Tracking the Flow of Cosmic Information

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Outline

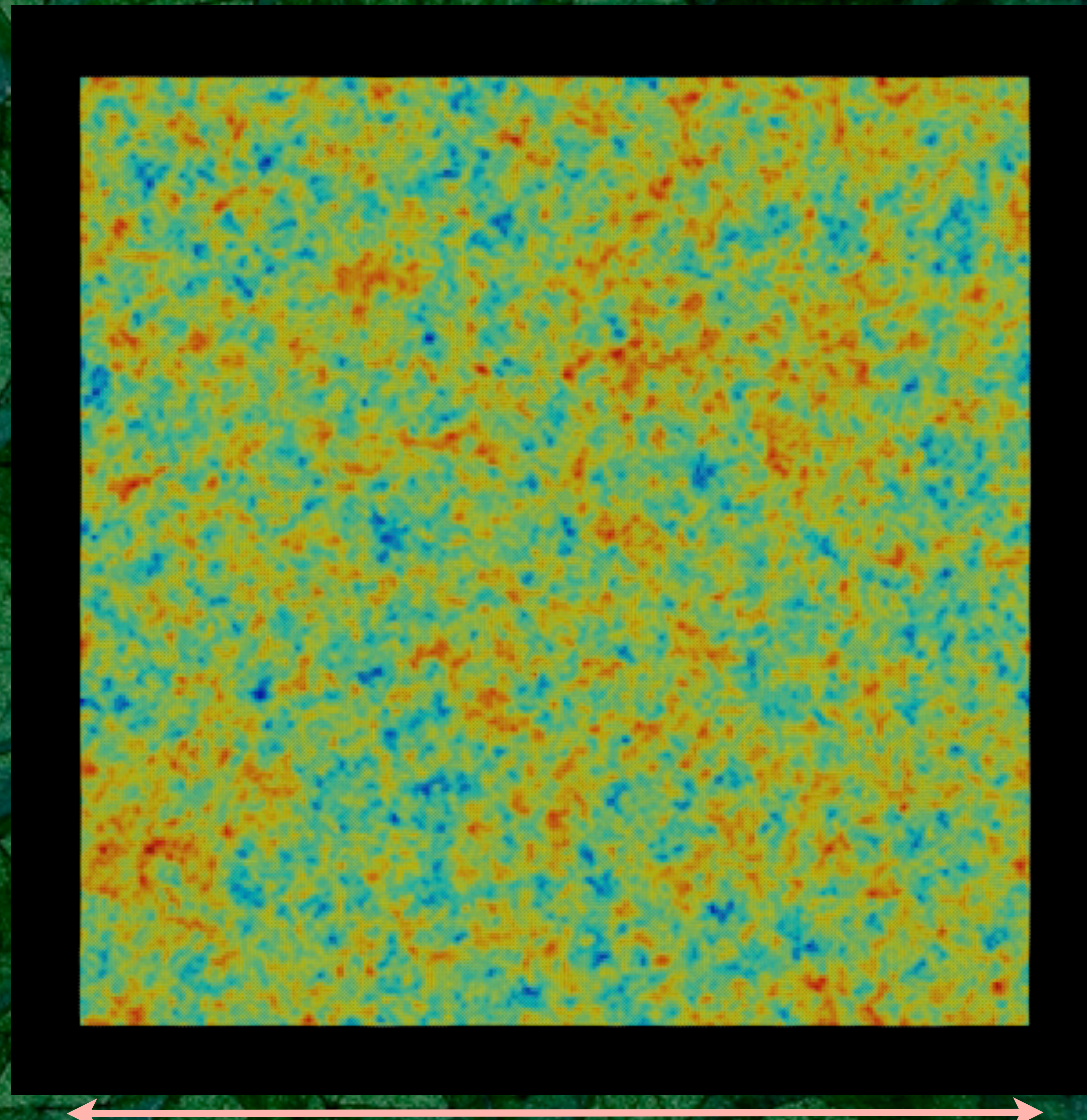
- Using one-point transformations to get information in different density regimes of the dark-matter sheet (response to initial spikes)

- Biasing in this language: MIP simulations: a powerful statistical ensemble to investigate galaxy biasing

Fluctuations (“information”), imprinted on the dark-matter sheet, tell it where to fold and form structures.

Some fluctuations crumple up, some stretch out.

Info lost in collapsed regions



200 Mpc/h

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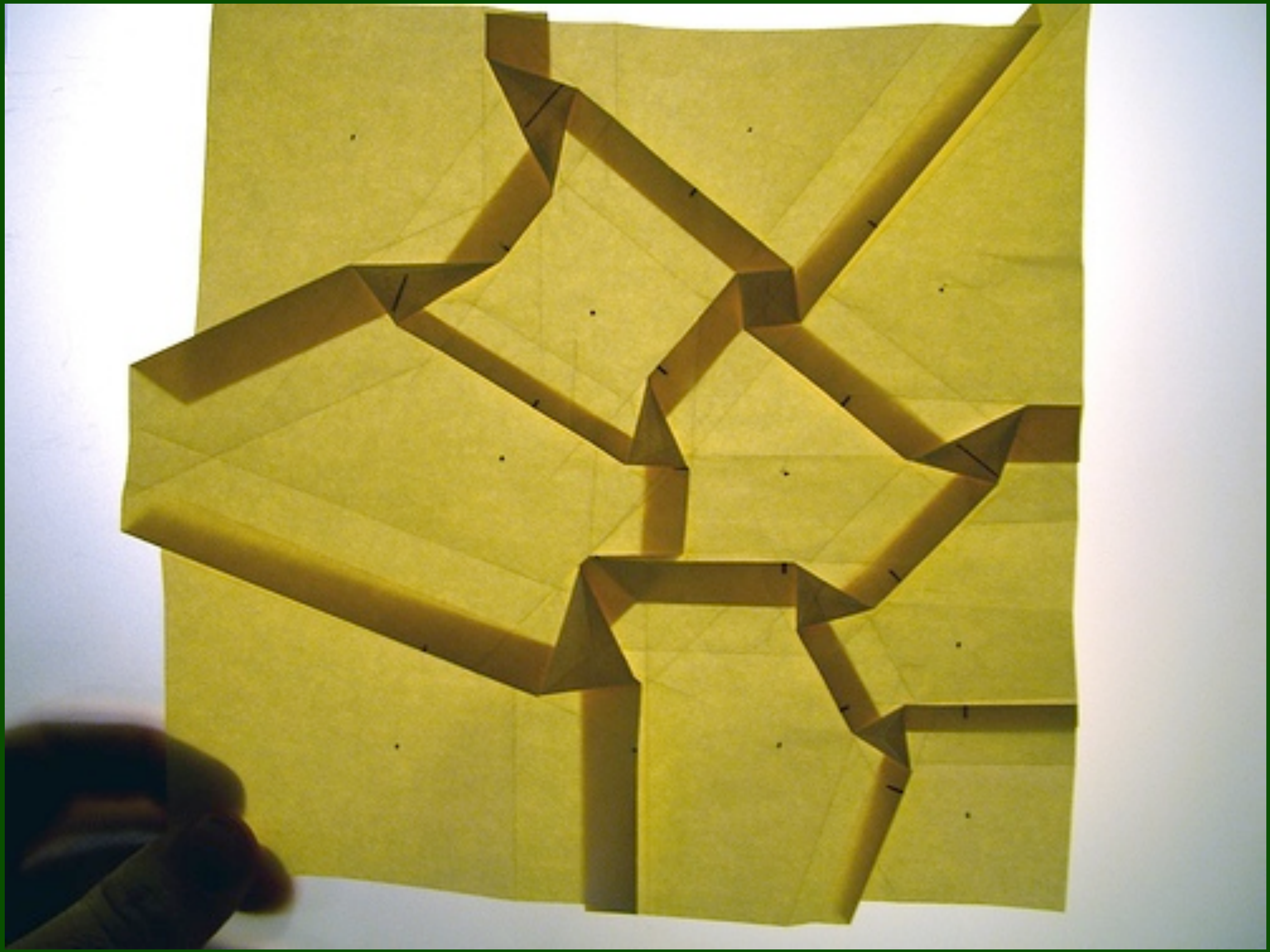
Rough analogy to origami: initially flat (vanishing bulk velocity) 3D sheet folds in 6D phase space.



Eric Gjerde,
origamitessellations.com

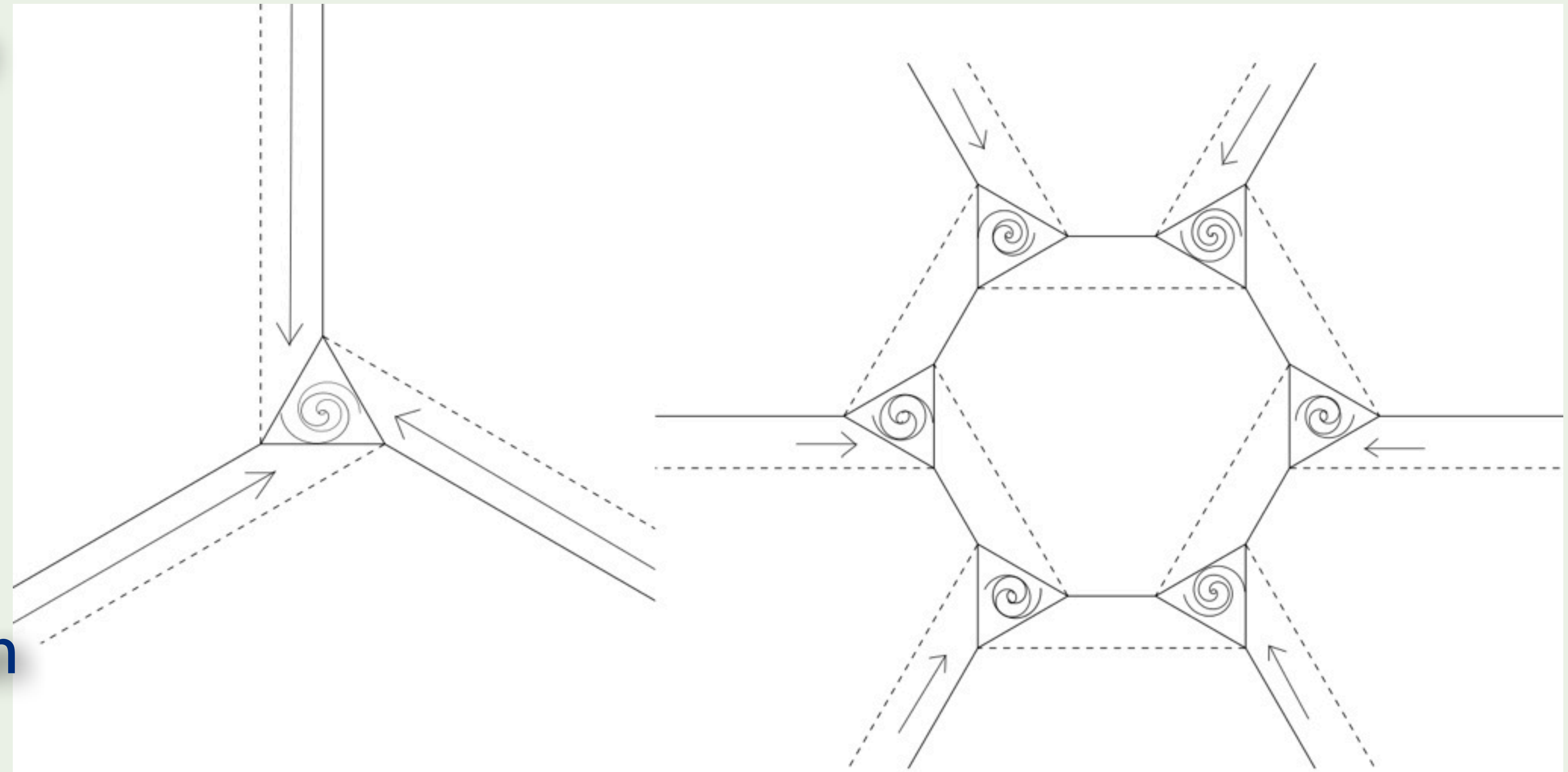
- recent related work:
Hahn, Abel et al. (2012),
Shandarin et al (2012)

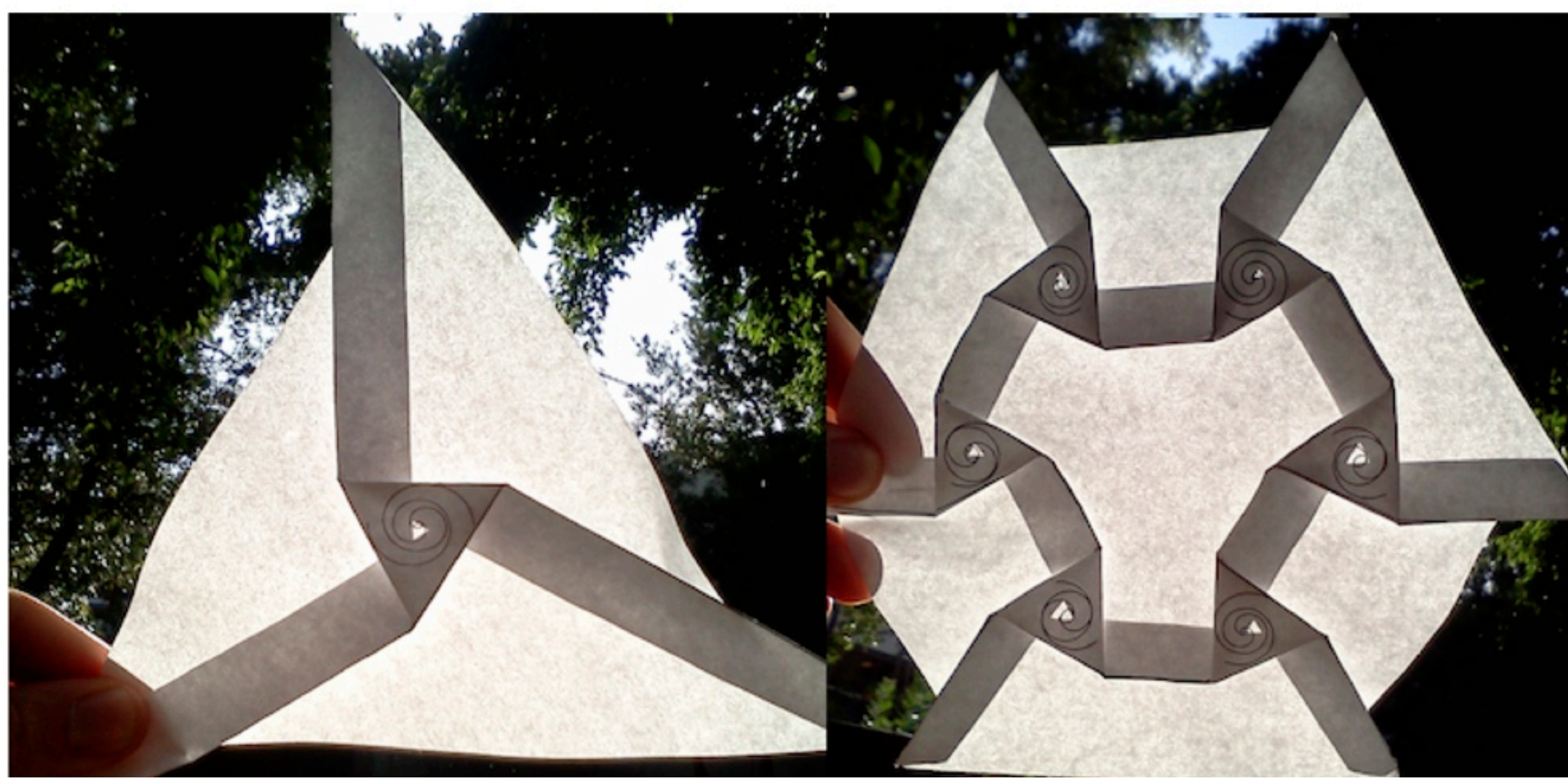
Crease patterns available at
http://skysrv.pha.jhu.edu/~neyrinck/origalaxies.html

- Without stretching the sheet, galaxies *cannot* form without filaments attached.

- Called a "twist fold," imparts spin at formation, then accretion w/ impact parameter continues

- Relates to simple picture of spin alignment w/ filament



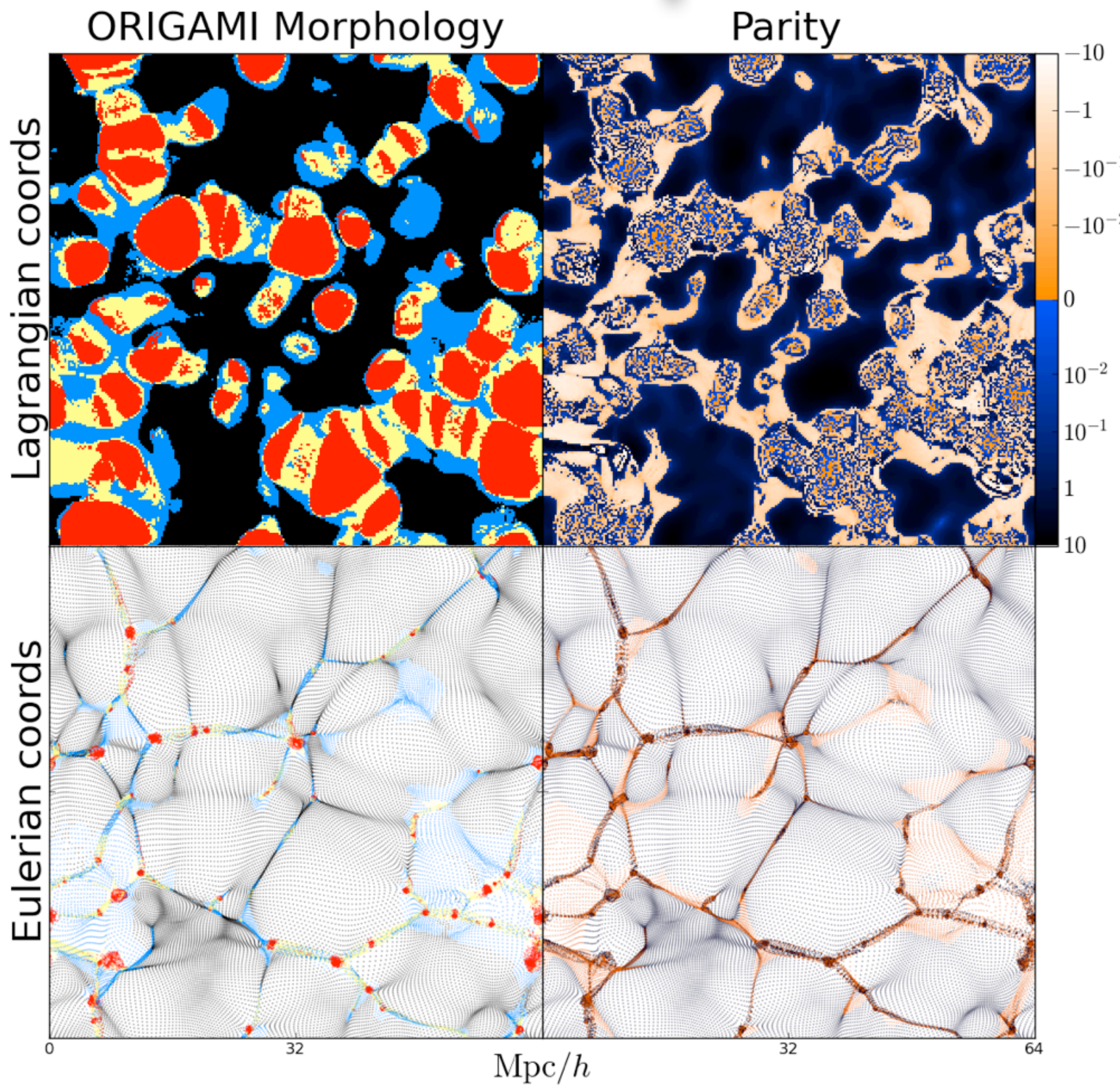


Based on a design by Eric Gjerde,
http://www.origamitessellations.com

The Universe's crease pattern

Crease pattern before folding

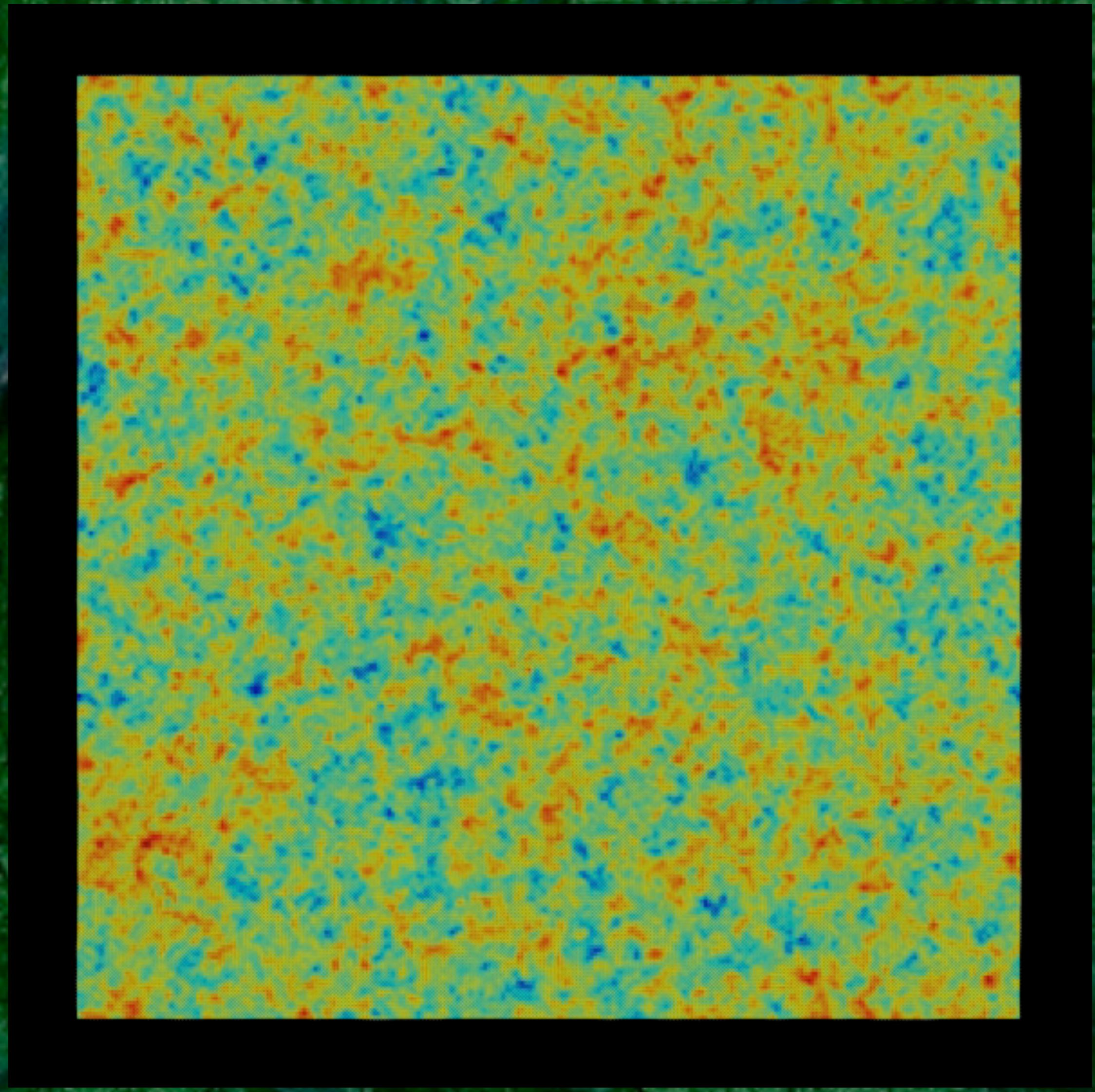
After folding



(Falck, Neyrinck & Szalay 2012, Neyrinck 2012)

Initial-fluctuation information is corrupted in ≥3 ways:

- Fluctuations printed on regions that have collapsed are lost entirely (fundamental info loss)
- Uncollapsed fluctuations (e.g. in sheets and voids) are stretched out (can be modeled)
- The usual correlation functions, power spectra are only sensitive to sharp peaks, not to these uncollapsed fluctuations (can be fixed by changing density variables)



(or, forward modelling, e.g. constrained realizations)

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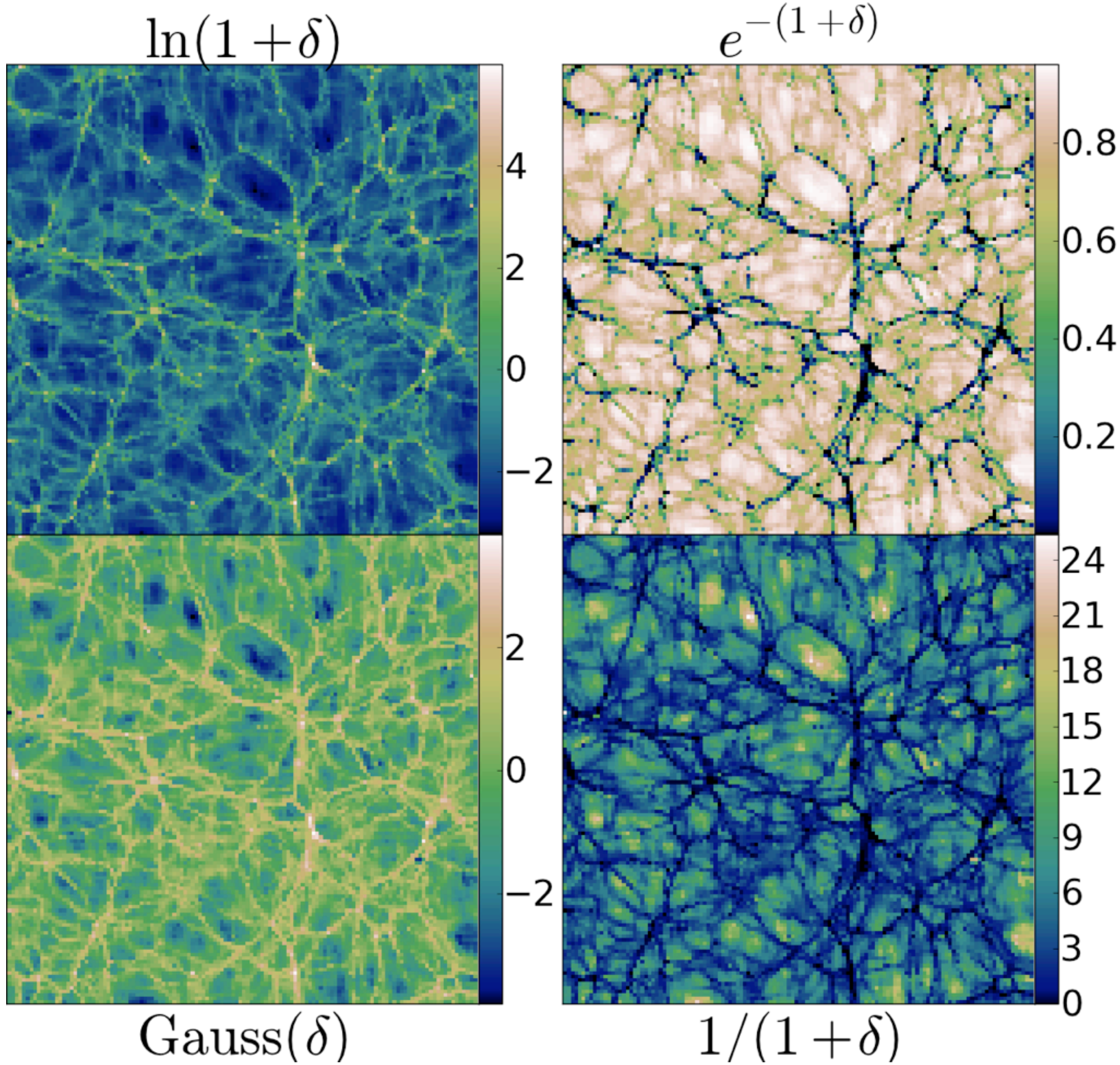
Some transforms that emphasize different regions differently



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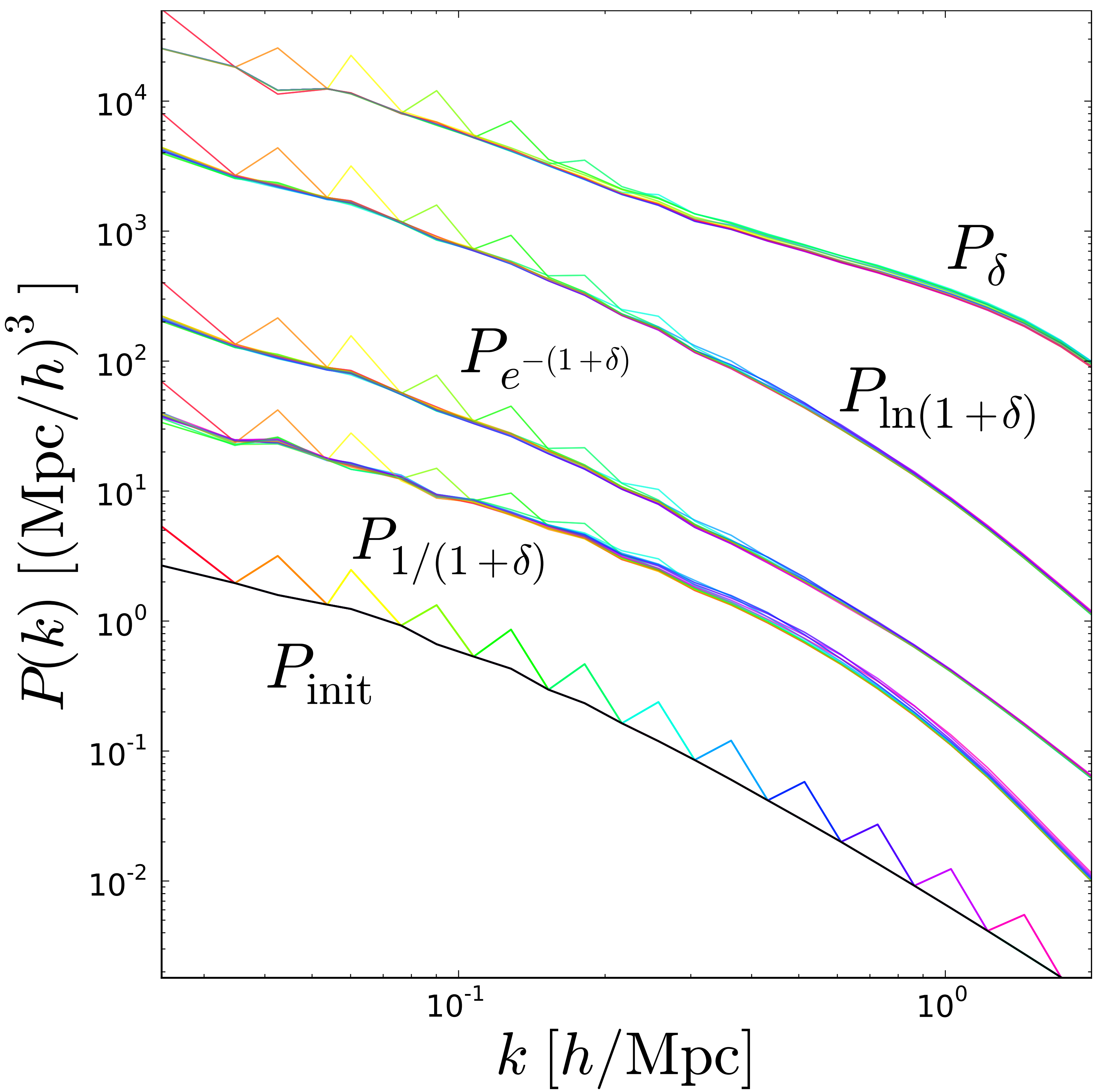
Neyrinck & Yang, MNRASL in press, 1305.1629

N-body experiment: the same initial conditions are "rung" at different wavenumbers



Neyrinck & Yang, MNRASL in press, 1305.1629
also see McCullagh, Neyrinck & Szalay 2013

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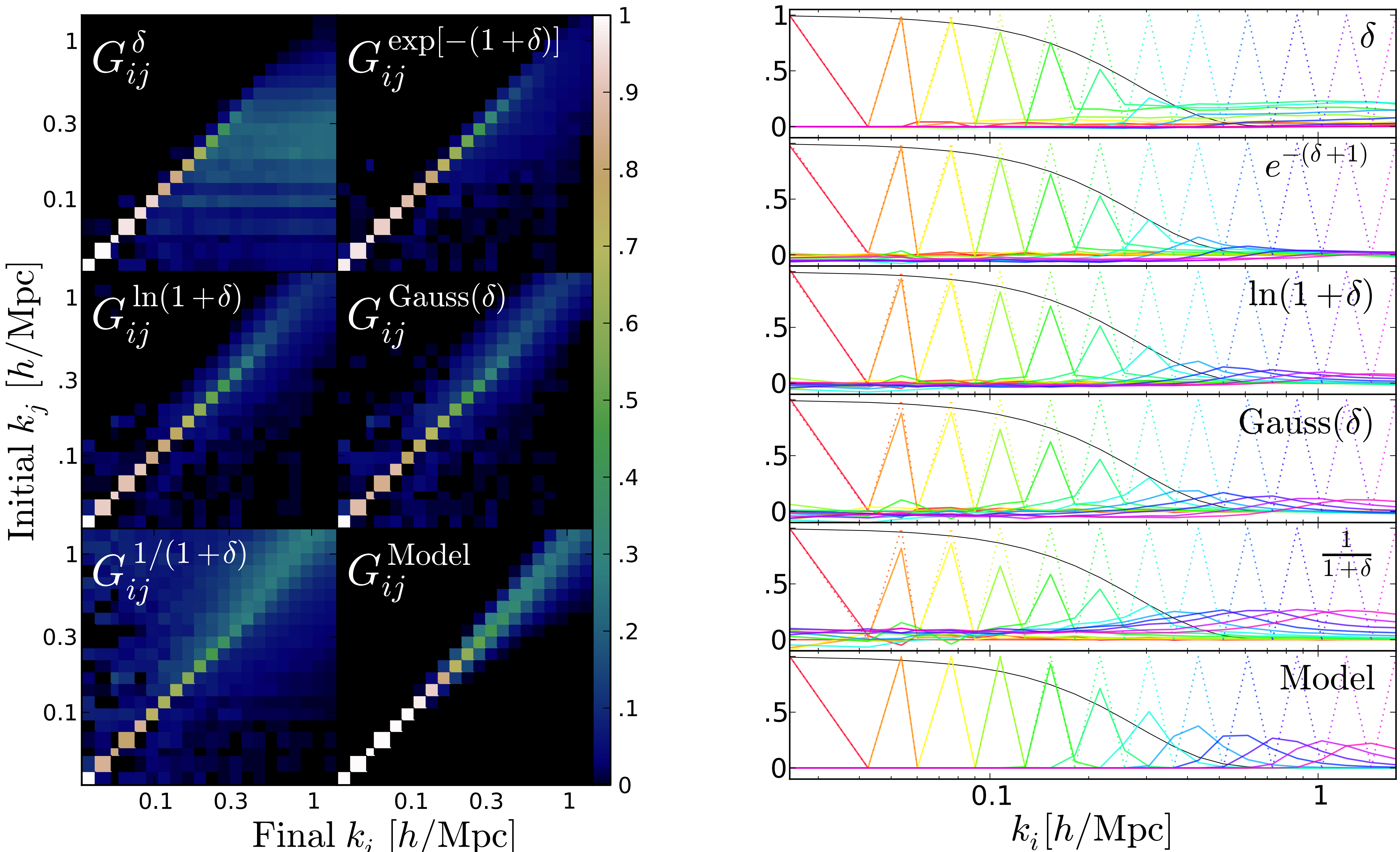
Different density variables behave differently, sensitive to different density regimes



Neyrinck & Yang, MNRASL in press, 1305.1629
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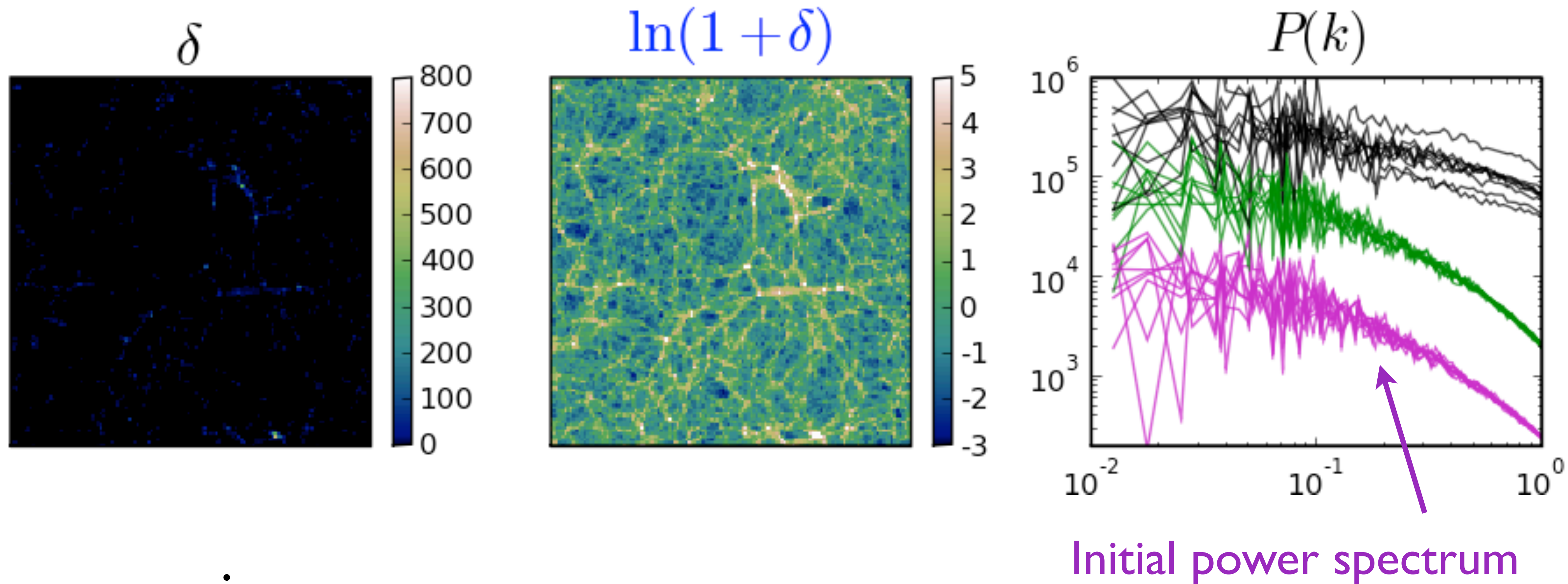
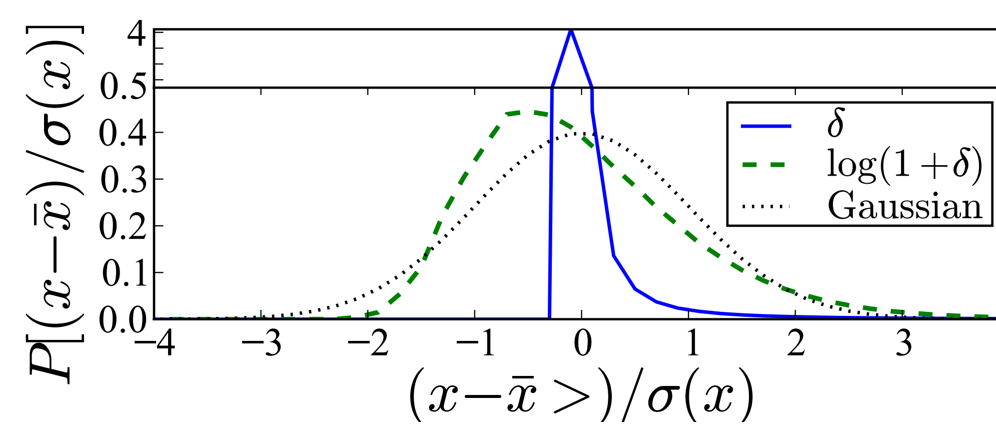
Smearing of power to small scales produces substantial covariance in $P_\delta(k)$.

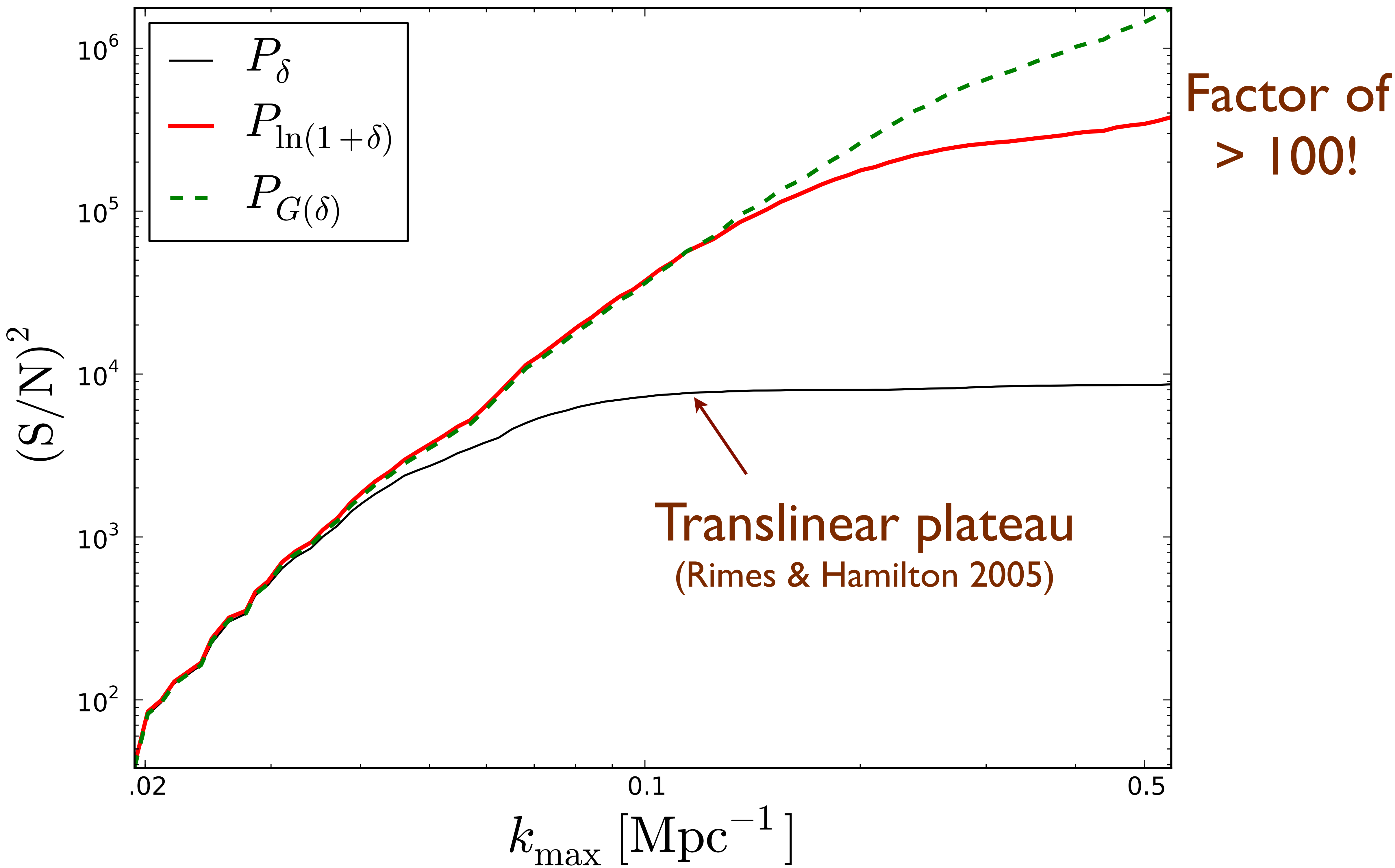


Log-mapping:
(Neyrinck, Szapudi & Szalay 2009)
~ Gaussianization (Weinberg 1992)
Similar cosmic-variance reduction with "clipping" (Simpson et al. 2012, 2013)

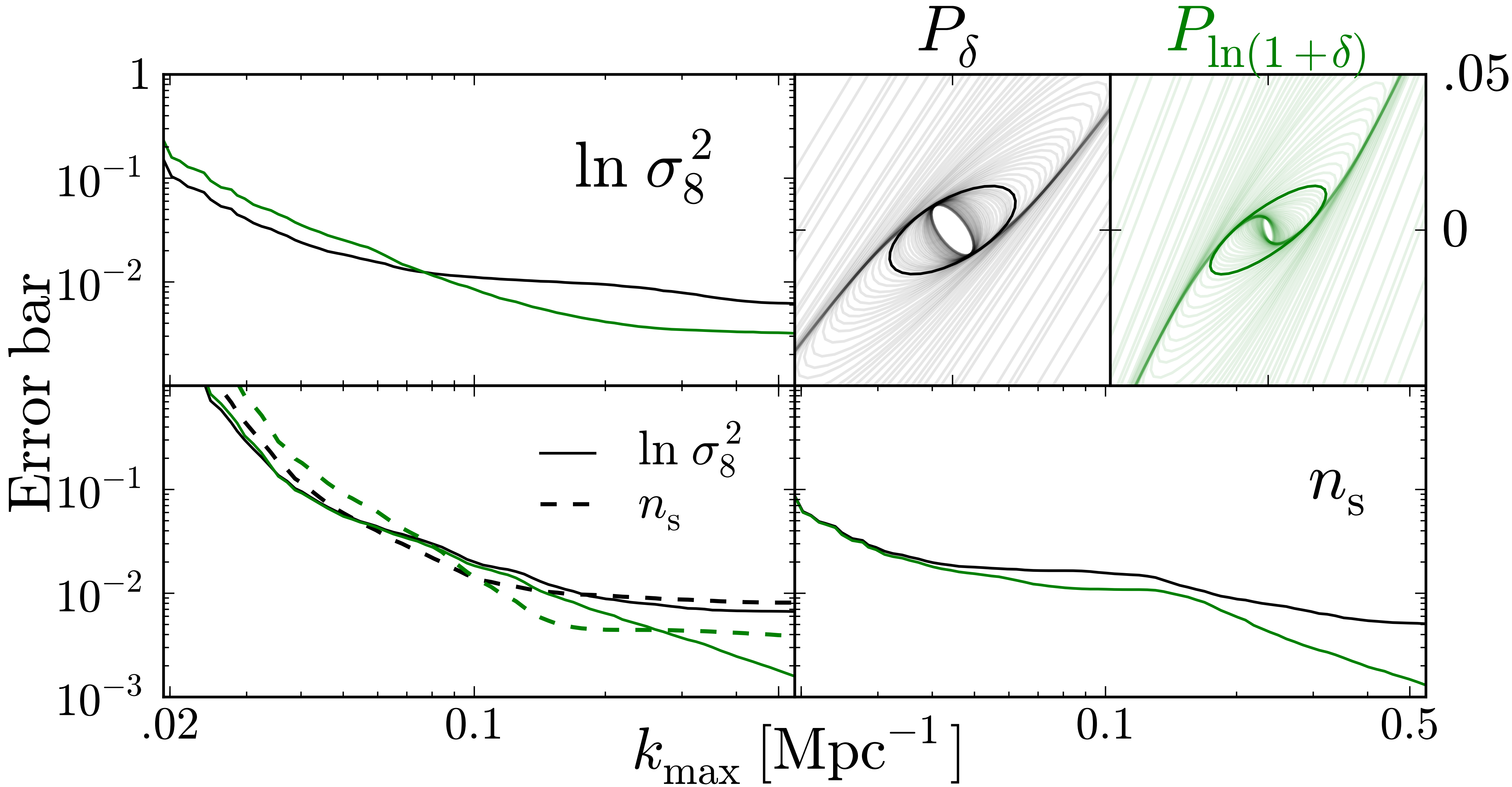


Intrinsic Fisher information greatly enhanced

statistically independent Fourier modes as a function of resolution (MN et al. 2009, 2011)



$P_{\ln(1+\delta)}$ significantly more cosmologically informative.



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Outline

- Biasing in this language: MIP simulations: a powerful statistical ensemble to investigate galaxy biasing

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Trying to decouple biasing from clustering

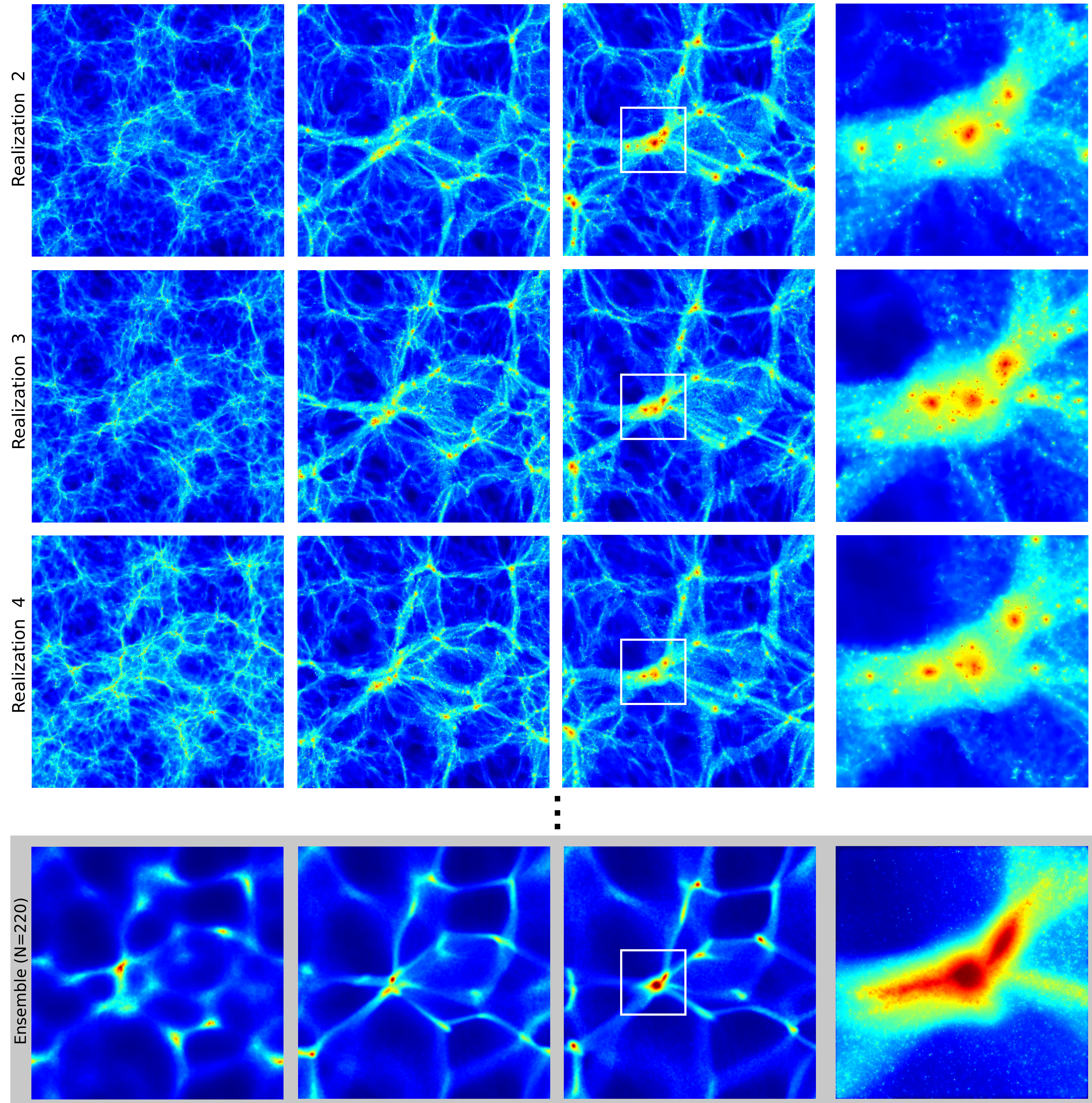
- Decouple the statistical information in a field into the one-point and the "reduced" (Gaussianized) *N*-pt functions

- Alternative to HOD that treats voids too:
  1-pt information/transformation -- galaxy/tracer bias.
  Gaussianized *N*-pt statistics -- clustering.

MIP

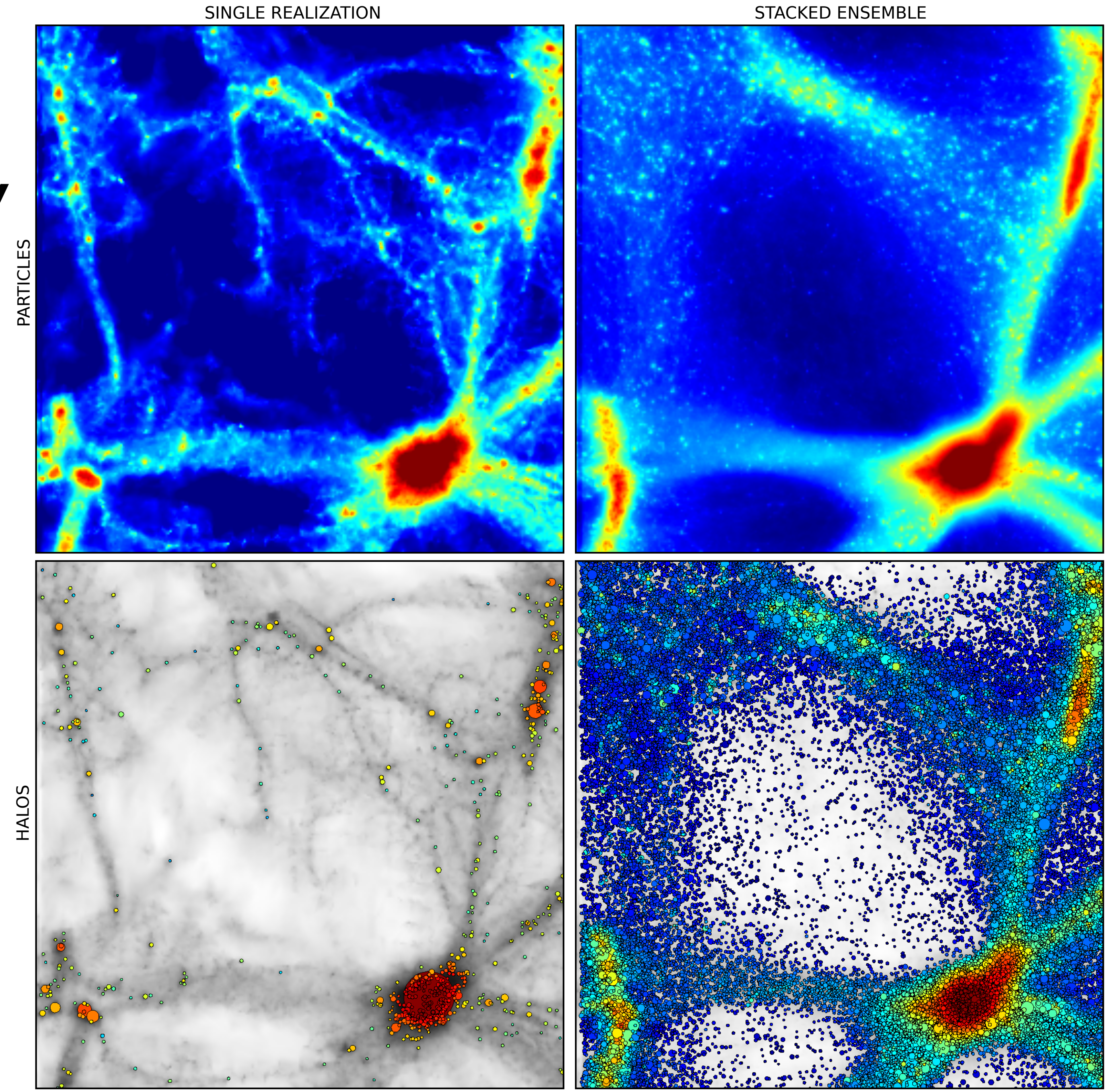
Multum In Parvo, many things in a small place (Aragón-Calvo 2012)

Allows a CWOD, "cosmic web occupation distribution" of haloes



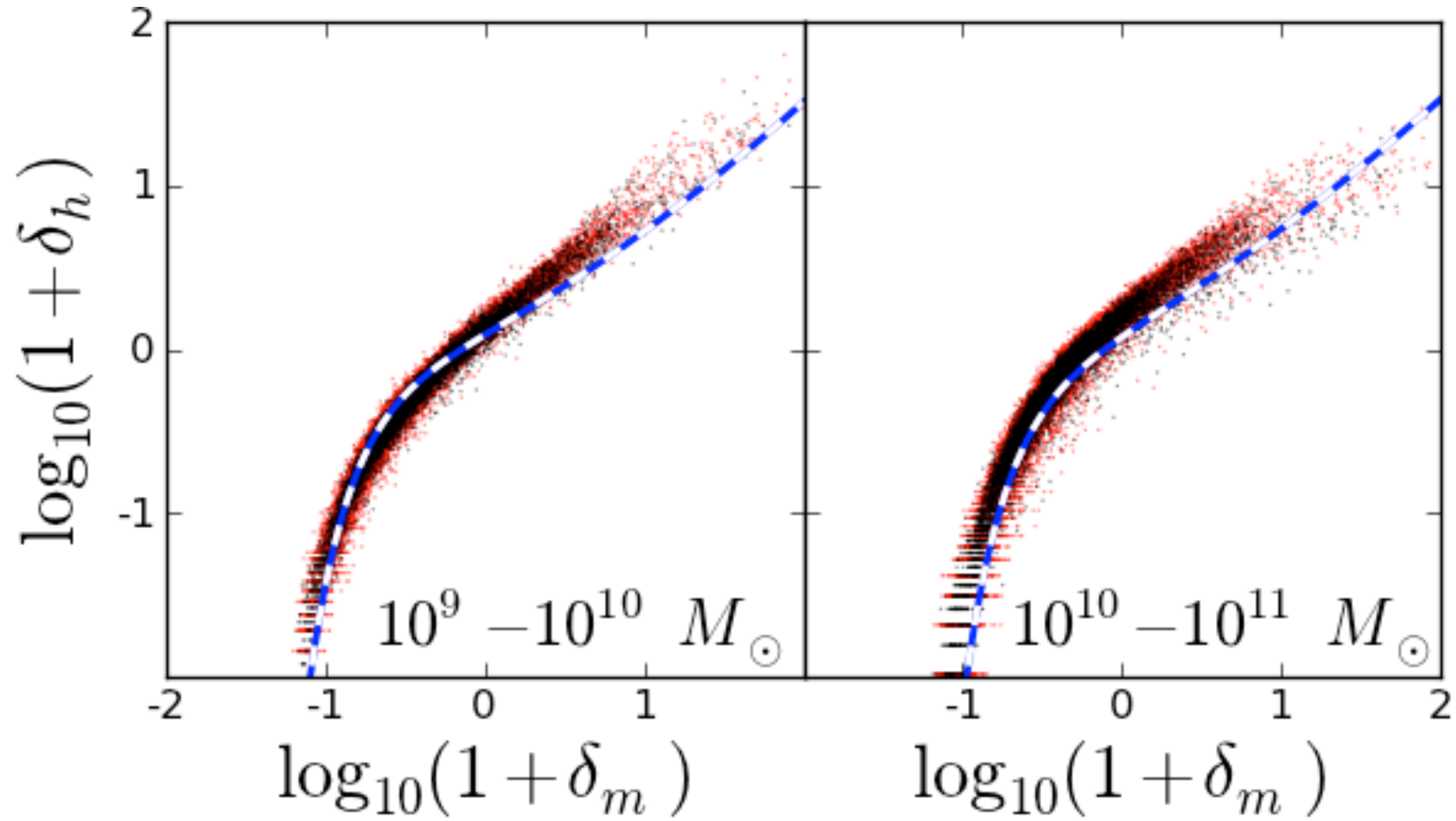
Time →

Gives a halo density field with negligible discreteness, exclusion.



Galaxy-halo bias deep into voids

.. - 4 h^{-1} Mpc cells
.. - 2 h^{-1} Mpc cells



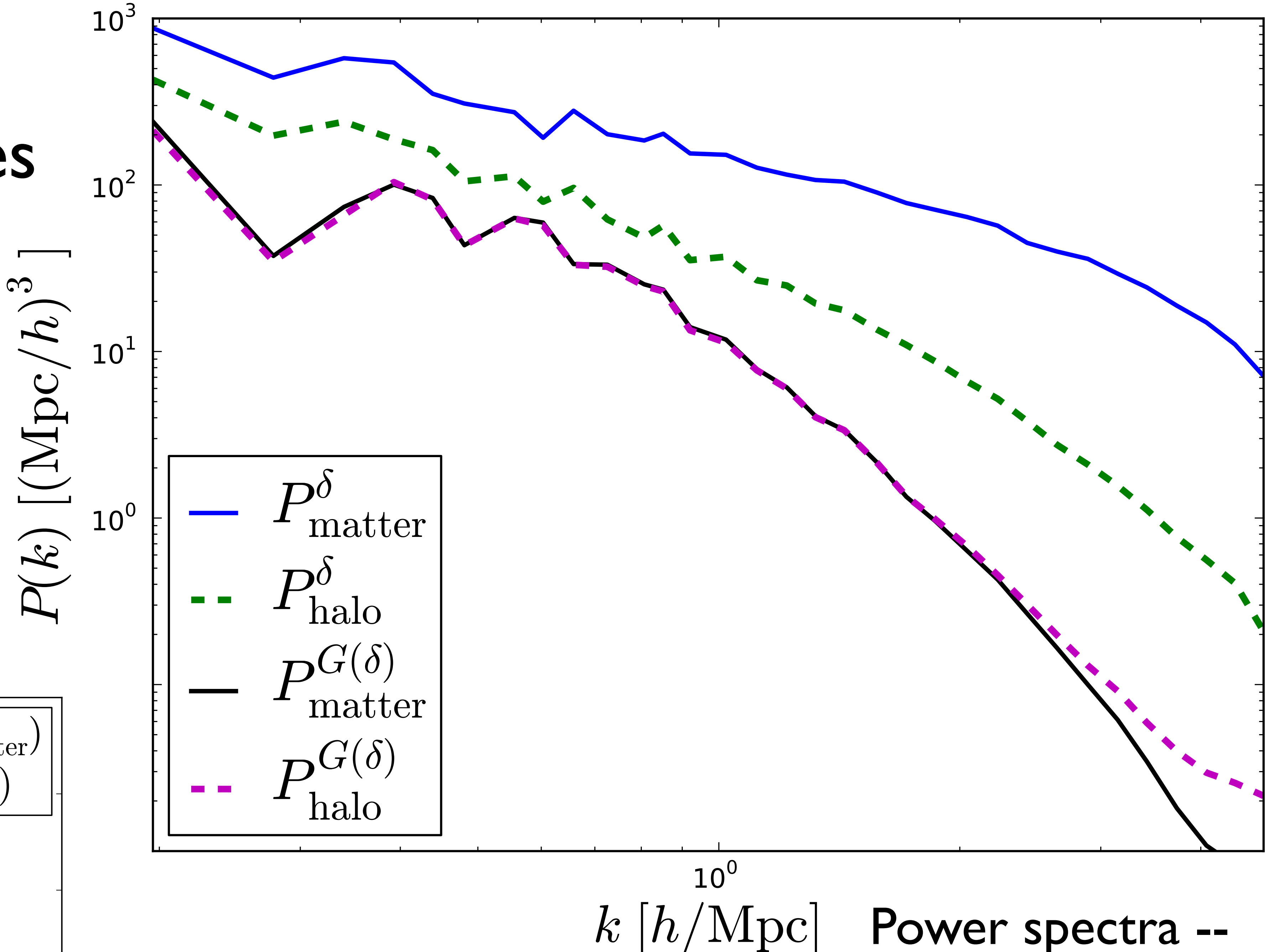
At low mass, bias scatterplot is well-fitted by Press-Schechter with an environment-dependent growth factor

Forming a galaxy in a void is like forming a rare cluster in an overdense region

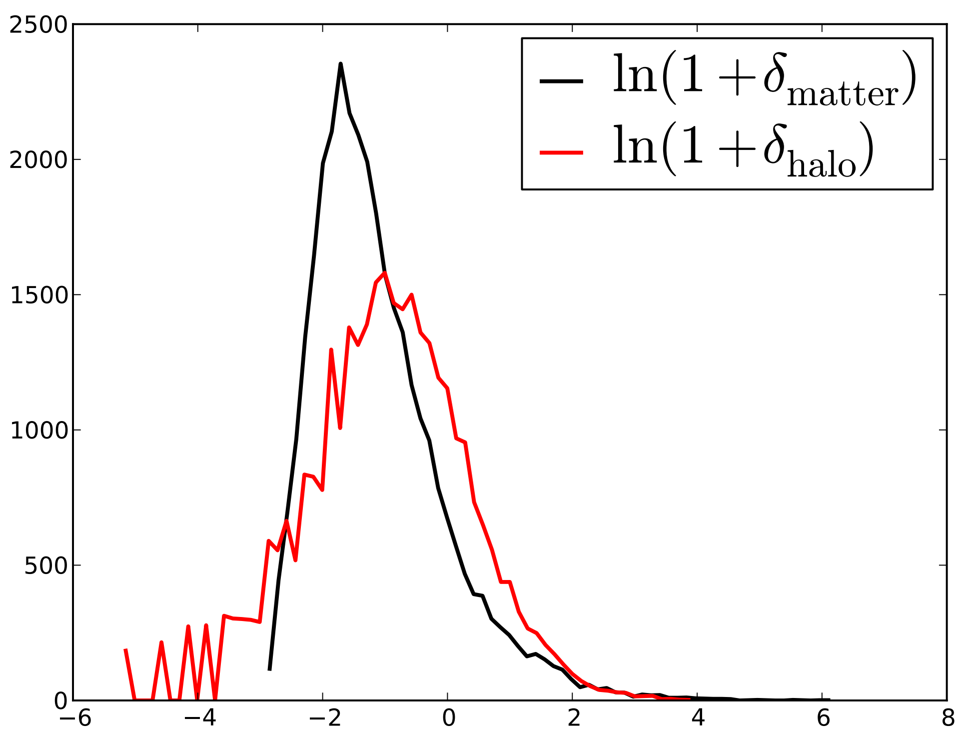
Testing the hypothesis that the halo $\delta_h(\delta_m)$ is a local monotonic function:

Gaussianizing both fields largely undoes galaxy bias!

$\delta_h = \delta_h(\delta_m) \Rightarrow$
$G(\delta_h)=G(\delta_m)$



Power spectra -- Gaussianization on 1 h^{-1} Mpc grid



Conclusions

- Different transformed densities probe different density regimes -- best statistical properties when sharp peaks are suppressed

- Decoupling 1-pt from (*N*>1)-pt info with Gaussianization is useful

- Averaging over "all possible universes" -- sets of small-scale fluctuations -- gives great statistical power to constrain a CWOD

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