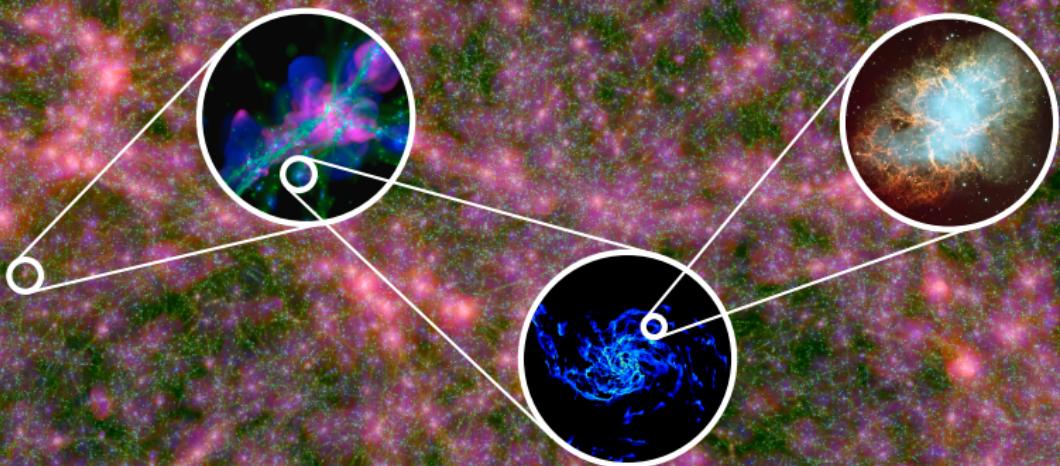


Galaxy formation and evolution: Models & Theoretical challenges 4°



Katarina Kraljic

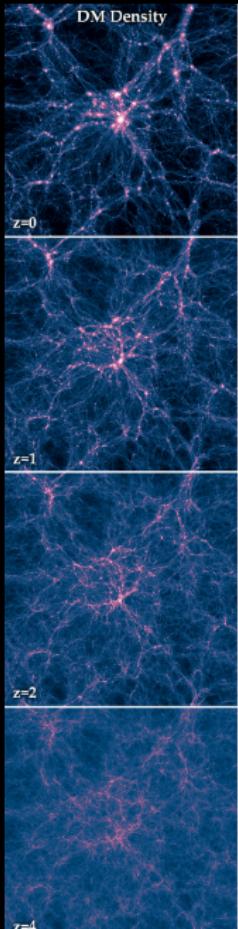
Institute for Astronomy, Edinburgh

July 2019, Petnica

Results

Structure formation . . . from simulations

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Cosmic web

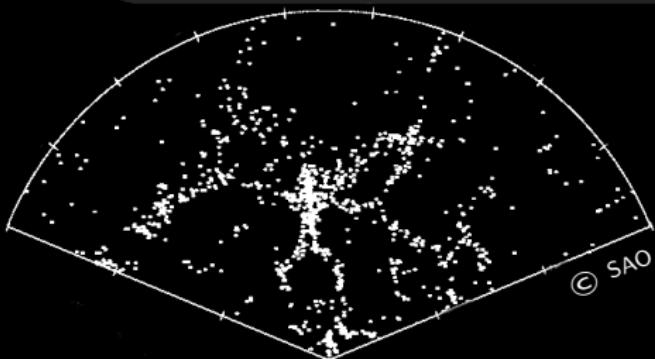
- almost empty *voids*
- sheet-like *walls*
- *filaments*
- *nodes*

Illustris (Vogelsberger et al. 2014); from Somerville & Davé 2016

Results

Structure formation . . . from observations

2/20

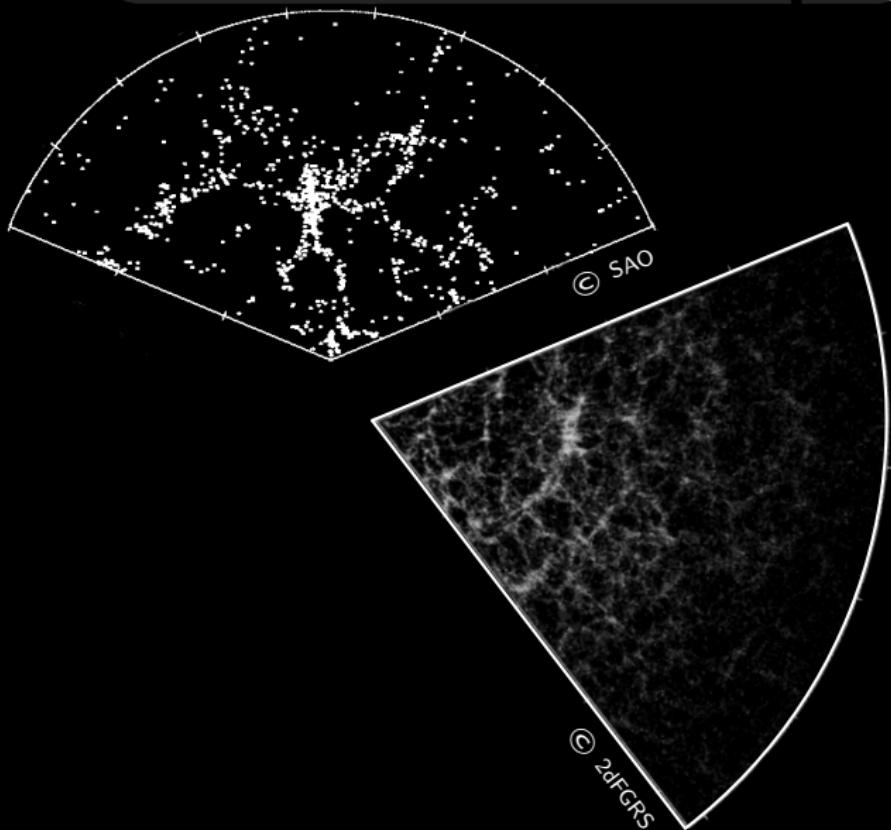


de Lapparent et al. 1986

Results

Structure formation . . . from observations

2/20



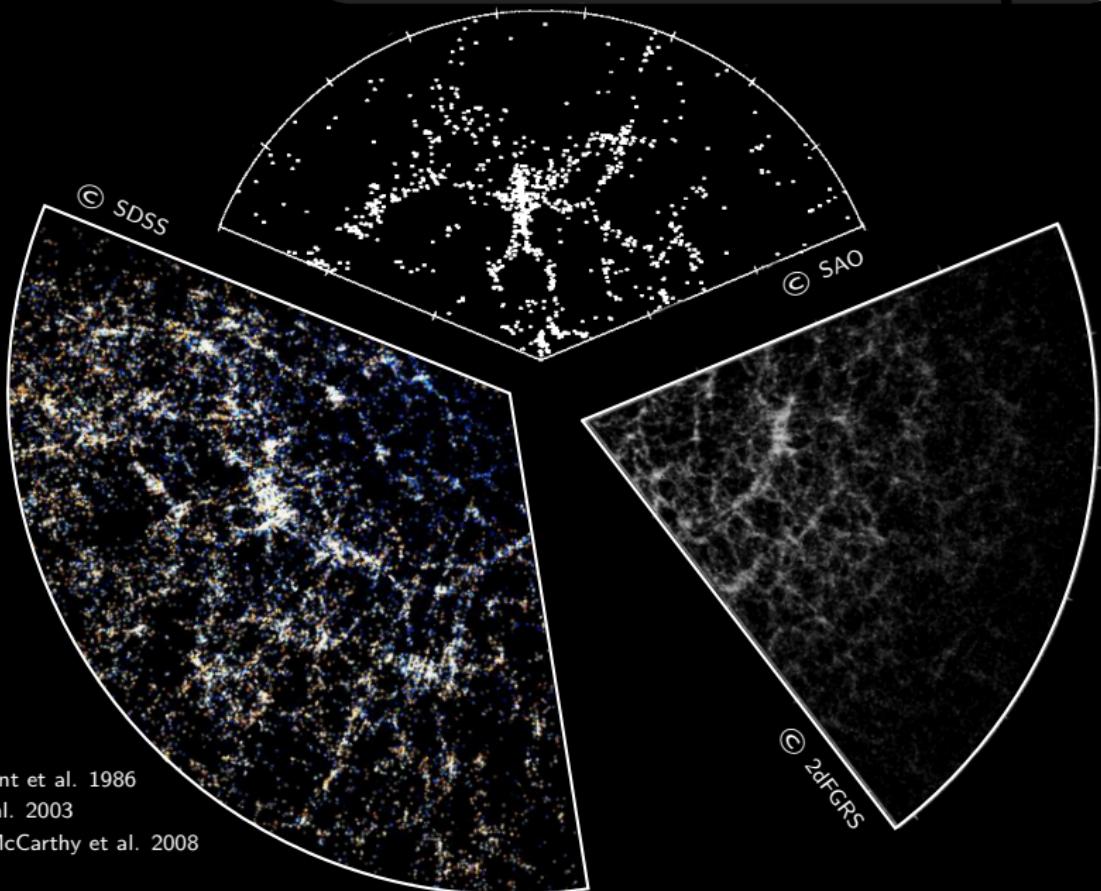
de Lapparent et al. 1986

Colless et al. 2003

Results

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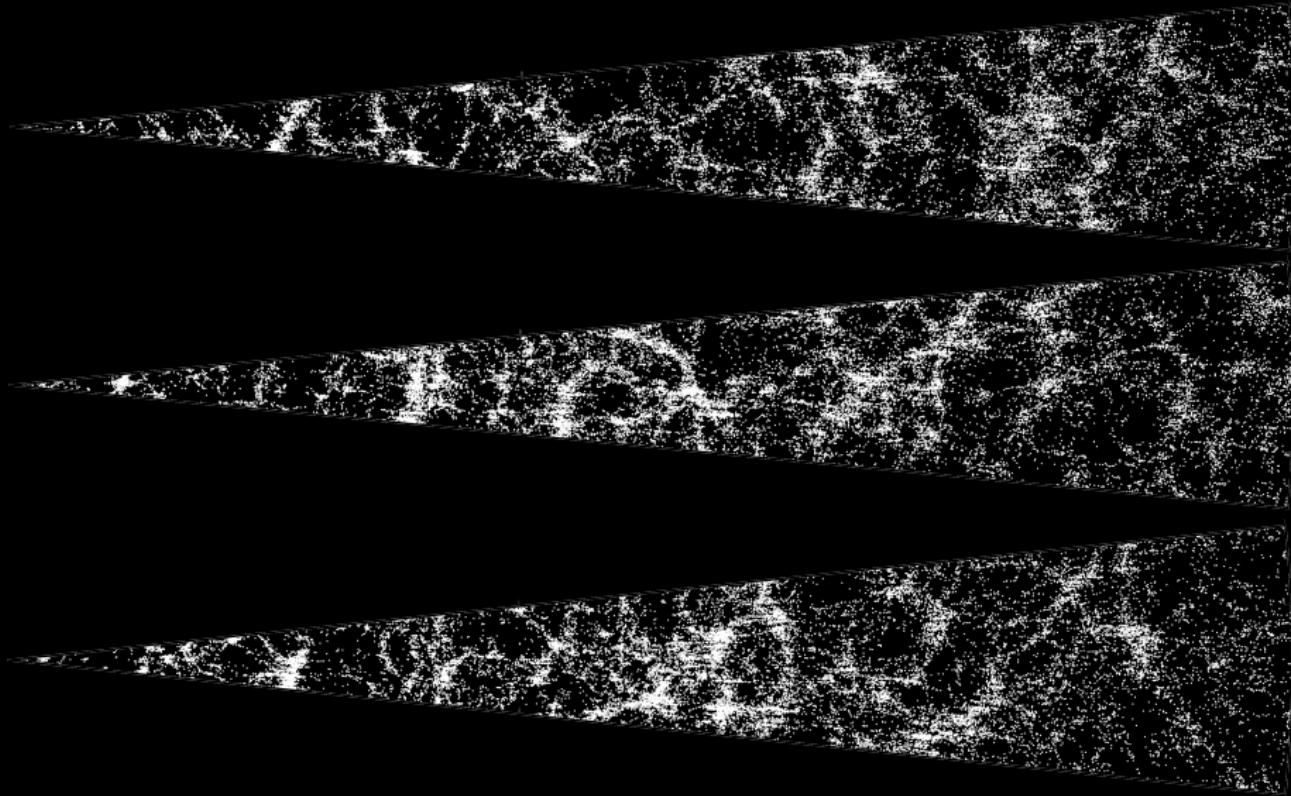
2/20



Results

Structure formation . . . from observations

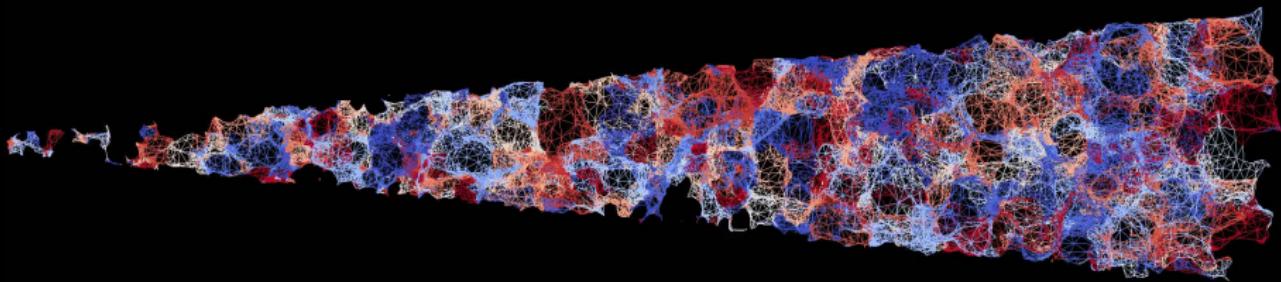
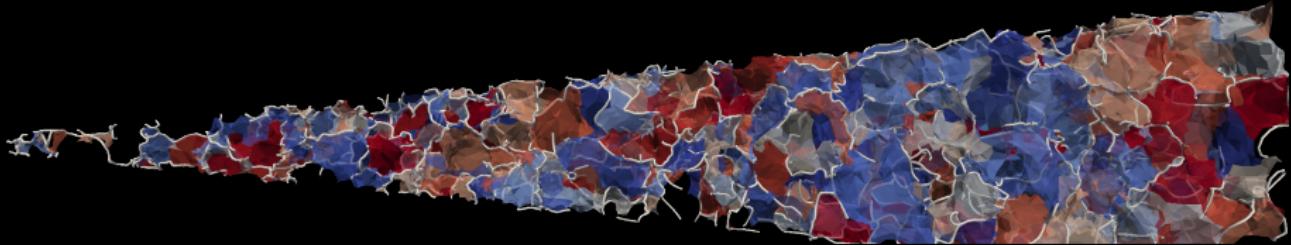
3/20



Results

Structure formation . . . from observations

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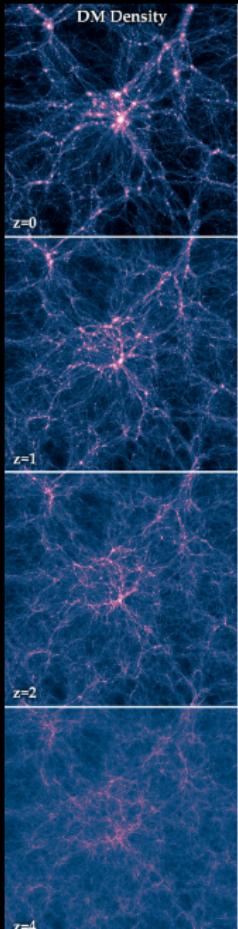


DisPerSE (Sousbie et al. 2011)

Results

Structure formation . . . from simulations

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Cosmic web

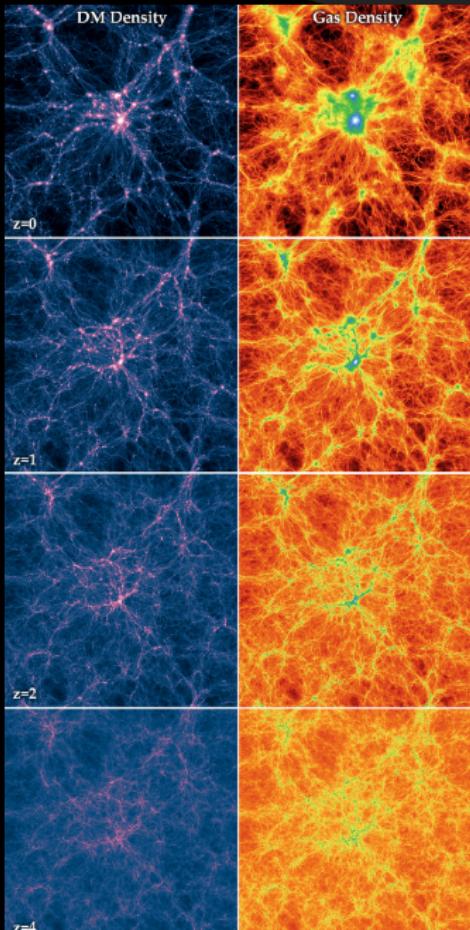
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5/20

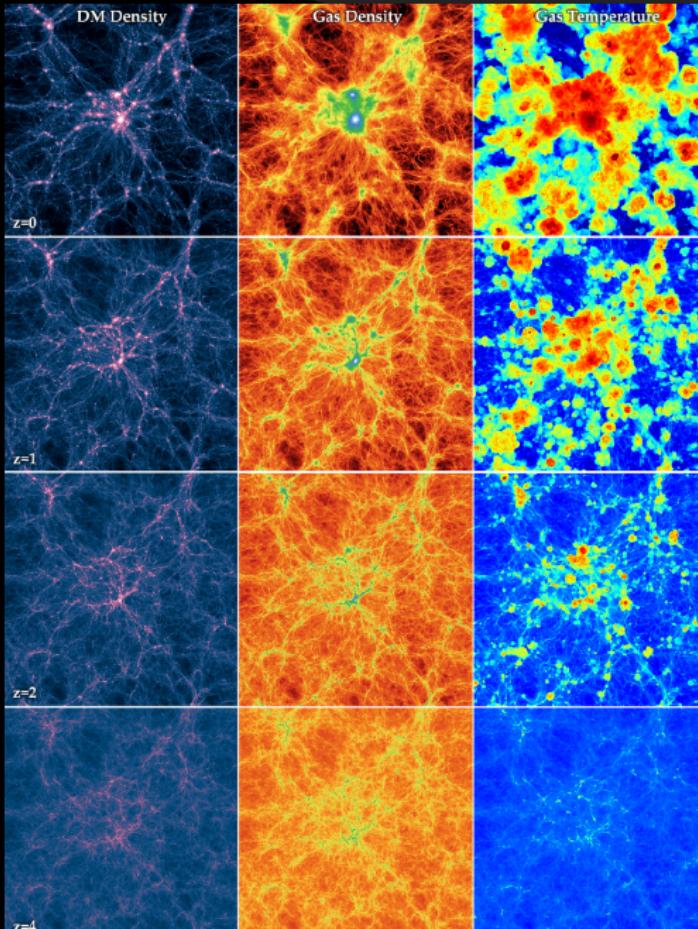


Illustris (Vogelsberger et al. 2014); from Somerville & Davé 2016

Results

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5/20

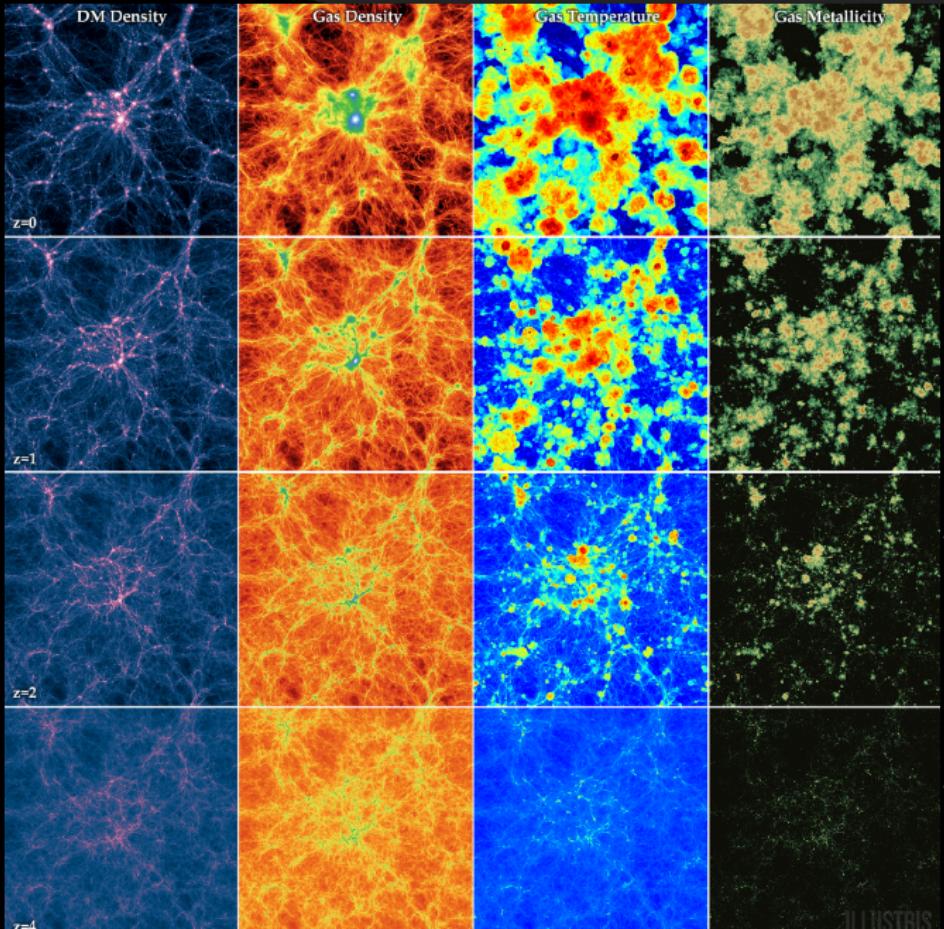


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Results

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5/20

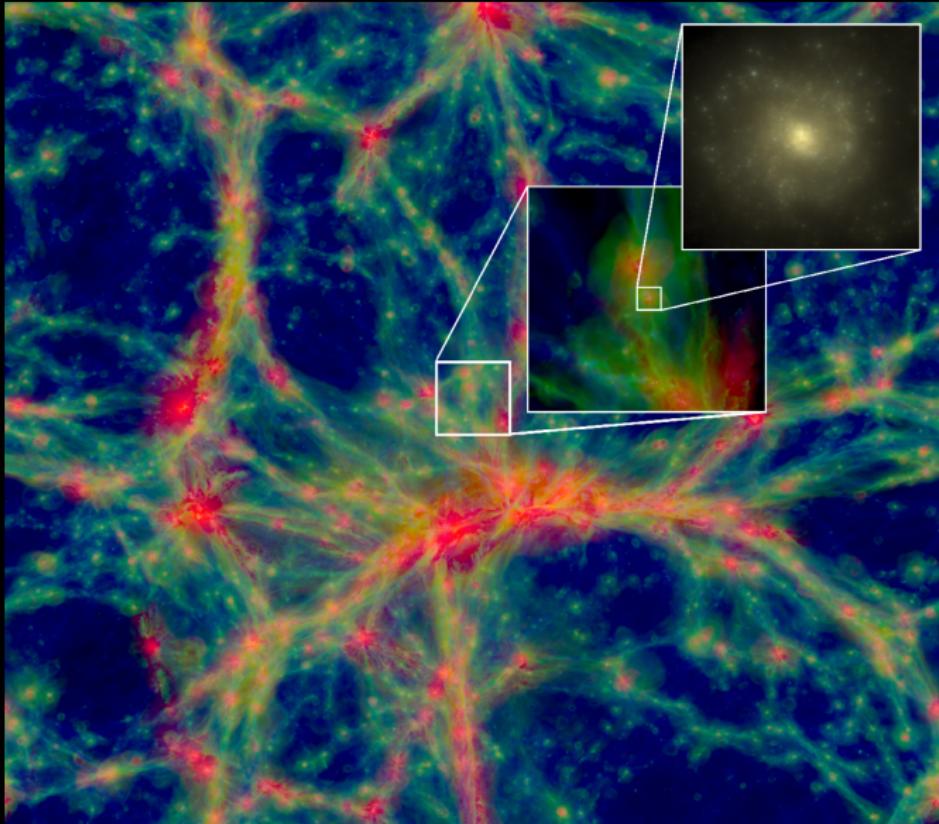


Illustris (Vogelsberger et al. 2014); from Somerville & Davé 2016

Results

Structure formation . . . from simulations

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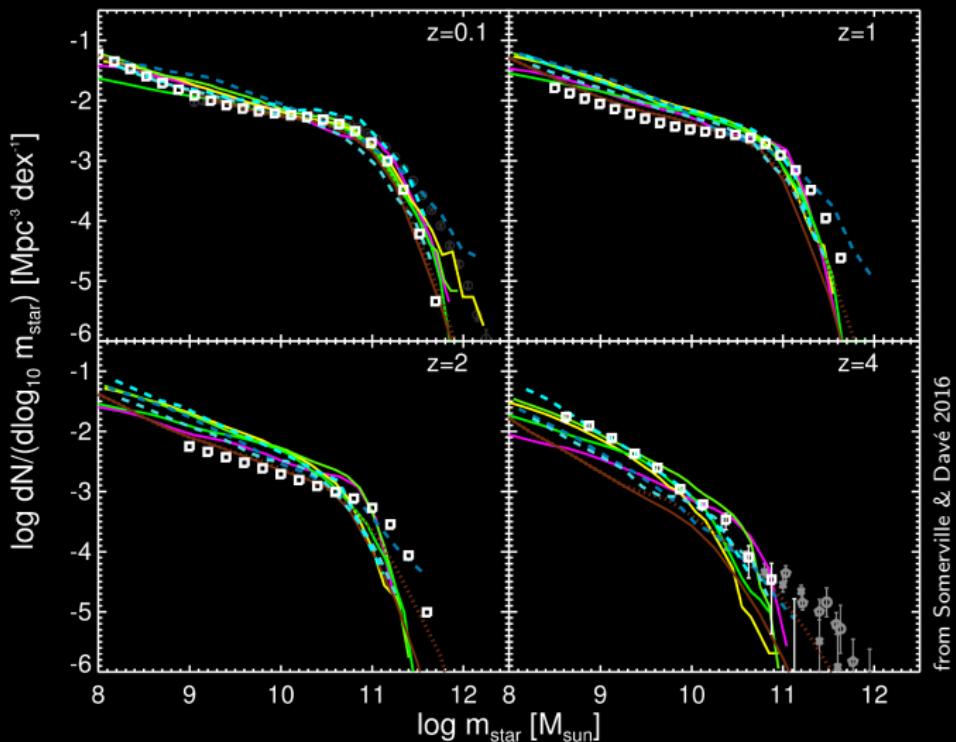


Eagle (Schaye et al. 2014); from Somerville & Davé 2016

Results

Stellar mass function

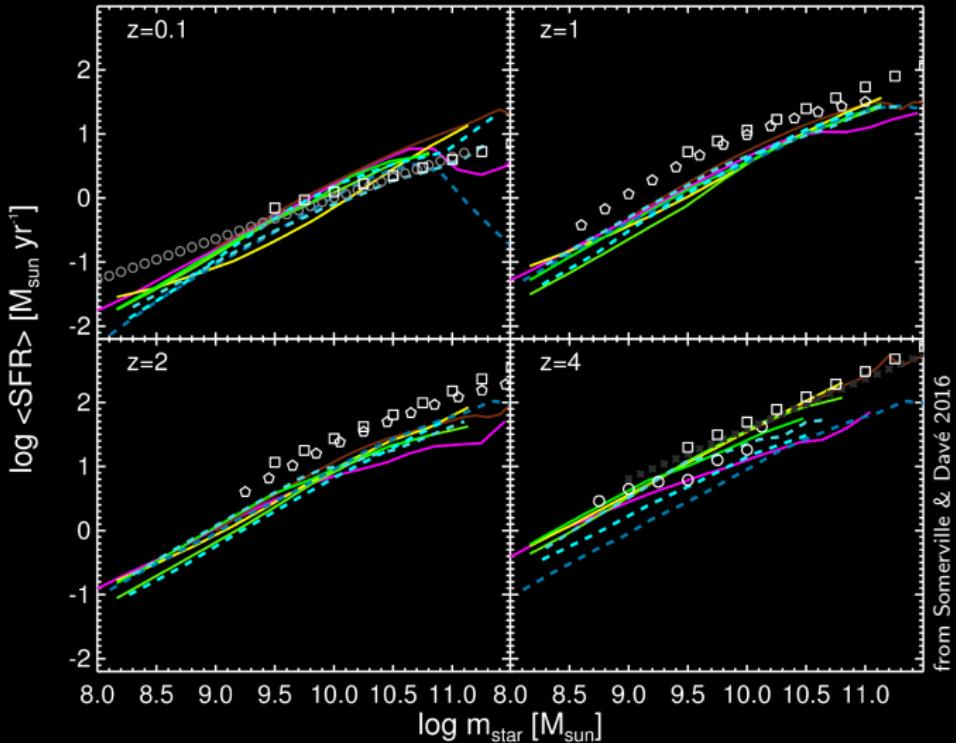
7/20



Results

SF main sequence

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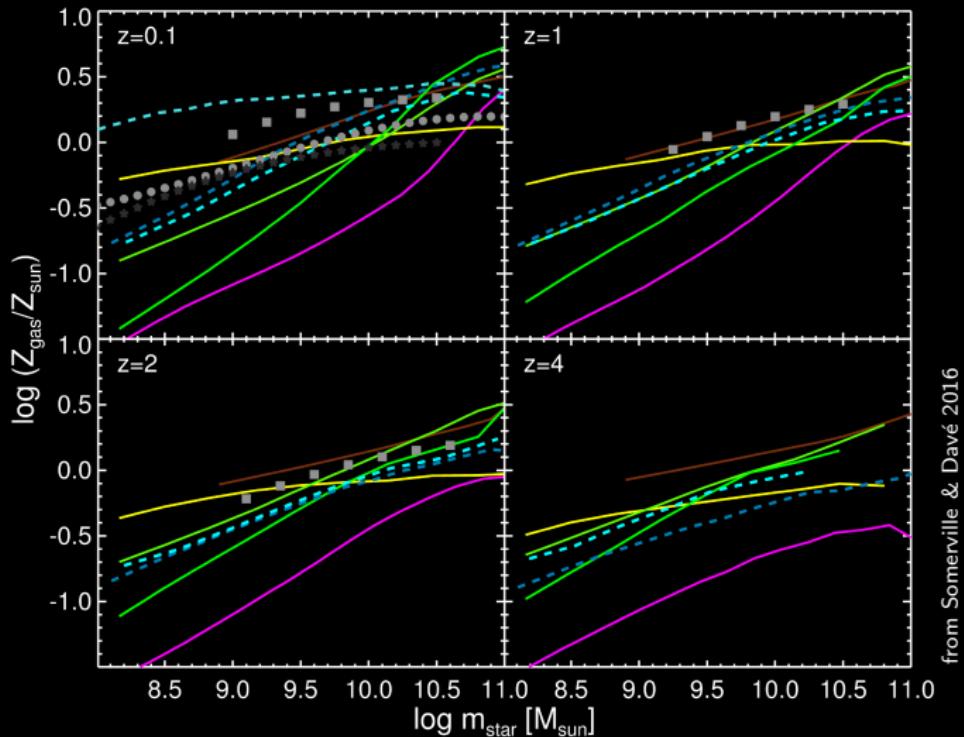


from Somerville & Davé 2016

Results

Mass-metallicity relation

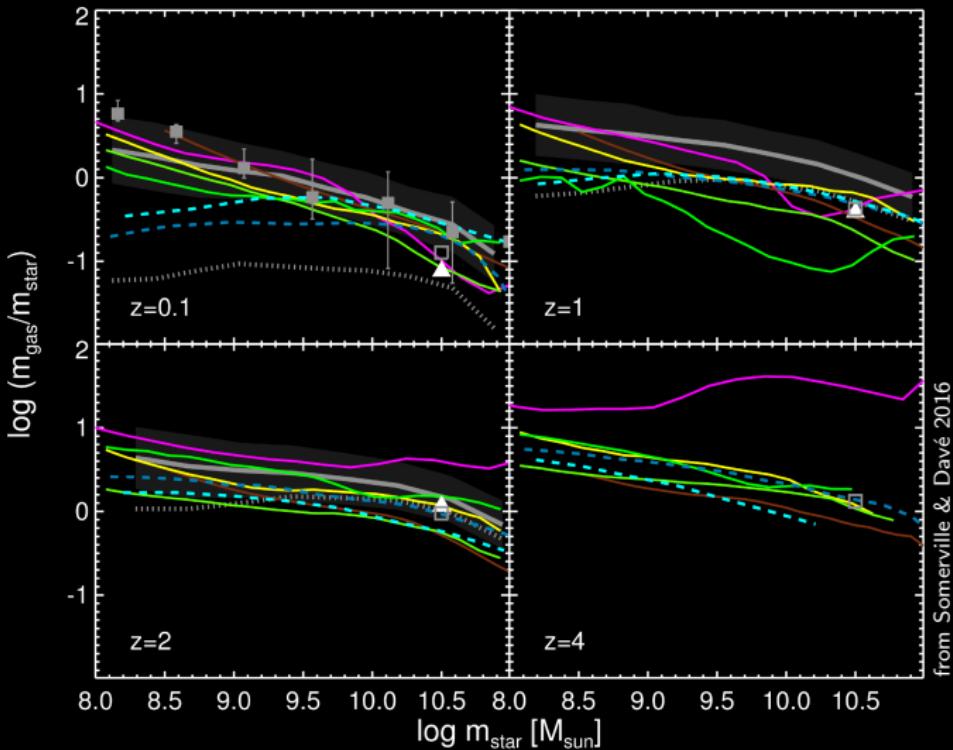
9/20



Results

Cold gas fractions

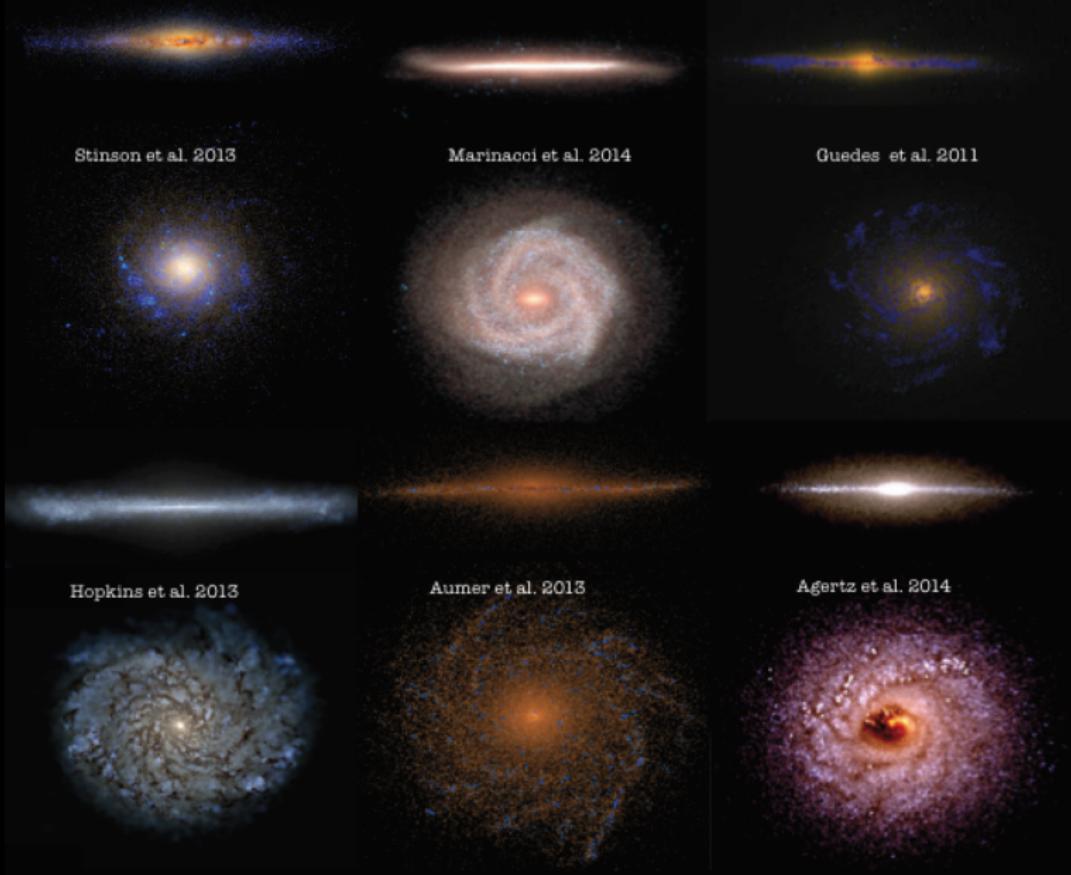
10/20



Results

Disks

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Results

Disks

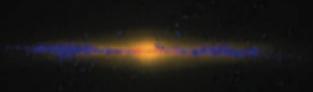
11/20



Stinson et al. 2013



Marinacci et al. 2014



Guedes et al. 2011



Disks



Aumer et al. 2013



Agertz et al. 2014

- *problem: 'AM catastrophe'*

Results

Disks

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Disks

- *problem:* 'AM catastrophe'
- *origin:* too-efficient SF & gas consumption in small objects at high z —> assemble into low z galaxies via gas-poor mergers

Hopkins et al. 2013

Aumer et al. 2013

Agertz et al. 2014



Disks

- *problem:* 'AM catastrophe'
- *origin:* too-efficient SF & gas consumption in small objects at high z → assemble into low z galaxies via gas-poor mergers
- *solution:*
 - stellar feedback → keep SF efficiency low & stellar winds → remove preferentially low-AM material
 - SF → in dense & highly clustered environment

Hopkins et al. 2013

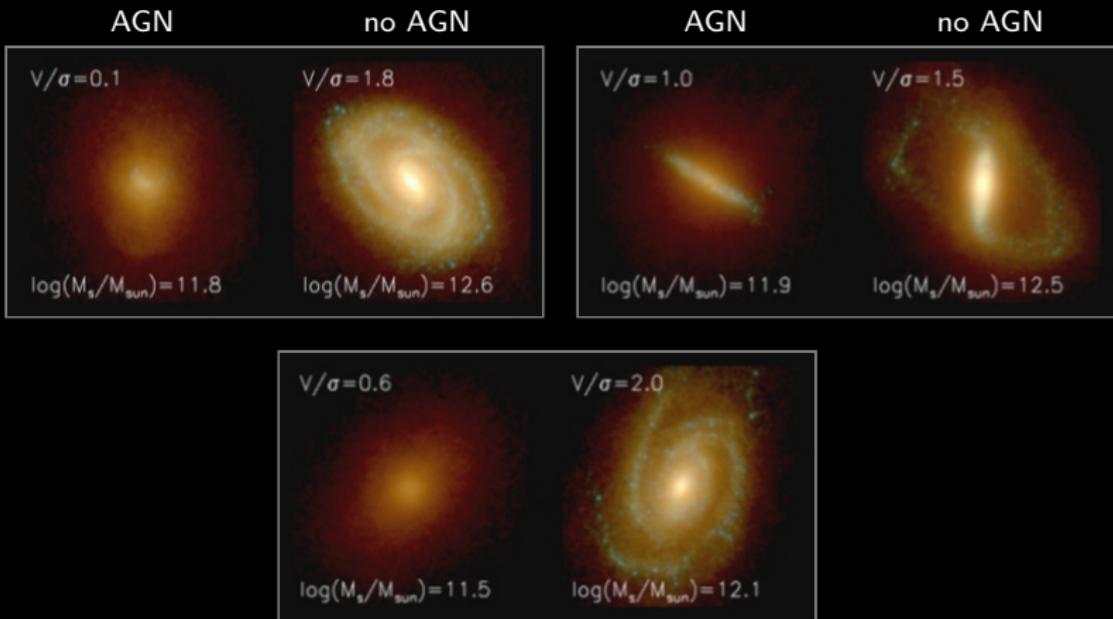
Aumer et al. 2013

Agertz et al. 2014

Results

Disks

12/20

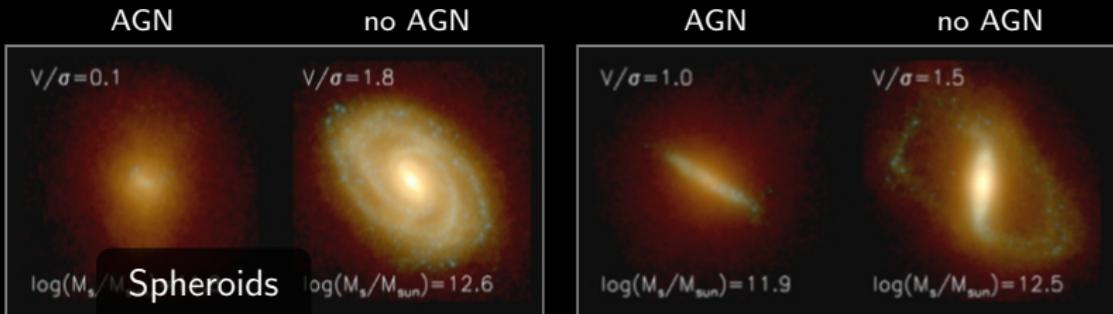


HORIZON-AGN/HORIZON-noAGN (Dubois et al. 2014, 2016)

Results

Disks

12/20

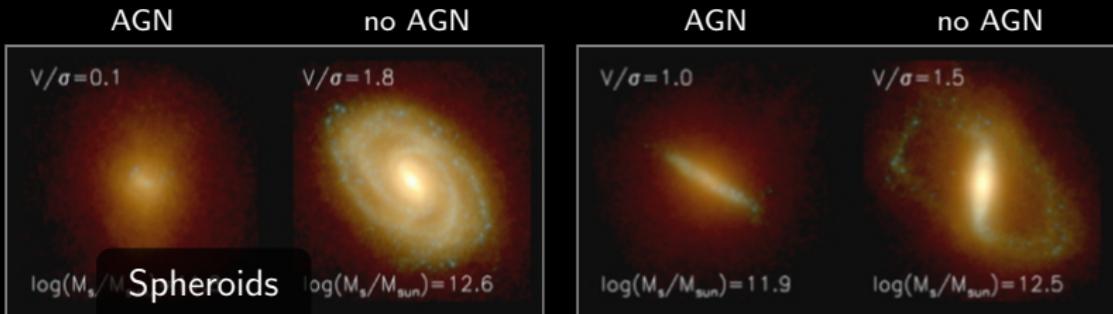


- *problems:* 'cooling-flow problem', central SFR too high

Results

Disks

12/20

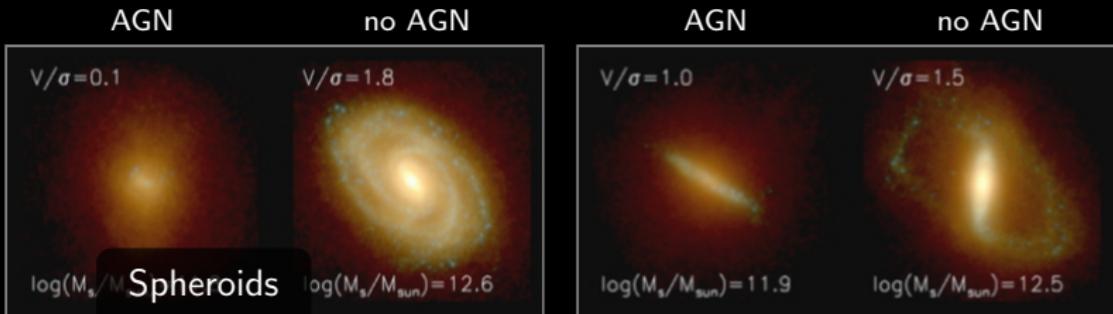


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Results

Disks

12/20



- *problems*: 'cooling-flow problem', central SFR too high
- *origin*: too-efficient cooling & SF
- *solution*: consume or remove gas early →
 - ejective AGN feedback ('jet mode')
 - preventive AGN feedback ('radiative mode')

Conclusions

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 - abundances
 - SFRs
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 - M_\star , M_{BH} , M_{halo} ...

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 - different techniques (0.5–3 kpc) \longrightarrow galaxy populations with realistic cosmological evolution of
 - sizes
 - abundances
 - SFRs
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 - M_\star , M_{BH} , M_{halo} ...
 - zoom-in simulations (~ 100 pc)
 - multi-phase ISM
 - stellar feedback
 - radiation & winds
- \implies potential to shed more light \longrightarrow physical processes

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 - outflows \rightarrow likely driven by energy injection from
 - SNe
 - cosmic rays
 - winds
 - radiation
 - accreting BHs
 - many conceptually different models \rightarrow 'successfully' reproduce
 - galaxy abundances
 - disk morphologies
- \Rightarrow essential characteristics of the problem revealed ... BUT

Problems

- sub-resolution models
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 - free parameters \Rightarrow limit predictive power

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- AGN feedback
 - empirical
 - accretion & E conversion efficiencies \longrightarrow adjusted \iff observed scaling relations

Outlook

We need to account for

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Outlook

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- long range effect of energy radiation from
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Outlook

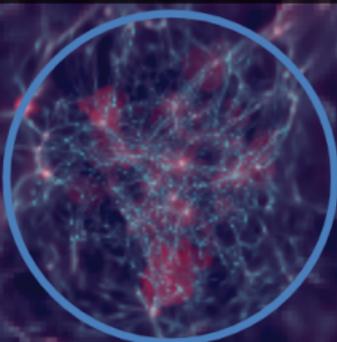
We need to account for

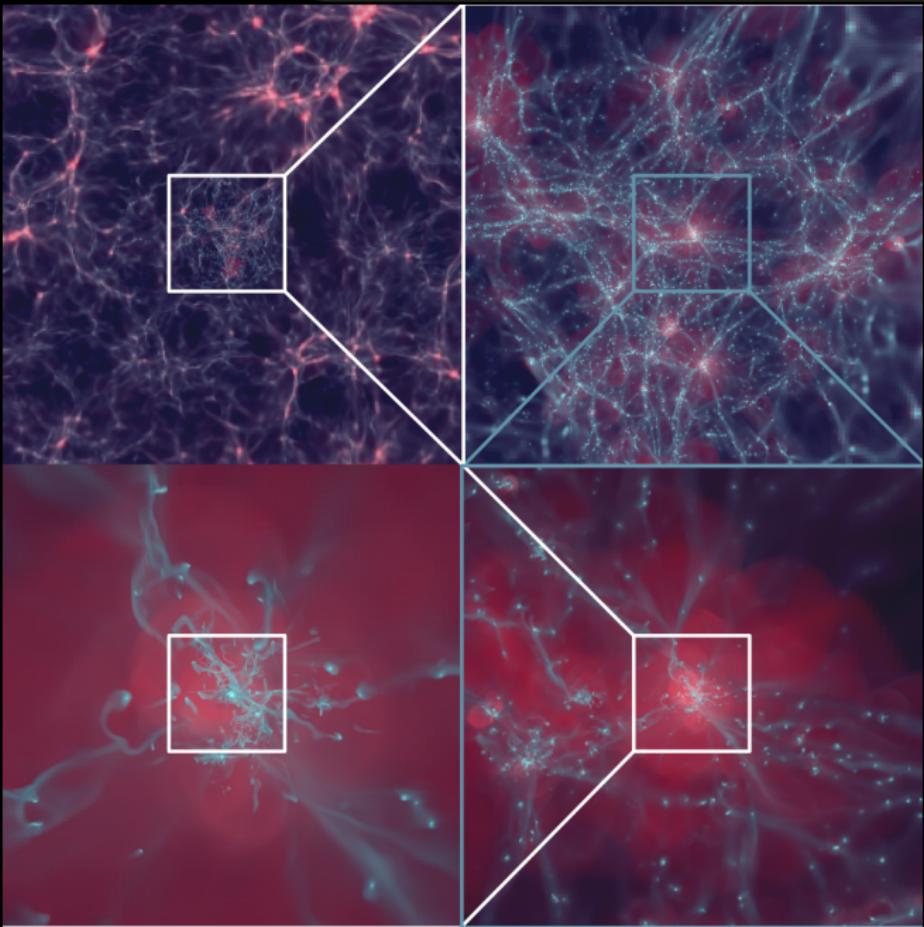
- energy input from stellar populations
- long range effect of energy radiation from
 - stars
 - AGN
- non-thermal components of the ISM
 - magnetic fields
 - cosmic rays

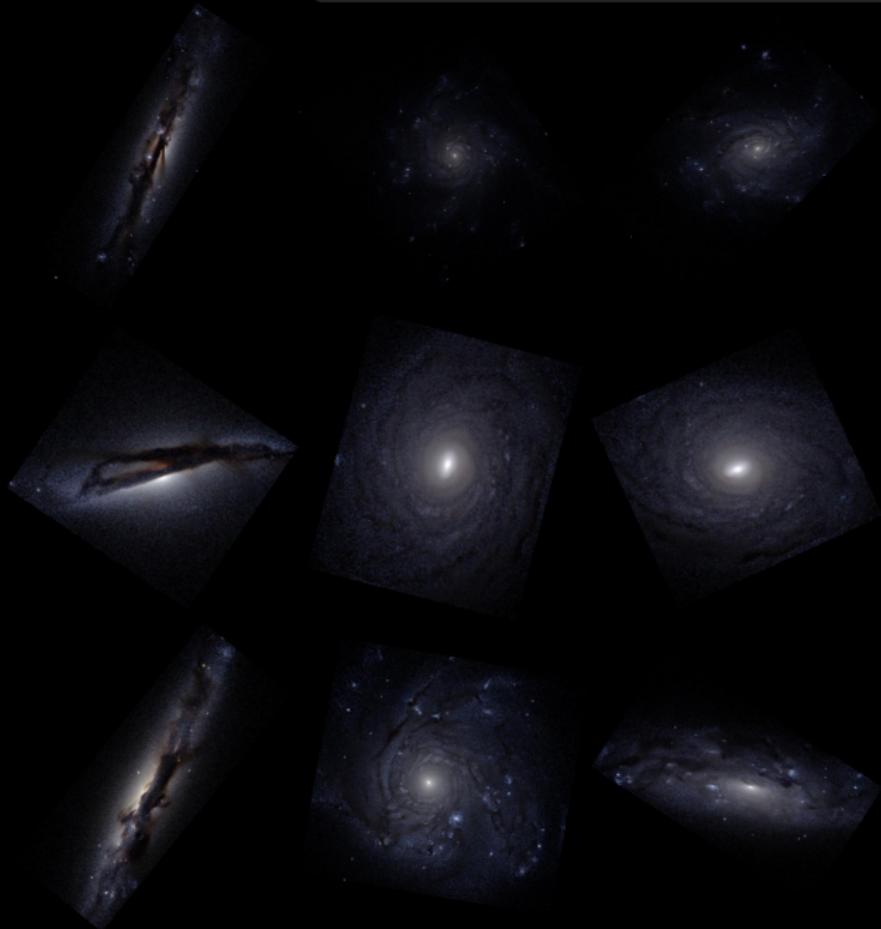
NewHorizon

- hydrodynamical cosmological simulation
- RAMSES (Teyssier et al. 2002)
- $R_{sphere} = 10 h^{-1} \text{ Mpc}$, $\Delta x = 40 \text{ pc}$
- SF: turbulent criterion
- mechanical SNe feedback (boost: UV radiation or E_{inter})
- AGN feedback

Dubois et al. in prep.







$z = 7.1804$

10.0 kpc

