How does the cosmic web impact assembly bias?

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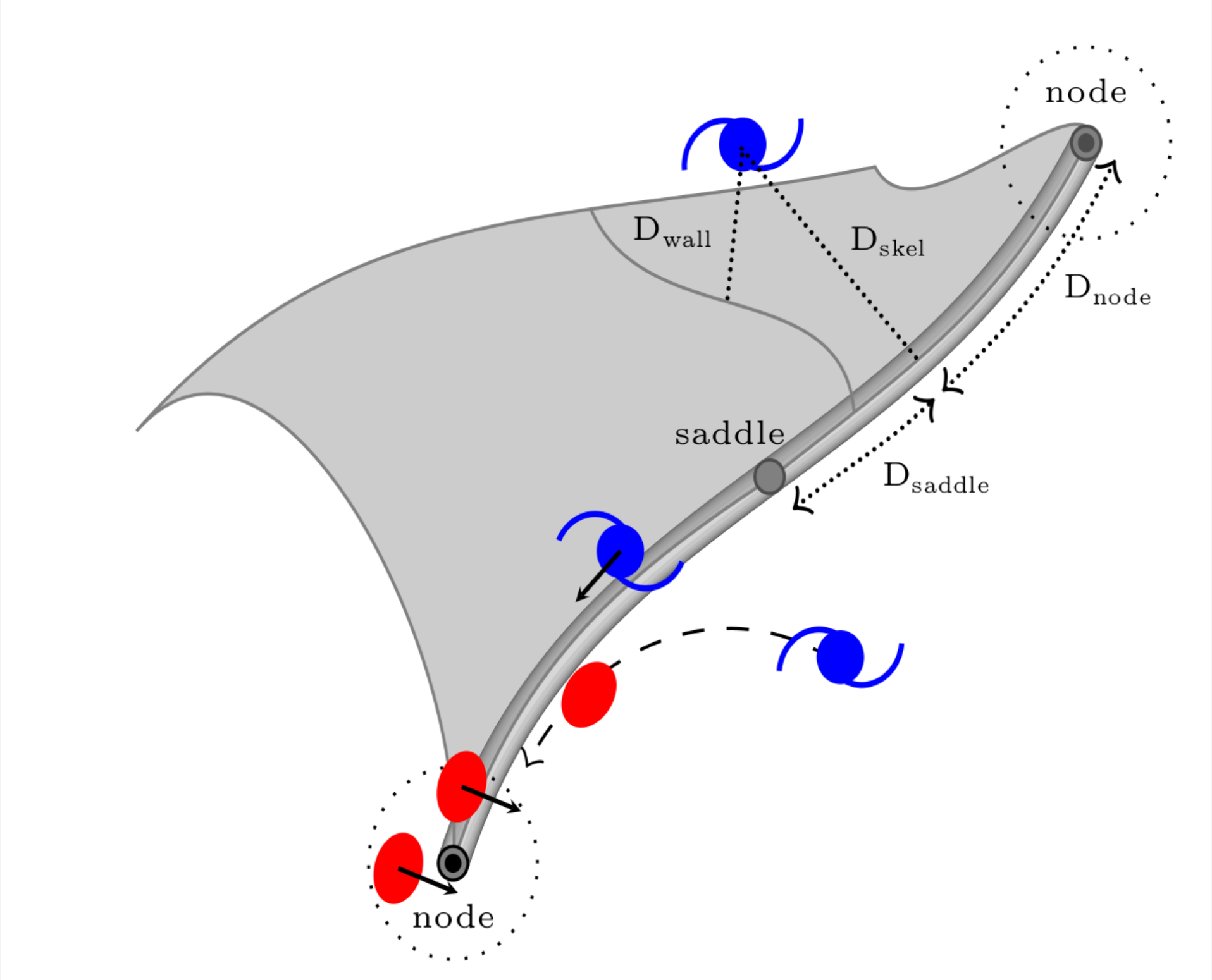
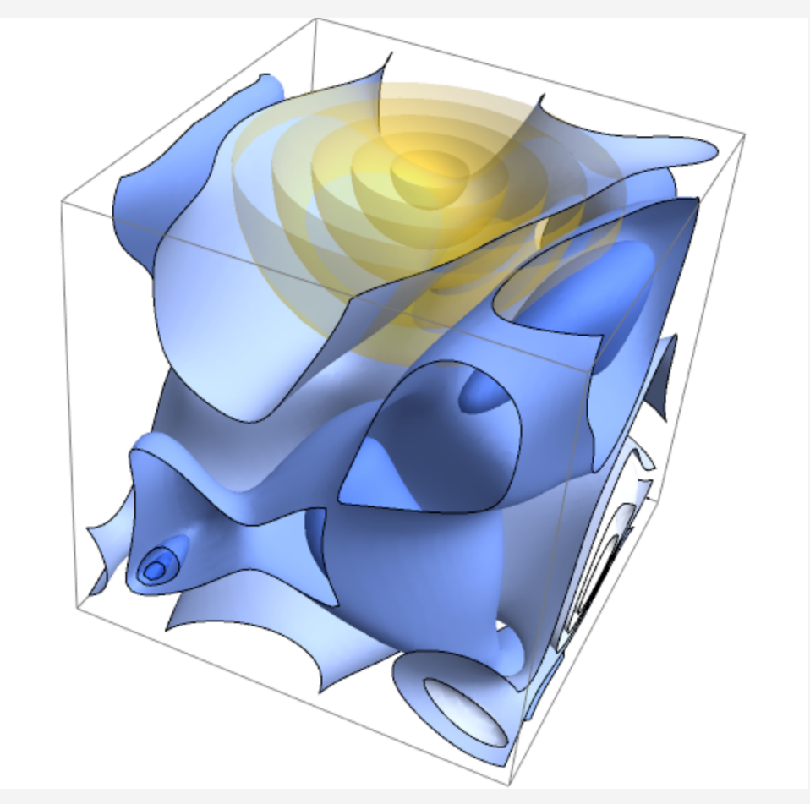
EFFECT OF LARGE SCALE STRUCTURES



Galaxies become redder, more massive, less star forming when flowing from voids to filaments to nodes (e.g. GAMA survey [2], COSMOS survey [3] and simulations [4]). The biasing effect is an effect *beyond* mass and local density.

EXCURSION SET THEORY

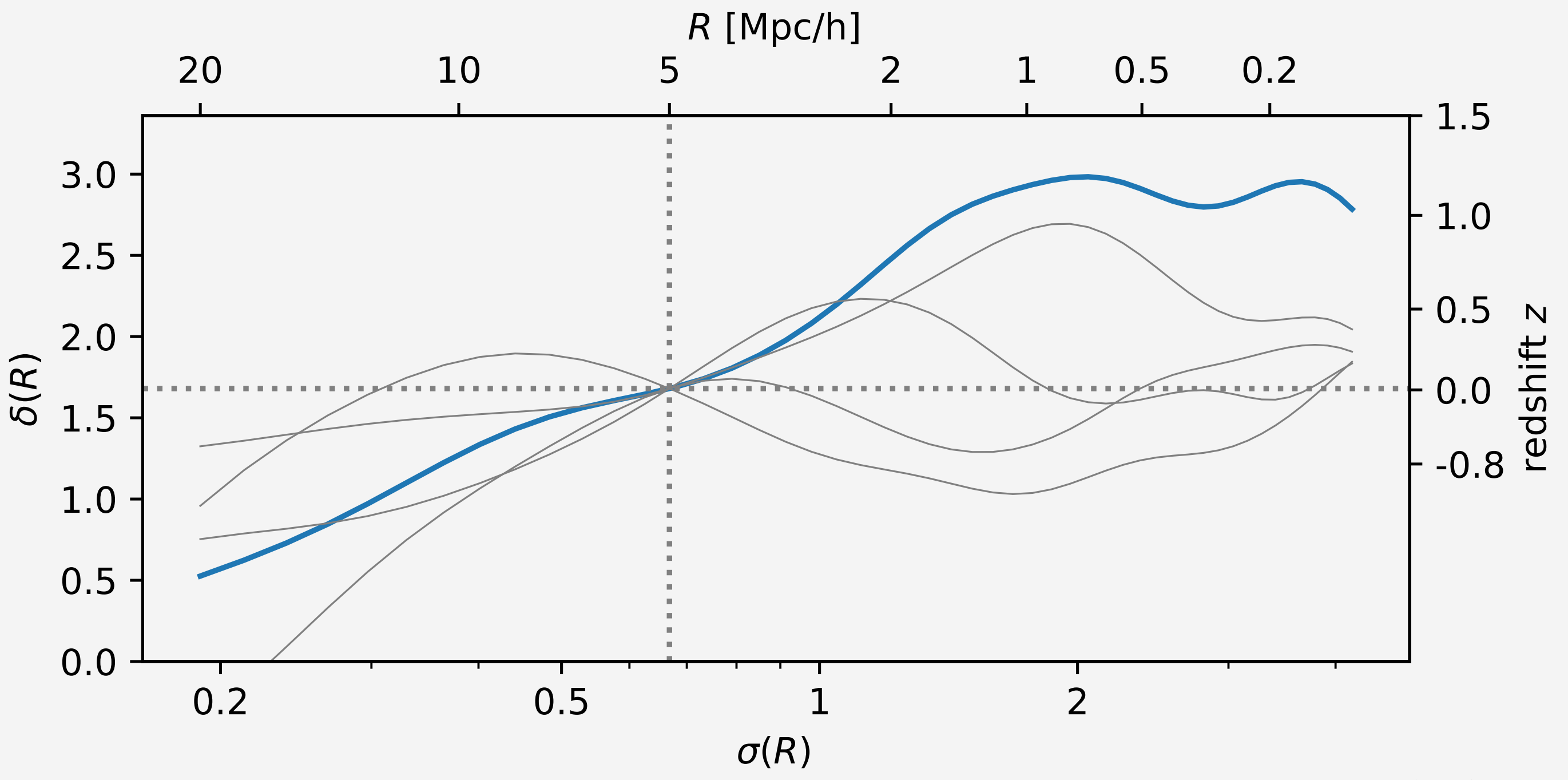


Let δ_m be the linear matter density (**G**aussian **R**andom **F**ield) and

$$\delta(R) \equiv \int_{\mathbf{x}} W(|\mathbf{x}|)\delta_m(\mathbf{x}), \qquad (1)$$

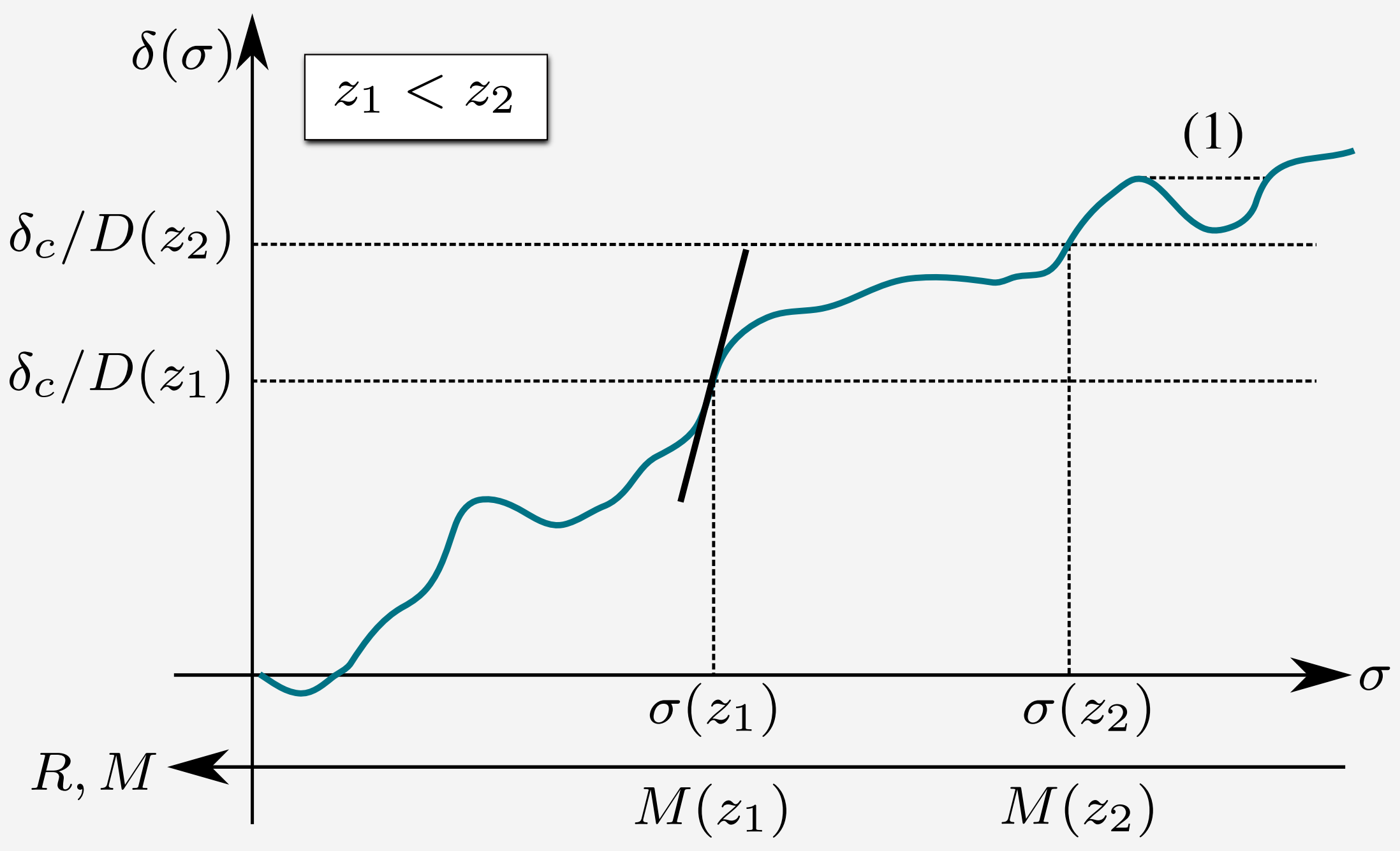
$$\sigma^2(R) \equiv \mathrm{Var}\left(\delta(R)\right). \qquad (2)$$

At a given redshift z, a point belongs to a halo of size R if R is the maximum smoothing scale at which the smoothed linear density contrast $\delta(R)$ exceeds the critical density contrast $\delta_c/D(z)$ [5].



In the δ–σ space, we look for the first crossing of $\delta(R) = \delta_c/D(z)$. $\sigma(R)$ is a proxy for mass (larger is less massive), $\delta(R)$ is a proxy for collapse time (larger is earlier).

INFERRING HALO PROPERTIES



Given z_1 and z_2, halos will collapse at $\delta_c/D(z_1)$ and $\delta_c/D(z_2)$. We can compute $\langle\sigma(z_i)|\delta = \delta_c/D(z_i)\rangle$ (or similarly expected masses M_1, M_2).

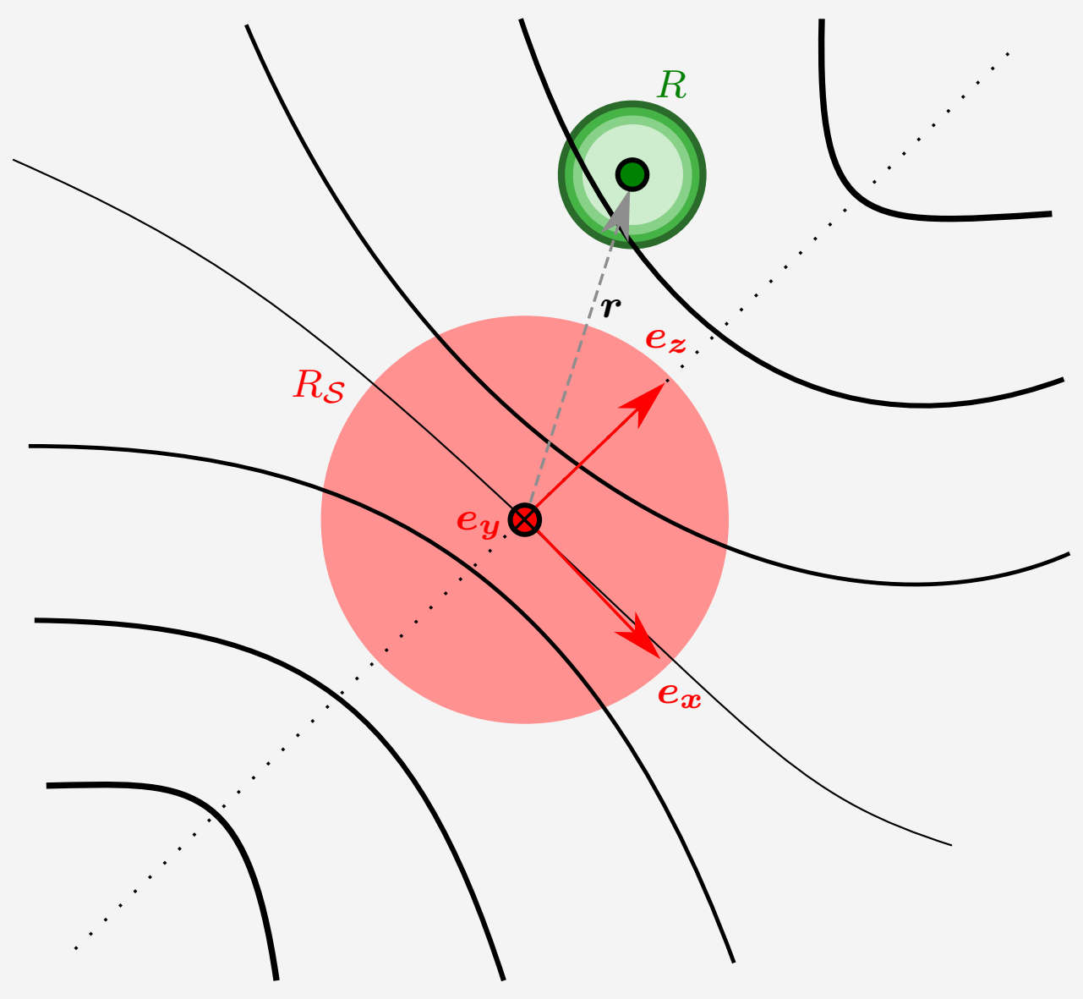
As $z_2 \to z_1$, we find the accretion rate

$$\frac{M_2 - M_1}{z_2 - z_1} \to \frac{\mathrm{d}M}{\mathrm{d}z}. \qquad (3)$$

If $M_2 = M_1/2$, we find the half mass time $z_{1/2}$ s.t.

$$\delta(\sigma_{1/2}) = \frac{\delta_c}{D(z_{1/2})}. \qquad (4)$$

COSMIC WEB



The center of a filament is a saddle point. We compress the information by fixing only the location, height and curvature of the saddle point.
The landscape becomes a constrained GRF.

ANISOTROPY VARS.

Let ϕ be the reduced potential such that

$$\Delta\phi \propto 4\pi G\delta, \qquad (5)$$

and $q_{ij} \equiv \nabla_i\nabla_j\phi$. The traceless tidal tensor is

$$\bar{q}_{ij} \equiv q_{ij} - \frac{1}{3}\mathrm{Tr}(q_{ij})\delta_{ij}. \qquad (6)$$

The anisotropy is encoded by the distance r to the saddle and the reduced anisotropy variable

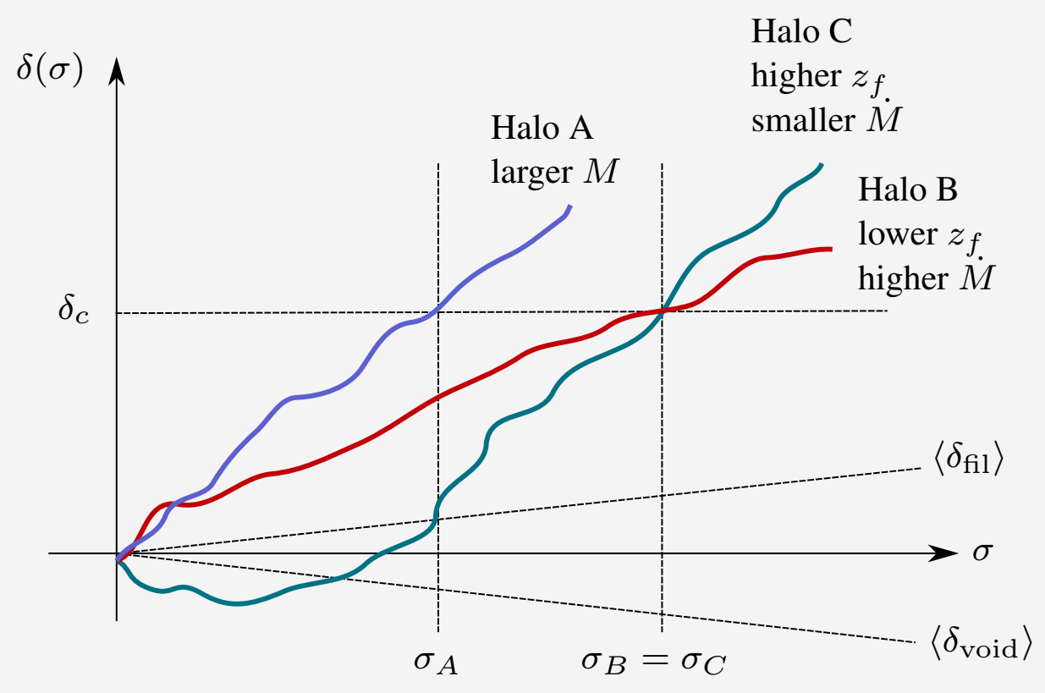
$$\mathcal{Q} \equiv \frac{r_i q_{ij} r_j}{r^2}. \qquad (7)$$

We note $\mathcal{S} = \{r, \mathcal{Q}\}$.

ANISOTROPIC E.S.

Large scale structures biases quantities

$$\delta(M) \leftarrow \delta(M, \mathcal{S})^a$$
$$\sigma(M) \leftarrow \sigma(M, \mathcal{S})$$
$$\dot{M}(M) \leftarrow \dot{M}(M, \mathcal{S})$$
$$z_{1/2}(M) \leftarrow z_{1/2}(M, \mathcal{S})$$



A and B are halos in filament, C in void.

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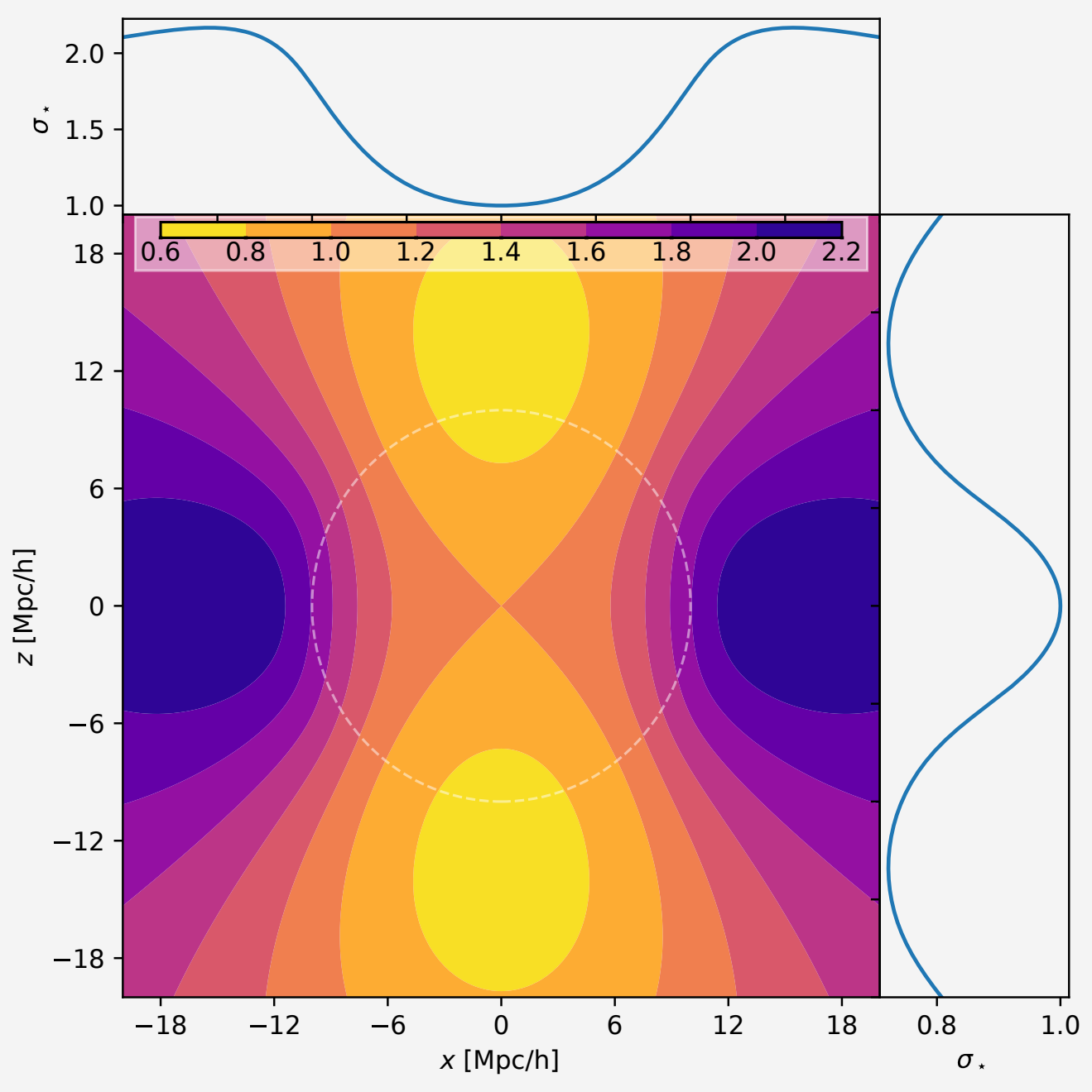
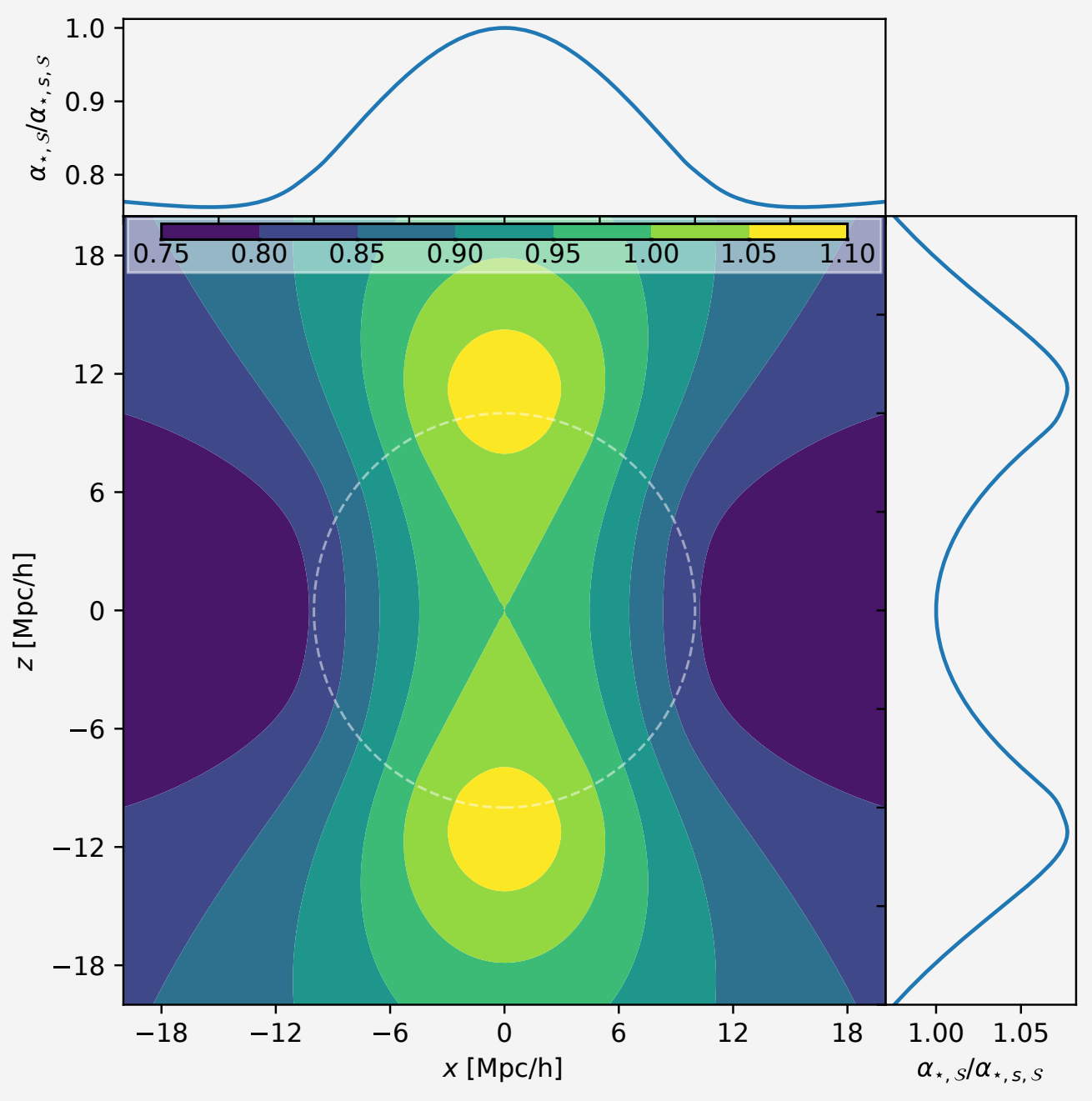
[a] Kaiser bias [6]

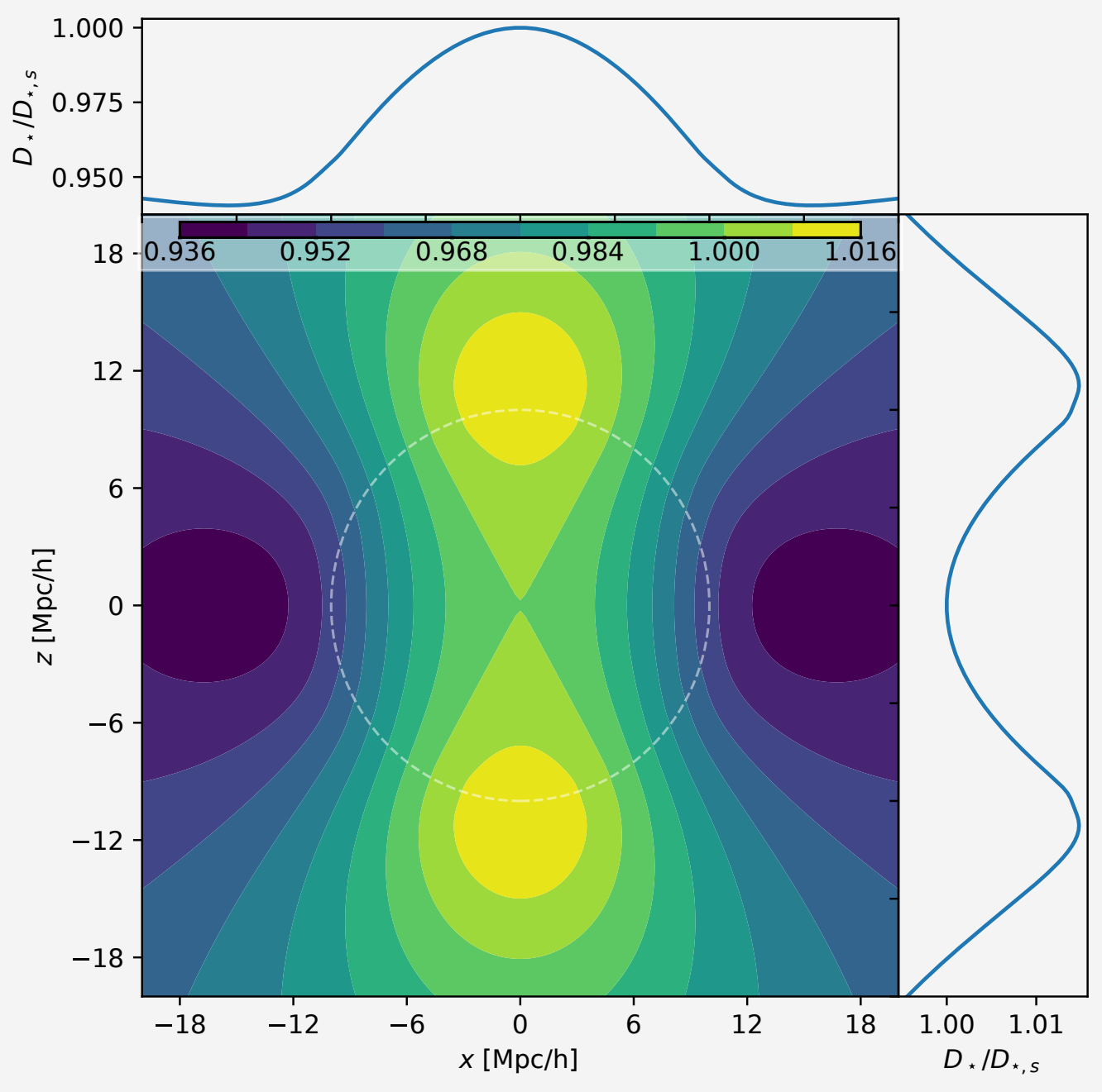
ANALYTICAL RESULTS



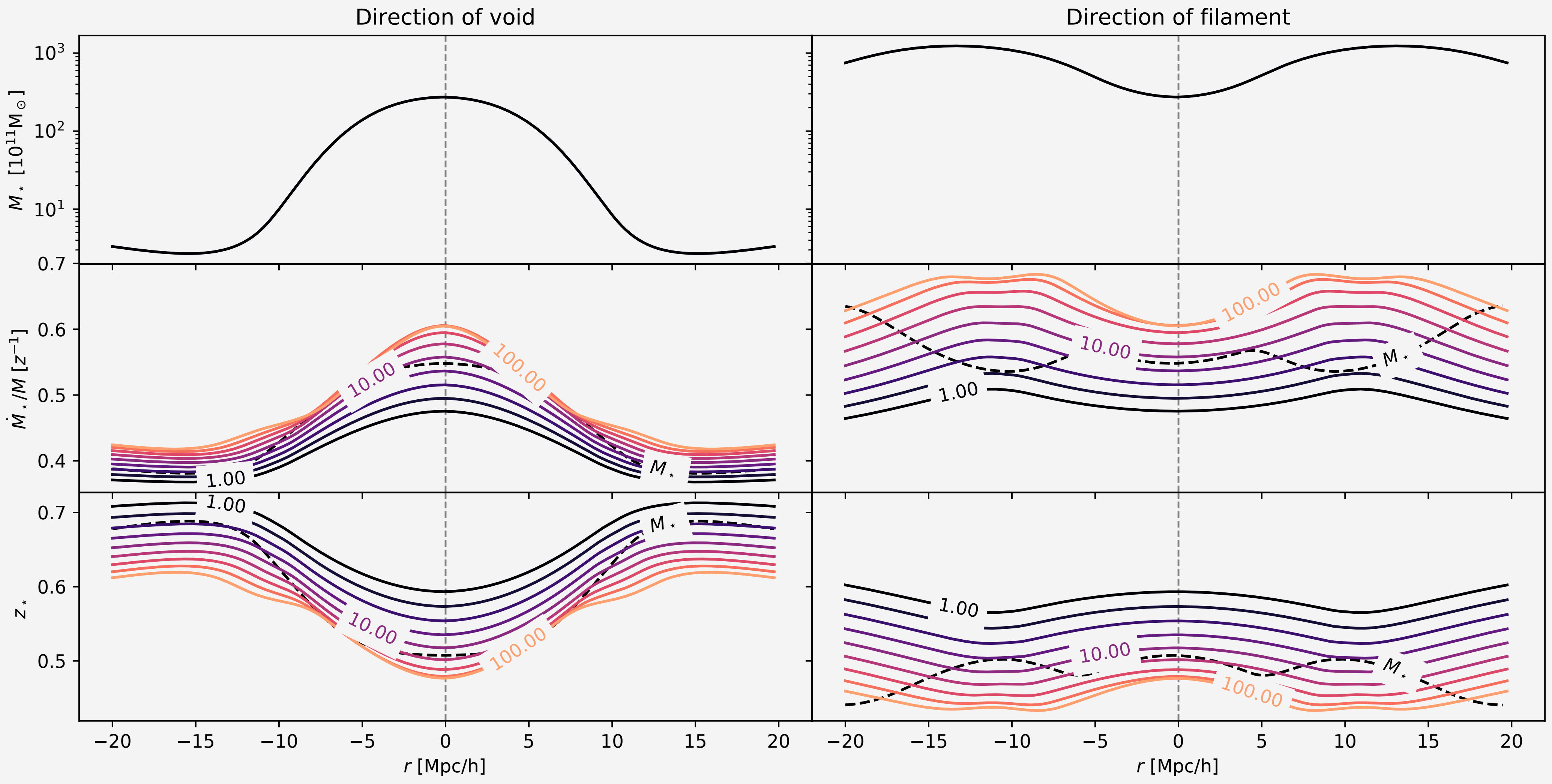
Typical mass at fixed z, yellow is more massive.



Accretion rate at fixed final mass, yellow is higher.



Formation time at fixed final mass, yellow is more recent.



CONCLUSIONS & PERSPECTIVES

1. Halos are more massive in filaments than in voids,
2. at fixed final mass, they are accreting more and formed more recently in filaments than in voids,
3. we find an effect beyond mass and density encoded by $r, \mathcal{Q}$,
4. distinct gradients are found for distinct quantities,
5. need AGN feedback to recover results for galaxies, in agreement with [7].

In the future we will take into account the elliptical collapse to include the effect of large-scale induced shear following e.g. [8].

Our results can be found in Musso, Cadiou, et al. [1].

BIBLIOGRAPHY

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