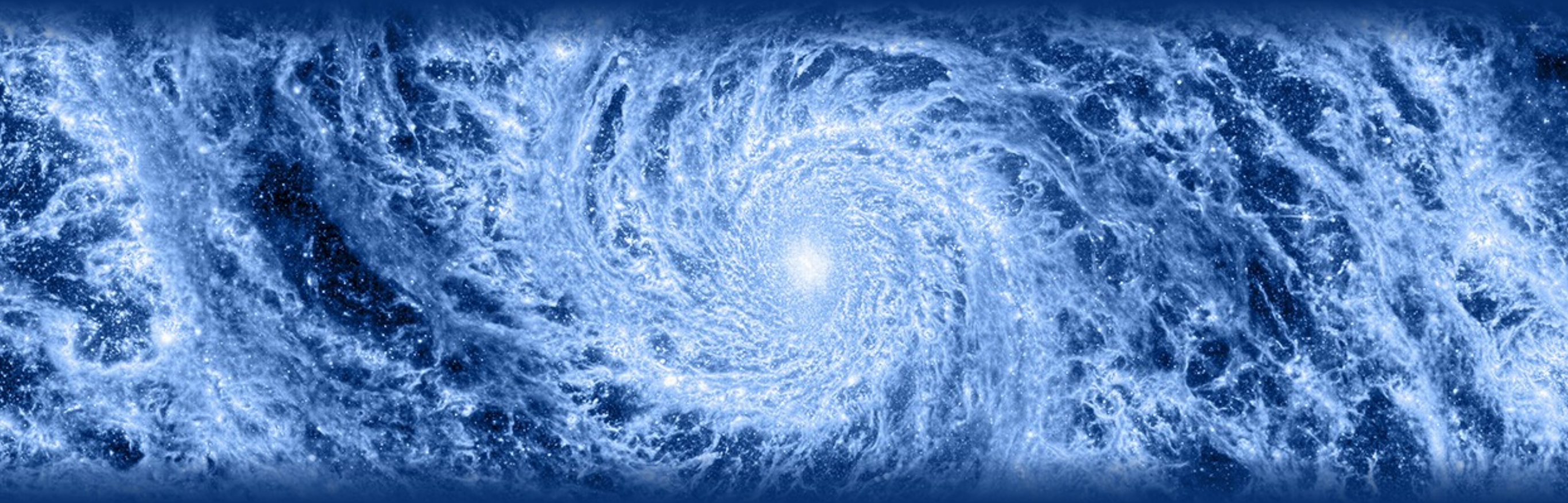


Galaxies

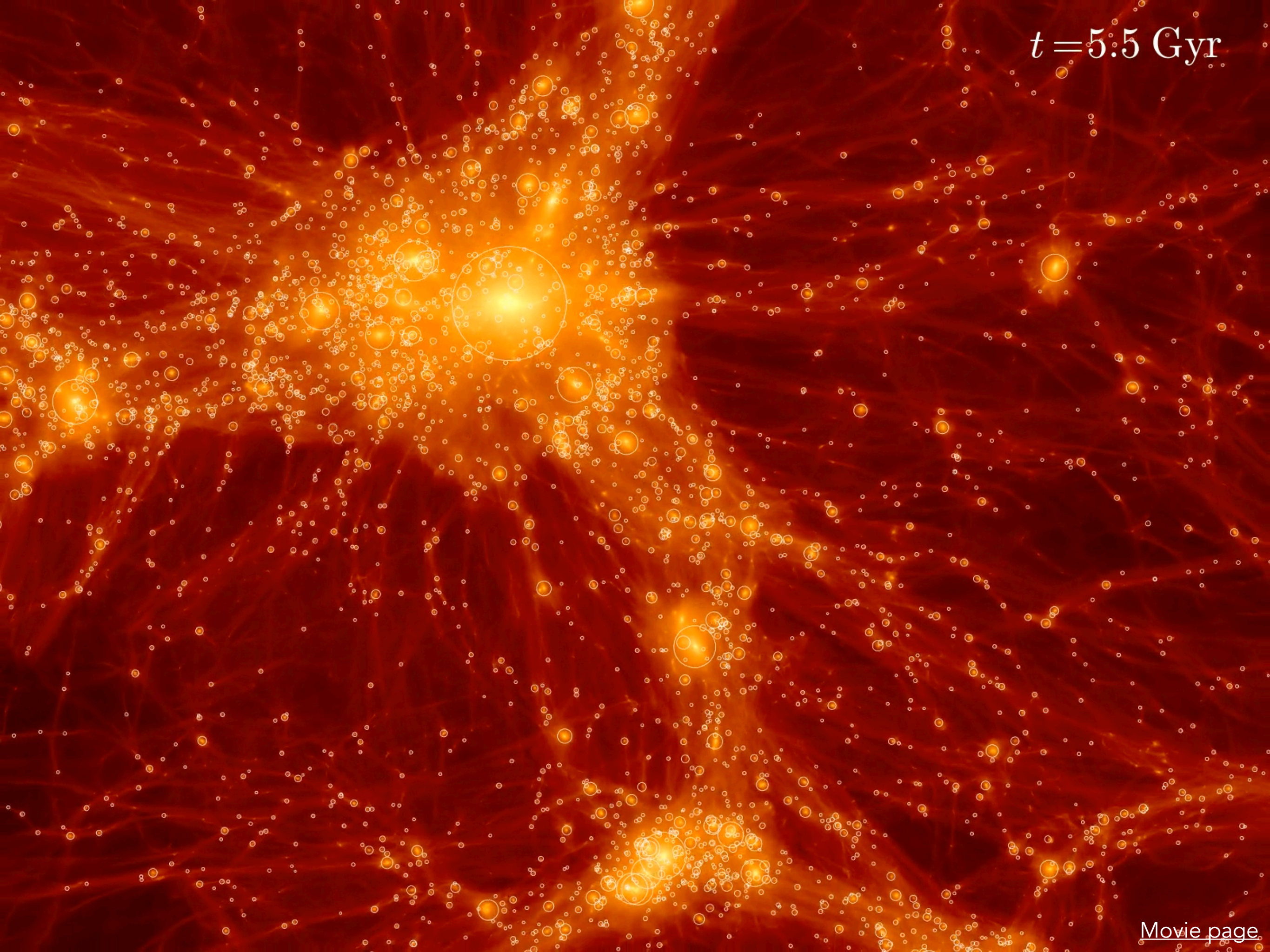
Prof. Benedikt Diemer



Chapter 10 • Subhalos, satellites, and mergers

§10.1 • Subhalos

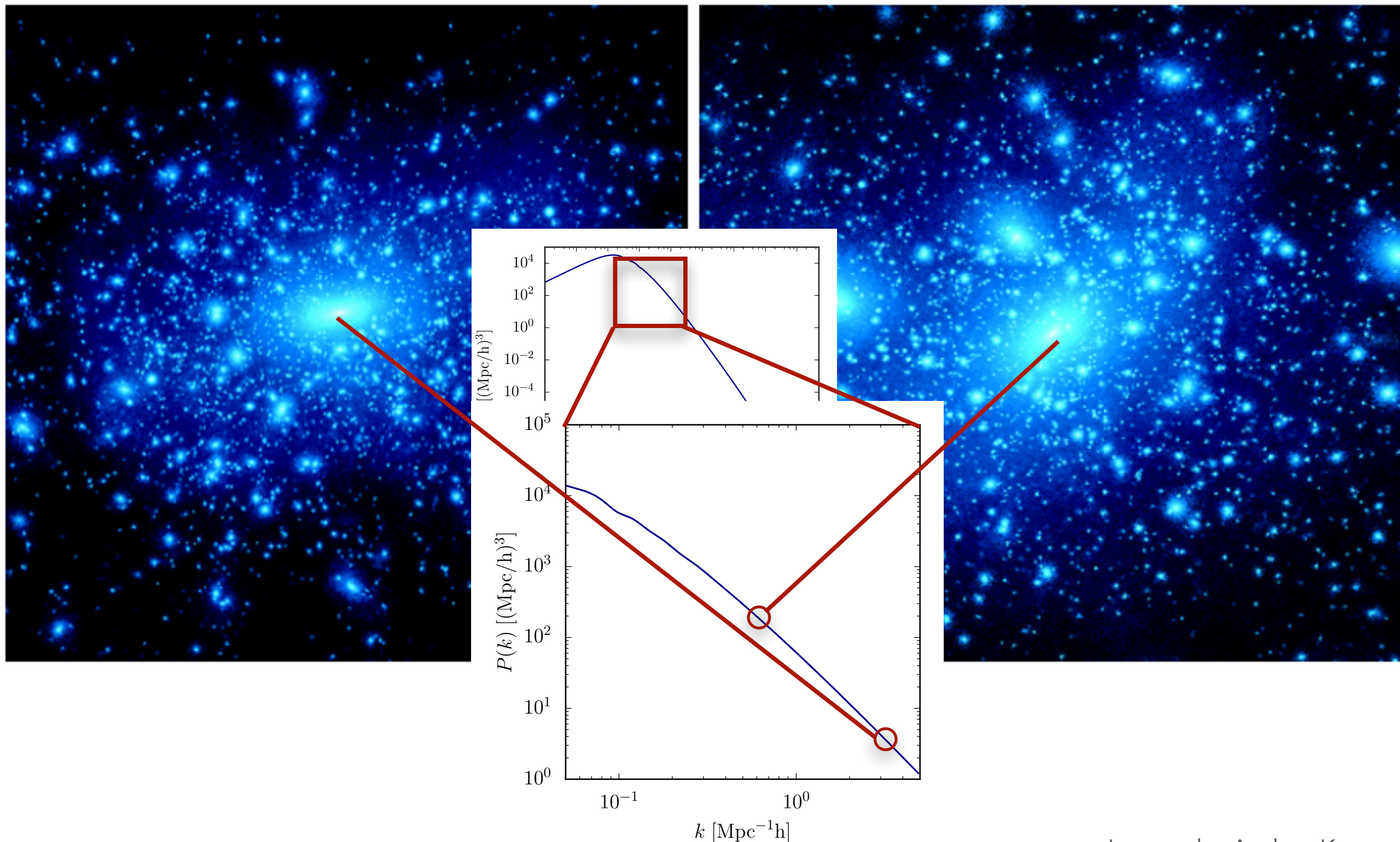
$t = 5.5 \text{ Gyr}$

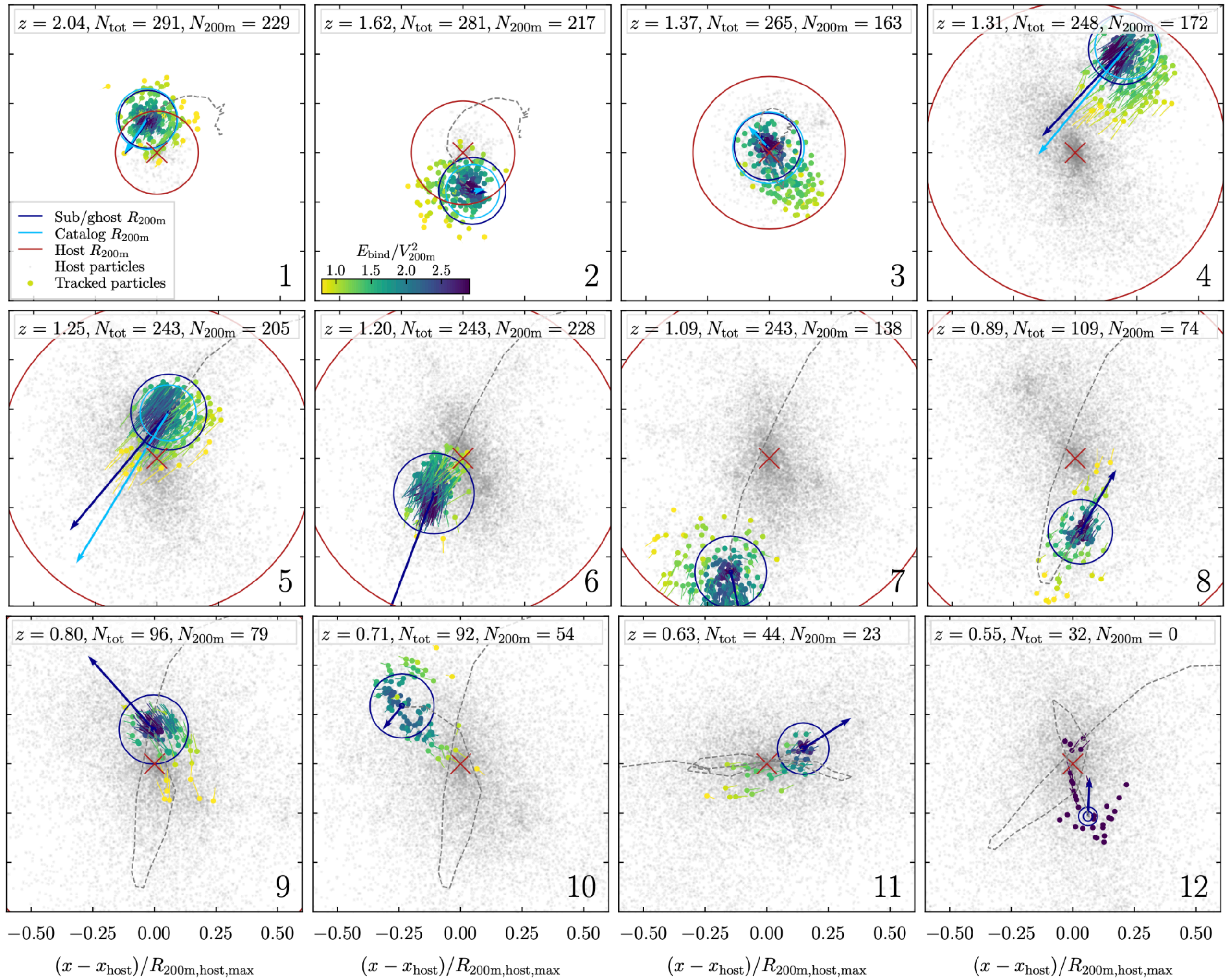


Self-similarity

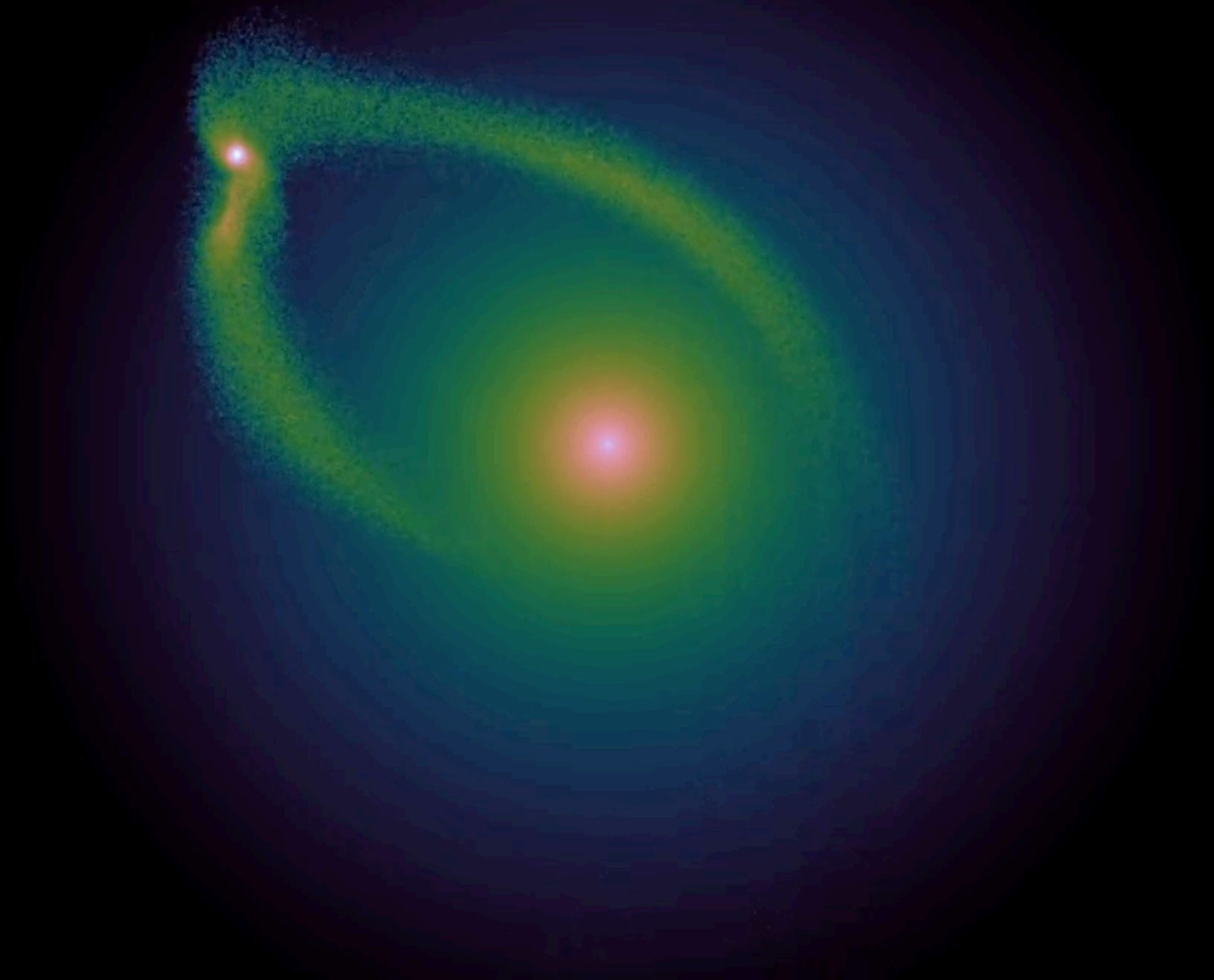
$$M = 3 \times 10^{12} M_{\odot}$$

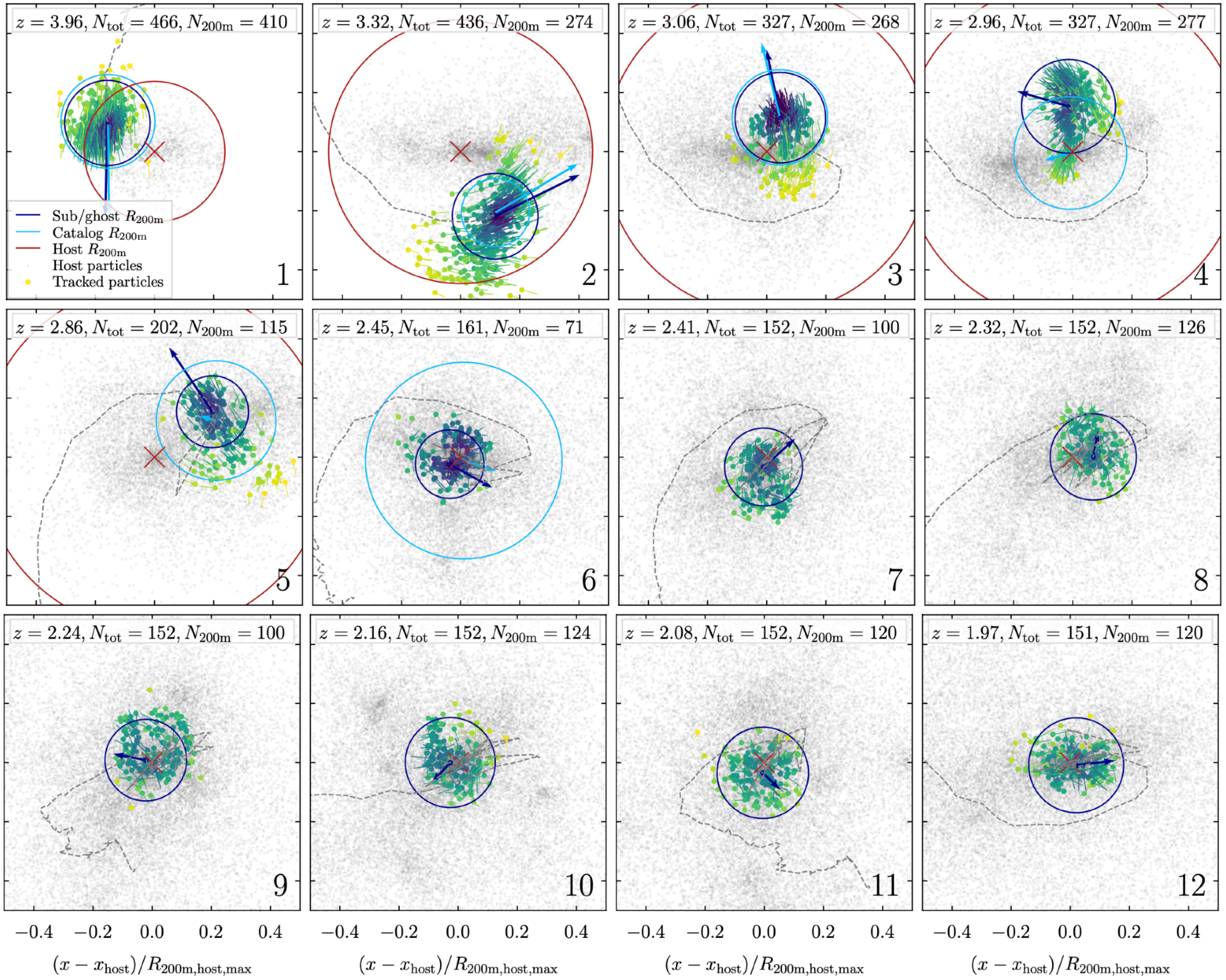
$$M = 3 \times 10^{14} M_{\odot}$$



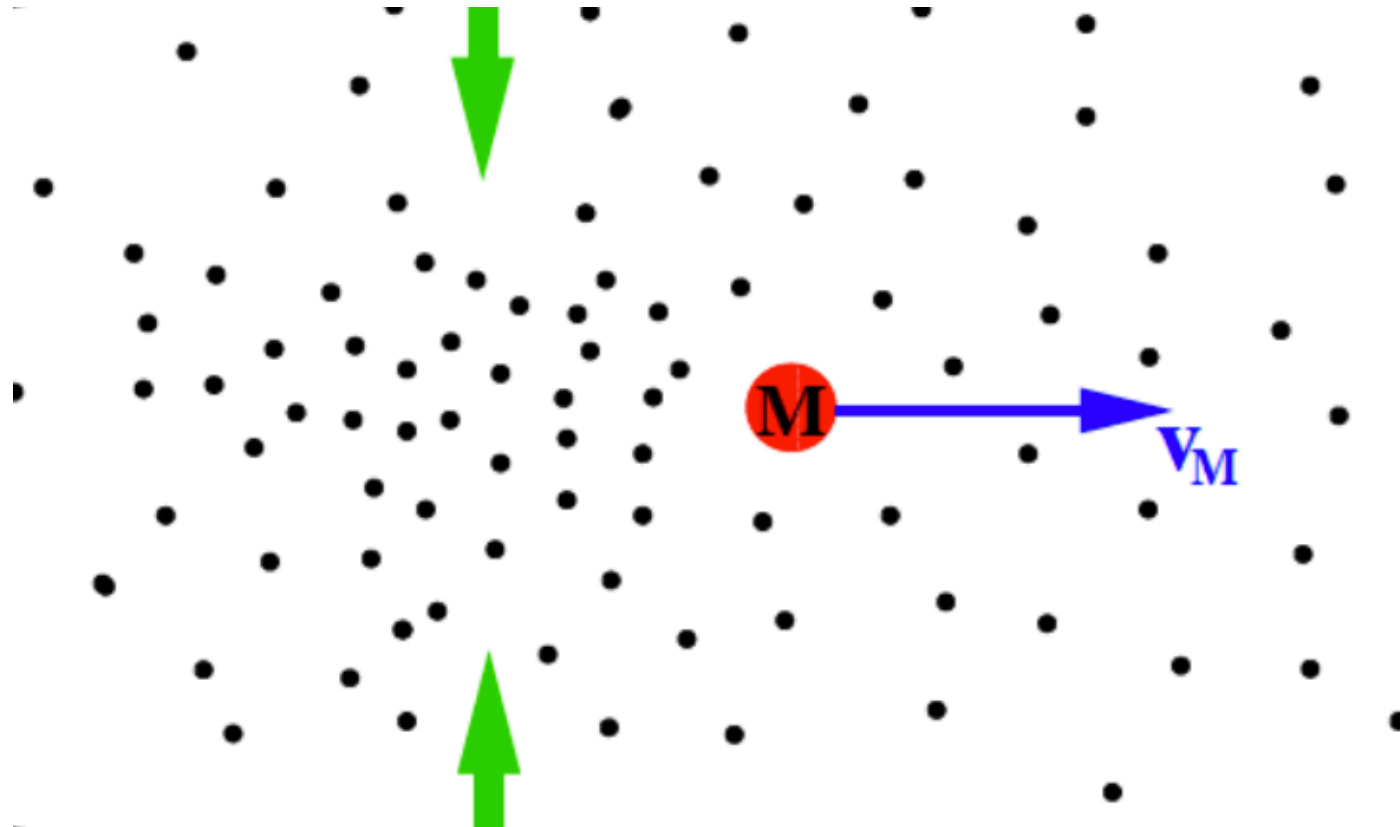


Tidal stripping

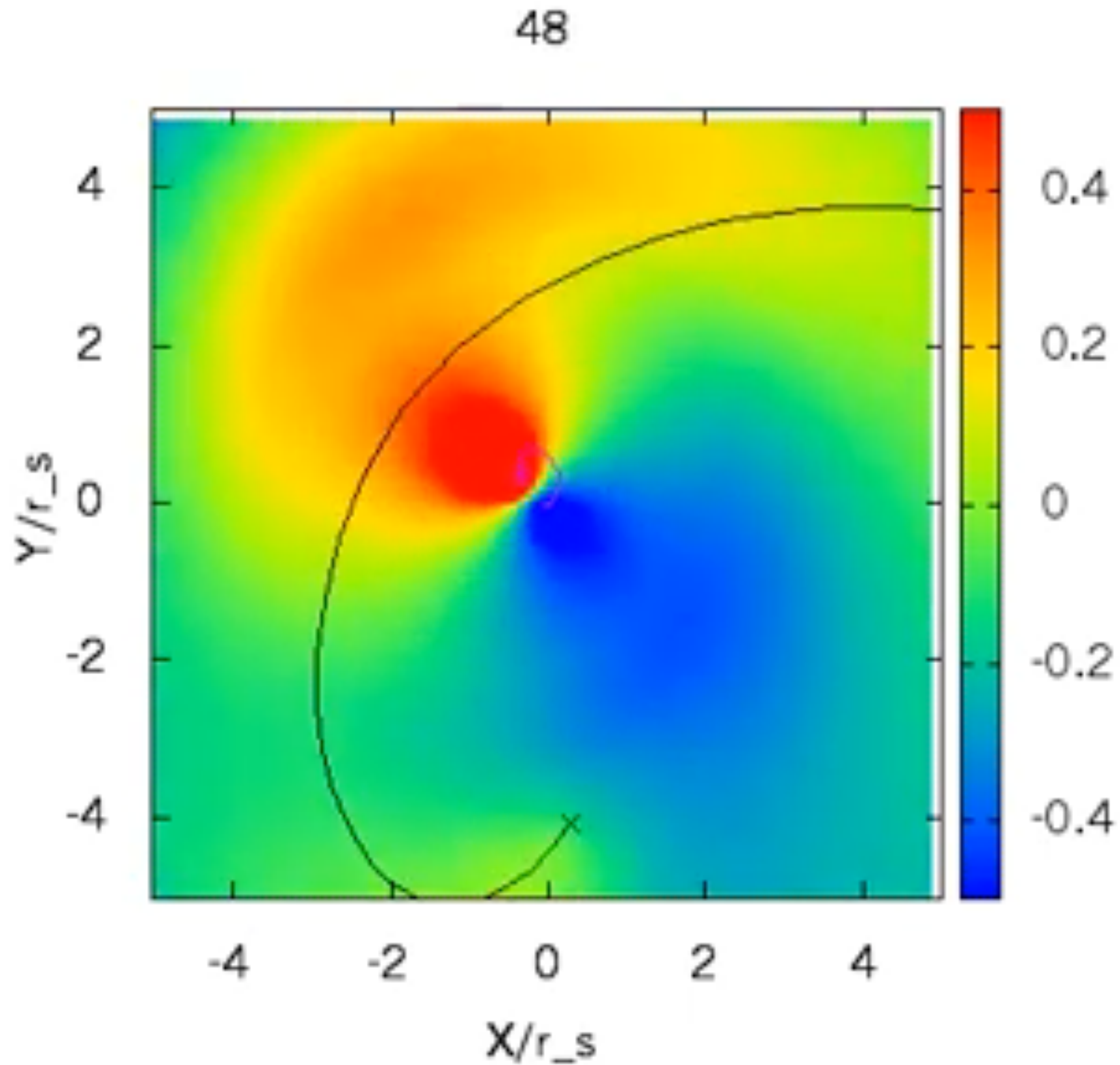




Dynamical friction



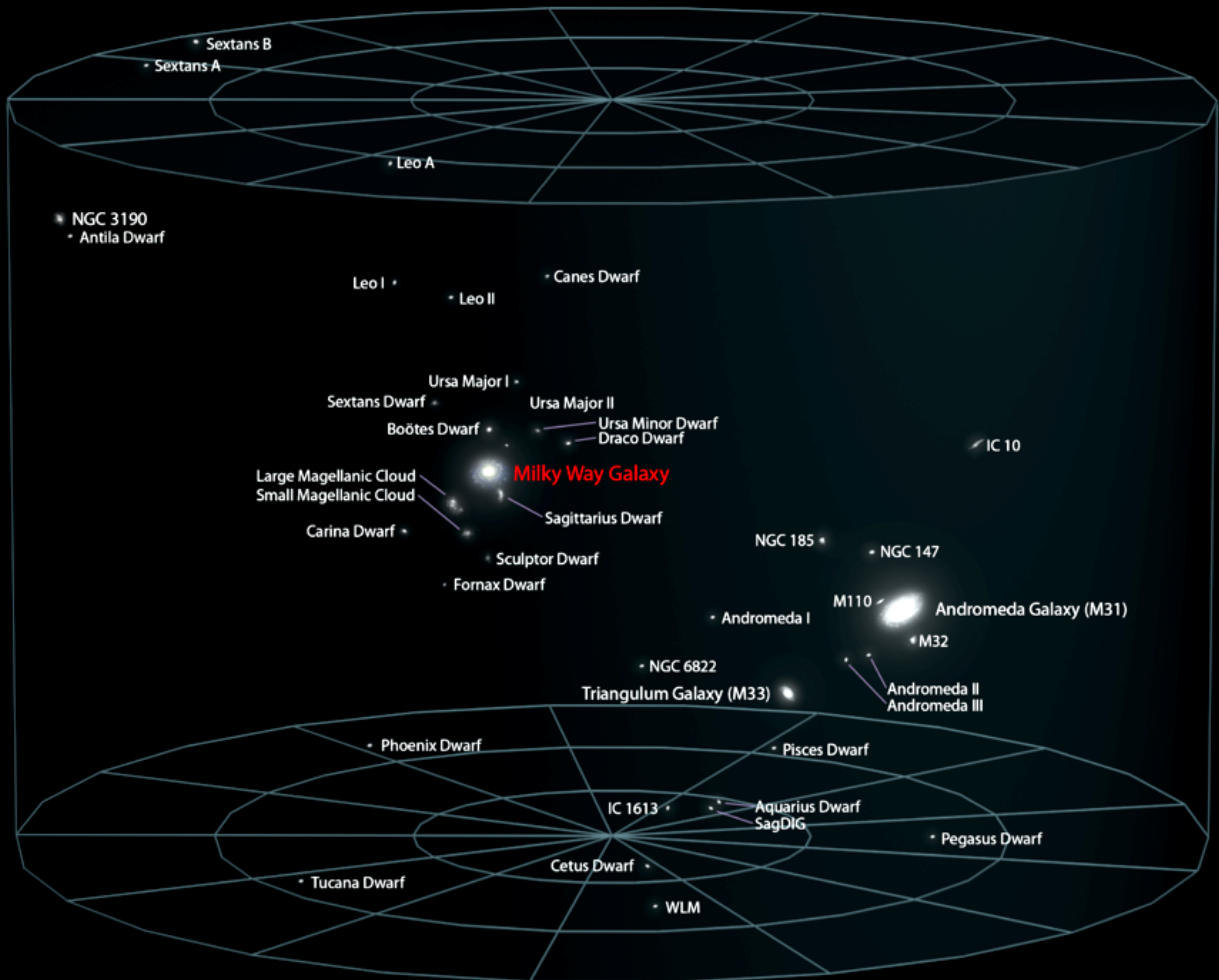
Dynamical friction

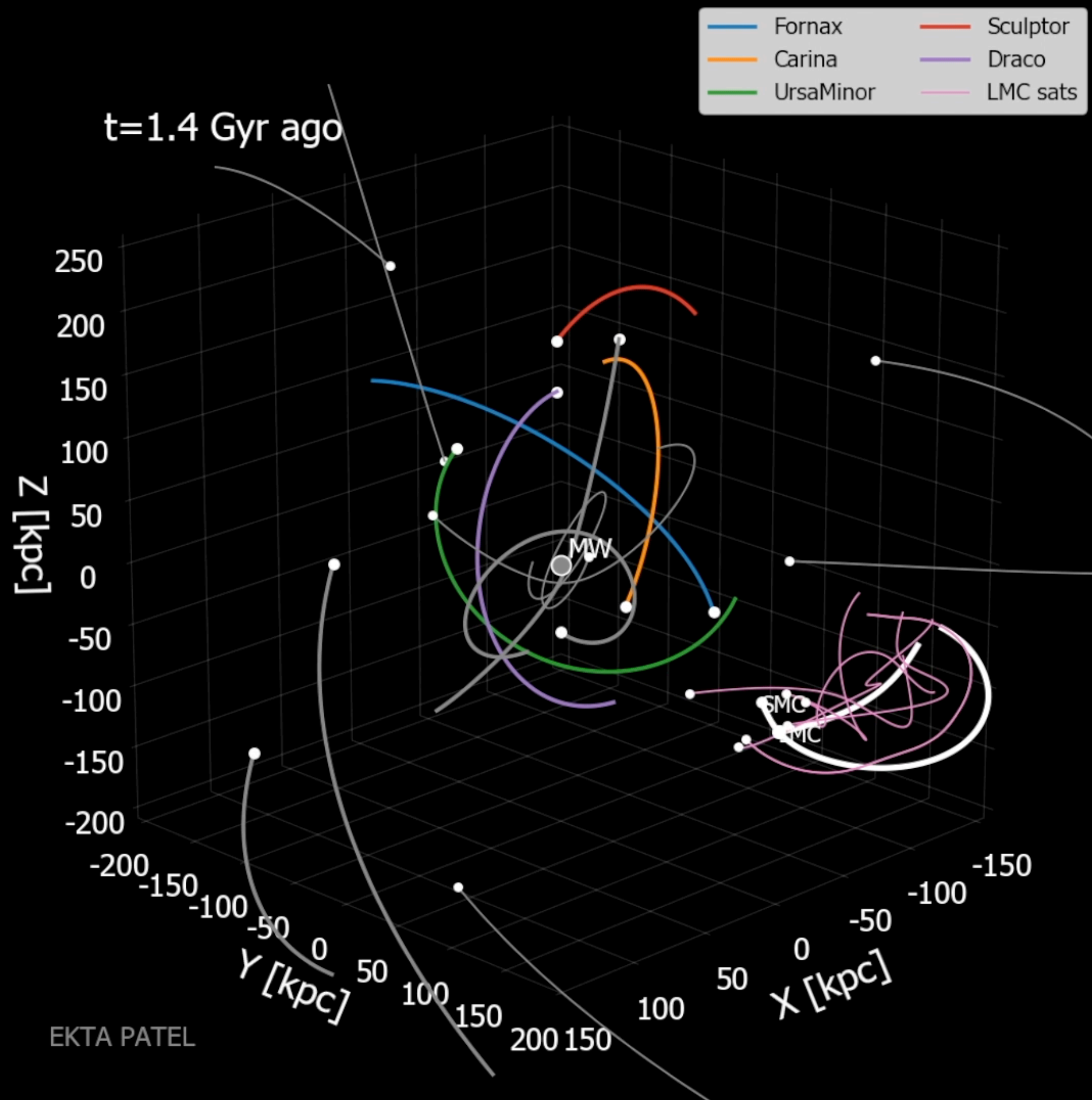


§10.2 • Satellite galaxies from dwarfs to clusters



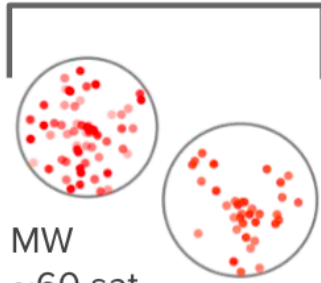






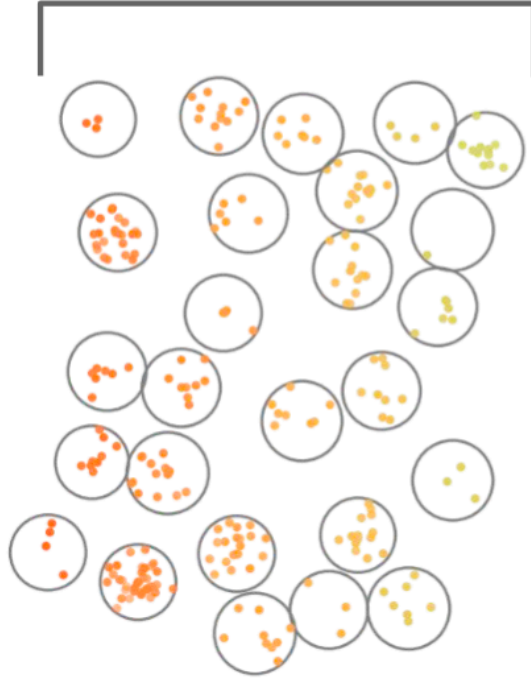
Satellites around MW-like galaxies

Local Group



MW
~60 sat.
M31
~25 sat.
e.g.,
Drlica-Wagner+2020
McConnachie+2012

Local Volume
< 20 Mpc



~10 satellites per system
~30 systems

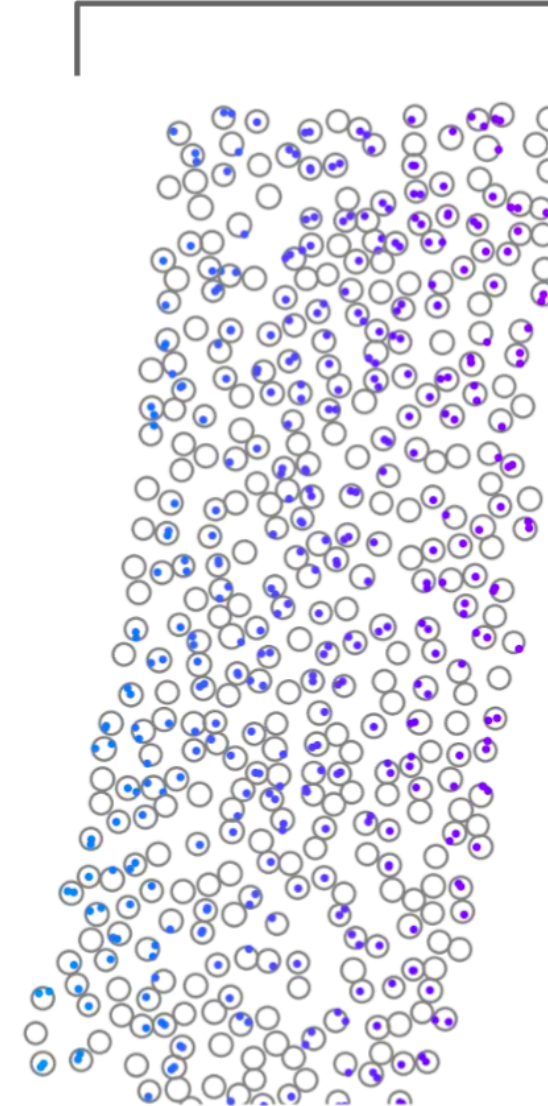
e.g., ELVES (Carlsten+2022)
& other single-system surveys

The **SAGA Survey**
25 – 40 Mpc



SAGA Survey (this work)
~4 satellites per system
~100 systems

SDSS
Up to ~200 Mpc



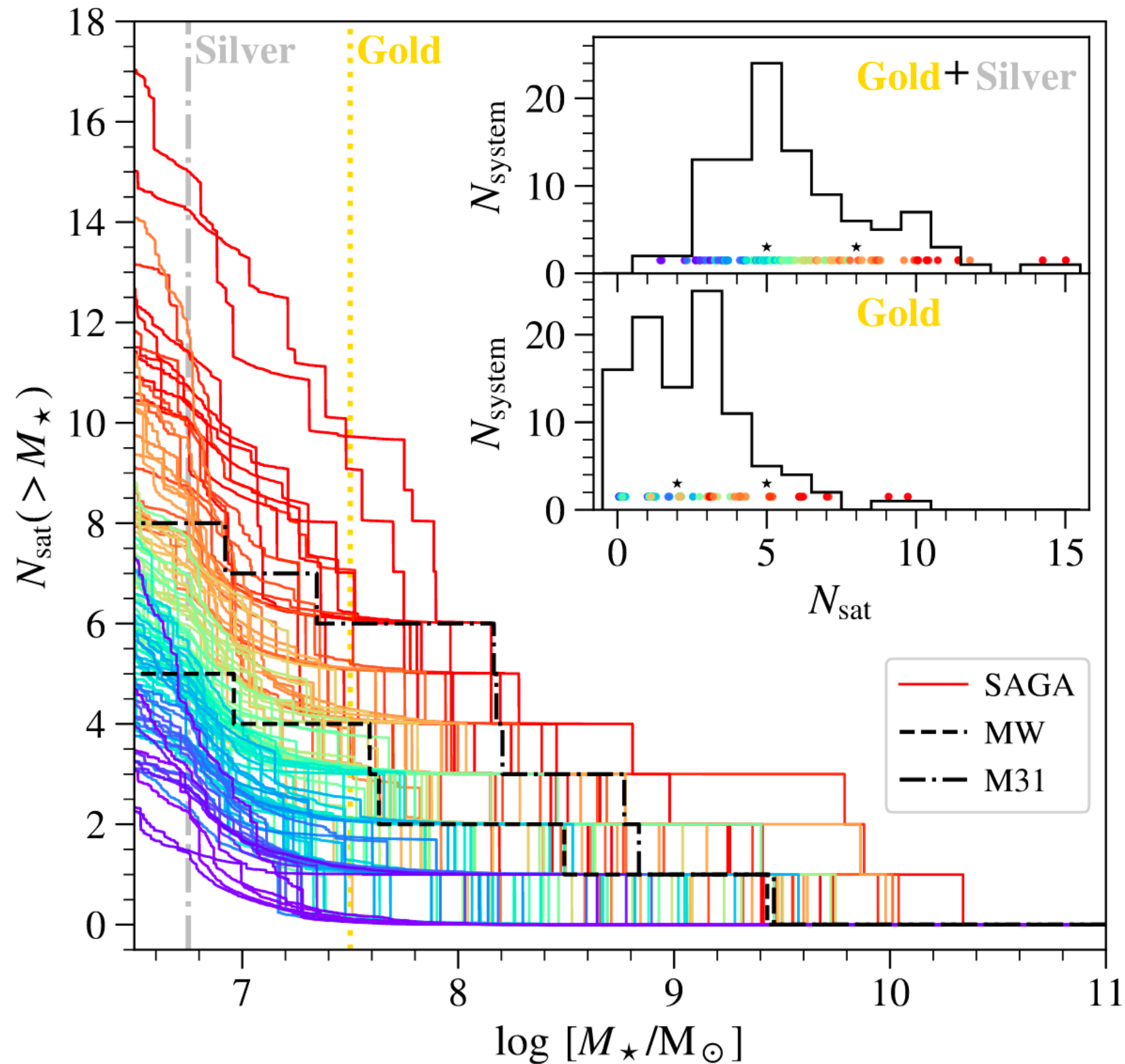
~ 1 satellite per system
e.g., Sales+2013

Distance

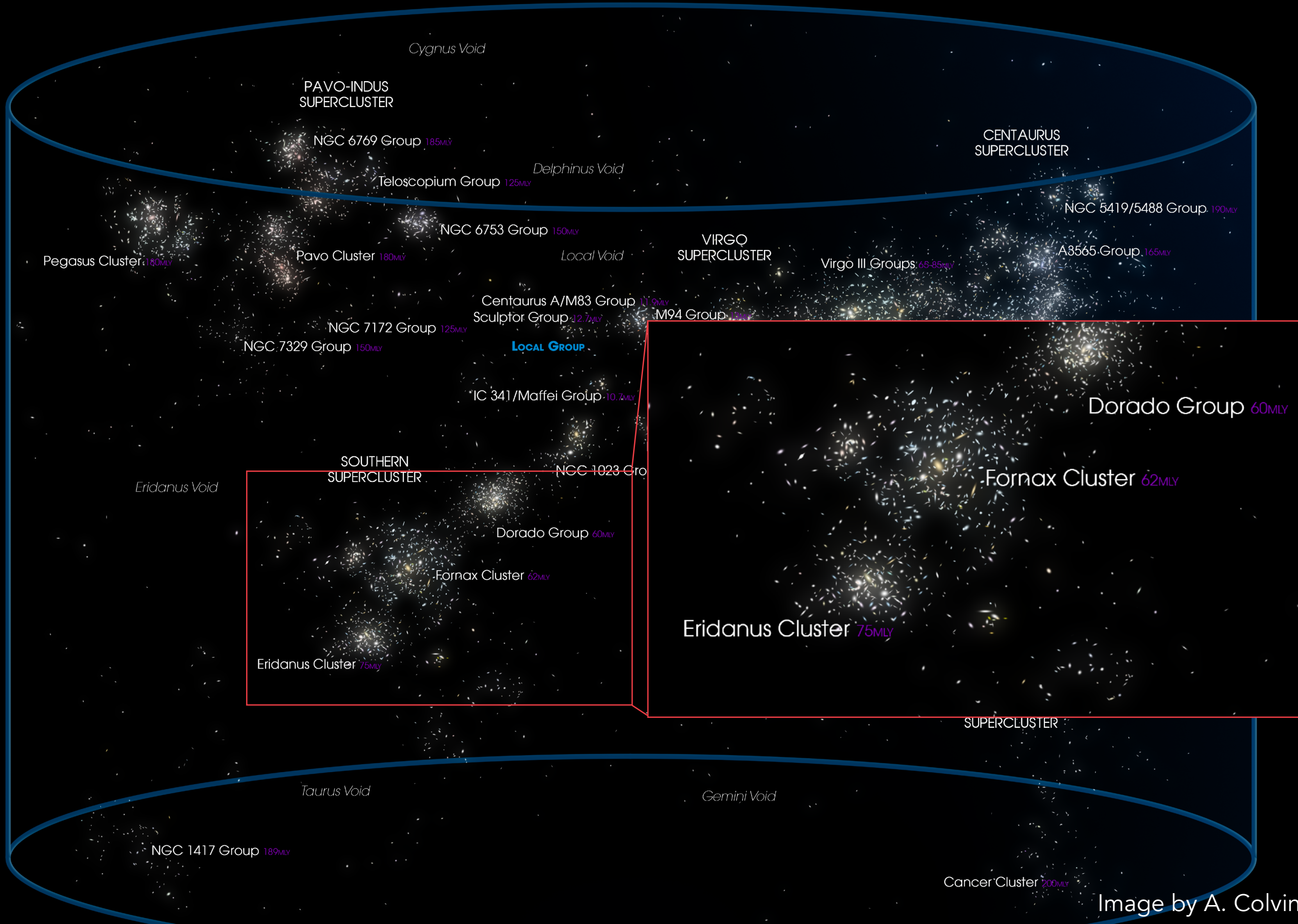




Is the MW satellite population typical?



Larger scale



Even larger scale



Shapley supercluster

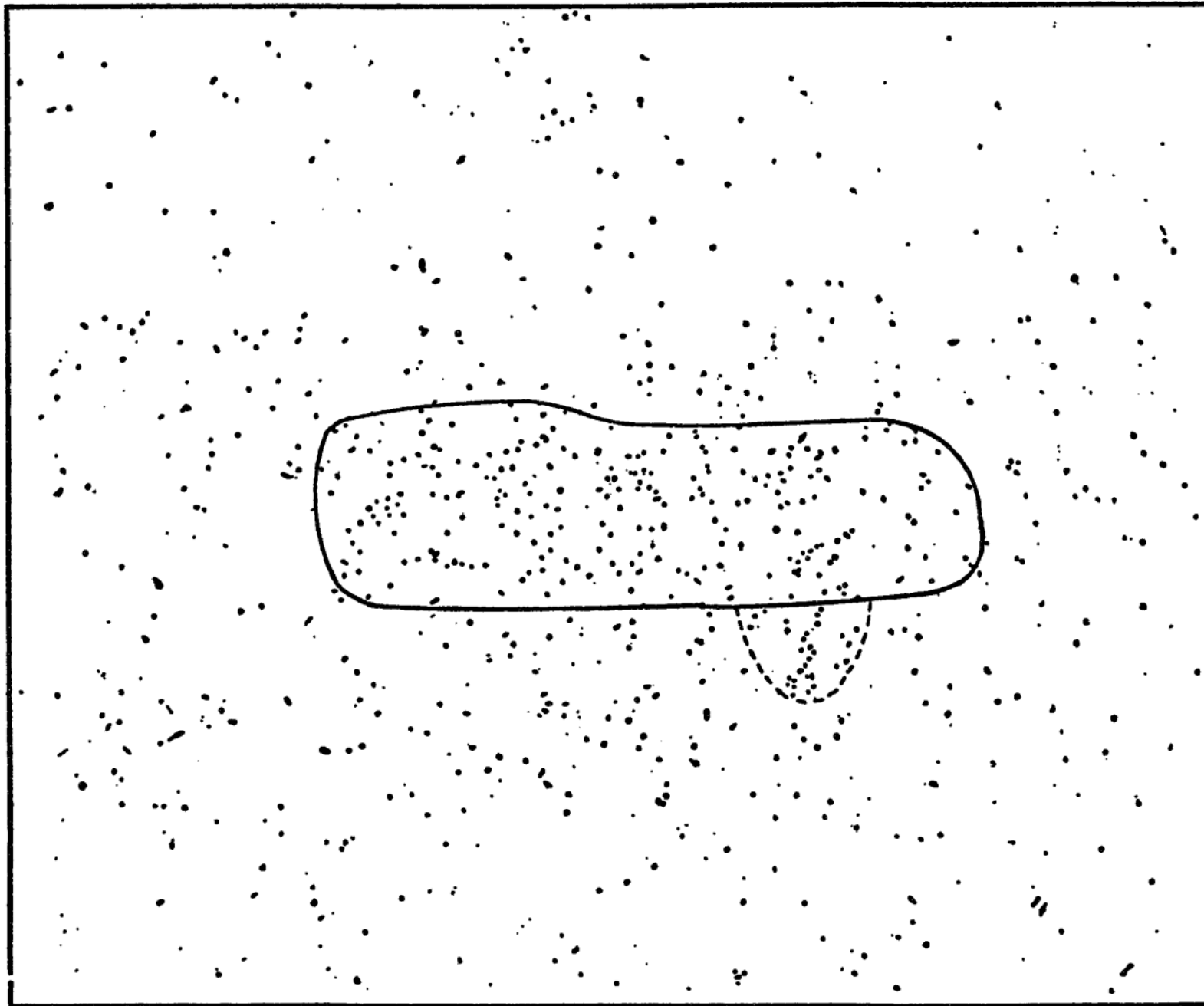
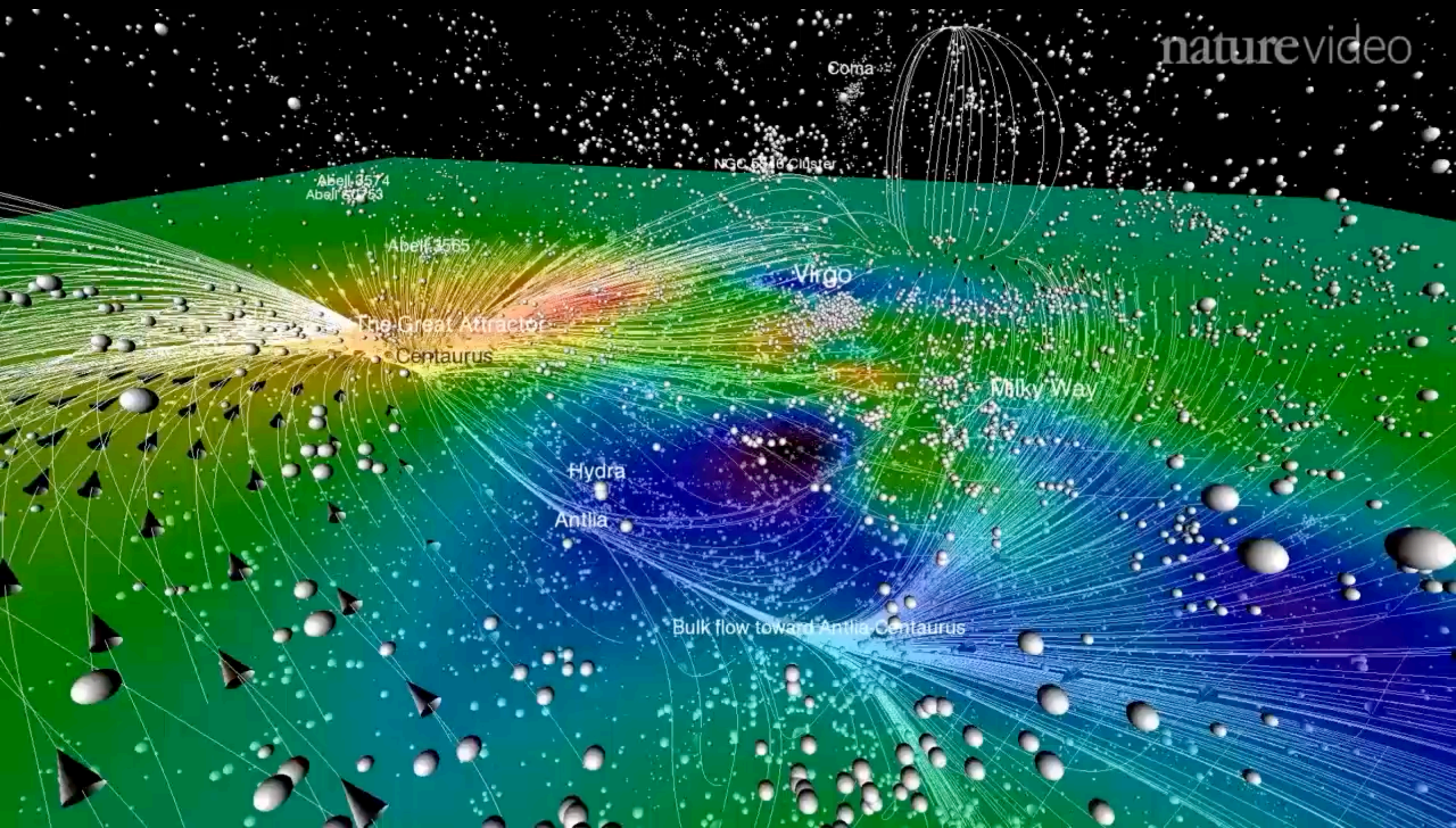
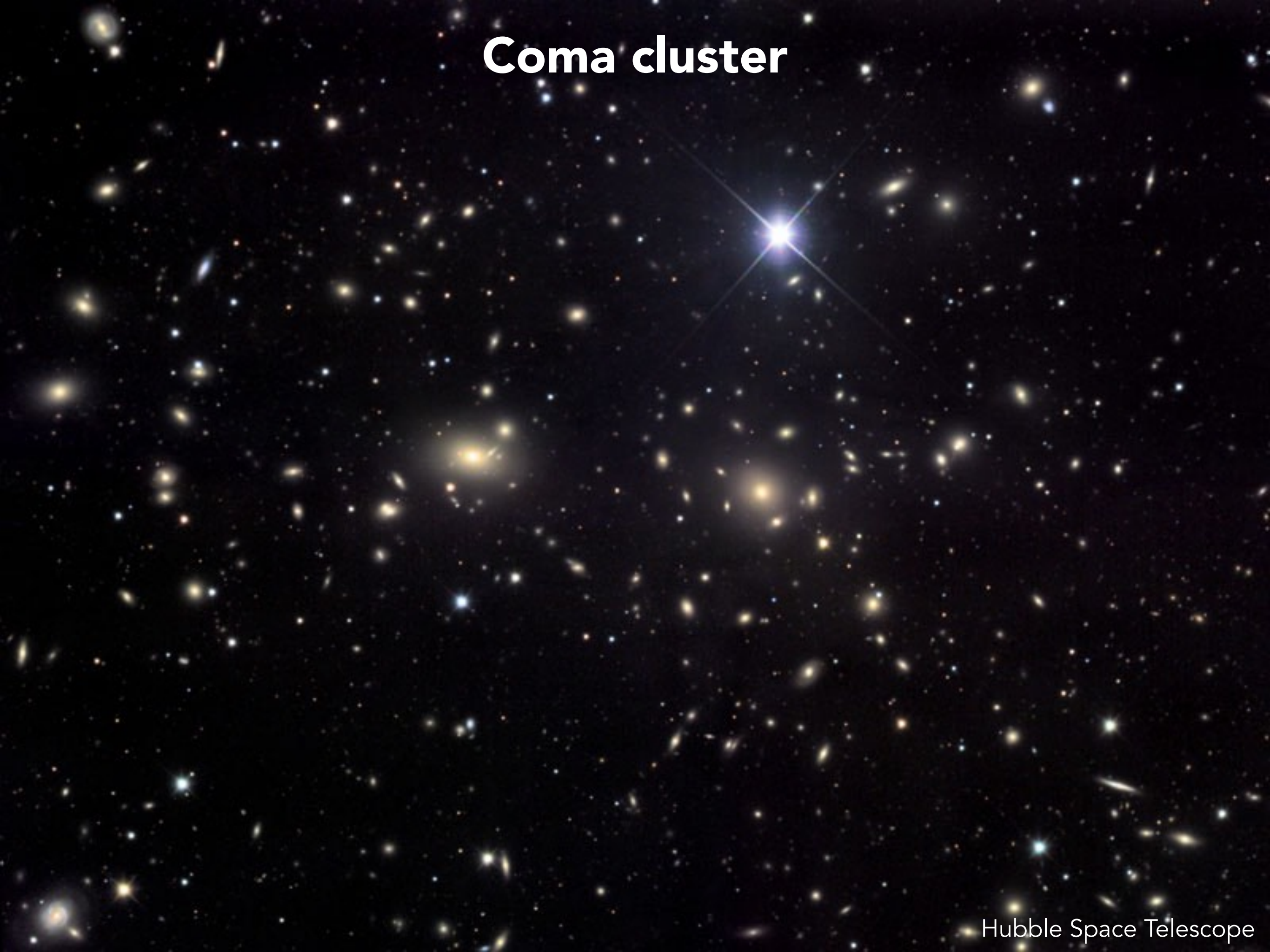


FIGURE 1

Laniakea Supercluster



Coma cluster



Mass census for Coma cluster (1993)

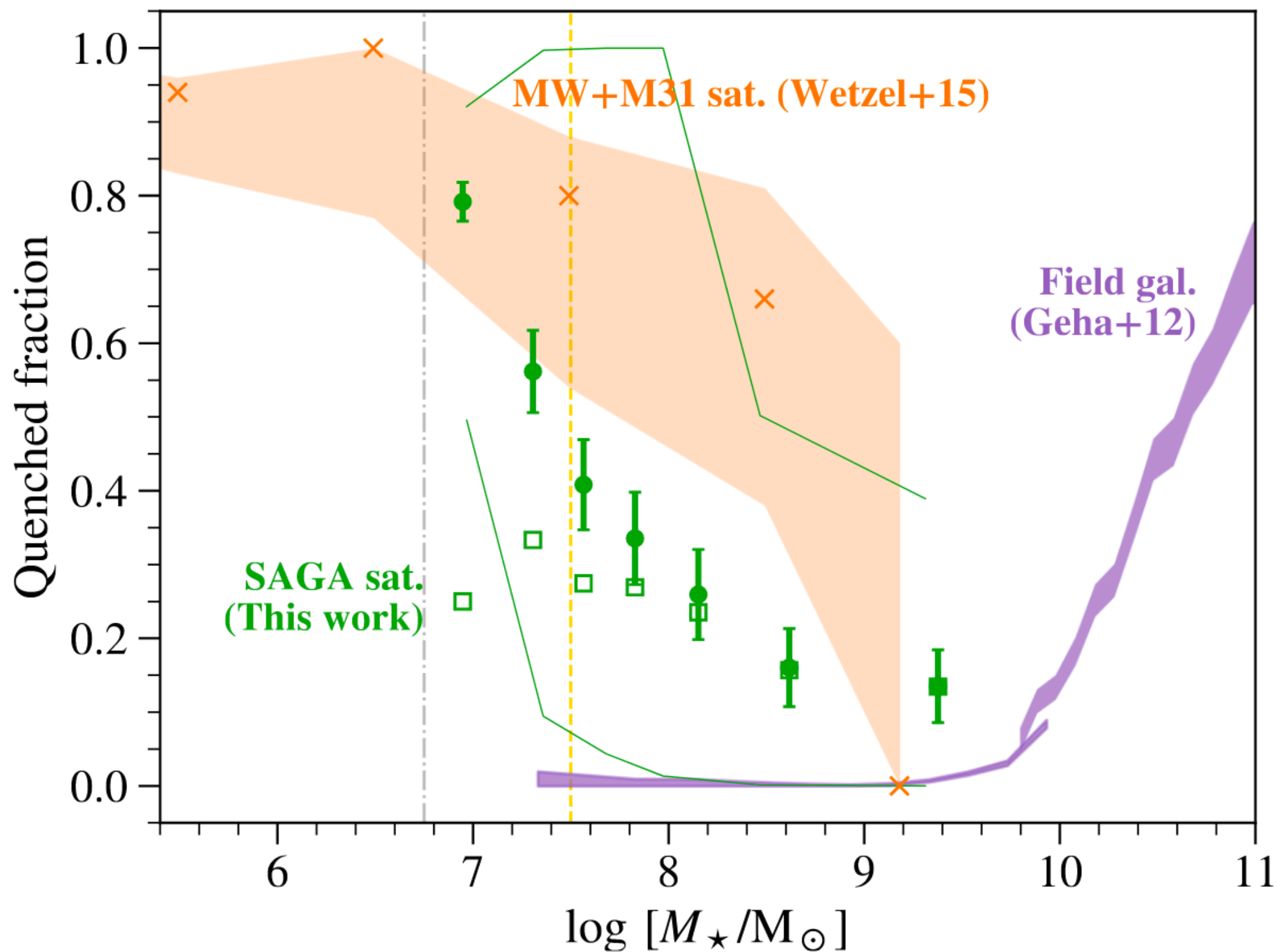
- $M_{\text{galaxies}} \approx 1.4 \times 10^{13} M_{\odot}$
- $M_{\text{gas}} \approx 1.3 \times 10^{14} M_{\odot}$
- $M_{\text{total}} \approx 1.6 \times 10^{15} M_{\odot}$
- $\Rightarrow M_{\text{total}} \approx 10 \times (M_{\text{galaxies}} + M_{\text{gas}})$



Ram pressure stripping

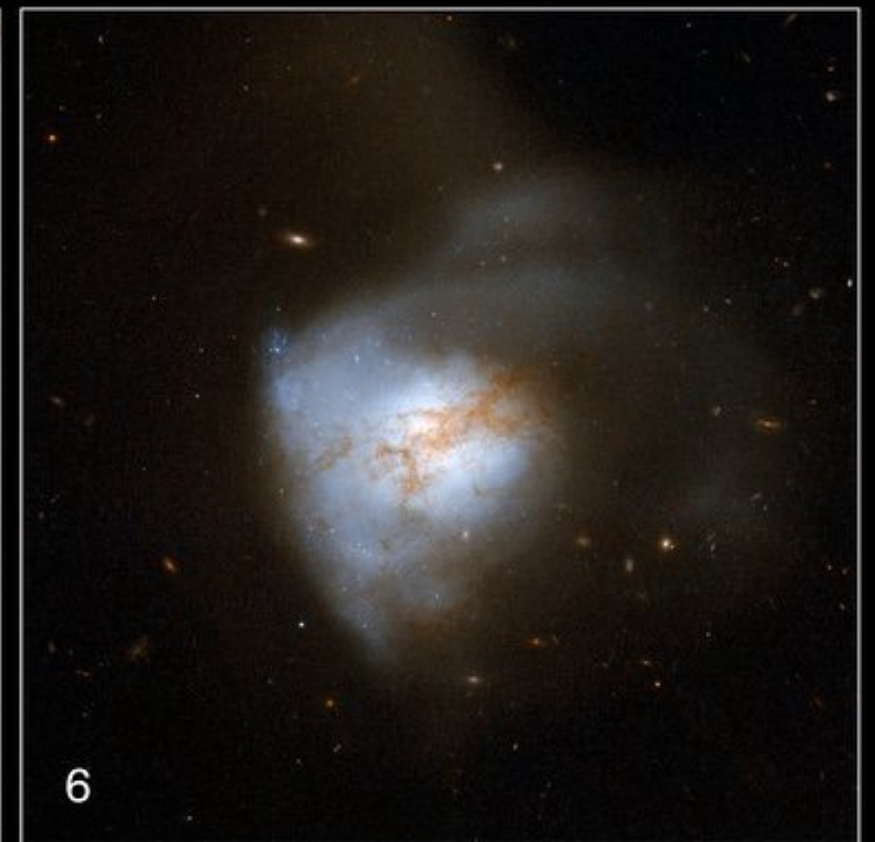
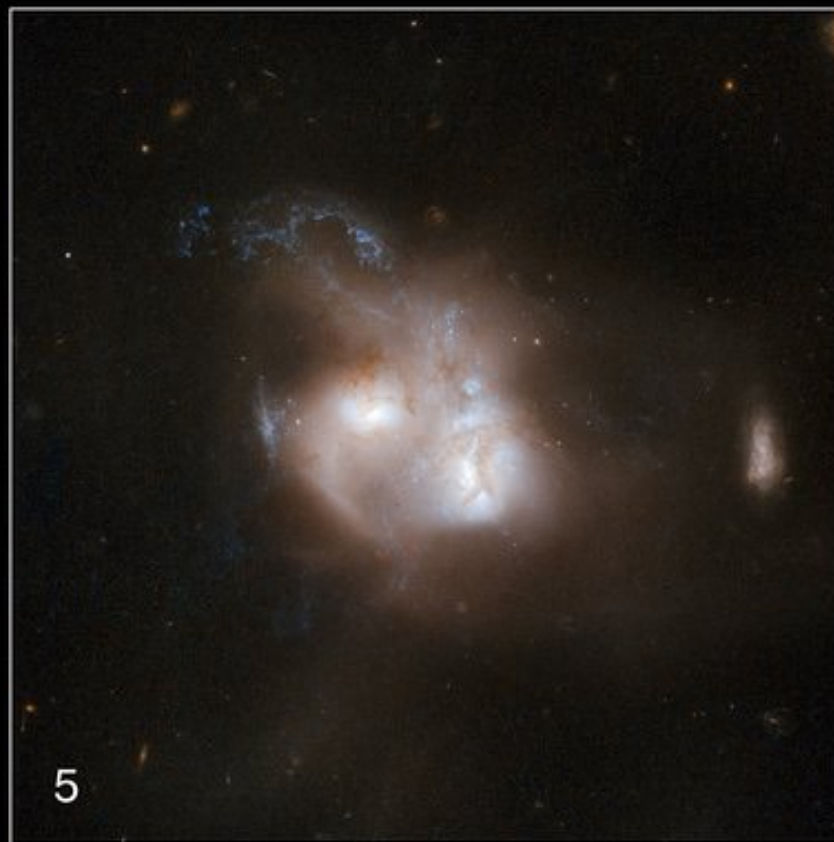


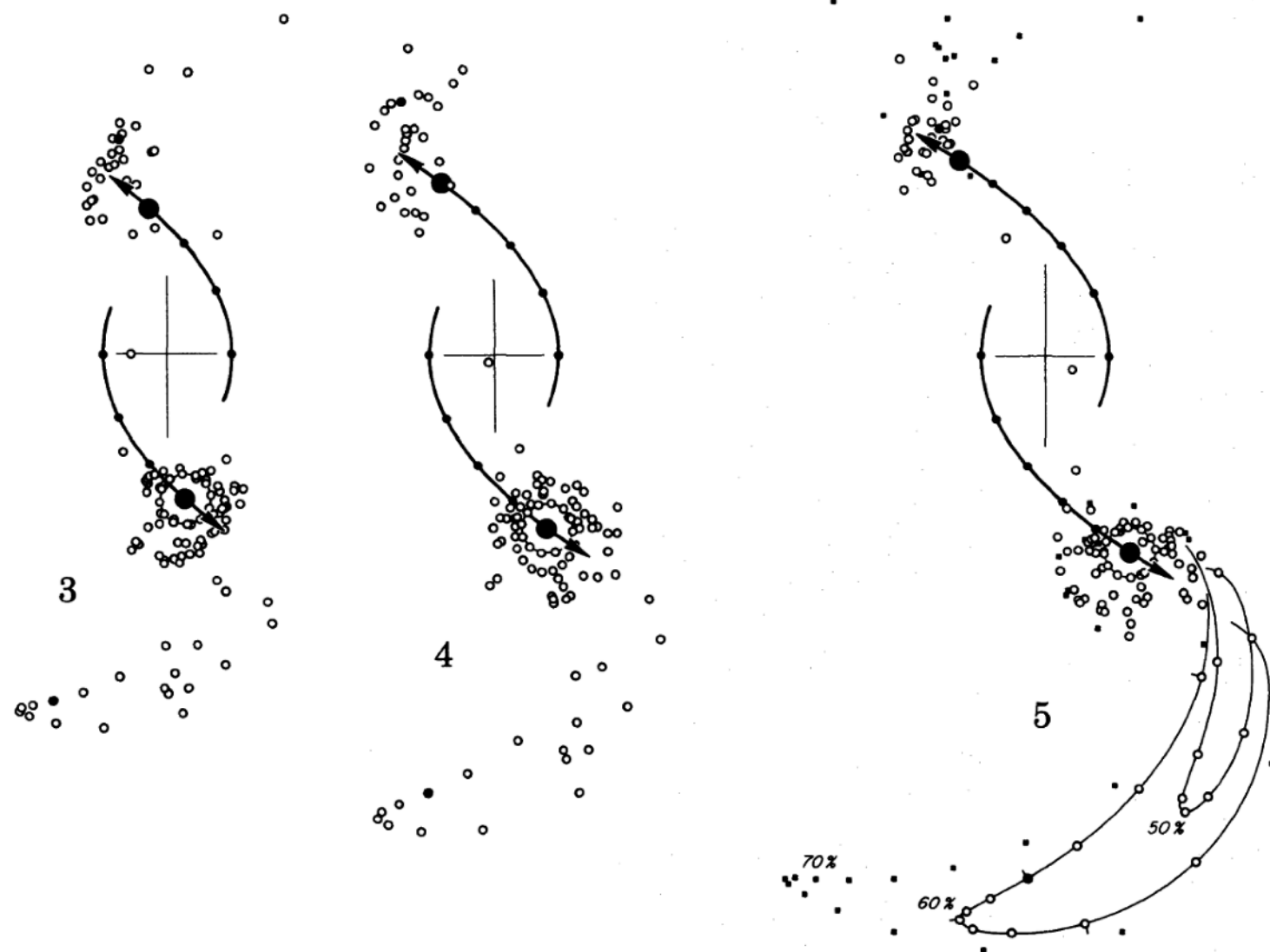
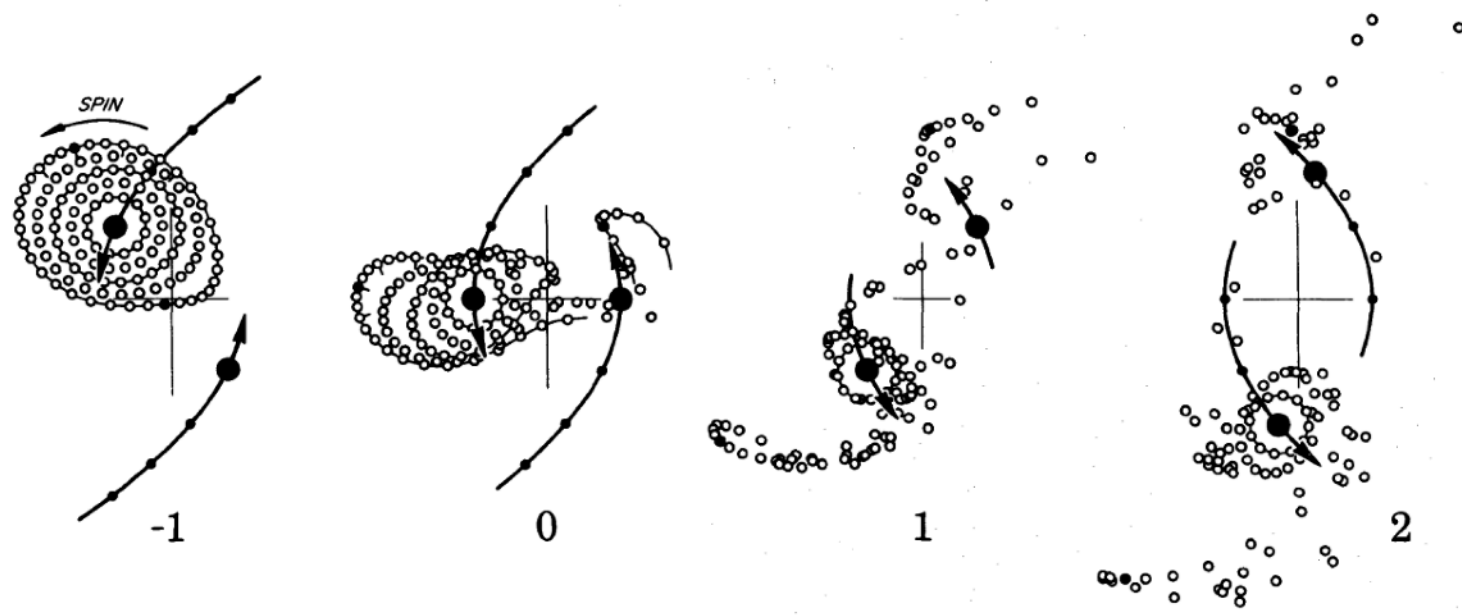
Quenched satellites



§10.3 • Mergers

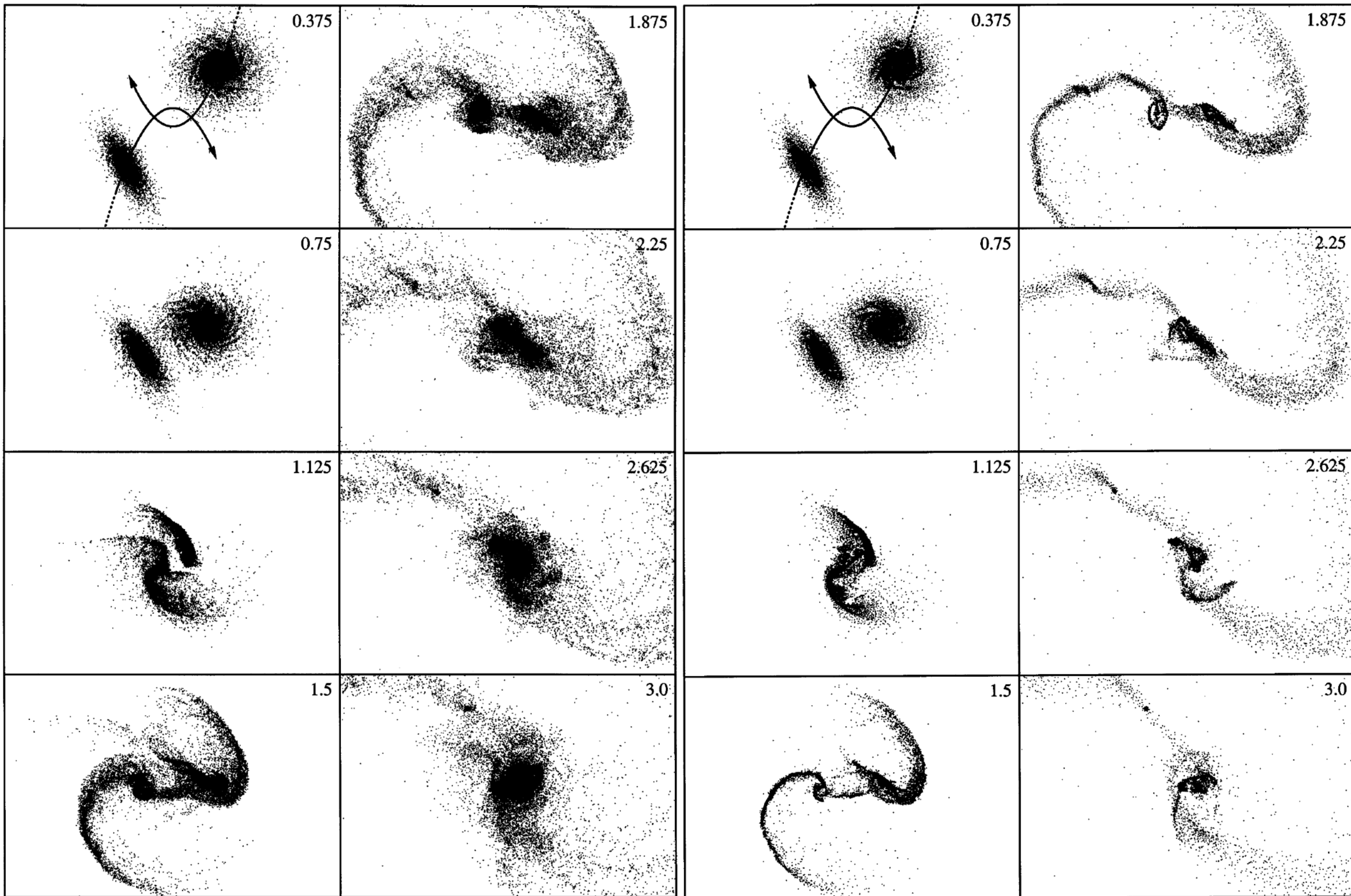
Merging galaxies (observations)





Stars

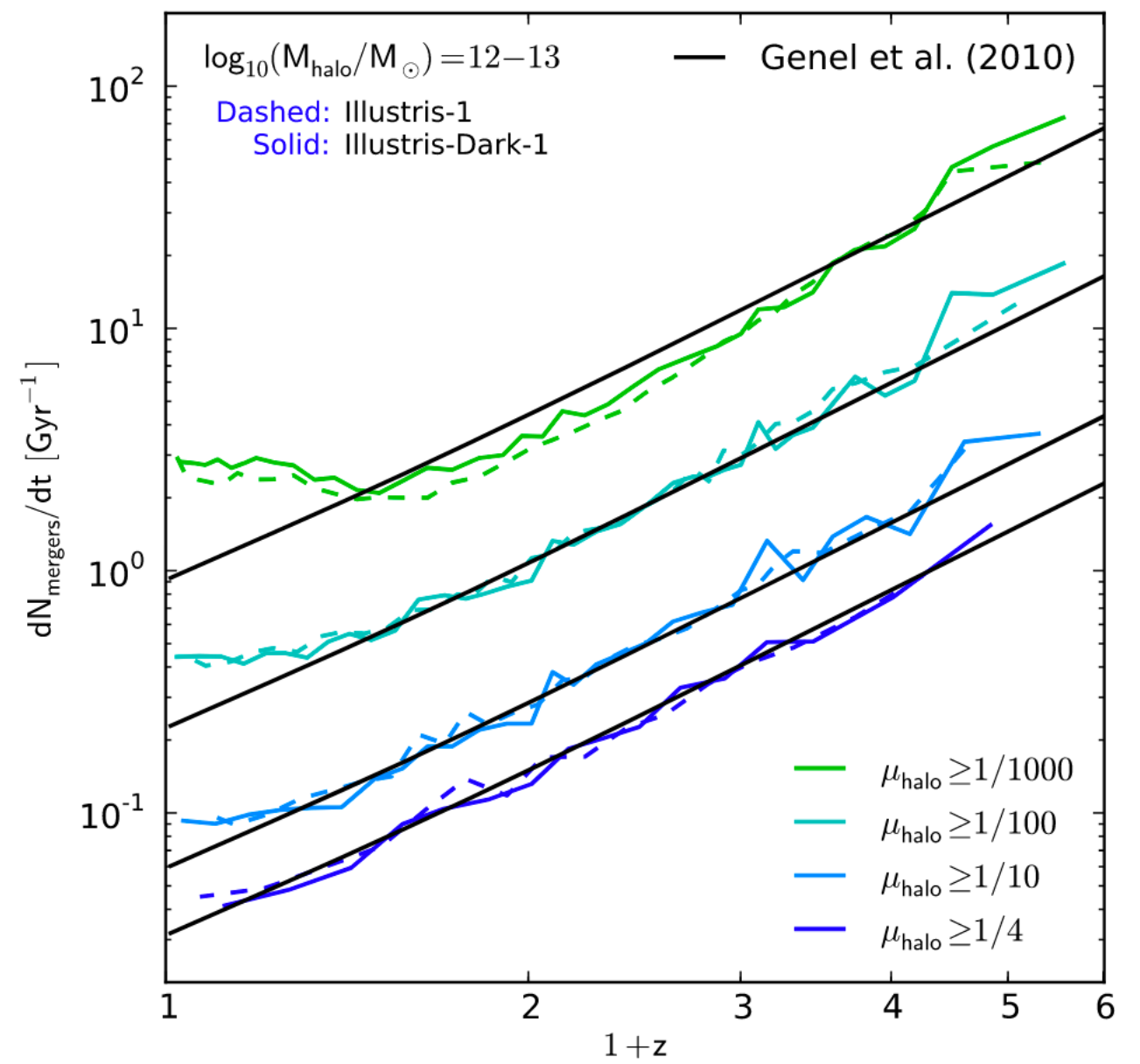
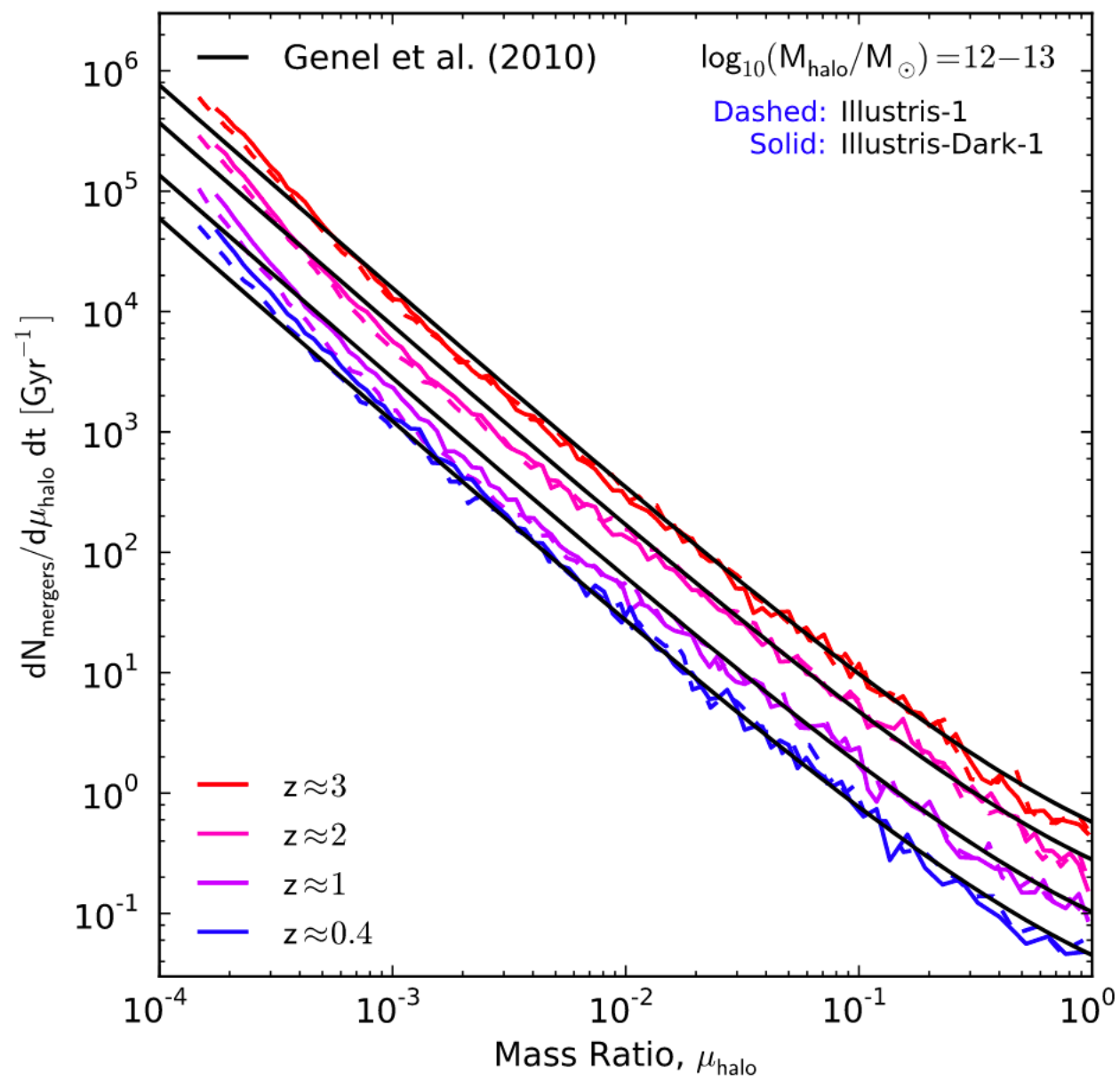
Gas



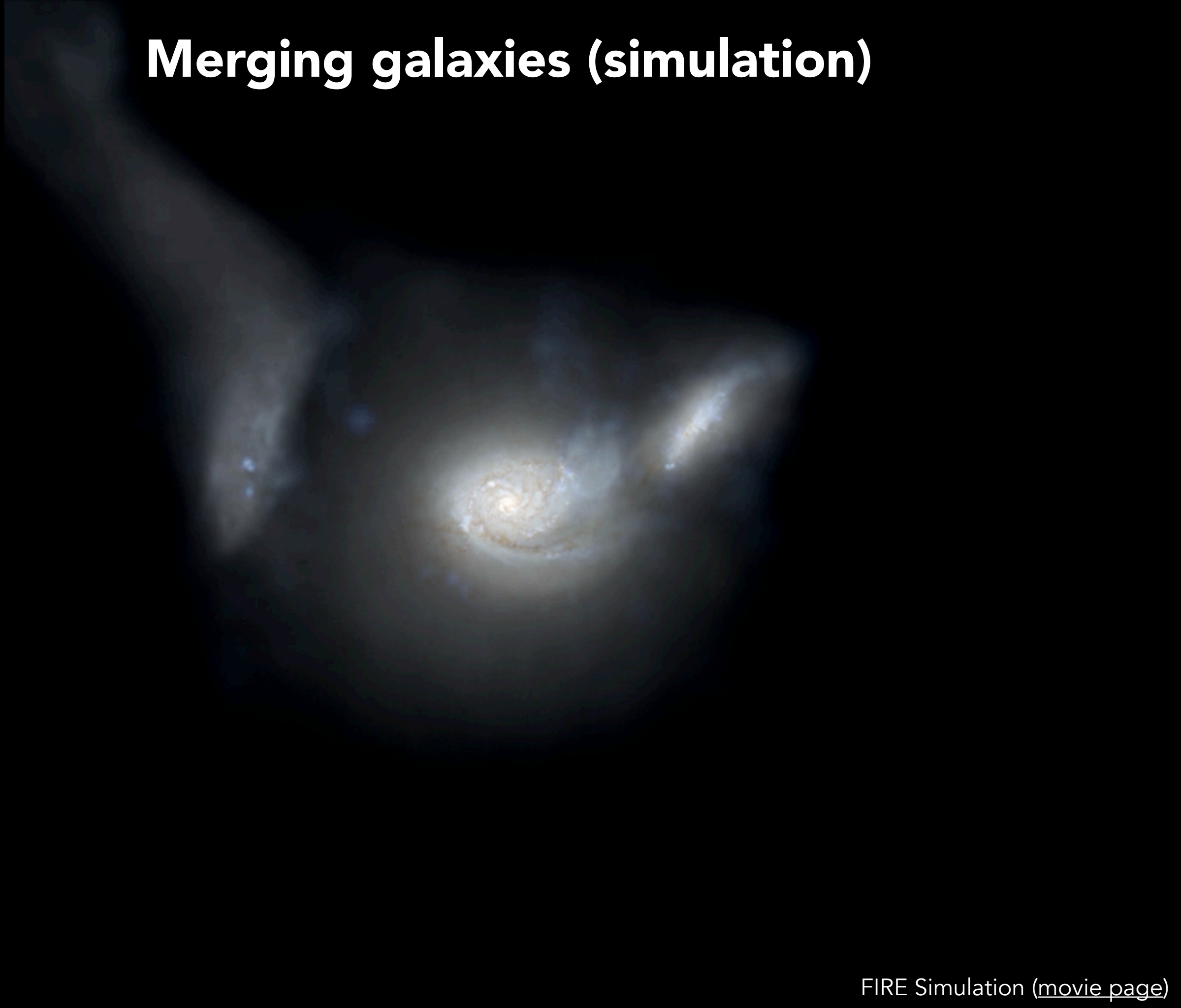
Merging galaxies (simulation)



Merger rates



Merging galaxies (simulation)



Formation of cluster (simulation)

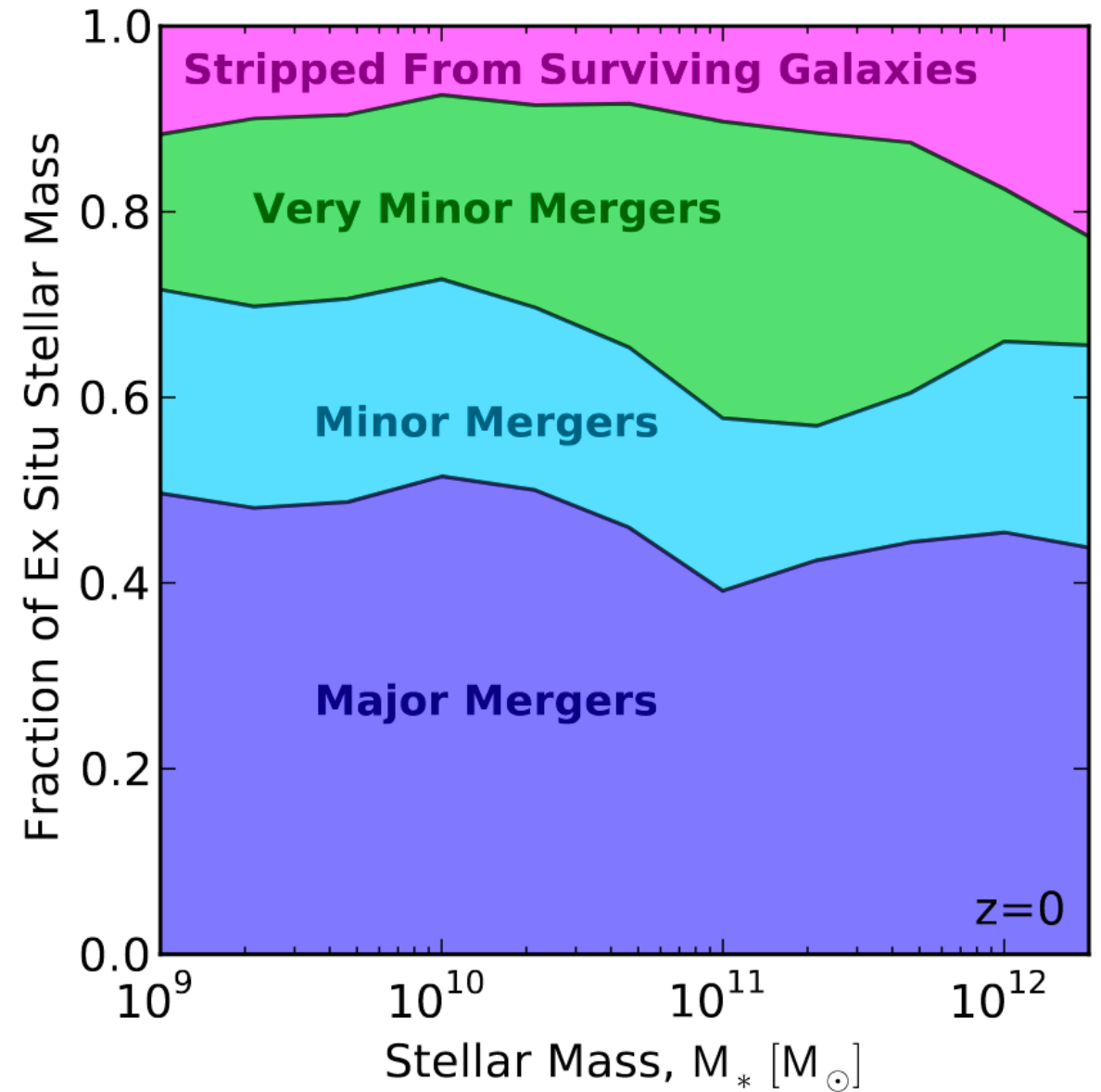
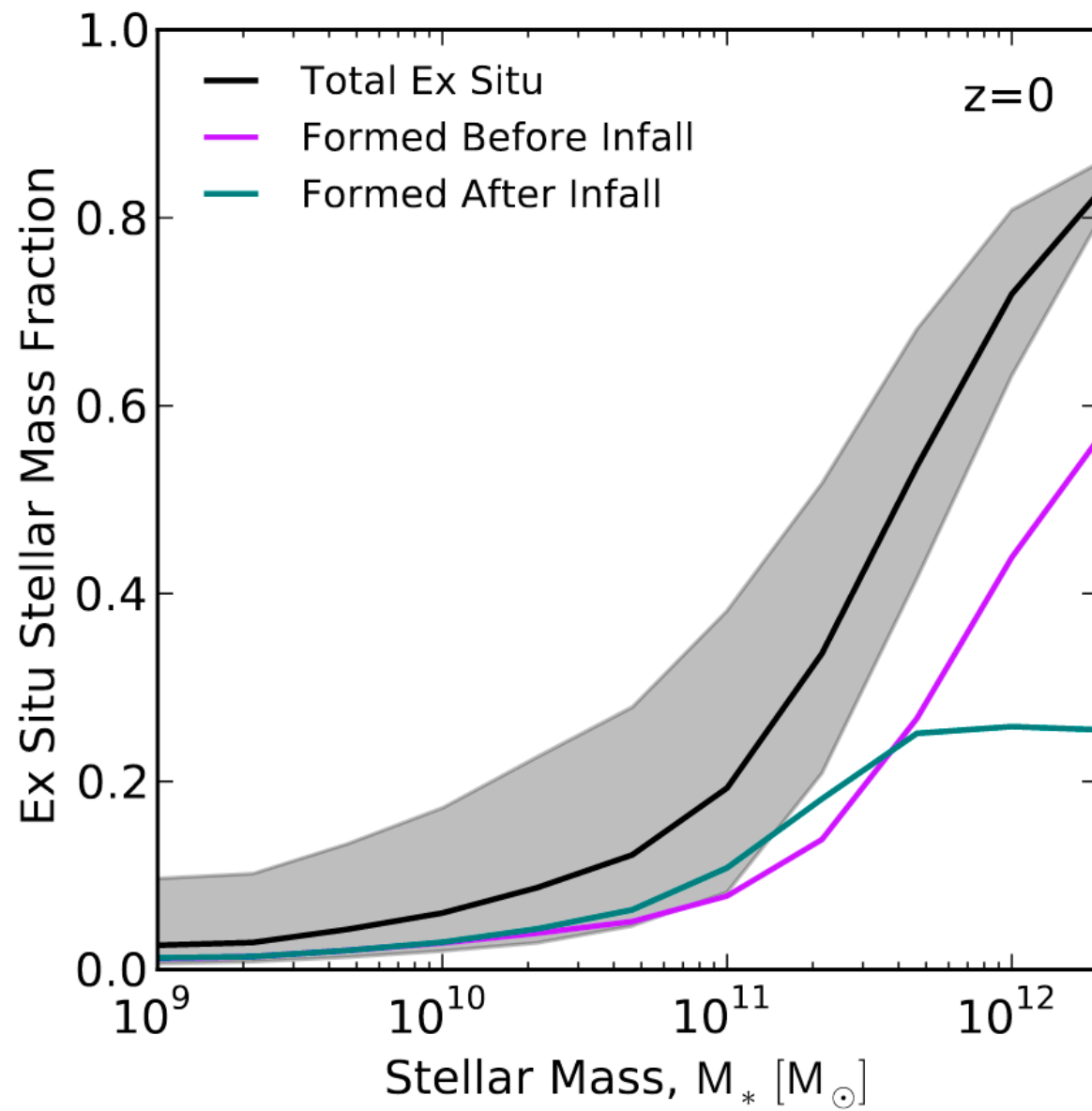
600 kpc

$z = 0.40$



TNG50

In-situ and ex-situ stars



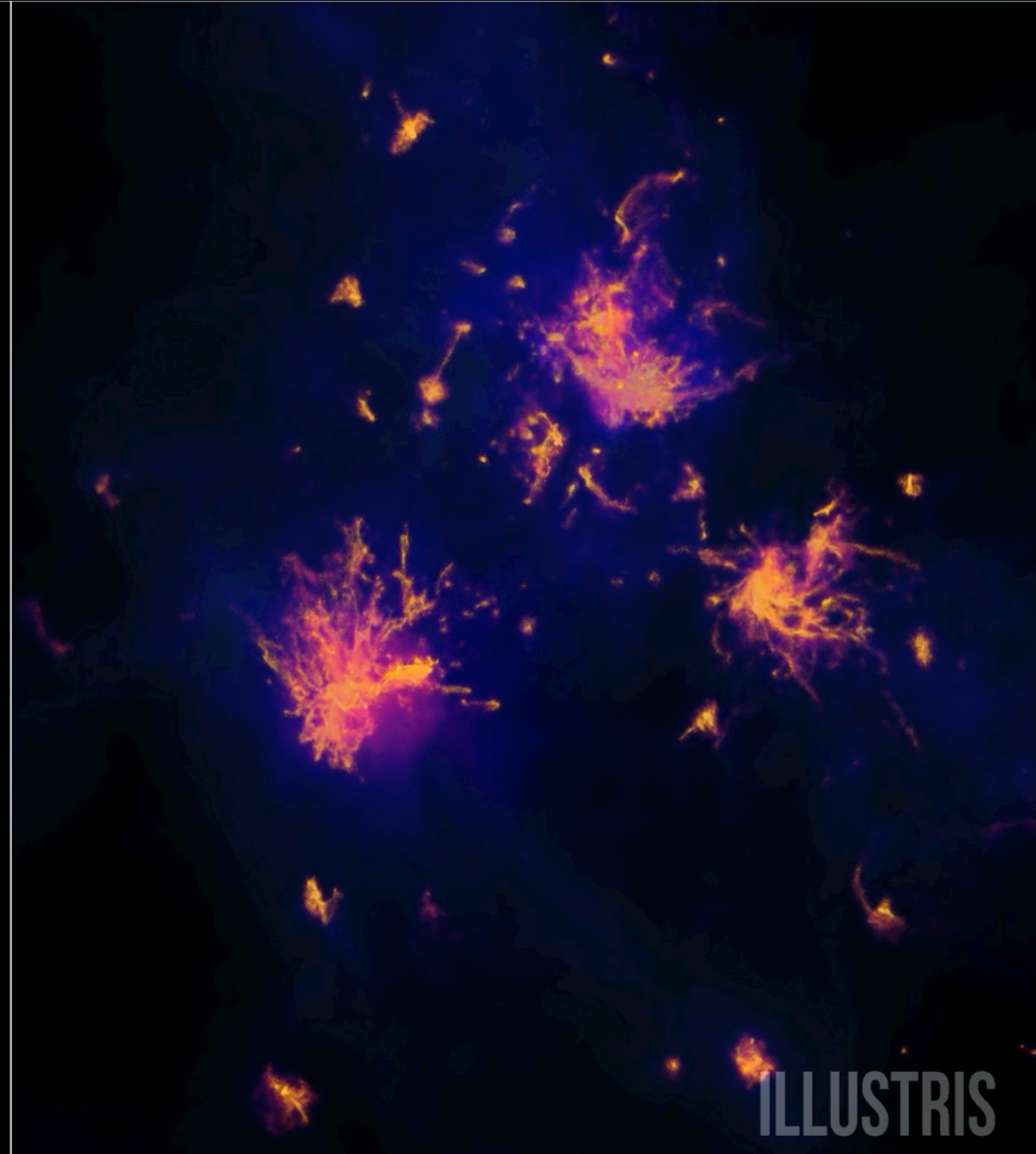
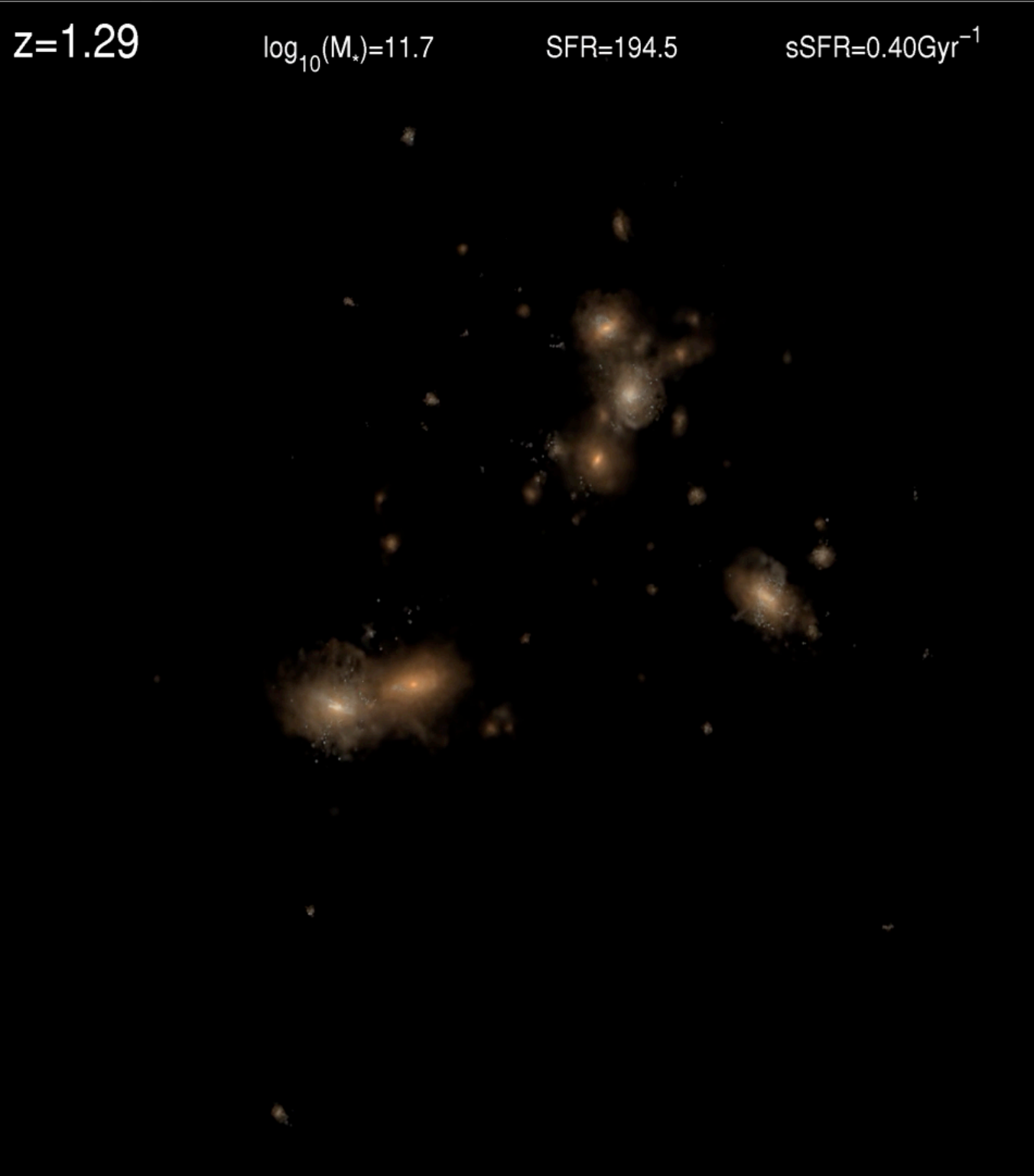
Formation of an elliptical galaxy (simulation)

$z=1.29$

$\log_{10}(M_*)=11.7$

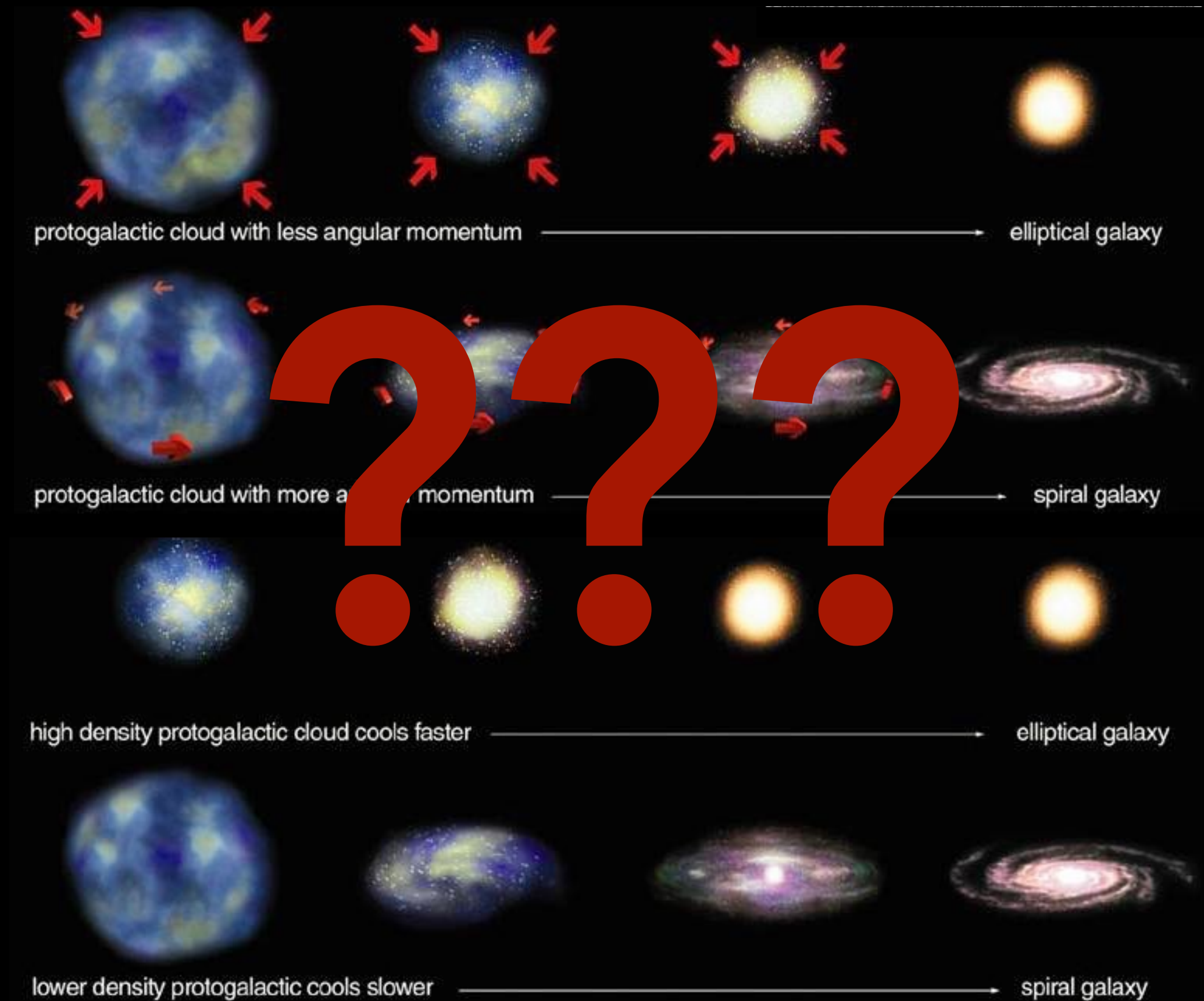
$\text{SFR}=194.5$

$\text{sSFR}=0.40\text{Gyr}^{-1}$

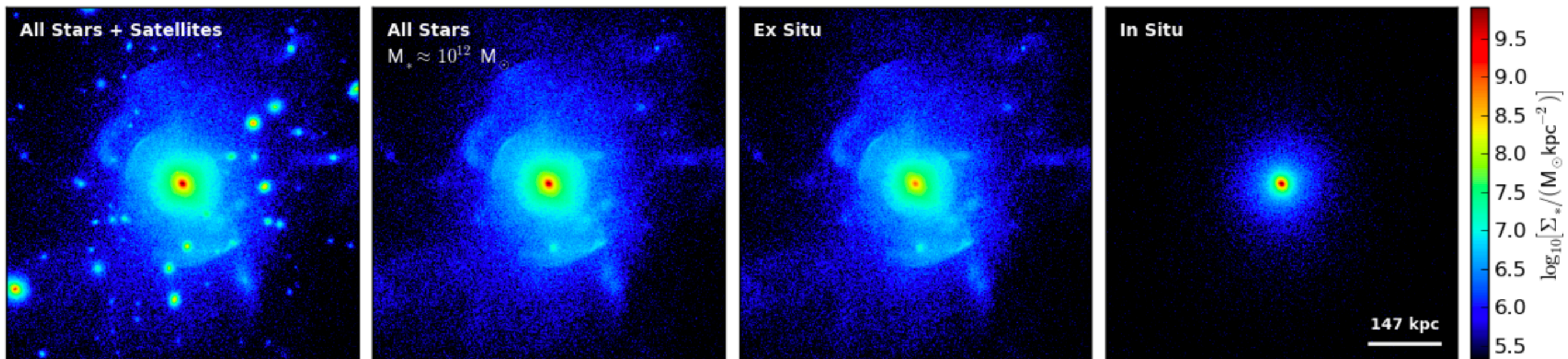


ILLUSTRIS

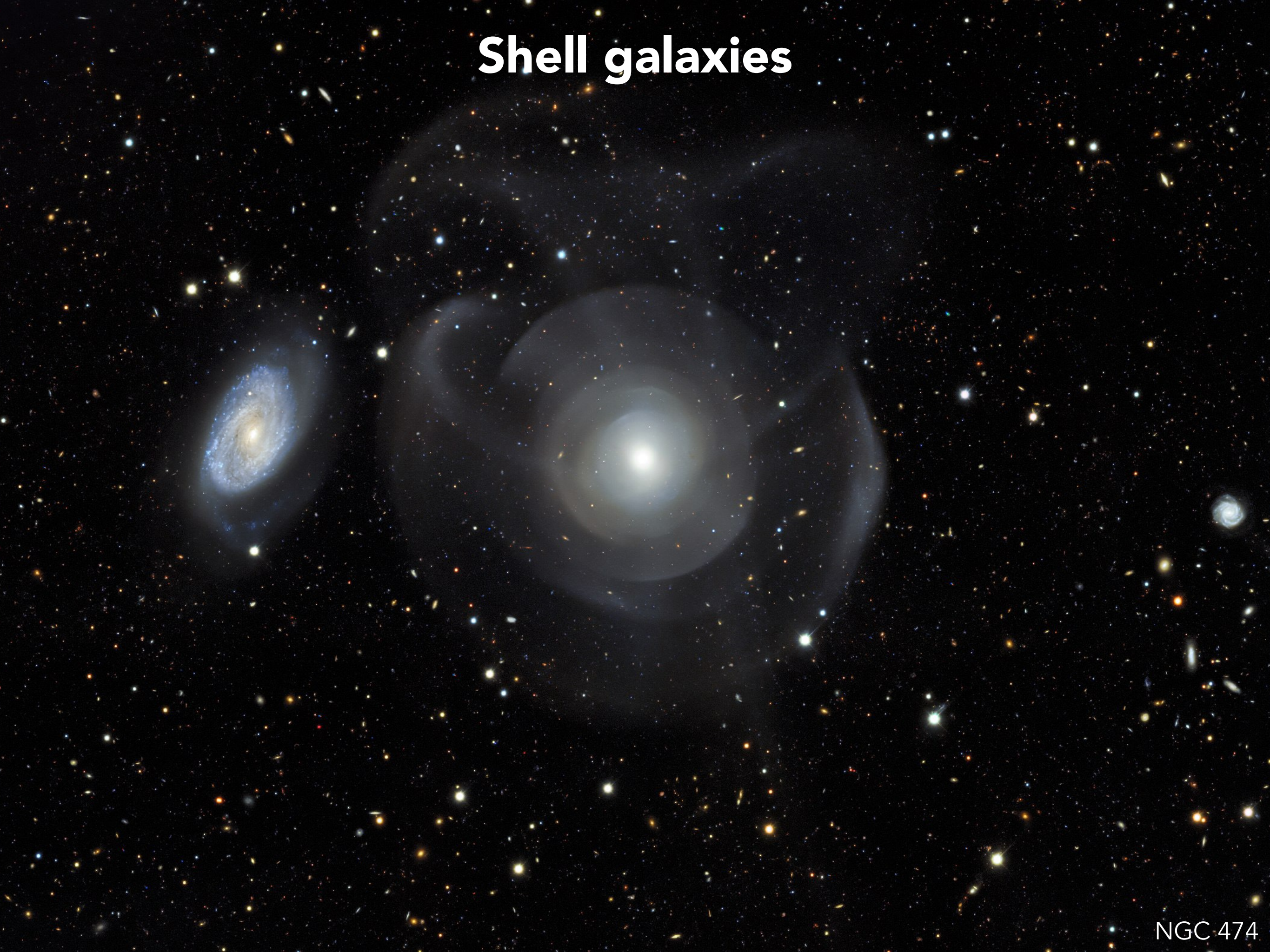
Nature vs. nurture debate in galaxies



In-situ and ex-situ stars

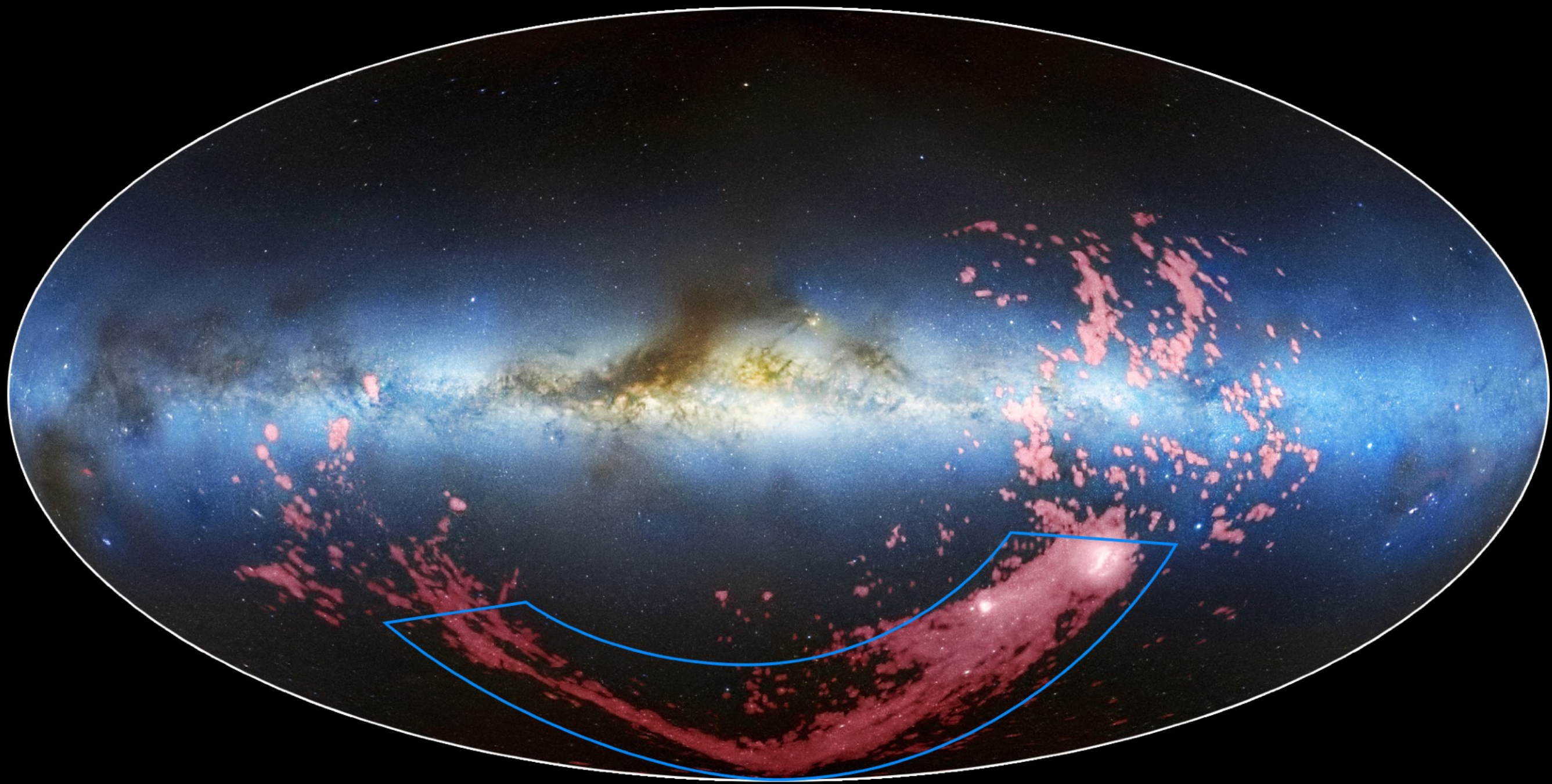


Shell galaxies

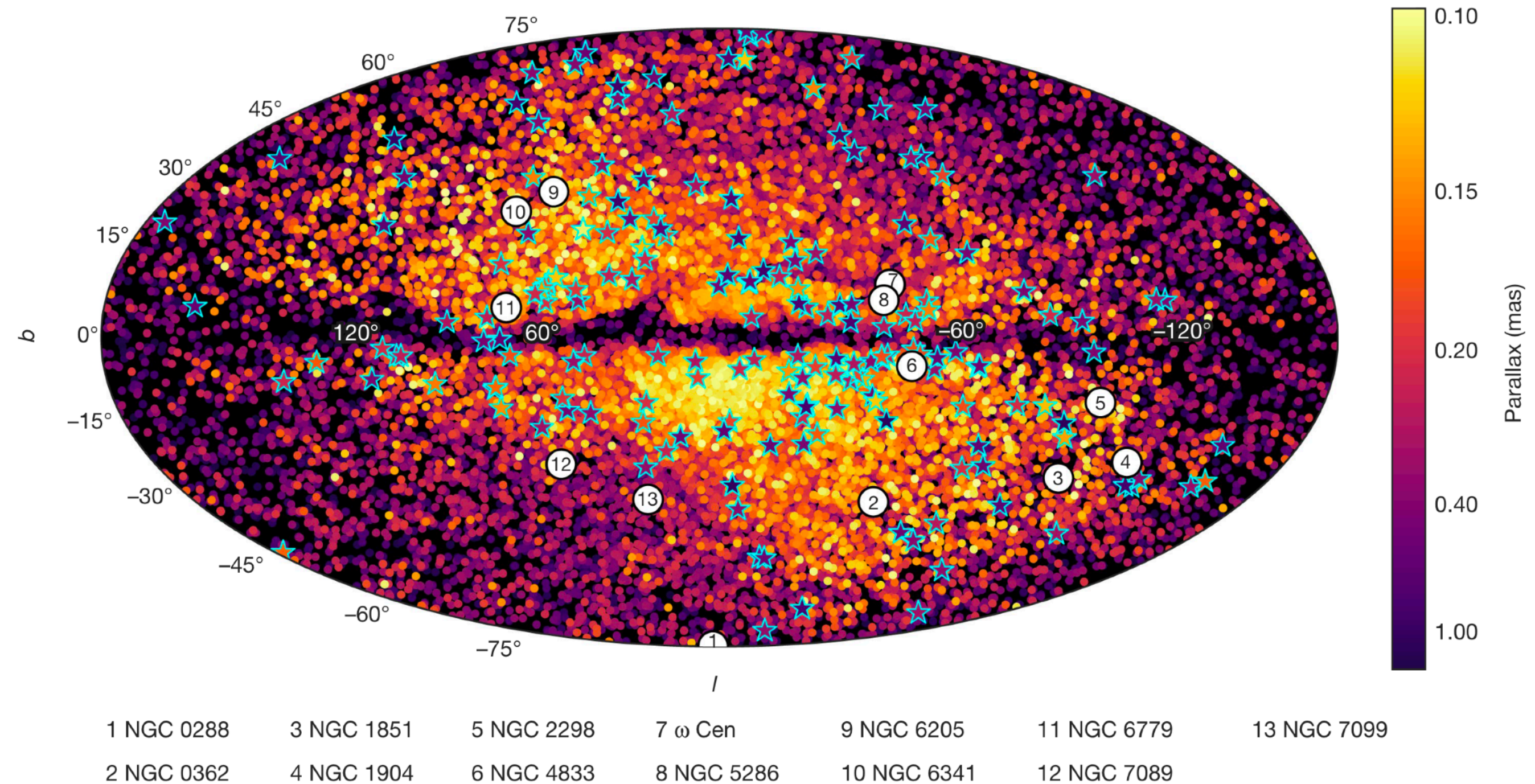


NGC 474

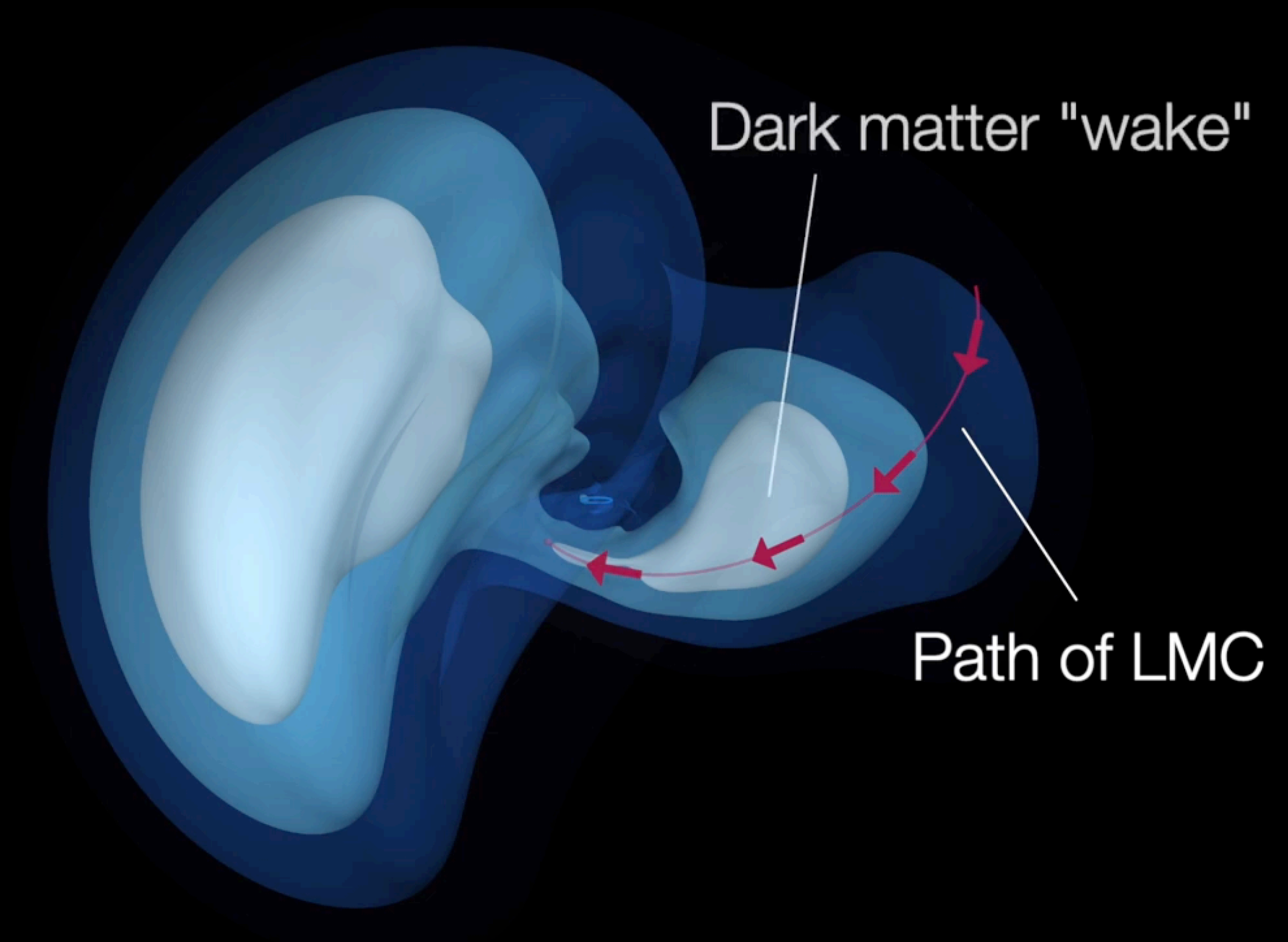
Streams



The merger history of the MW

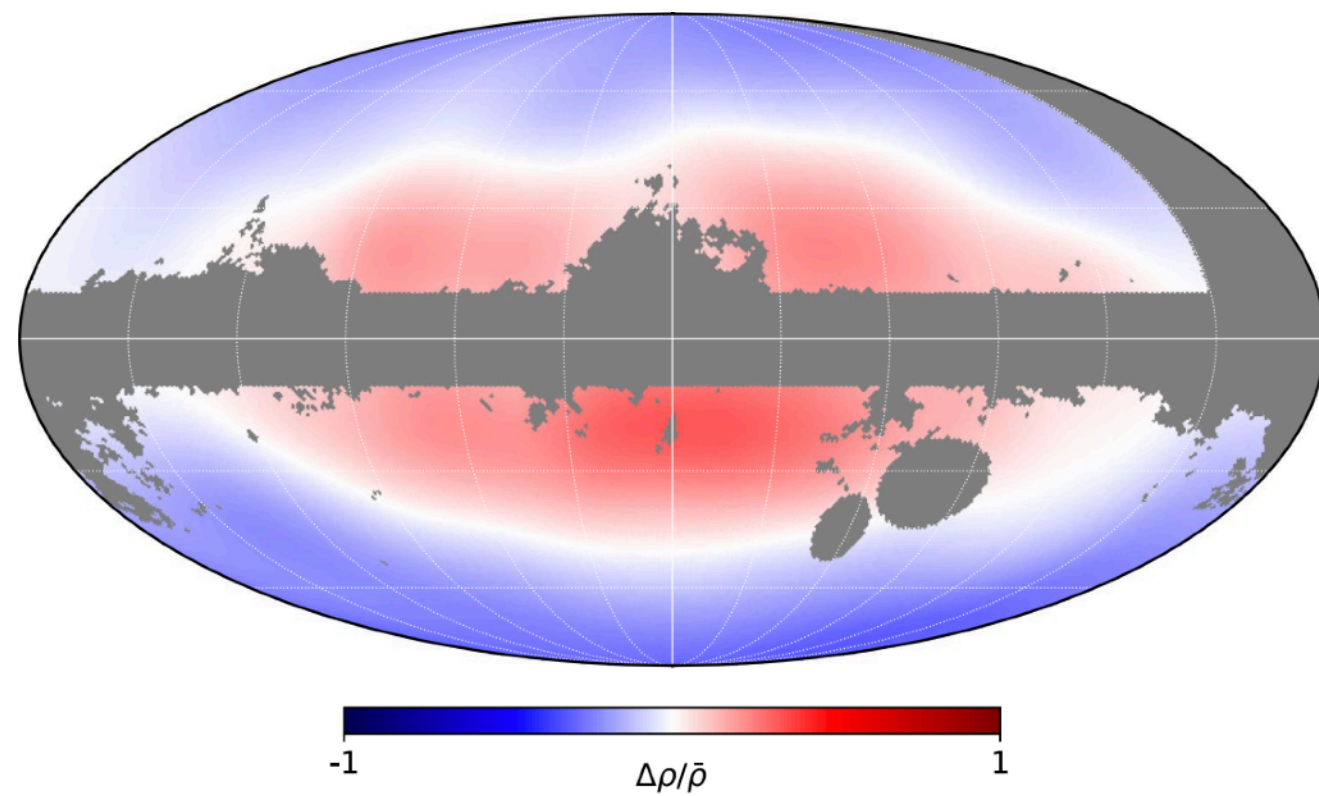


Impact of the LMC

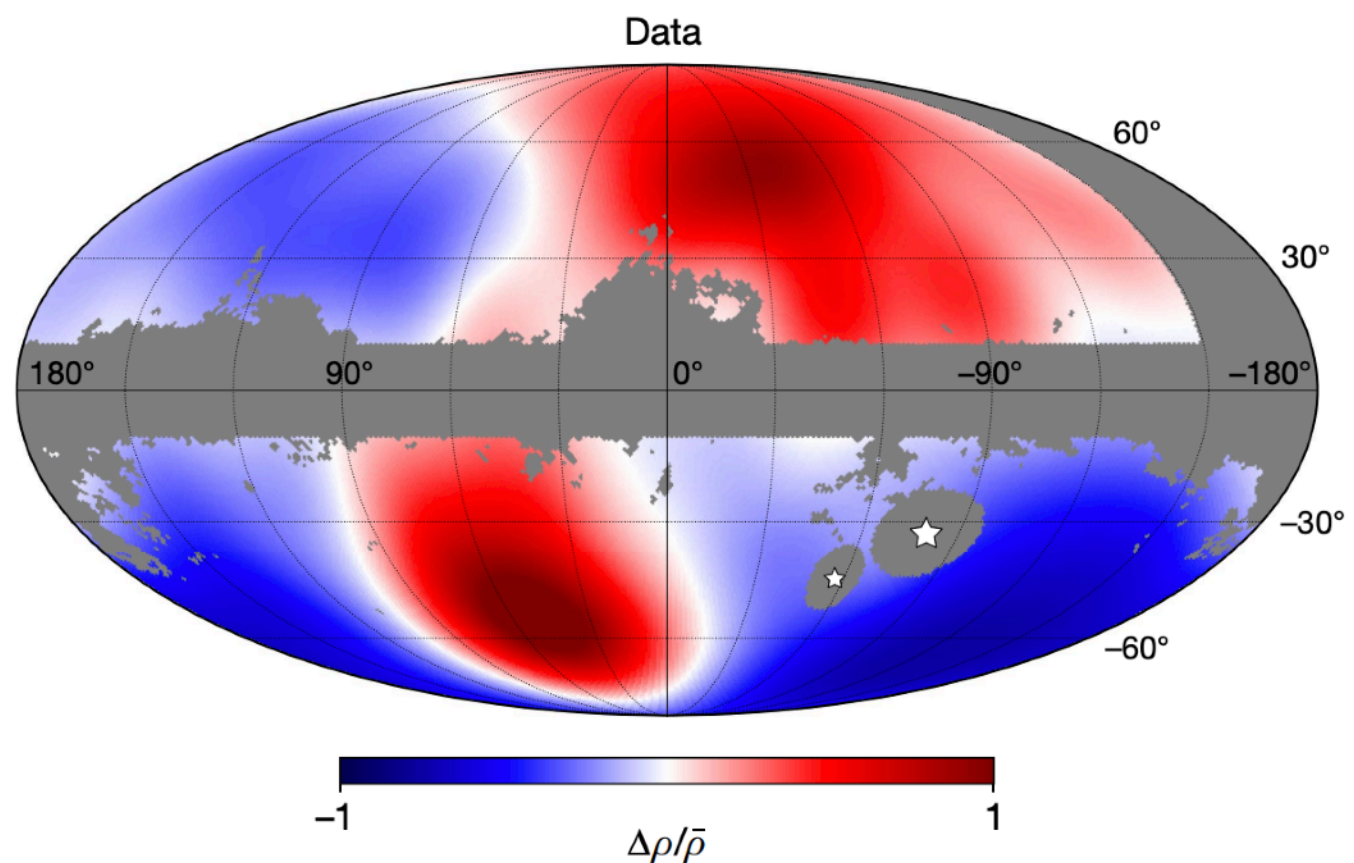
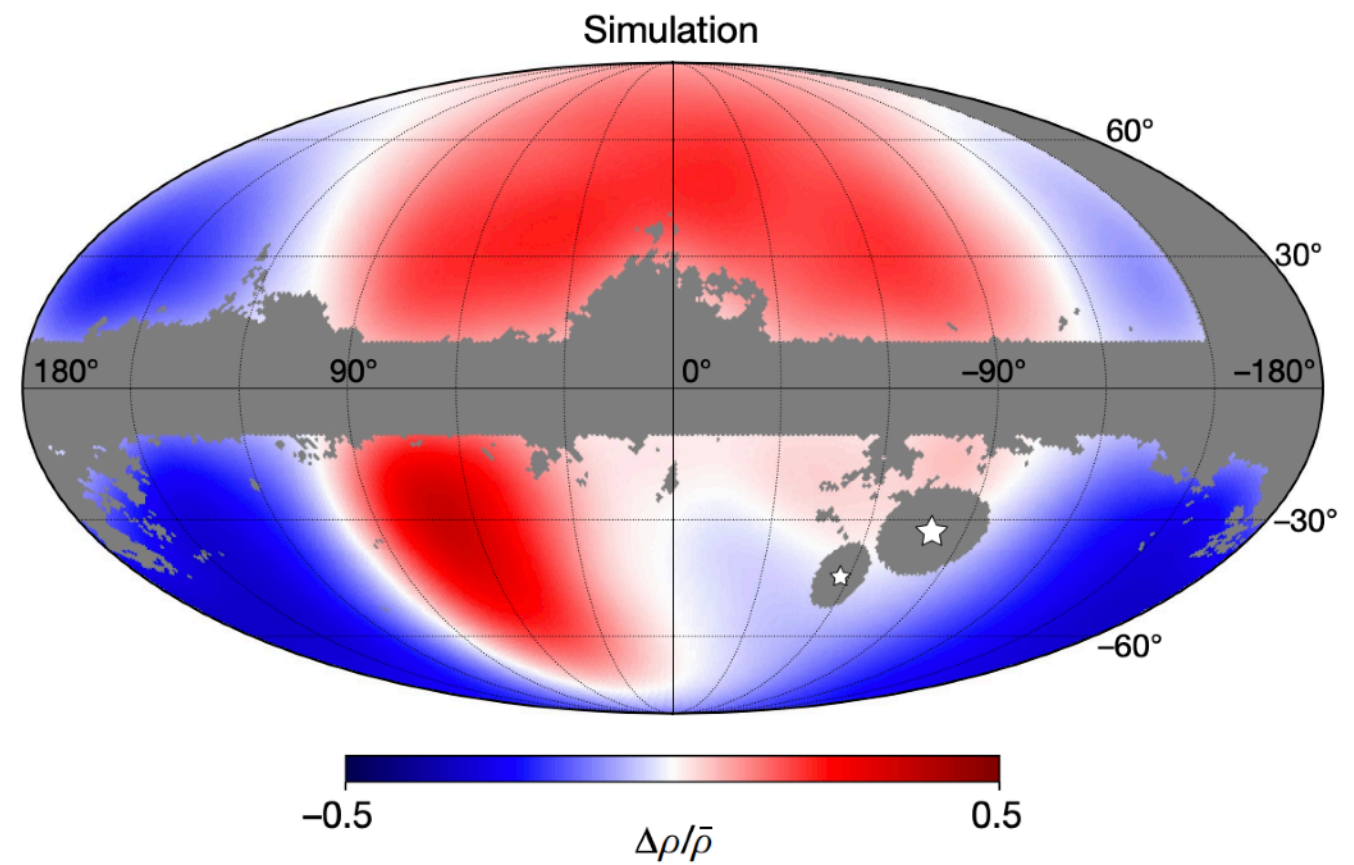


LMC influence on MW

Without LMC wake



With LMC wake



Milky Way-Andromeda merger (visualization)

3.75 Gyr: Andromeda is close to the Milky Way



3.85 Gyr: Merger is triggering new star formation



3.90 Gyr: Ongoing burst of star formation



4 Gyr: both galaxies deformed from tidal interactions



5.1 Gyr: Two bright cores are visible



7 Gyr: Fully merged to elliptical galaxy



Reading

- CFN §6.1-6.4.1, §8.9-8.9.5, §10.3-4, §10.8
- MvdBW §2.5, §12, §13.2.2-3