Weighted density fields as improved probes of modified gravity models

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Intro

- Models:
  - Symmetron
  - $f(R)$ Hu & Sawicki
    - Screening.
    - Fifth force.

Intro

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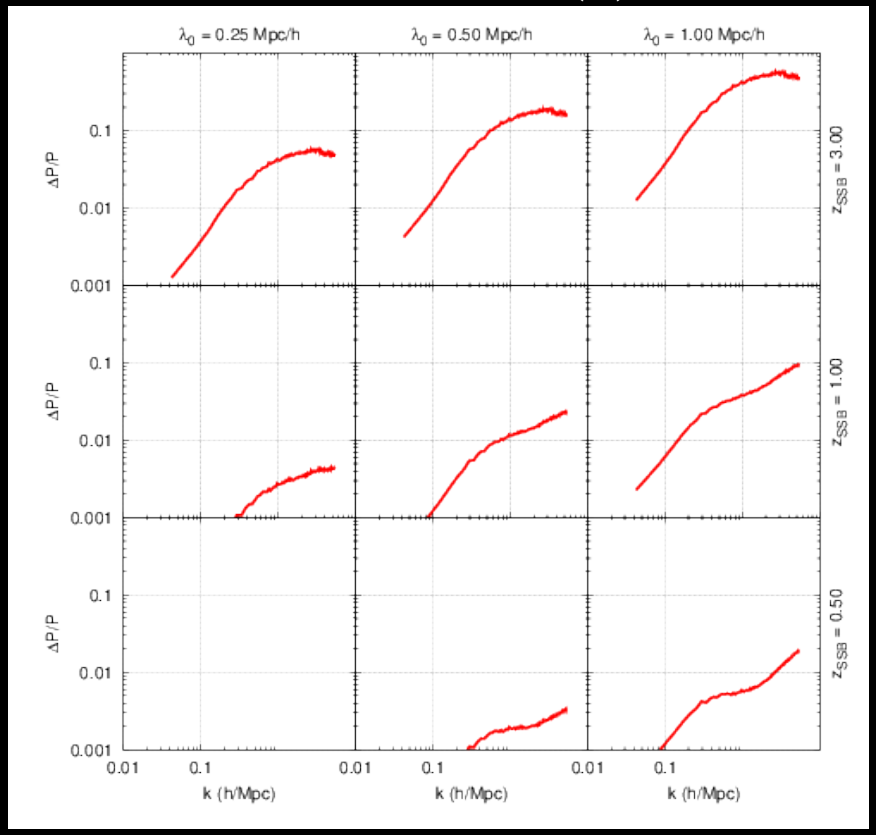
  - Symmetron
  - $f(R)$ Hu & Sawicki
    - Screening.
    - Fifth force.
- Can we detect the first force?
- Can we differentiate between different models?

Symmetron simulations and the bad news

Difference in $P(k)$



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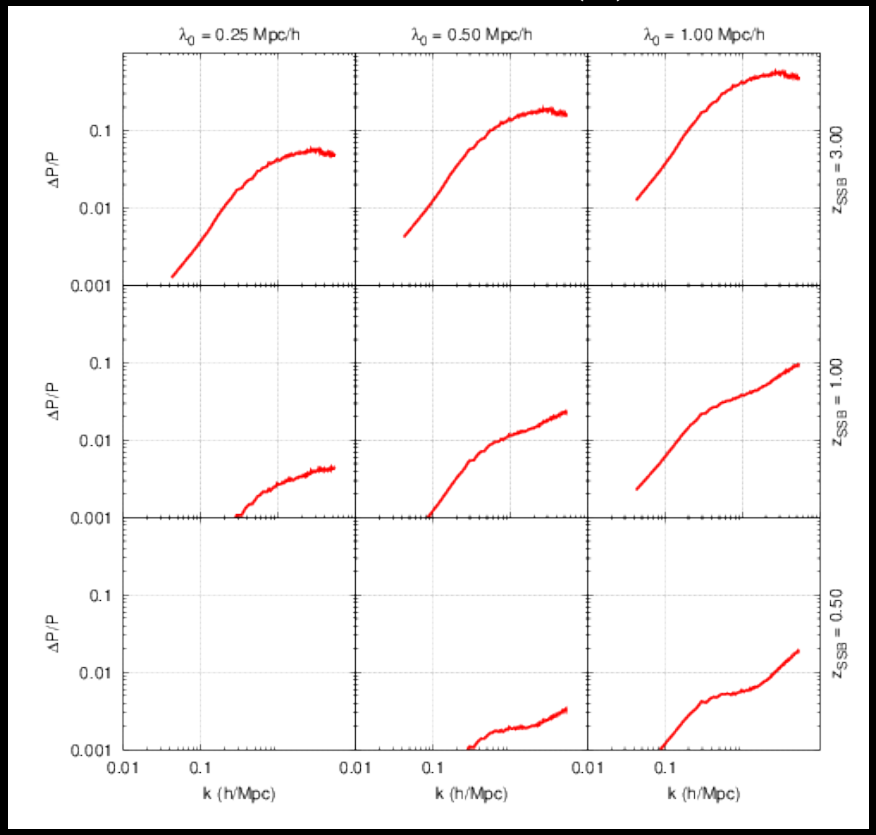
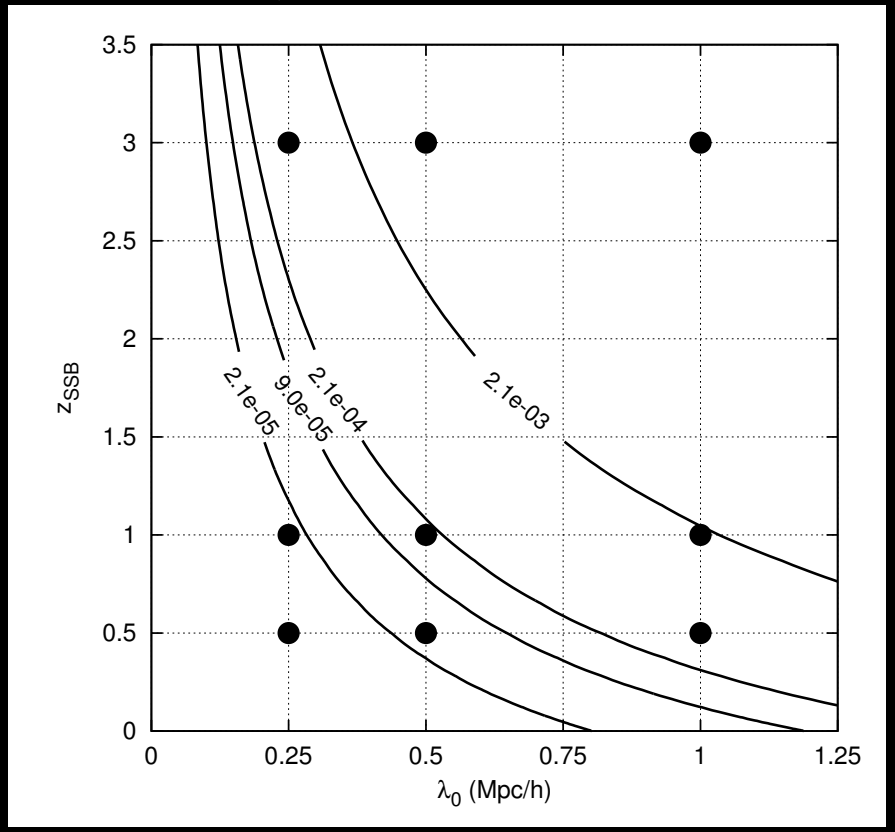
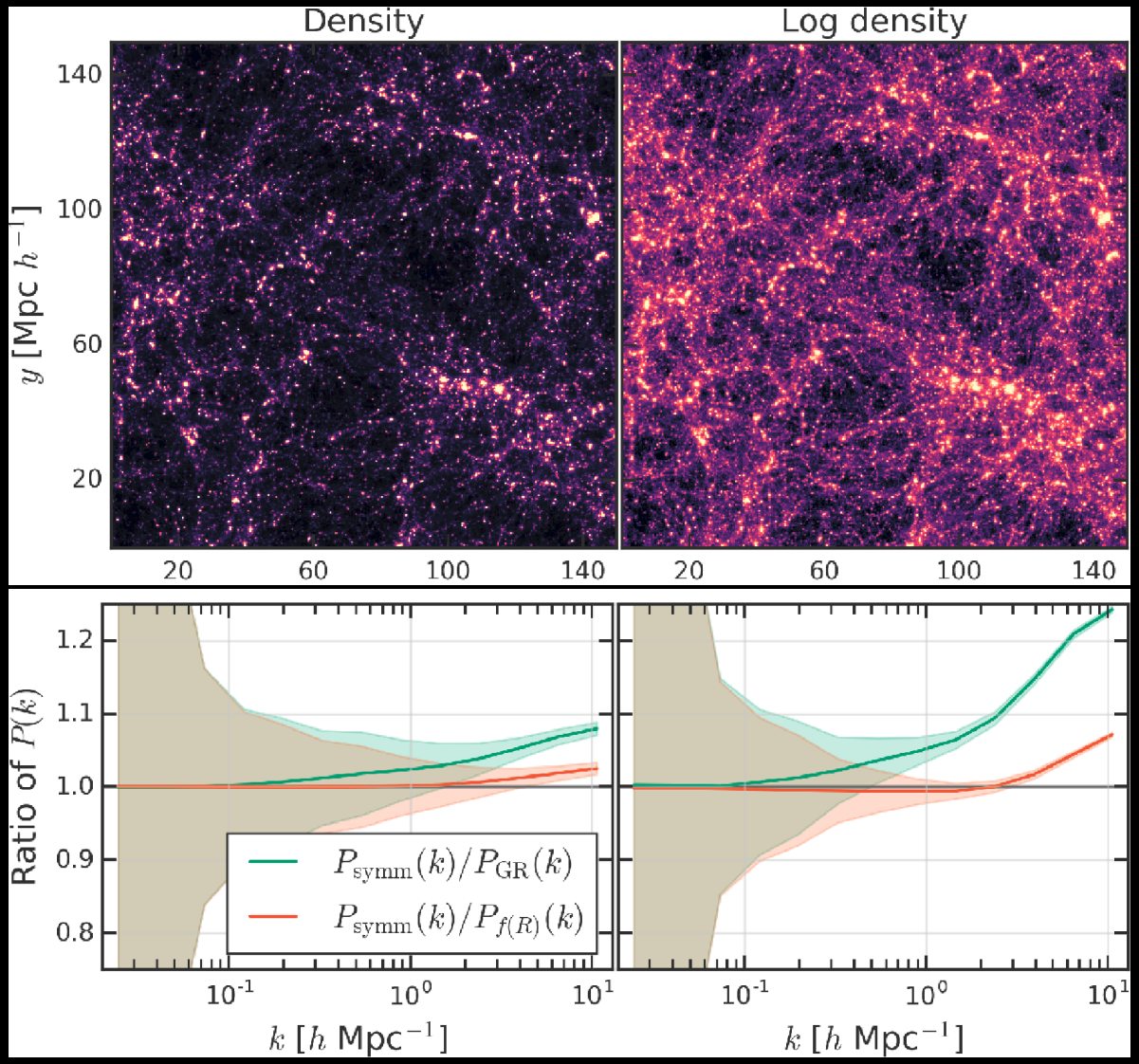


Solar system constraints



Log transform



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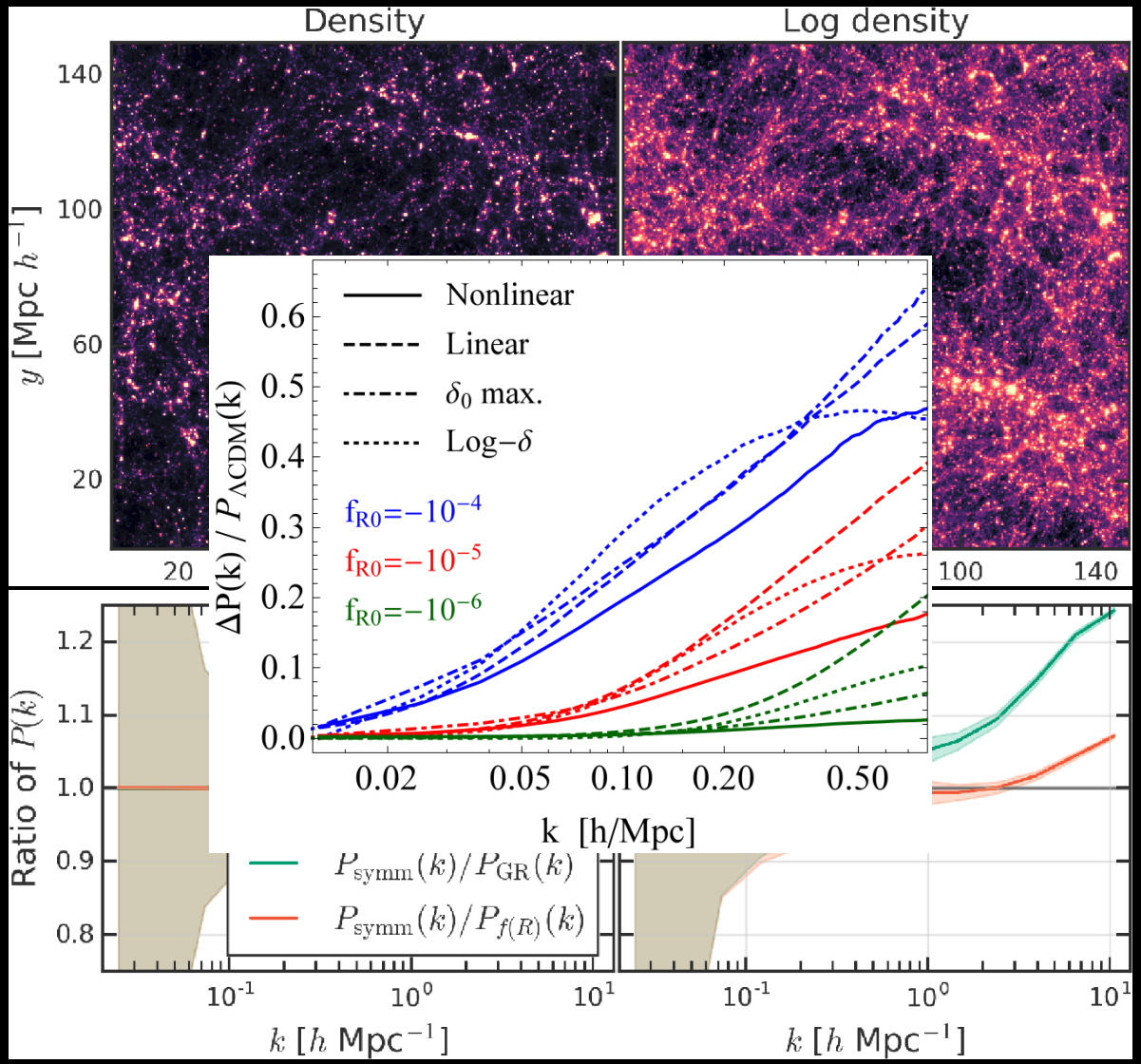
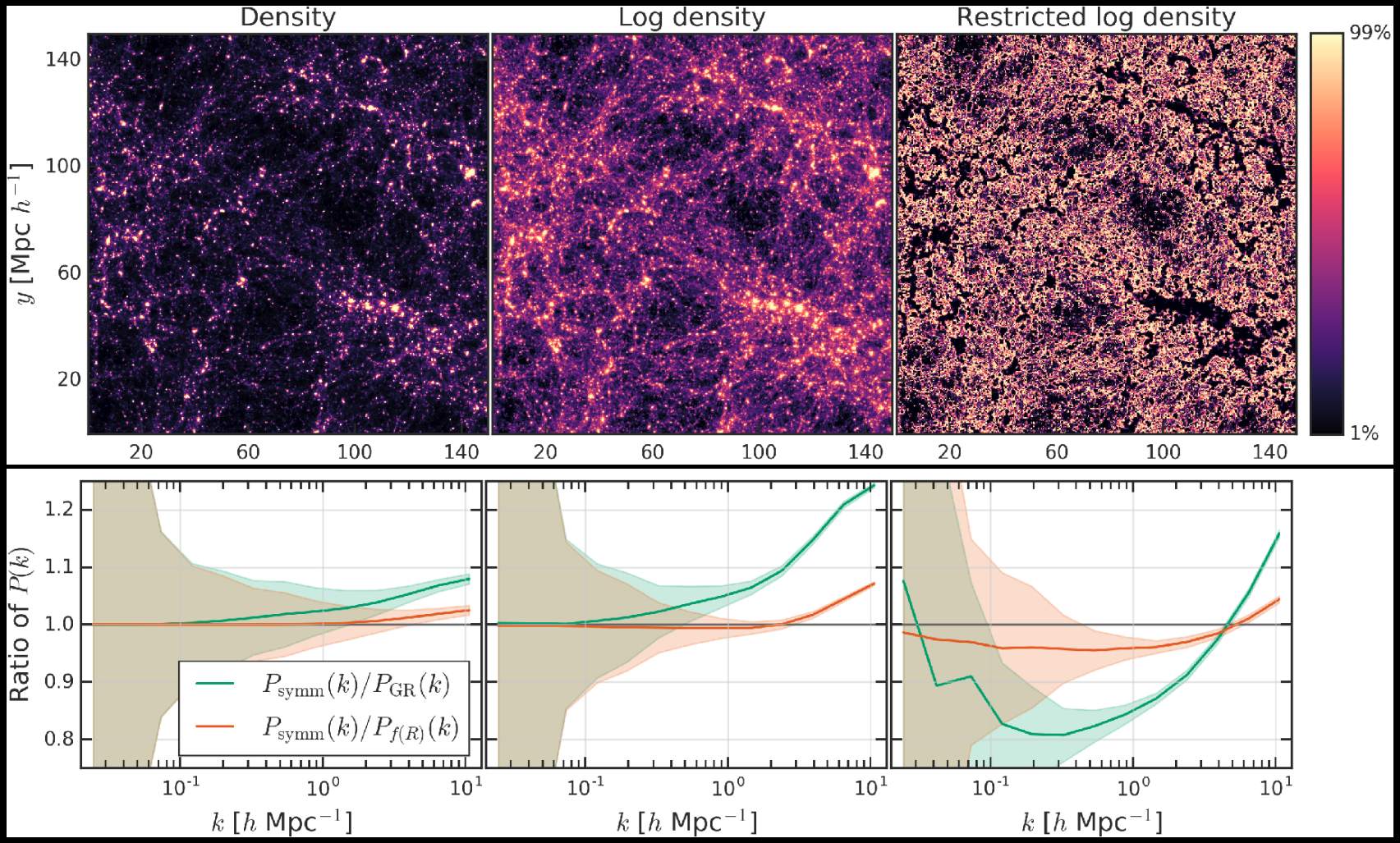


Lombriser, Simpson, Mead, 2015. arXiv: 1501.04961

Restricted log transform

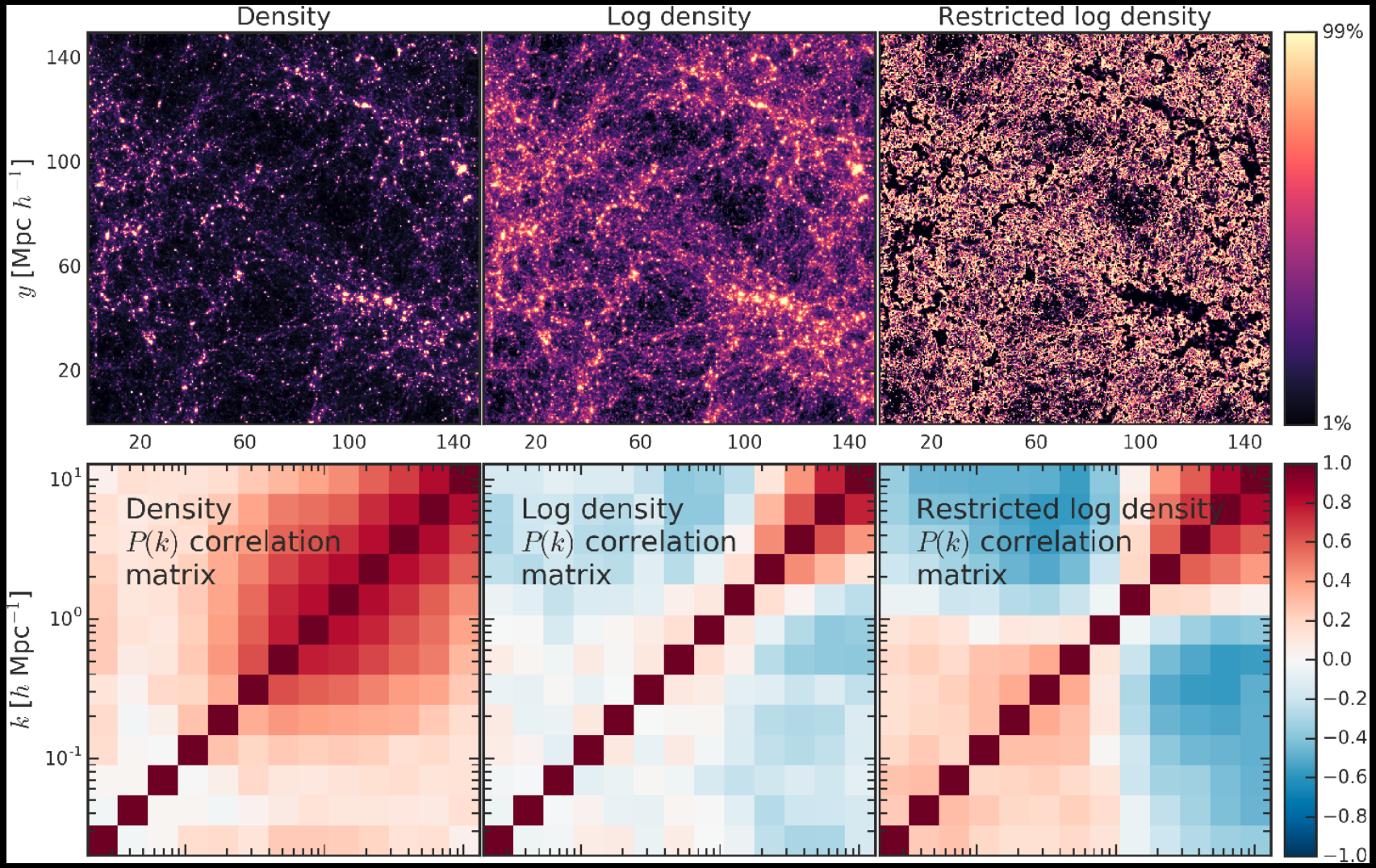


Density $\Rightarrow$	$f_0(\rho)$	$= \rho/\rho_0$
Log transform $\Rightarrow$	$f_1(\rho)$	$= \log_{10}(\rho/\rho_0)$
Restricted log transform $\Rightarrow$	$f_2(\rho; A, B, C)$	$= \log_{10}(A\rho/\rho_0)\exp\left[-(\log_{10}(A\rho/\rho_0) - B)^2/(2C)^2\right]$

C. Llinares & N. McCullagh, 2017, arXiv:1704.02960 (MNRAS Letters)

Covariance matrices and signal-to-noise

- 100 ΛCDM and 50 symmetron simulations.



Covariance matrices and signal-to-noise

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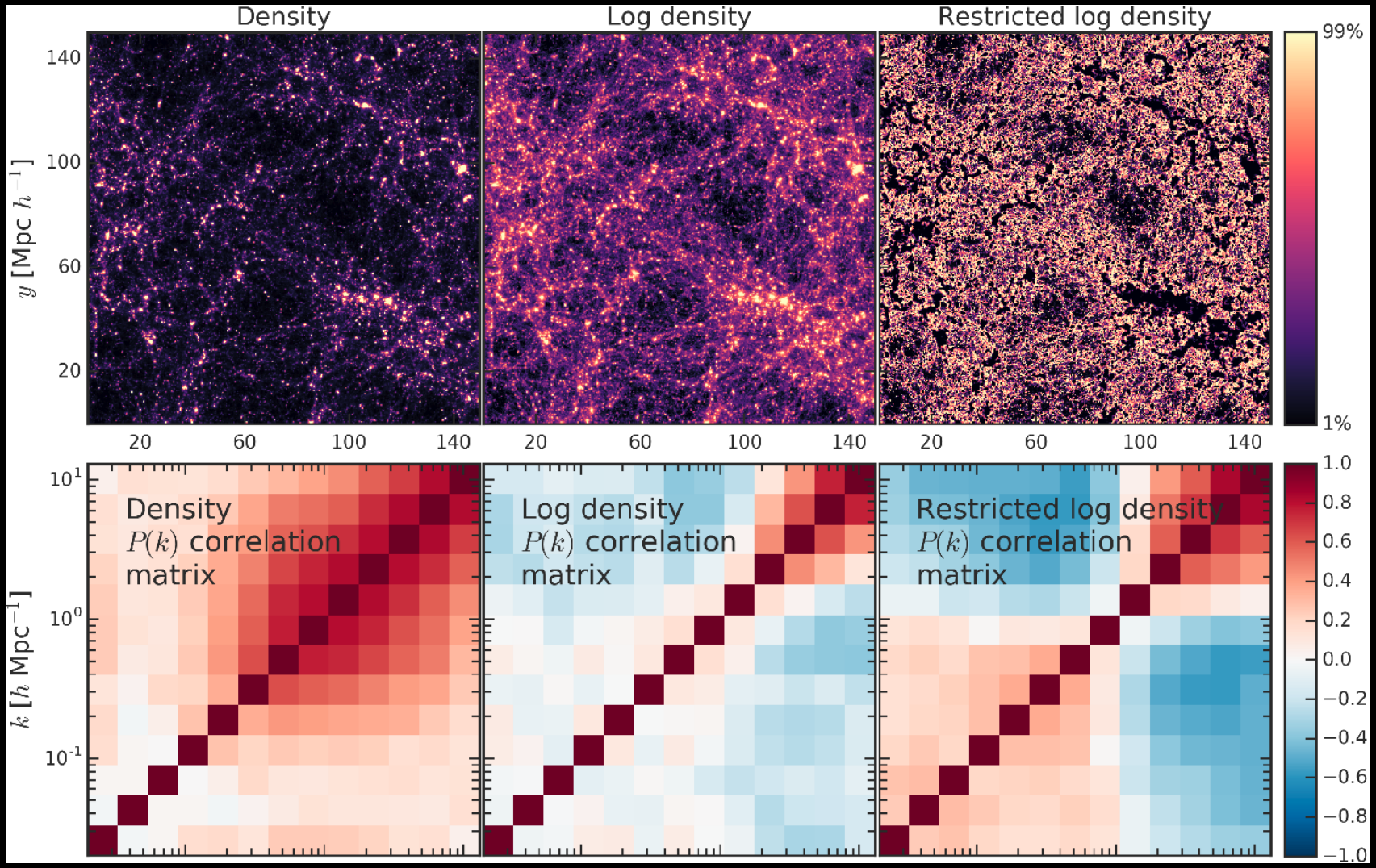

S/N (GR)	85.80	434.60	485.67
$\sigma(P_{symm}/P_{GR}; k = 0.88\ h/\mathrm{Mpc})$	0.083	0.039	0.033
$\sigma(P_{symm}/P_{f(R)}; k = 0.88\ h/\mathrm{Mpc})$	0.081	0.036	0.040

Choosing parameters of restricted log transform

$$f_2(\rho; A, B, C) = \log_{10}(A\rho/\rho_0) \exp\left[-(\log_{10}(A\rho/\rho_0) - B)^2/(2C)^2\right]$$

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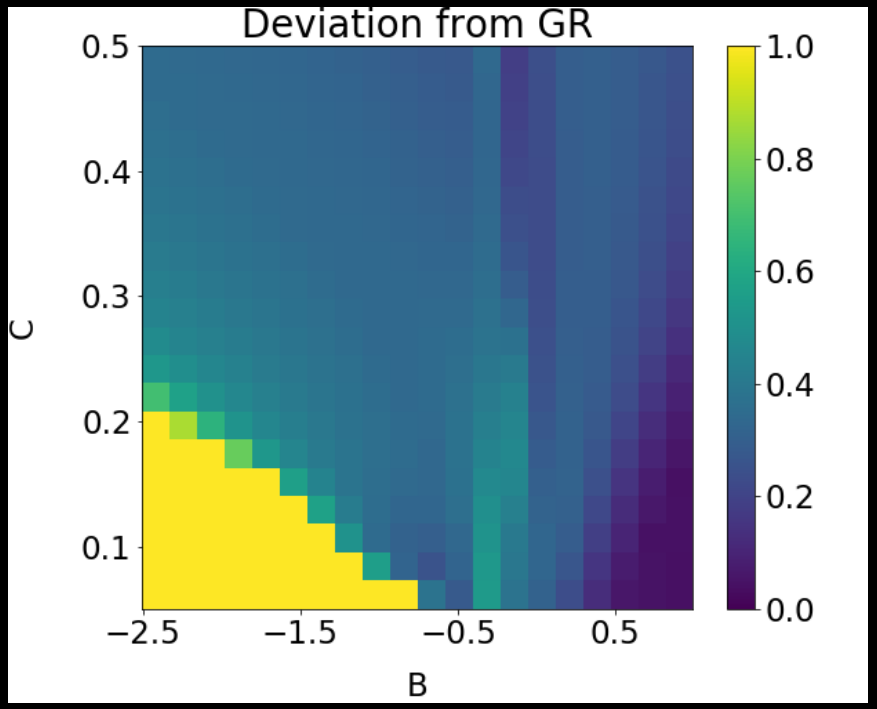

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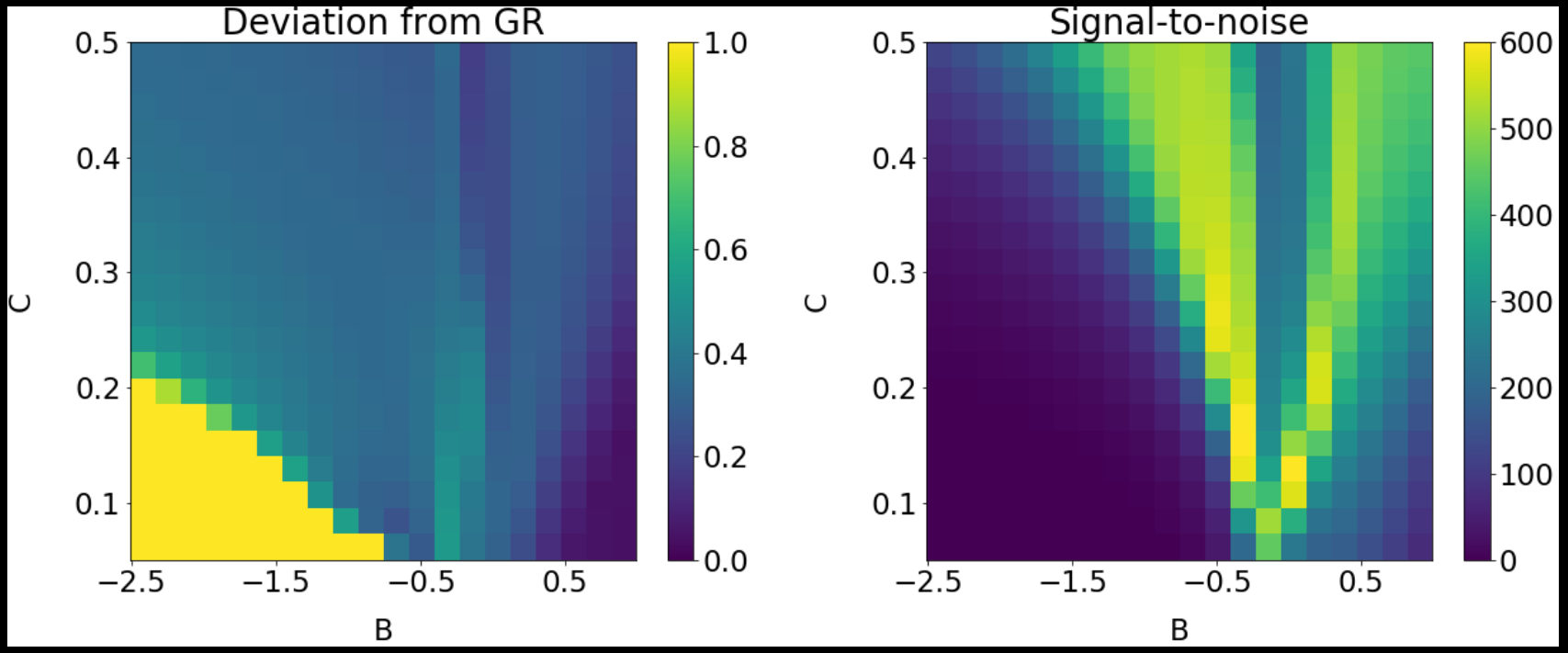
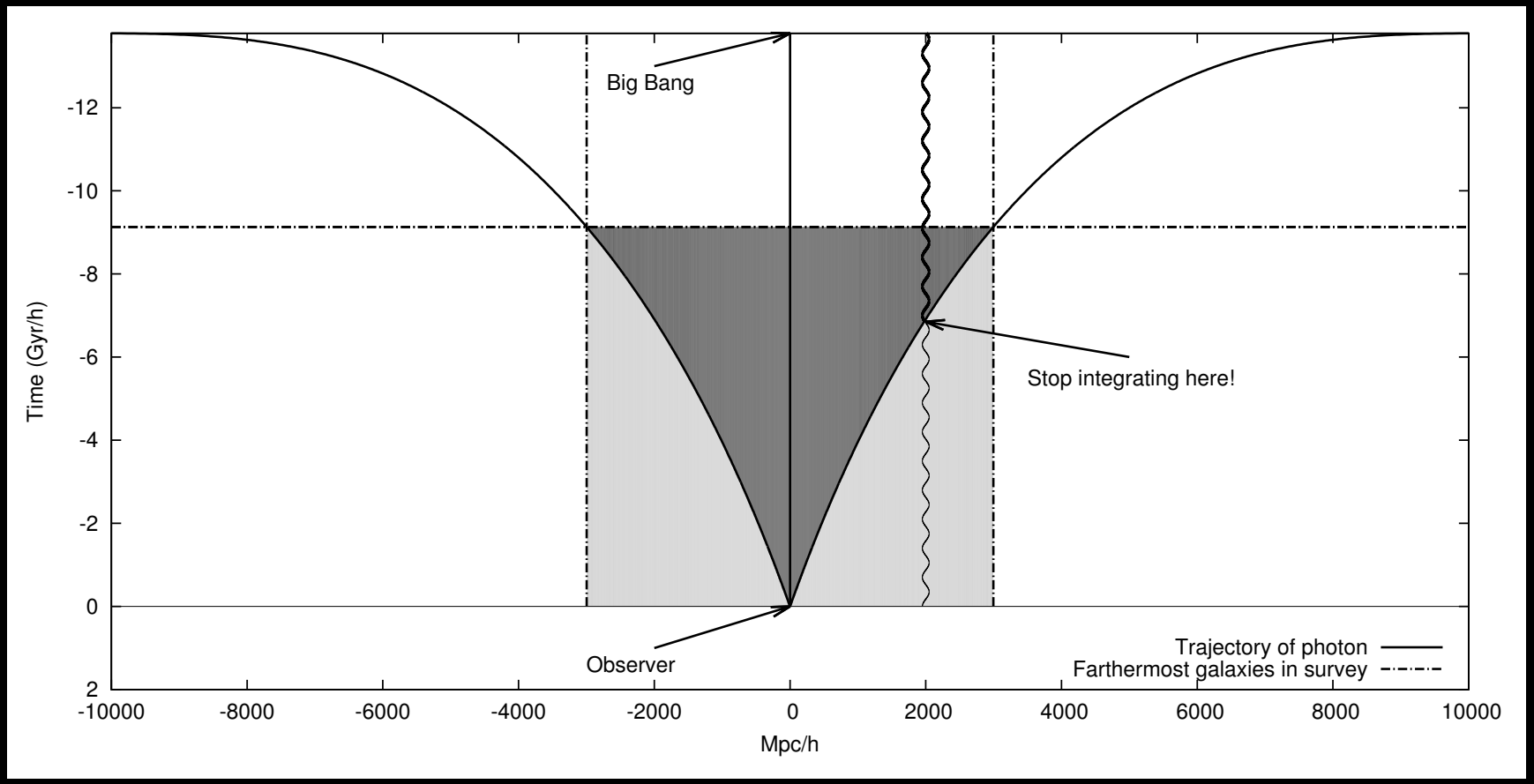


The shrinking box framework: a new, faster, more efficient approach to cosmological simulations

Llinares, C. arXiv:1709.04703

The shrinking box framework

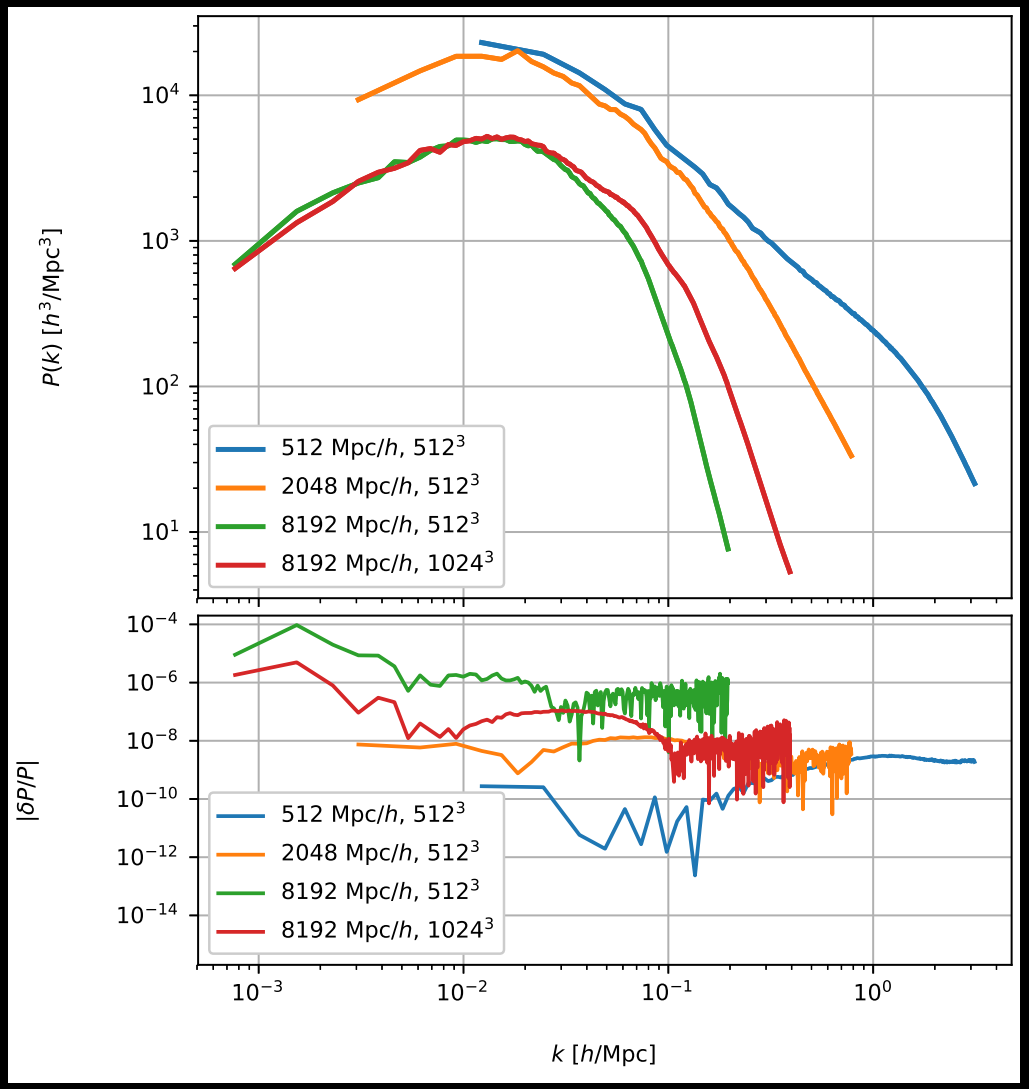


The shrinking box framework

$$
\begin{aligned}
ds^2 &= -a^2(t)(1+2\Phi)dt^2 + a^2(1-2\Phi)(dx^2+dy^2+dz^2) \\
G_{ab} &= 8\pi G T_{ab} \\
T^{ab} &= (\rho_0 + \delta\rho)u^a u^b \\
&\Rightarrow tt \text{ equation is } \ \dot{\Phi} - \nabla^2\Phi = -4\pi G a^2 \delta\rho
\end{aligned}
$$

- Code: Solve (particle mesh with uniform grid).
- Solver for diffusion equation: alternate direction explicit.

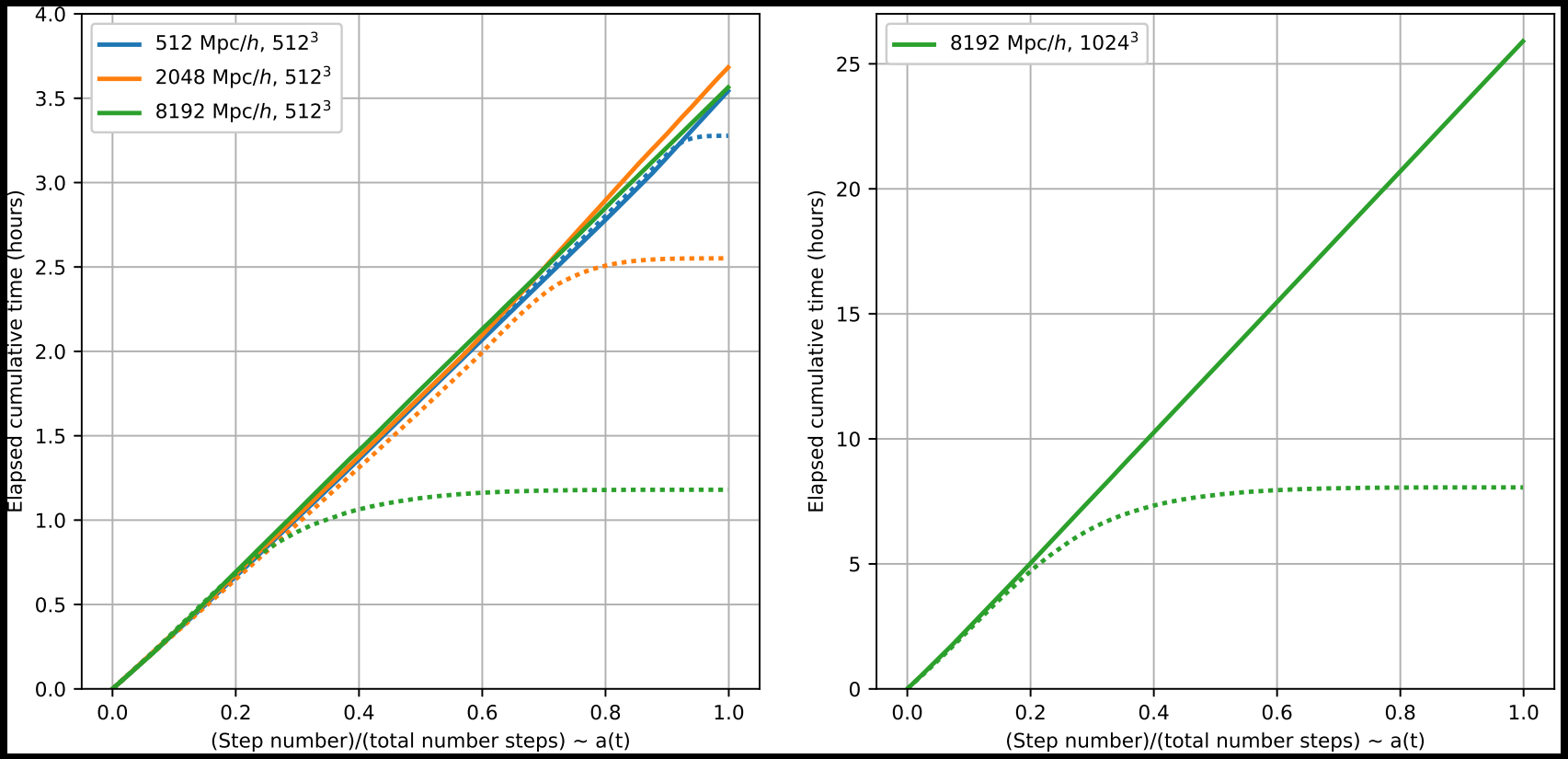
Testing the shrinking box framework



Box (Mpc/h)	$N_{\text{particles}}$
512	512^3
2048	512^3
8192	512^3
8192	1024^3

- Power spectrum of lightcone.

Speed up


512 Mpc/h, 512³
2048 Mpc/h, 512³
8192 Mpc/h, 512³
Elapsed cumulative time (hours)
(Step number)/(total number steps) ~ a(t)
8192 Mpc/h, 1024³
Elapsed cumulative time (hours)
(Step number)/(total number steps) ~ a(t)

Conclusions

- Density transformations are cool.
  - To do: calculate noise associated to real surveys.
- Shrinking the box gives a speed up of a factor of at least three.