Near field cosmology with constrained simulations: the CLUES project

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Collaborators

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Why are we interested in the Local Universe?

- The local neighborhood of the Milky Way is the most well known piece of the universe.

- Thus it is an ideal place to test on small scales models of structure formation against observations.

- However, the local universe is not a representative part of the universe. It is dominated by the Local Group with two massive galaxies, the the huge Local void and a few clusters which build together the Laniakea Supercluster (Brent's talk on Tuesday, lani = sky, heaven, akea = broad, wide).

- Constrained simulations are an ideal tool to compare theoretical predictions (computer experiments) with local observations

- see also Paco Kitaura's talk yesterday

Observational data and constraints for CLUES

- Wiener Filter algorithm (Zaroubi et al., 1995)
- Radial velocity field (MARK III, Willick et al., 1997, Tonry 2001, Karachentsev 2004)
- Nearby cluster positions (Reiprich & Böhringer, 2002)

- Cosmic Flows 2 (Courtois, Tully 2013)
- Reverse Zeldovich Approximation (Doumler et al. 2012, Sorce et al 2014)
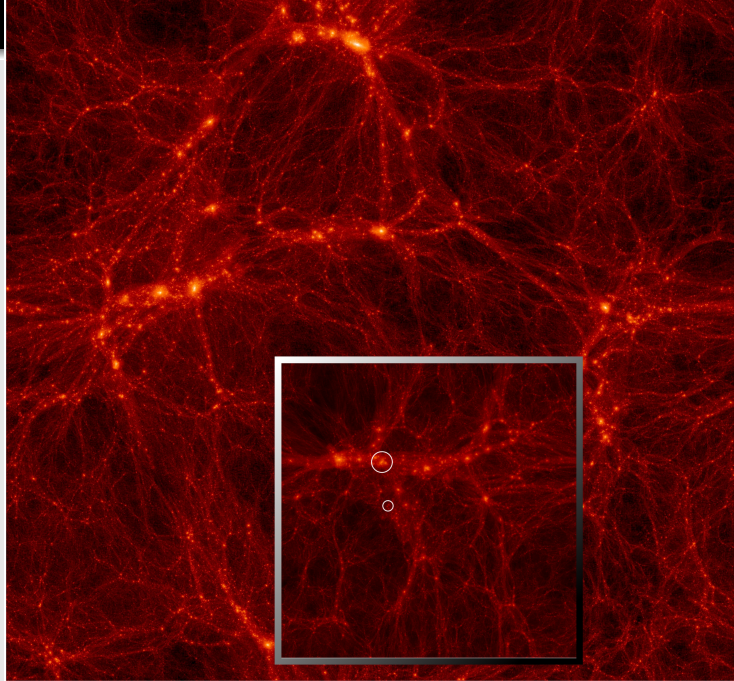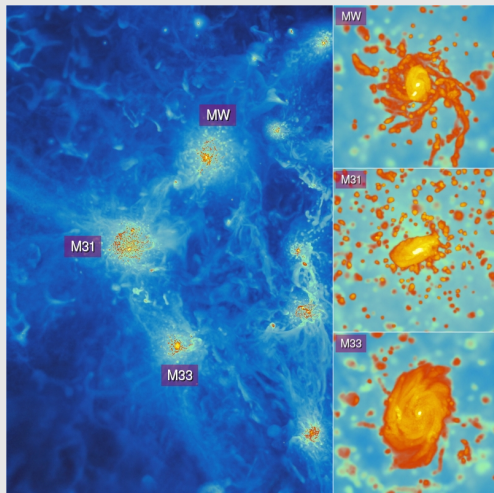- Grouping of velocity data (Tully 2014)
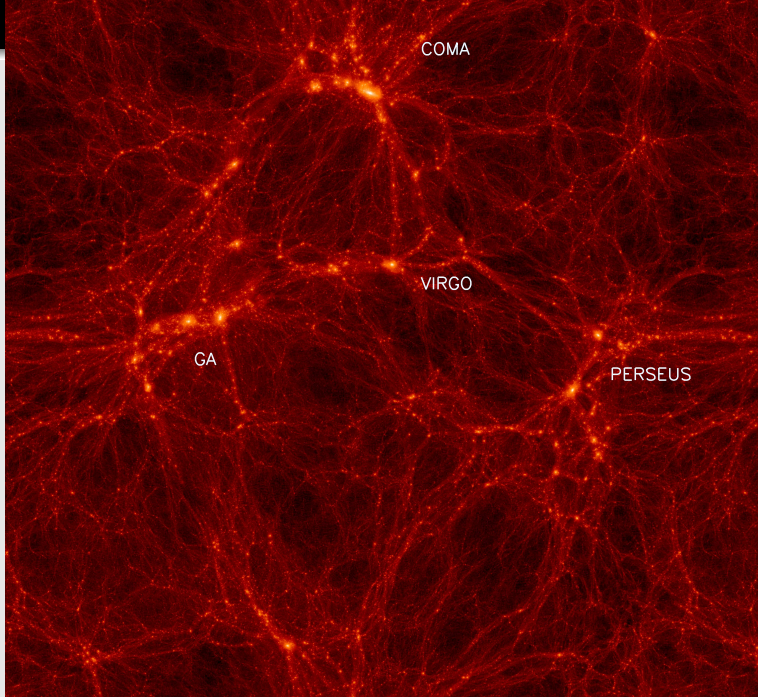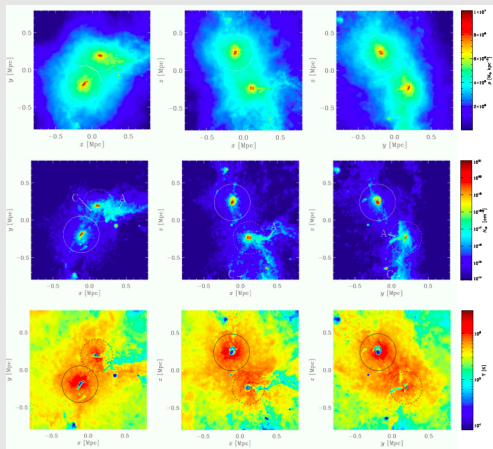
COMA

VIRGO

GA

PERSEUS

$160h^{-1}\mathrm{Mpc}$

$64h^{-1}\mathrm{Mpc}$

Gas distribution in the local group

- box $64h^{-1}\mathrm{Mpc}$
- 4096^3 particles locally
- DM particles: $2.1 \times 10^5 h^{-1}\mathrm{M}_\odot$
- gas particles: $4.4 \times 10^4 h^{-1}\mathrm{M}_\odot$
- force resolution: $150h^{-1}\mathrm{pc}$
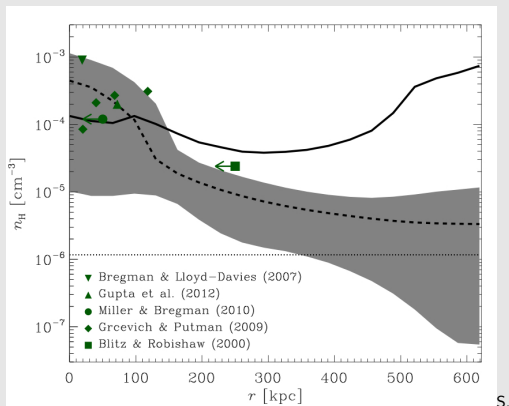
Gas distribution in the local group

S. Nuza et al. (2013)

- gas density (upper panel)
- HI column density (middle panel)
- temperature (lower panel)
- virial radius (circles)

Gas distribution in the local group

Nuza et al. (2013)

- hydrogen number density profile
- shaded area:standard deviation over random directions
- thick line: direction to Andromeda

Dwarfs in the Local Group

- isolated dwarfs without interactions with one of the massive galaxies in the past
- all within a sphere of $R = 1.5$ Mpc/h of the center of the Local Group
- triangles: galaxies that form stars at rates comparable to their past average
- circles: star formation has largely ceased

Alejandro Benitez-Llambay et al. (2013)

Dwarfs in the Local Group
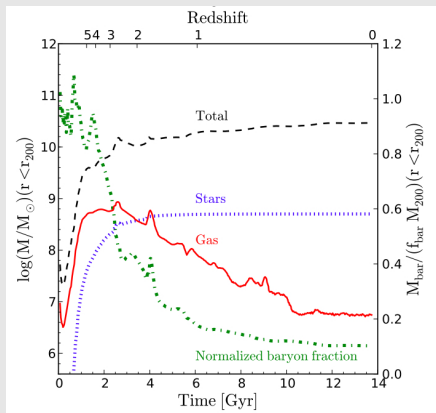
- masses within the virial radius of galaxy 30
- sudden loss of baryons at $z \approx 2$
- ram pressure arising from crossing a large-scale pancake

Cosmic web stripping
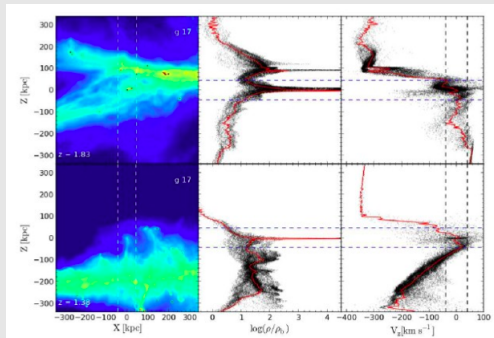
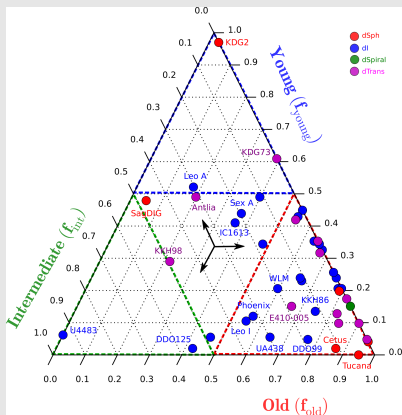Alejandro Benitez-Llambay et al. (2013), movies made by Alejandro

- gas from the halo is removed by the cosmic web environment due to ram pressure
- **Cosmic Web Stripping**

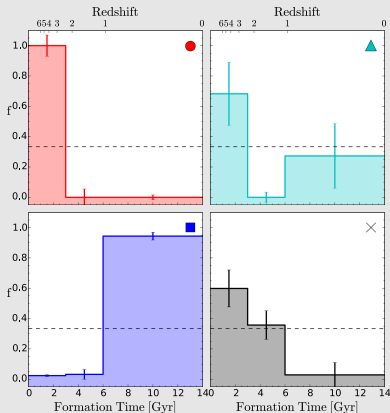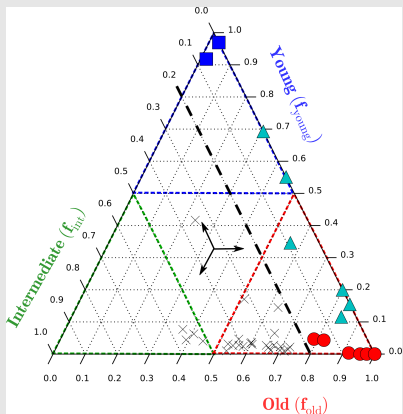# Classification of star formation histories
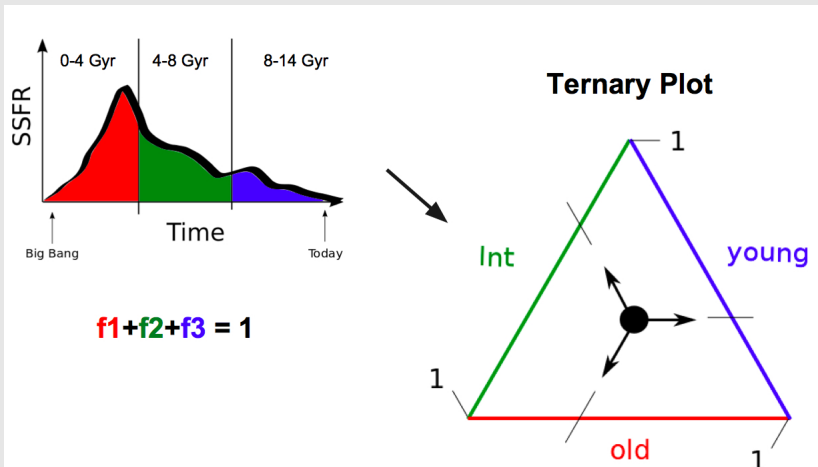
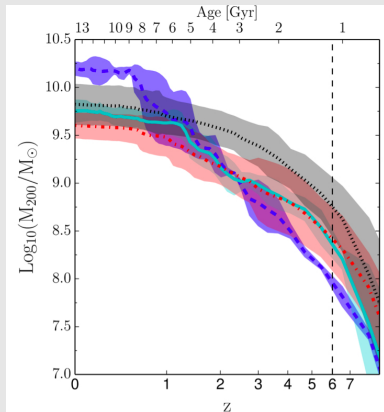Alejandro Benitez-Llambay et al. (2014)

Nearby observed dwarfs
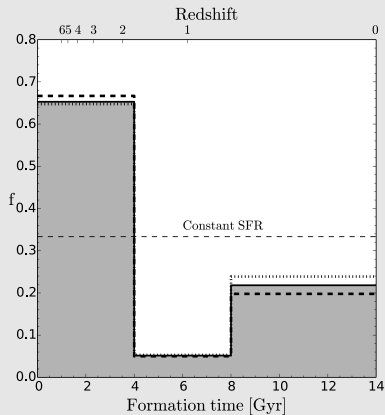
Nearby dwarfs from literature (LCID4 and the ANGST5 projects),
$7 < M_B < 16$ ($10^5 < M_{gal}/\mathrm{M}_\odot < 10^9$), out to 4.5 Mpc from
MW, no satellites (> 300 kpc to MW, M31, M81 and M82)

Simulated dwarfs next to the LG

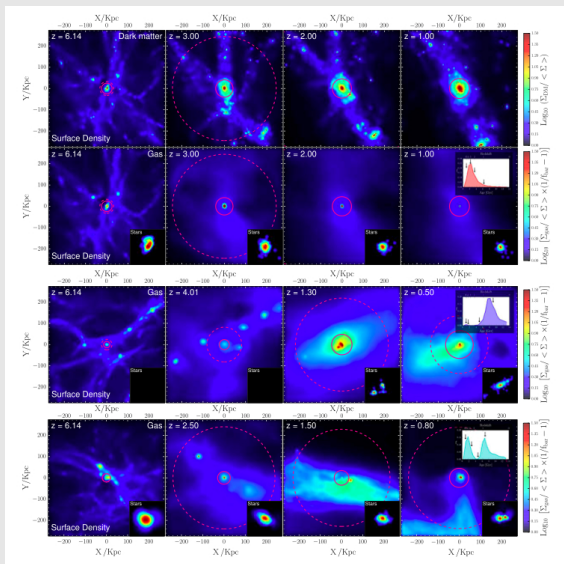Can we see the observed distribution also in the simulation. Yes, we can!
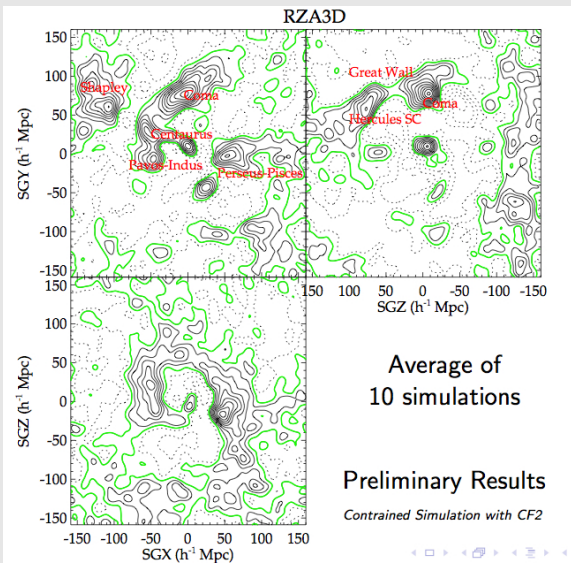
Dwarfs in the Local Group

- colors (grey,red,blue,cyan) as in the previous plots
- most massive (grey) keep gas after reionisation
- less massive lose it fast, single old population (red)
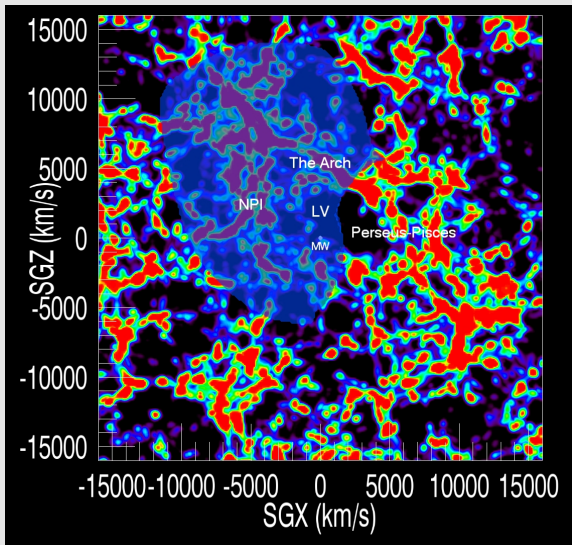- least massive may grow and collect gas for late star formation (blue)
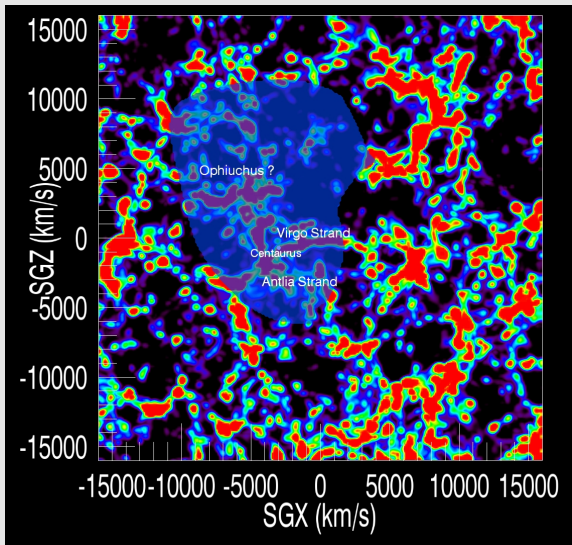
Evolution of DM, gas and stars

Constrained simulations from Cosmic Flows 2

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Constrained simulations from Cosmic Flows 2

Summary

- **Constrained numerical simulations are an important tool to study the formation of the observed structures in the local universe.**

- **Web stripping is an important ingredient for understanding the evolution of dwarfs.**

- **Reionisation changes the subsequent star formation history.**

- **The CF2 data together with the improved technique substantially improve the quality of our constrained simulations**

CosmoSim database

http://www.cosmosim.org/

Kristin Riebe, Adrian Partl, Harry Enke

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