How does the cosmic web impacts assembly bias?

Impact of large-scale structures on halo & galaxy evolution

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In collaboration with M. Musso & C. Codis

Journe des Doctorants, March 24, 2017

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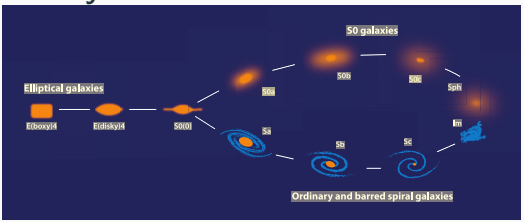
Introduction

What's the link between galaxy/halo formation and large-scale structures?

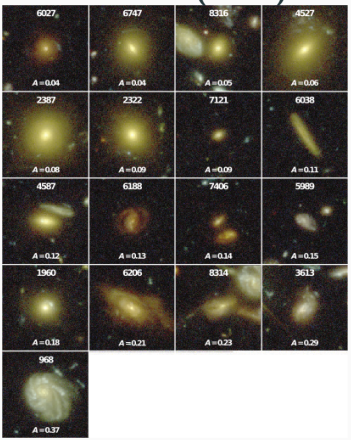
Describing galaxies?

Theory



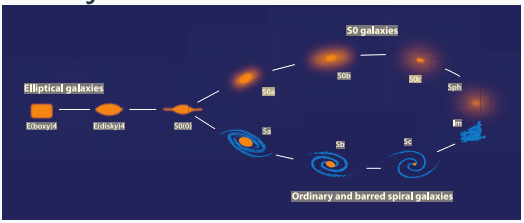
+ star forming?
+ bulge?
+ mass?
+ DM halo mass?
+ DM profile?
+ ...

Observations (HDF)

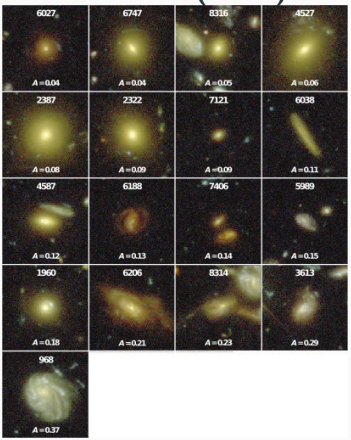


Describing galaxies?

Theory



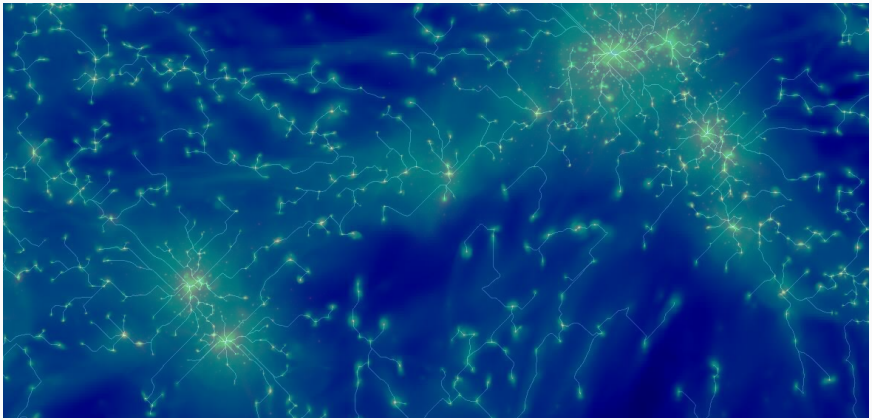
Observations (HDF)



+ star forming?
+ bulge?
+ mass?
+ DM halo mass?
+ DM profile?
+ ...

And all the properties **change with cosmic time**...

Cosmic Web

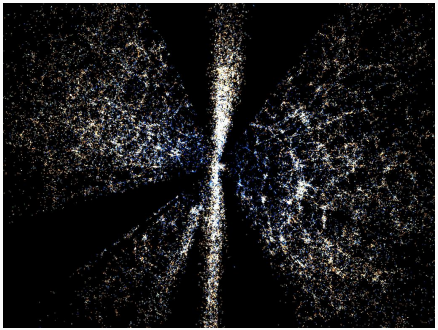


Horizon-AGN simulation with skeleton, Dubois+12

And all the properties **change with cosmic time** and location w.r.t. **the cosmic web** (see .e.g K. Kraljic+2017)!

Cosmic web

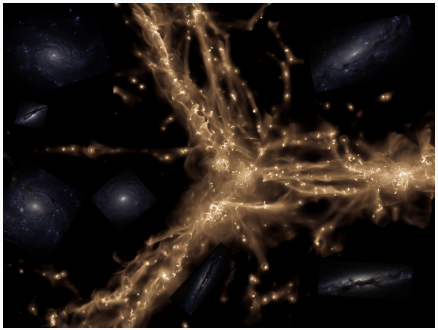
- Geometry of the density/potential field
- Voids, walls, filaments, peaks (resp. 3, 2, 1, 0D)



SDSS

Cosmic web

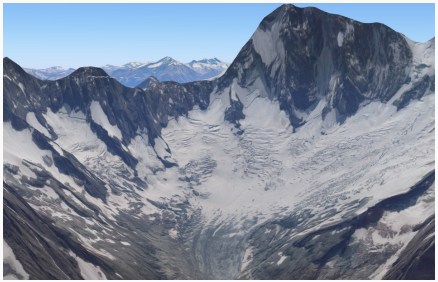
- Geometry of the density/potential field
- Voids, walls, filaments, peaks (resp. 3, 2, 1, 0D)



New Horizon simulation

Cosmic web

- Geometry of the density/potential field
- Voids, walls, filaments, peaks (resp. 3, 2, 1, 0D)
  or
- Critical points (0D)

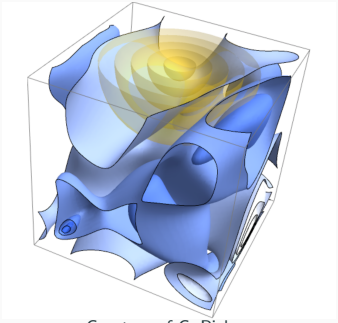


Effect on assembly

Theoretical setup

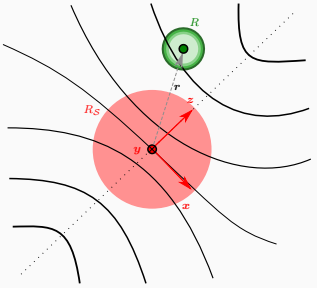
Excursion set theory
Galaxy properties & evolution from initial conditions

$\Rightarrow$ Find largest mass that will collapse by z at given location

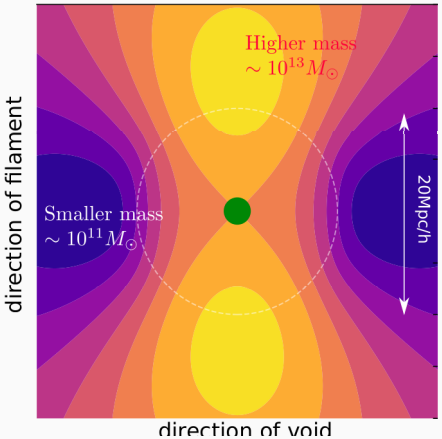


Courtesy of C. Pichon

Simulation	Theory
M	R
z, t	$\delta = \frac{\rho - \bar{\rho}}{\bar{\rho}}$



Typical mass of DM halo



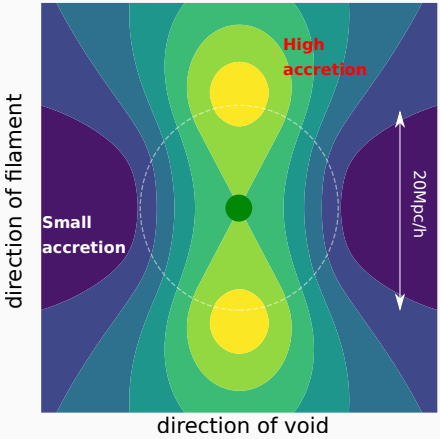
The typical mass at $z = 0$.

1. Larger galaxies in nodes
2. Smaller galaxies in voids

In agreement with *n*-body simulations.

M. Musso, C. Cadiou *et al.*, MNRAS

Effect on (DM) accretion rate



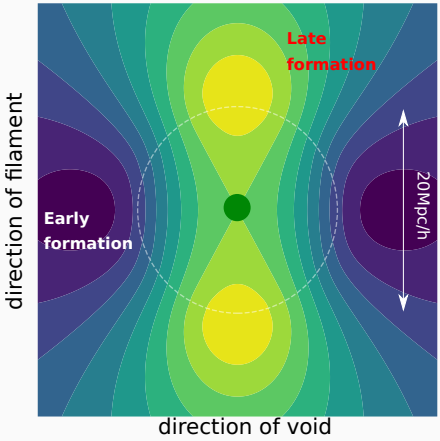
Accretion rate at **fixed** final mass

$M \simeq 3 \times 10^{11}\,\mathrm{M}_{\odot}$.

M. Musso, C. Cadiou *et al.*, MNRAS

1. High accretion rate in node
2. Small accretion rate in voids

Effect of halo formation time

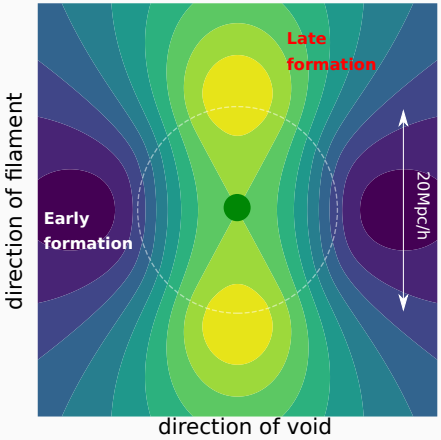


Formation time at **fixed** final mass $M \simeq 3 \times 10^{11}\,\mathrm{M}_{\odot}$.

1. Late formation in node (low z)
2. Early formation in voids (high z)

M. Musso, C. Cadiou *et al.*, MNRAS

Effect of halo formation time



Formation time at **fixed** final mass $M \simeq 3 \times 10^{11}\,\mathrm{M}_{\odot}$.

1. Late formation in node (low z)
2. Early formation in voids (high z)

Tension with observations?

M. Musso, C. Cadiou *et al.*, MNRAS

Tension with observations?

Theory
Higher DM accretion + late formation:

blue central galaxy?

Observations
Massive red central galaxies

Tension with observations?

Theory
Higher DM accretion + late formation:
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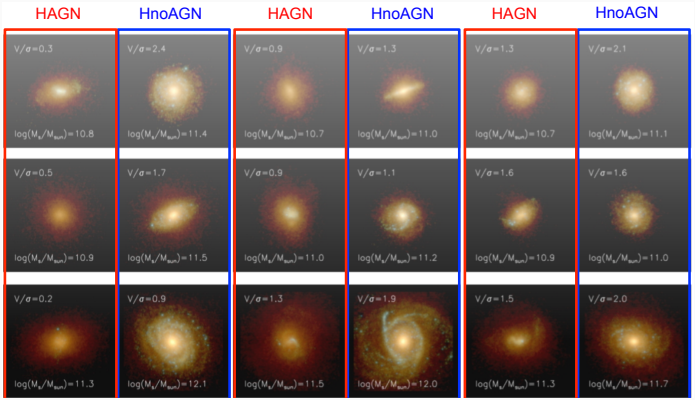
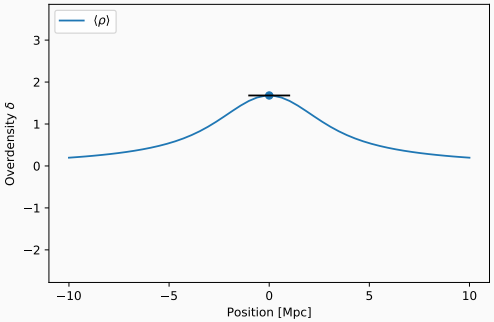


Dubois+16

Beyond Mass-Density

4 parameters dictate mass/accretion/formation time/. . . :

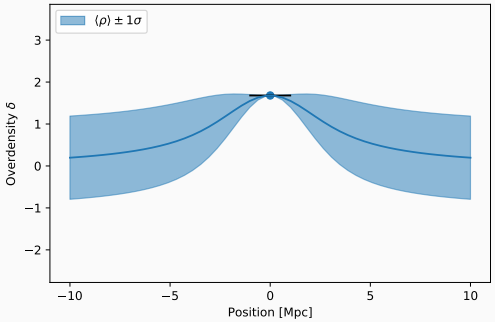
- mean density δ
- mean derived density $\delta' = \frac{\mathrm{d}\delta}{\mathrm{d}R}$



Beyond Mass-Density

4 parameters dictate mass/accretion/formation time/...:

- mean density δ
- mean derived density $\delta' = \frac{\mathrm{d}\delta}{\mathrm{d}R}$
- variance of density
- variance of accretion



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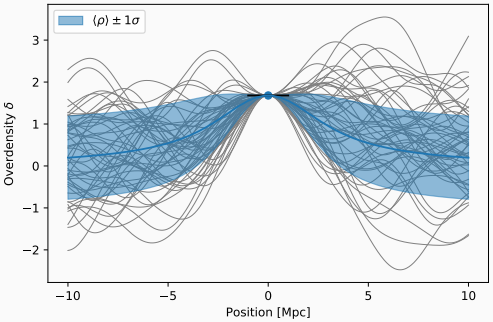
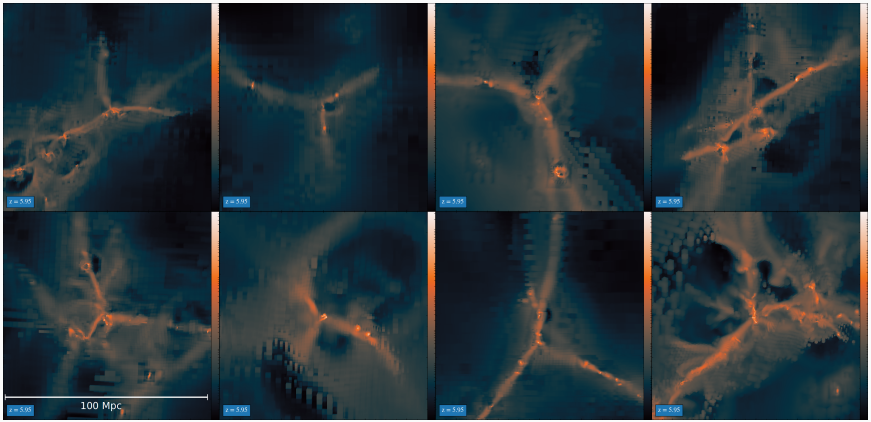


Environments with different variance do not behave the same: what matters is $(\delta - \langle\delta\rangle)/\sqrt{\mathrm{Var}(\delta)}$

Filamentary accretion at high z

From simulations



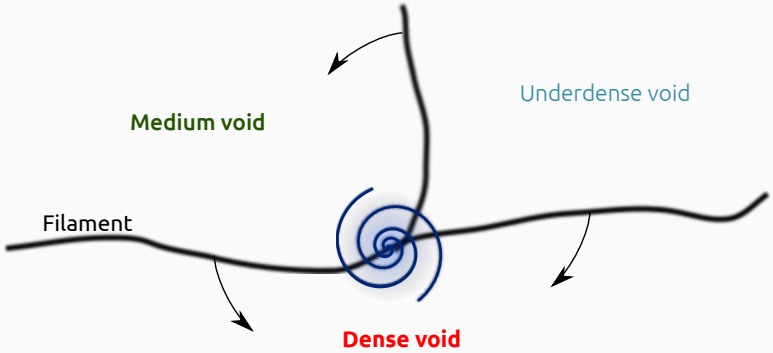
Density maps of galaxies from New Horizon simulation @ $z = 6$, Dubois+, in prep.

Typical setup: planar with 3 filaments

Simple 2D model

Open questions

- Net torque on filaments?
- Galaxy spin-up or down?
- Typical coherence scale?



C. Cadiou, C. Pichon & S.Codis, in prep

Simple 2D model

Open questions

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- Galaxy spin-up or down?
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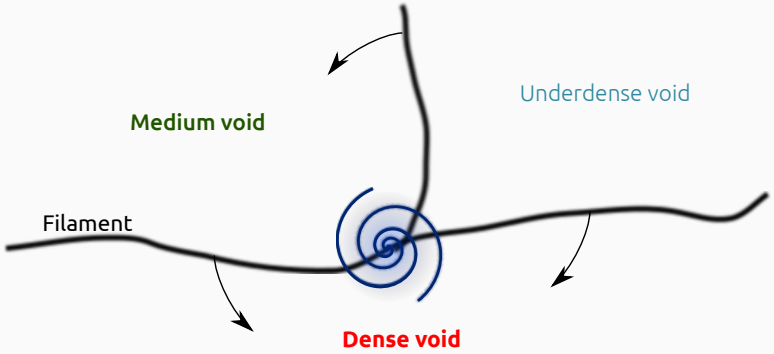
Model

- Planar (2D)
- 3 voids $\rightarrow$ 3 filaments
- 1 central peak

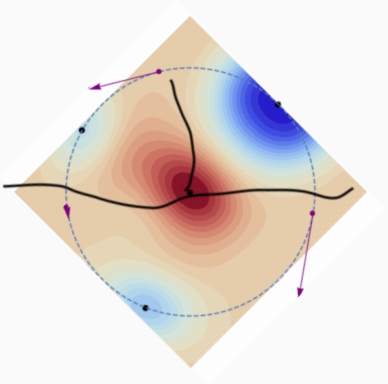


C. Cadiou, C. Pichon & S.Codis, in prep

Predicting the torque

Using constrained theory + Λ-CDM power spectrum

Voids are pushing filaments



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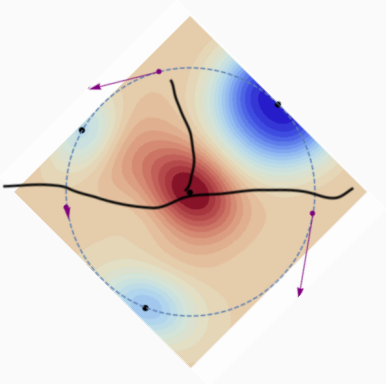
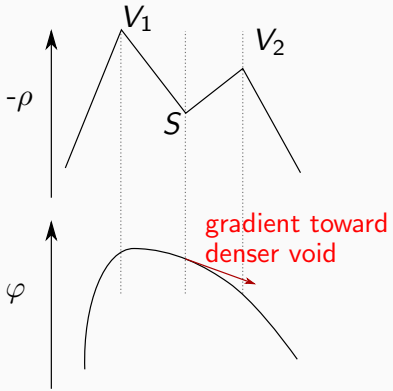


C. Cadiou, C. Pichon & S.Codis, in prep



Conclusions

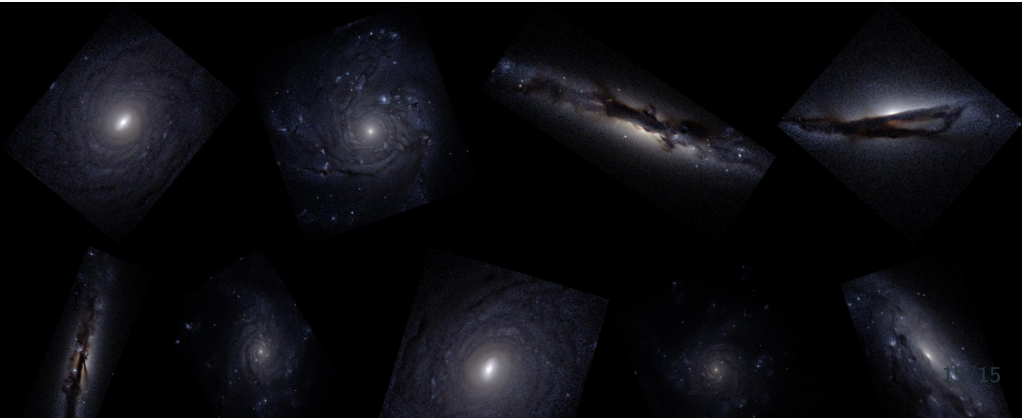
Conclusions

Assembly of DM halo

- Influenced by LSS
- Recovers *n*-body sim
- Still need baryonic physics

Torque on filament

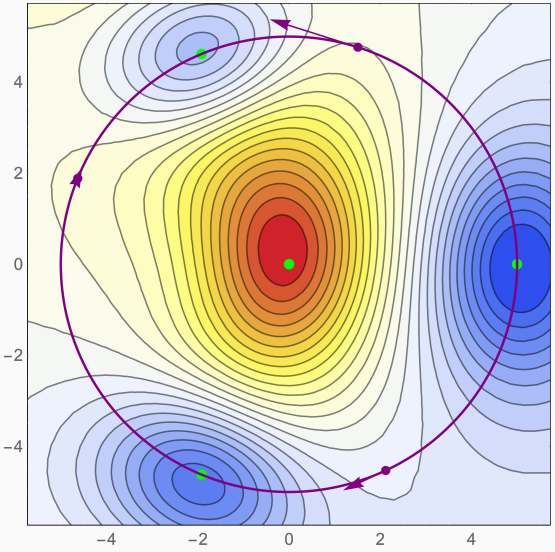
- Expect torque on filament
- Quantitative results?
- Compare with simulations?



Thank you!

More torque plots

Torque on filament



Effect of AGN