

Galaxy groups & clusters

galaxy groups

- Galaxies often are not distributed uniformly
- They tend to reside in a 'clustered' manner
- Galaxy groups → a collection of few to ~10 galaxies

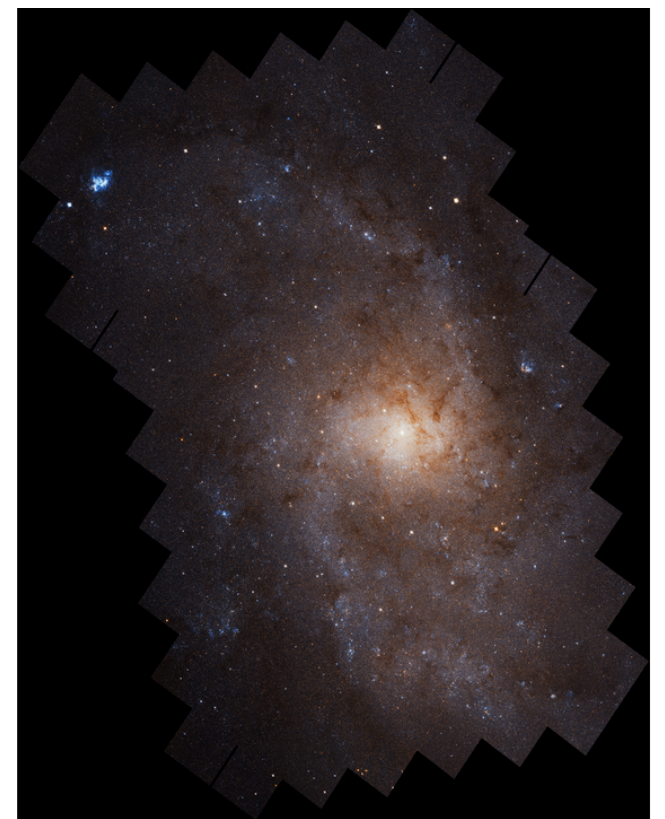
'Local group'



Milky Way



Andromeda (M 31)



M 33

+ some 'dwarf' galaxies

Galaxy clusters

- Conglomeration of ~ 100 galaxies
- Typical radius $r_{\text{cl}} \sim 1$ Mpc
- Higher proportion of (large) Elliptical galaxies

In fact, most of the central galaxies are
Massive ellipticals

Mostly random motion of galaxies within
the cluster

- Typical velocity dispersion
 $\sigma \sim 1000$ km/s

Virgo - the nearest cluster

- Distance ~ 15 Mpc



Virgo Cluster

Credit ESA/HST

Cluster crossing time-scale

$$r_{\text{cl}} \sim 1 \text{ Mpc}$$

$$\sigma \sim 1000 \text{ km/s}$$

$$\tau_{\text{cc}} \sim \frac{r_{\text{cl}}}{\sigma} \sim 10^9 \text{ yr}$$

Are Clusters collisionless?

First, let's compute the collision time-scale, $\tau_{\text{coll}} = \frac{1}{n\sigma v}$

The relative velocity between two galaxies, $v \sim 500 \text{ km/s}$

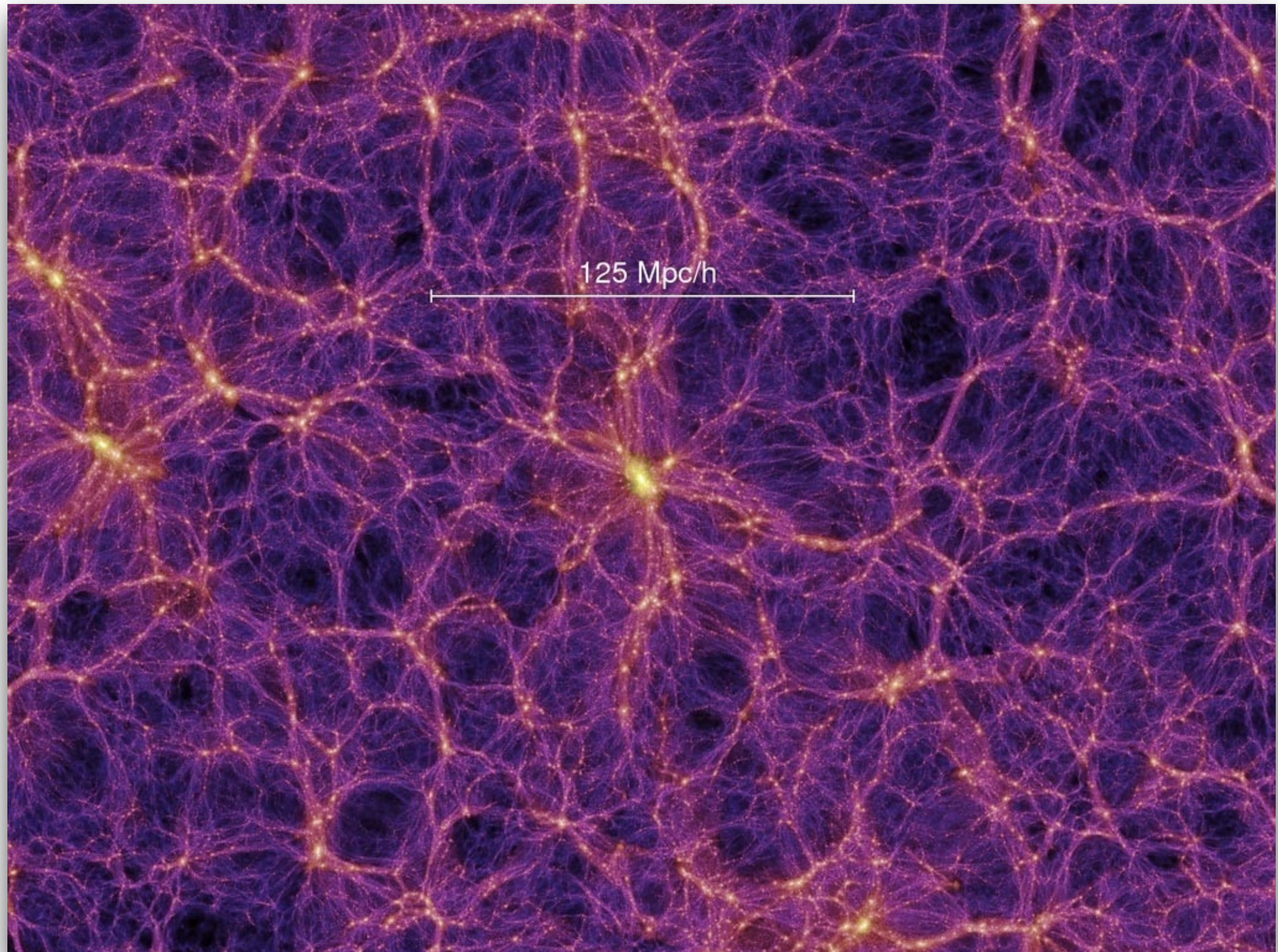
Average galaxy radius $\sim 50 \text{ kpc}$; $\sigma = \pi \times (2r)^2$ where $r \sim 50 \text{ kpc}$

For calculating n , assume around 100 galaxies within a radius of $\sim 1 \text{ Mpc}$

$$\tau_{\text{coll}} \sim \text{few} \times 10^9 \text{ yr} < \text{Age of the Universe}$$

Galaxies collide with each other...

Cosmic web Millenium Simulation Max Planck Institute for Astrophysics



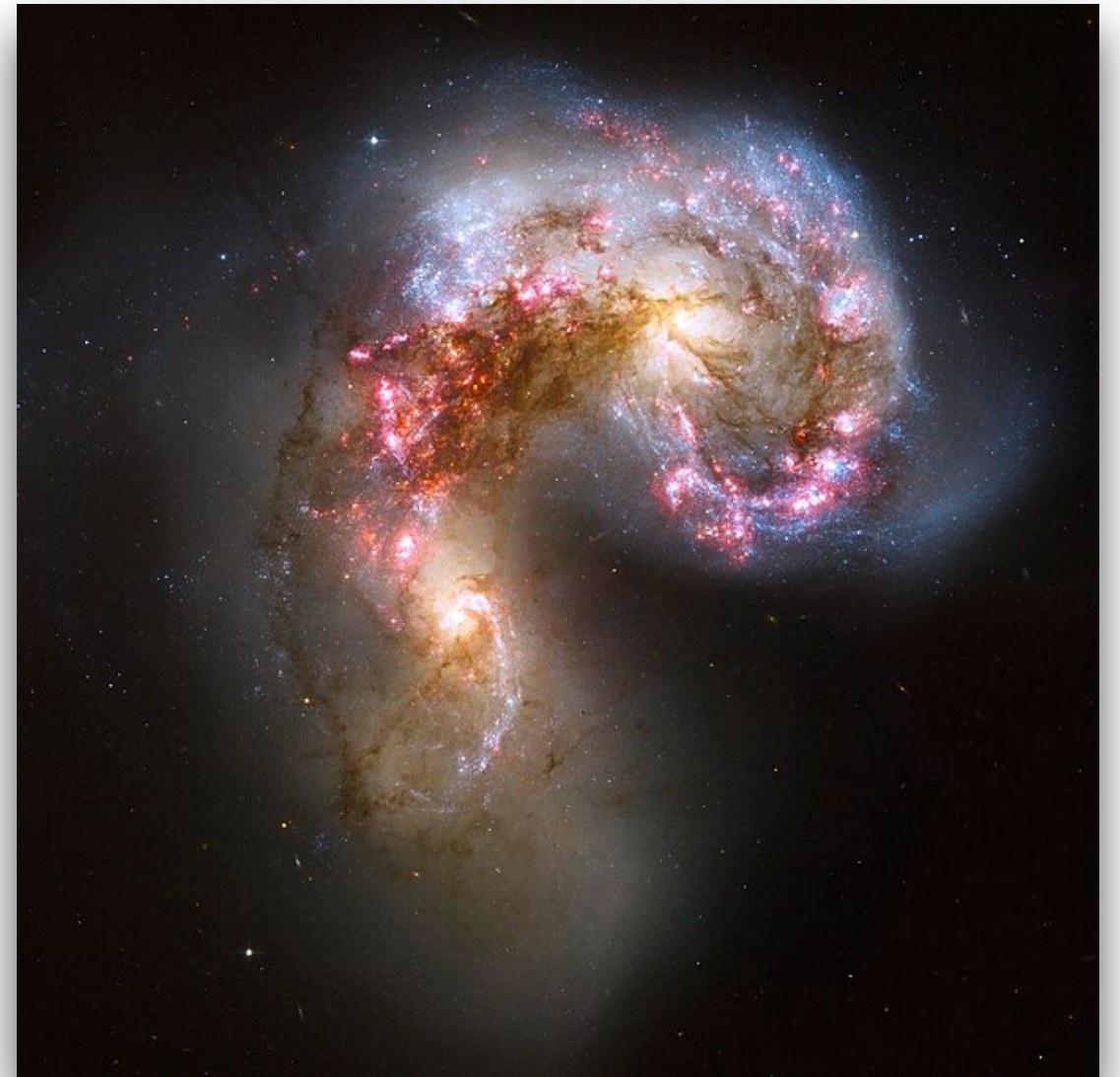
Starburst galaxies

Galaxies undergoing exceptionally high rate of star formation

In other words, galaxies experiencing a 'burst' of star formation

Possible origin

Merger or tidal interaction between gas-rich galaxies



Antennae Galaxies

Credit NASA/ESA

They can often be 'funny-looking' - showing tidal tails, ring-like feature, jets