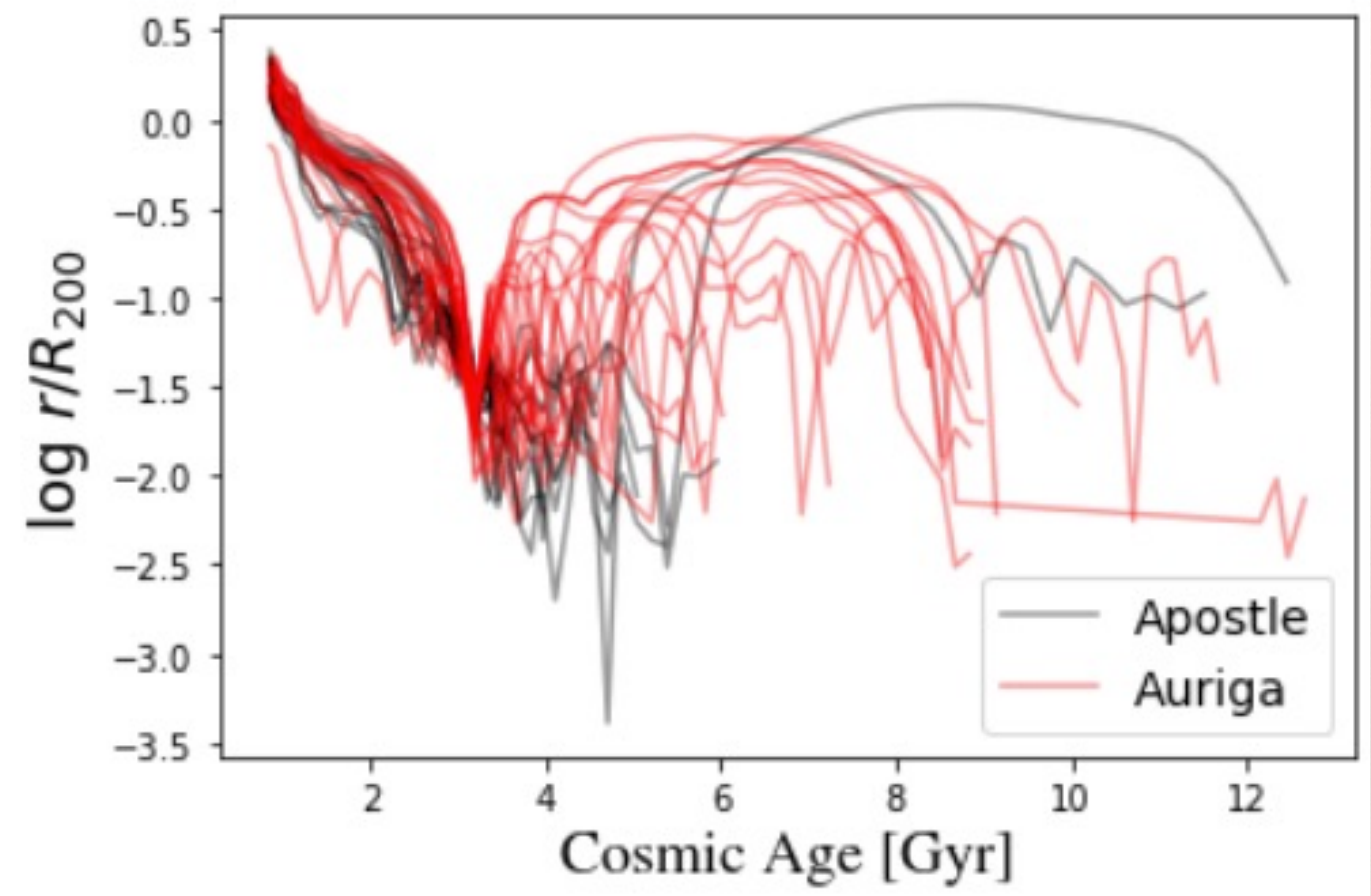
Time and Angular Momentum Distribution

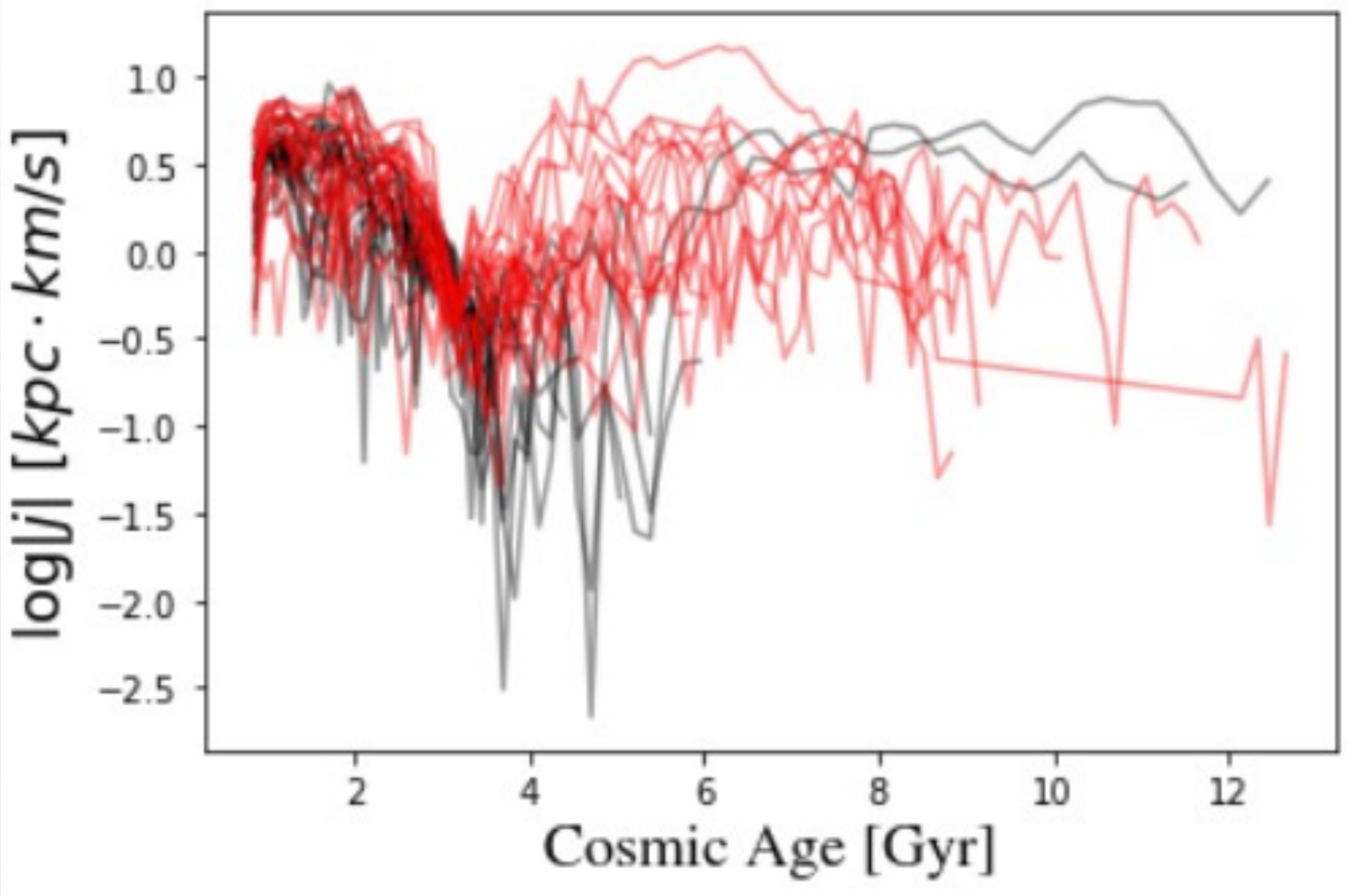




- Similar AM and Time distributions suggest the most differences on angular momentum evolution come from physical processes within the galaxy.

Fountain Flow





- In the case of restoring other observational properties, kinetic feedback can more effectively launch gas out.

Conclusion

- We find that there is size—spin relation in modern simulations. However, the relationship of different analog predictions is different.
- Fountain cycle by different model caused the difference in the evolution of angular momentum.
- Future observations are needed to judge which model is more realistic.