Gas filaments and Galaxy Clusters properties

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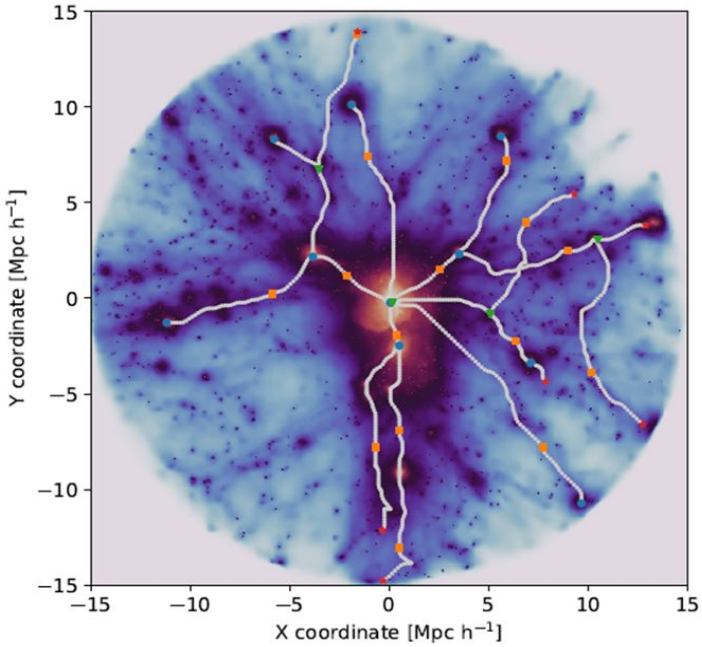
FILAMENTS OF THE COSMIC WEB

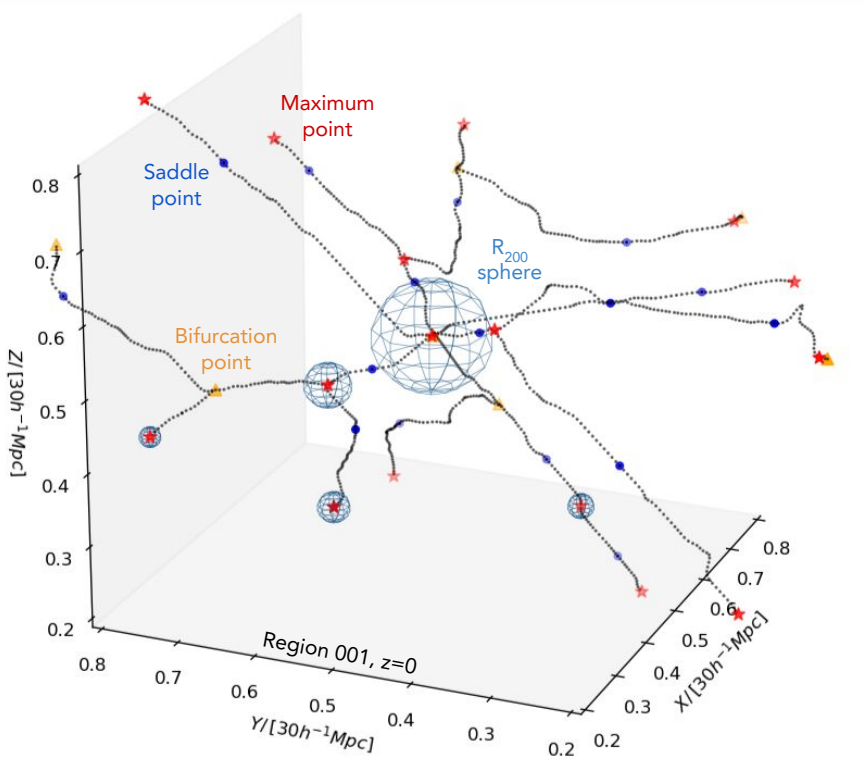
- Galaxy clusters outskirts are unique laboratories to test astrophysics and structure formation (Kravtsov+2012)
- Connected to LSS through filaments of the Cosmic Web (Bond+1996)
- Matter is accreted via filaments (DM, Gas, Galaxies)

Properties of galaxy clusters influenced by presence of filaments?



Rost+2020

FILAMENTS AND CONNECTIVITY



- Number of filaments globally connected to the cluster: Connectivity k (Codis+2018)
- Number of filaments crossing the surface at R_{Δ} from the centre of cluster

THIS WORK

Connectivity k_{200} from gas filaments

- 3D skeletons extracted with DisPerSE in The Three Hundred hydrodynamical simulation (Cui+2018)

THE300 DATASET

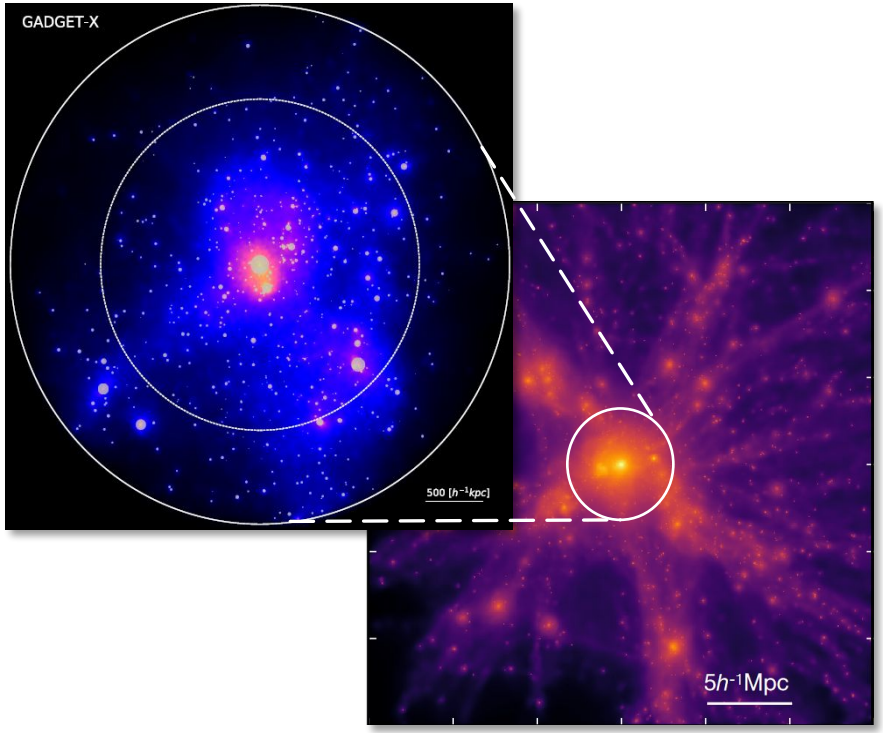
The Three Hundred Project
(Cui+2018)

- 324 spherical regions with 15 h^{-1} Mpc radius, simulated with SPH codes
- 128 redshift snapshots from z=0 to z=17
- Each region is centered on a massive galaxy cluster with $M_{200} > 10^{14}\ h^{-1}\ M\odot$

See D. De Andres, W. Cui and J. Gomez talks!

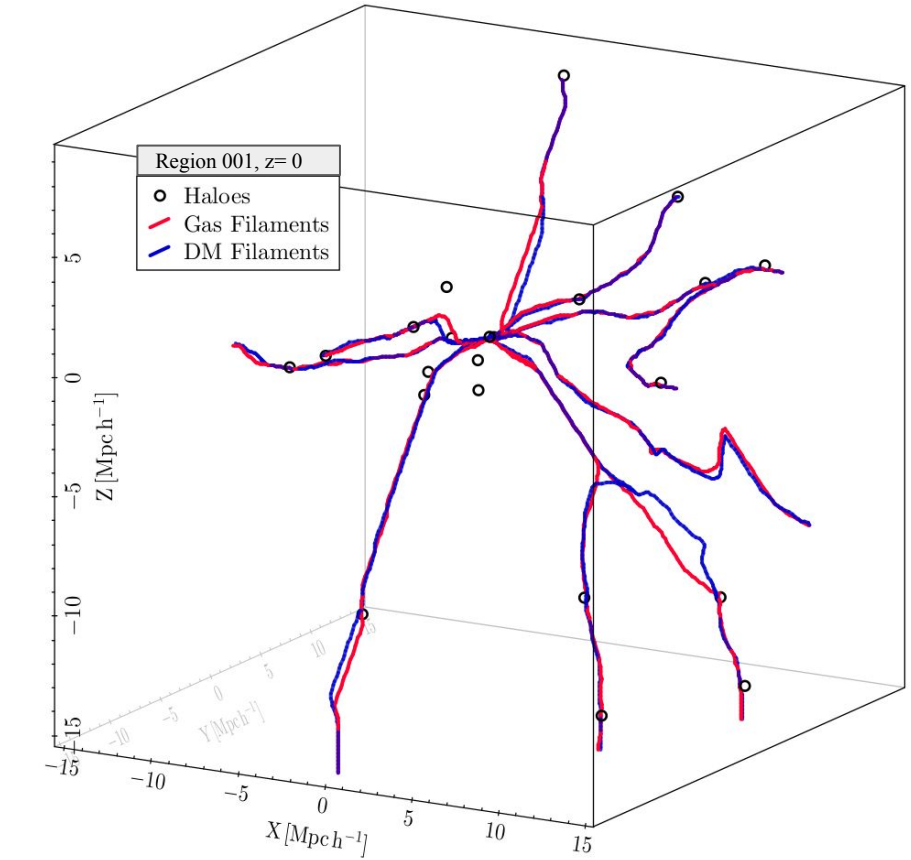
THIS WORK

- Connectivity of ~10^3 haloes and clusters at z = 0 and with mass range of $10^{13} < M_{200}\ h^{-1}\ M\odot < 10^{15}$



Cui+2018 (top)
Kuchner+2020 (bottom)

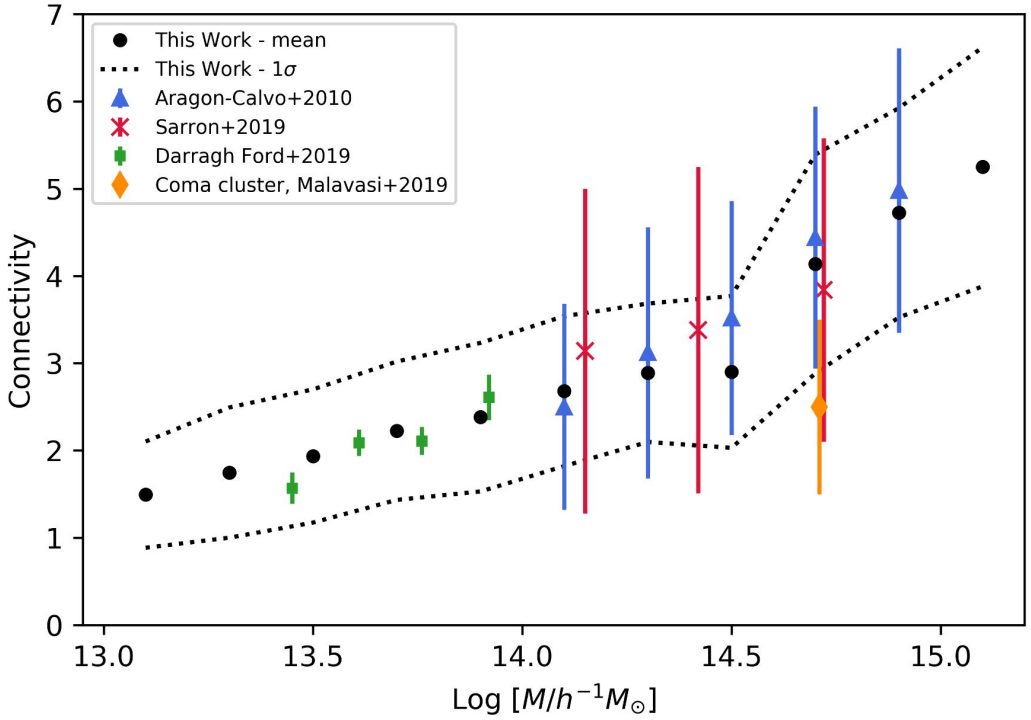
GAS AND DM SKELETONS



Why gas filaments?

- Three filament components: gas, DM and galaxies
- In the simulation, gas filaments trace the underlying DM distribution (to be quantified..)
- Spatial correlation also between gas filaments and galaxies filaments (Kuchner+2020)

FILAMENTS AND GALAXY CLUSTERS MASS

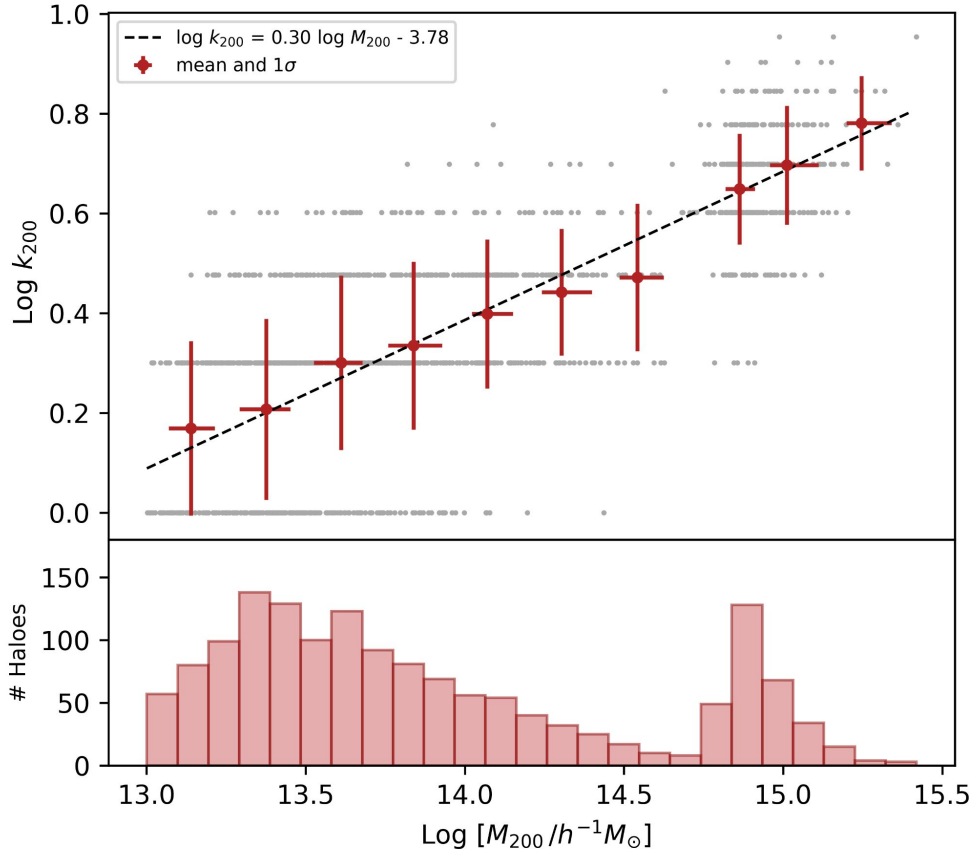


- Connectivity plays a role in shaping the properties of galaxy clusters, mainly their mass
- Massive clusters have on average more filaments connected

	Data	k_R	M	CW extraction
This Work	Hydro sym	R_{200}	M_{200}	3D gas
AC+10	DM sym	3 Mpc	M_{Vir}	3D DM
S+19	Obs	1.5 Mpc	M_{200}	2D galaxies
DF+19	Obs	1.5 R_{Vir}	M_{200}	2D galaxies
M+19	Obs (Coma Cl.)	R_{Vir}	M_{200}	2D galaxies

* The bars are the standard deviation errors, except for DF+19 where the errors of the mean are plotted

FILAMENTS AND GALAXY CLUSTERS MASS



Connectivity and Mass

- Massive galaxy clusters are more likely to be more connected

THIS WORK

$$\log k_{200} = A \cdot \log M_{200} + B$$

$$A = 0.298 \pm 0.016$$
$$B = -3.78 \pm 0.23$$

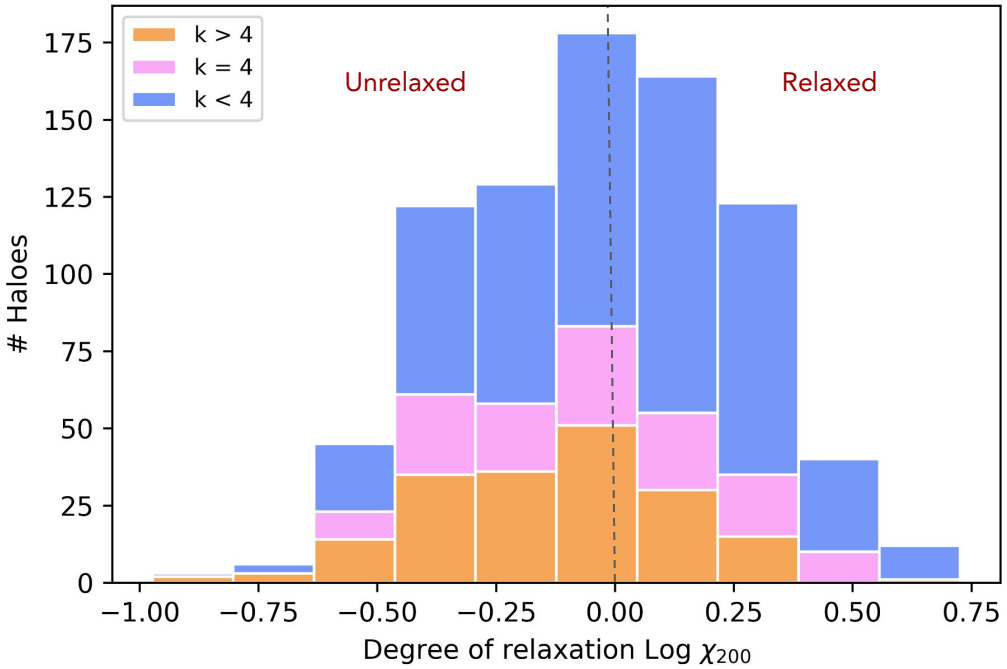
Connectivity from simulated 3D gas skeletons!

GALAXY CLUSTERS DYNAMICAL STATE

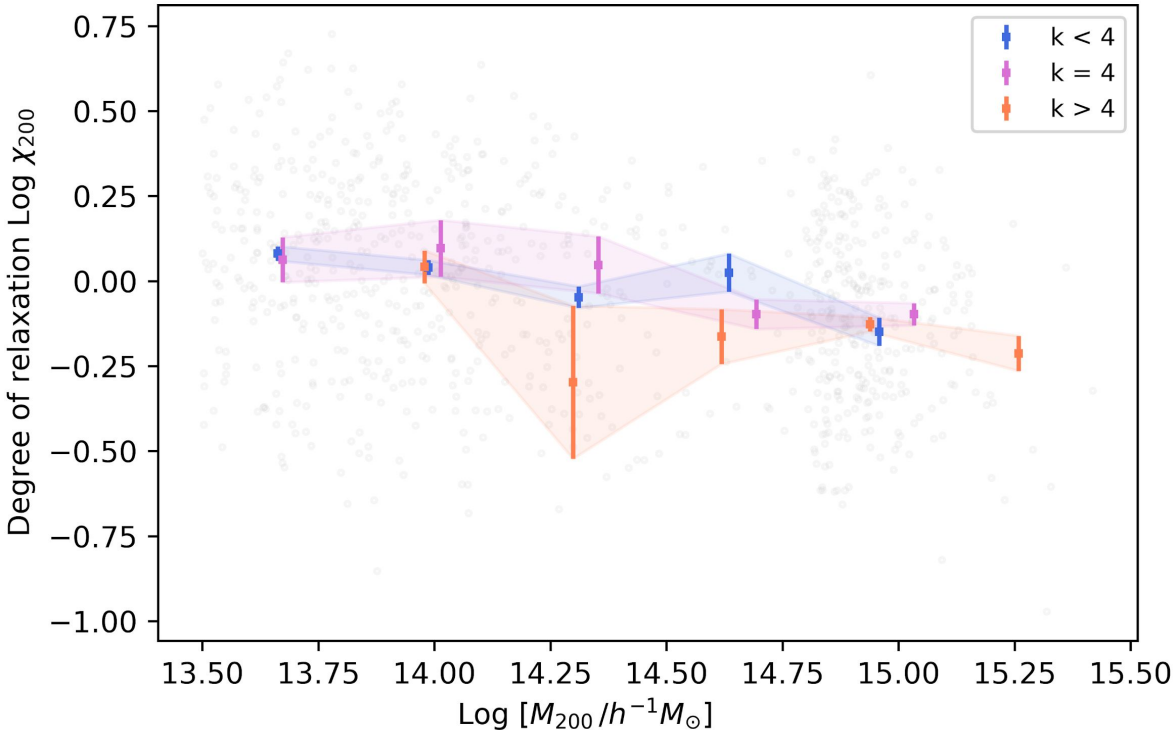
Dynamical state of clusters can be described with the **degree of relaxation** parameter (Haggar+2020):

$$\chi = \left(\frac{(\frac{f_s}{0.1})^2 + (\frac{\Delta_r}{0.04})^2 + (\frac{|1-\eta|}{0.15})^2}{3} \right)^{-1/2}$$

- Total sub-halo mass fraction f_s
- Virial ratio η
- Centre-of-mass ratio Δr



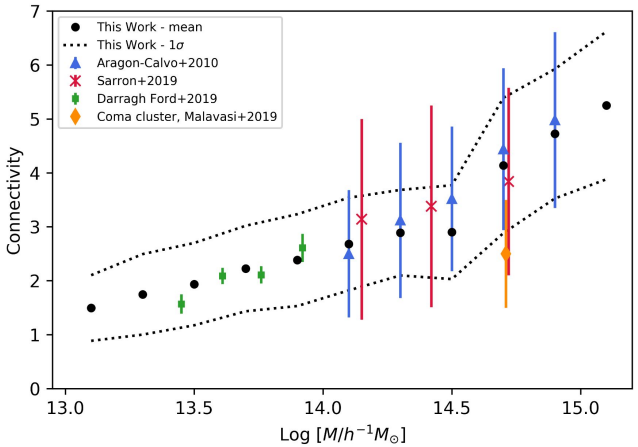
FILAMENTS AND DYNAMICAL STATE

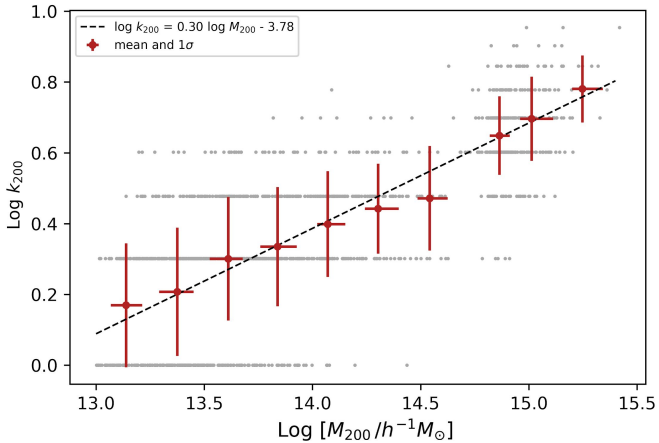


- Three samples with different connectivity values to neglect the dependence of k with the mass
- Dynamical state does not seem to correlate with connectivity (in The Three Hundred dataset)

CONCLUSIONS

- Filaments accrete matter onto galaxy clusters and can have an impact their properties
- Connectivity is defined as the number of filaments connected to an halo, crossing the surface at an aperture of R_{200}
- From The Three Hundred project, 324 region analysed with DisPerSE filament finder, connectivity from gas filaments of 10^3 haloes at z=0
- More massive haloes are more likely to be more connected
- No evident correlation between connectivity and dynamical state





ONGOING ACTIVITIES

- Study of projection effects (interlopers and filaments oriented along the line of sight) in the estimate of the connectivity from gas projected maps
- Difference between k2D and k3D
- Filament extraction from y maps available in The Three Hundred:
    - statistic of y filaments
    - forecasts for tSZ observation

THANK YOU FOR YOUR ATTENTION!

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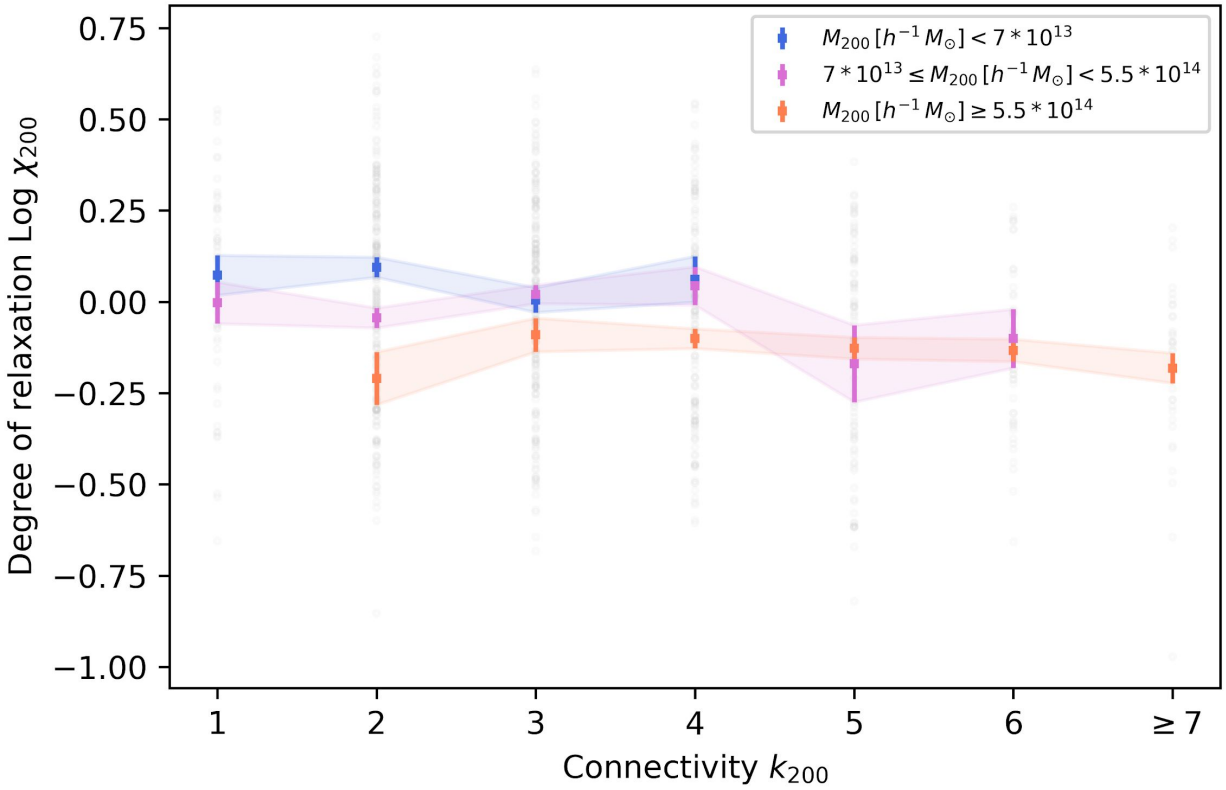

- Three mass samples, dynamical state and connectivity relation
- The three samples are more separated (than the previous case): possible relation between mass and degree of relaxation