Avoiding tensions with a functioning cosmological model

Corfu Summer School
"Tensions in Cosmology"
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Pavel Kroupa

Charles University in Prague

University of Bonn

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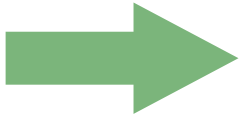

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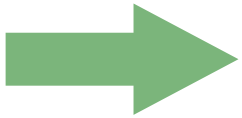

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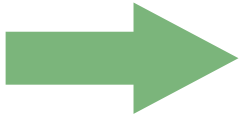

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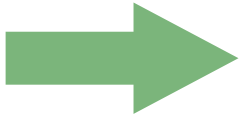

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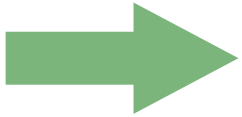

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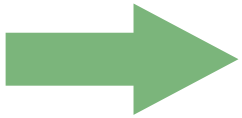

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These can be tested for using existing data

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Existence of dark matter particles ruled out with > 5sigma confidence

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Looking along the line between Milky Way and Andromeda

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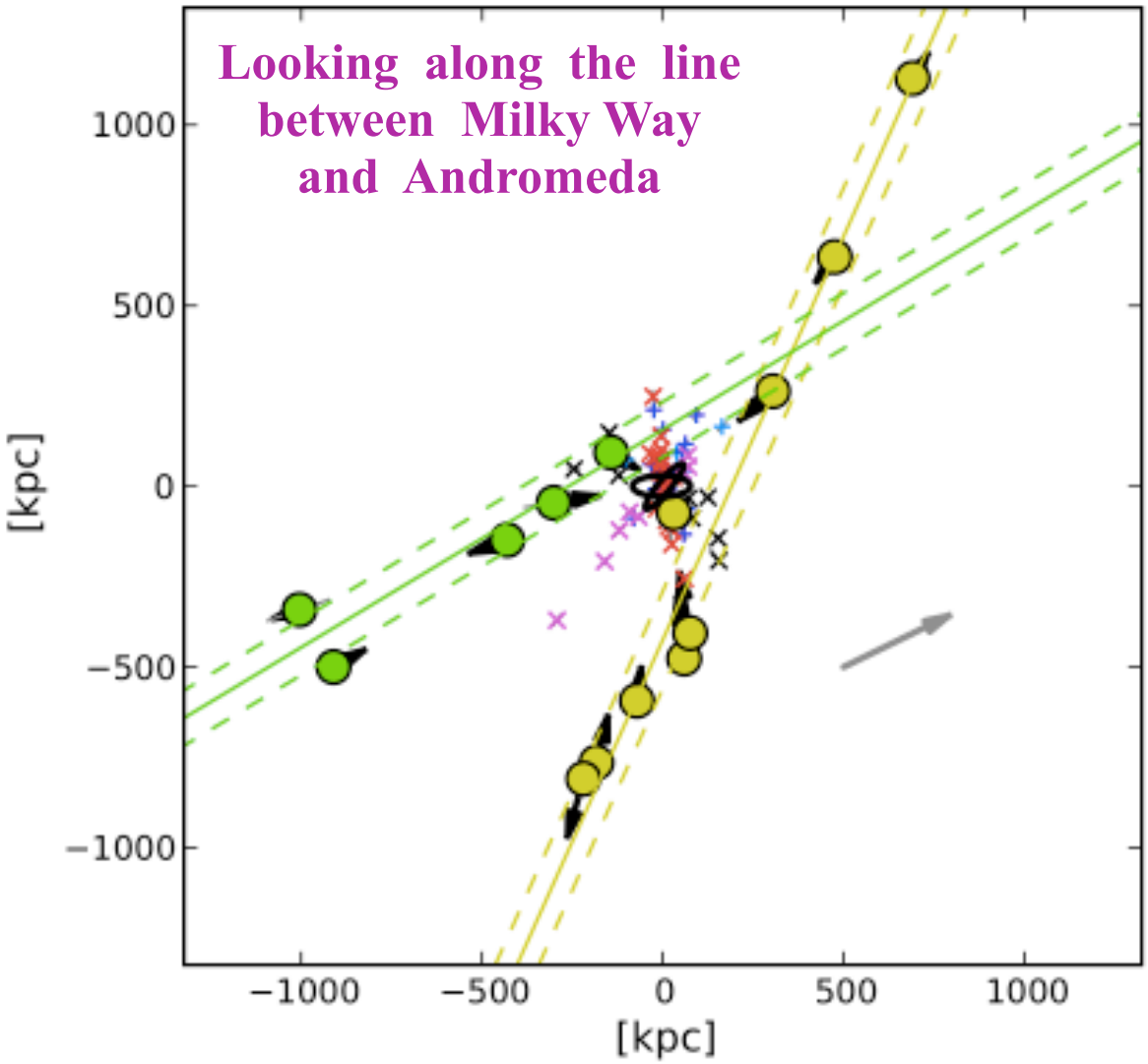

Figure 9. Edge-on view of both LG planes. The orientation of the MW and M31 are indicted as black ellipses in the centre. Members of the LGP1 are plotted as yellow points, those of LGP2 as green points. MW galaxies are plotted as plus signs (+), all other galaxies as crosses (×), the colours code their plane membership as in Fig. 6. The best-fitting planes are plotted as

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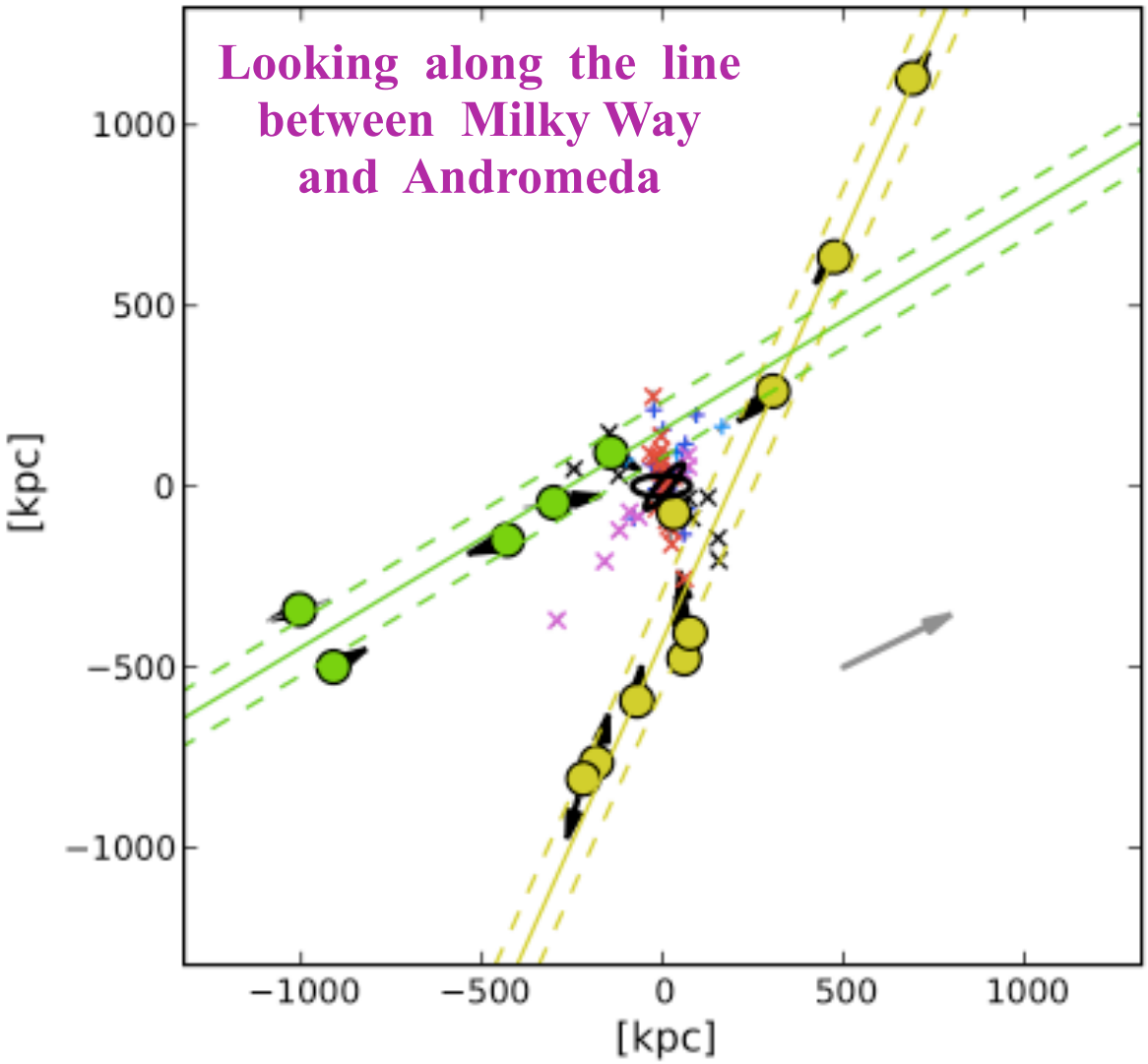

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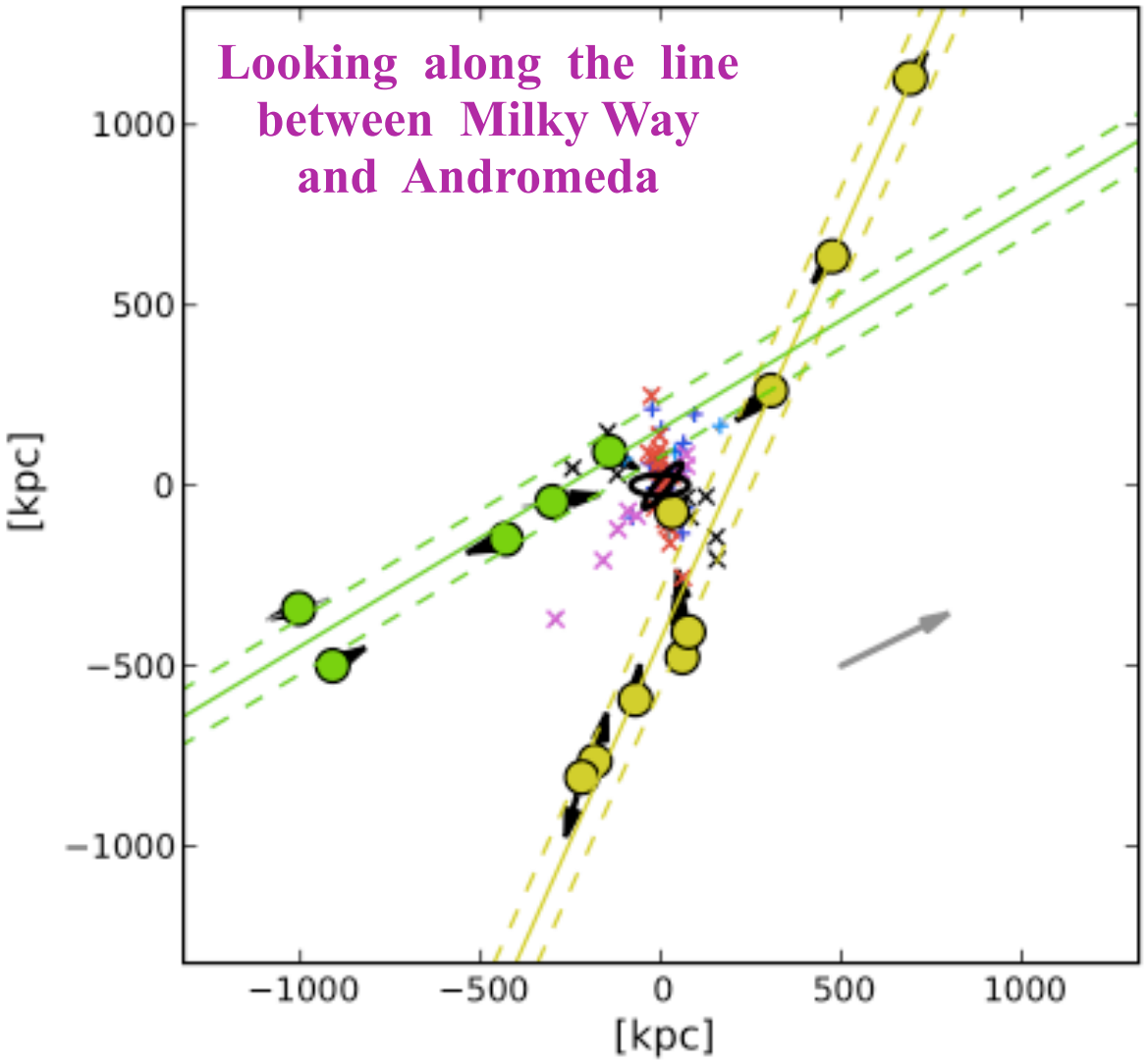

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NOT SMoC at ∞ sigma

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KBC void and Hubble Tension

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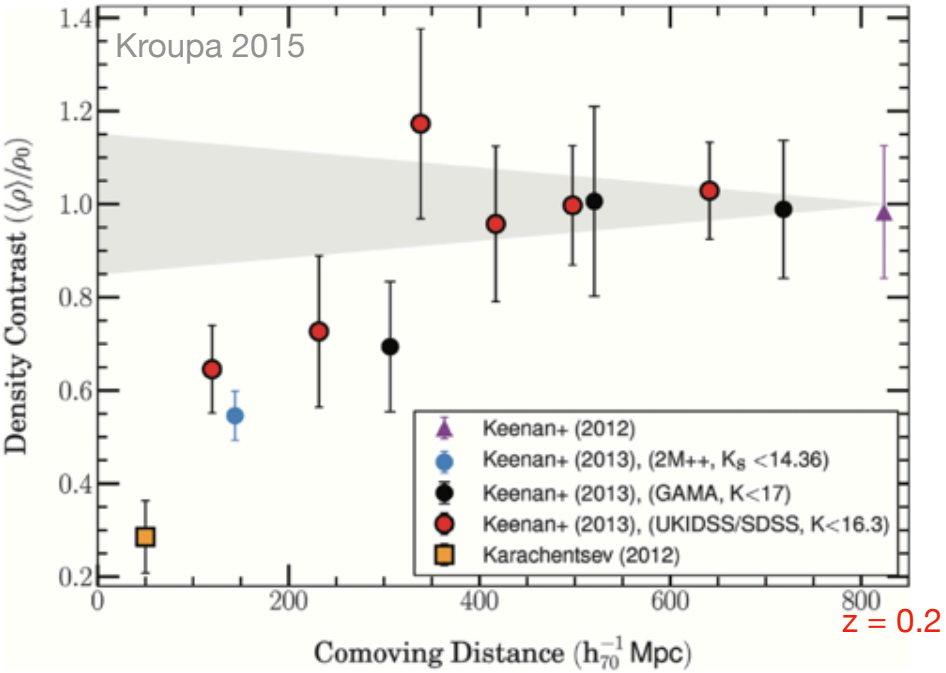

Figure 1. The KBC void: the actual density of normal matter divided by the mean cosmological density is plotted in dependence of the distance from the position of the Sun (which is in the Local Group of galaxies). The grey area indicates the density fluctuations allowed by the ΛCDM model. Taken from fig. 1 in Kroupa (2015).

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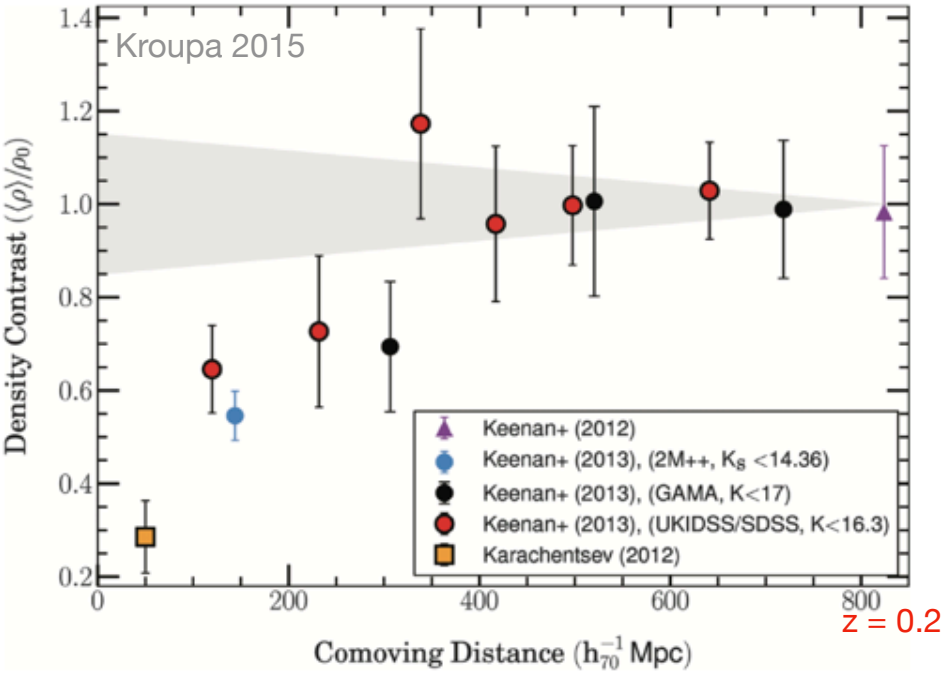

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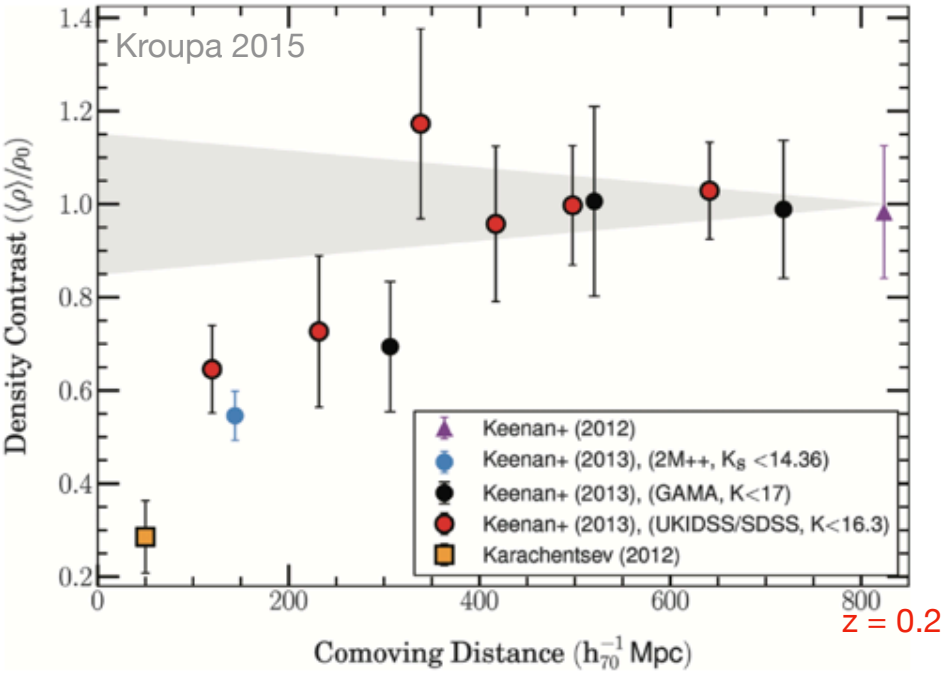

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CMB dipole indicating large-scale bulk flows as expected for such a void (radio observations)

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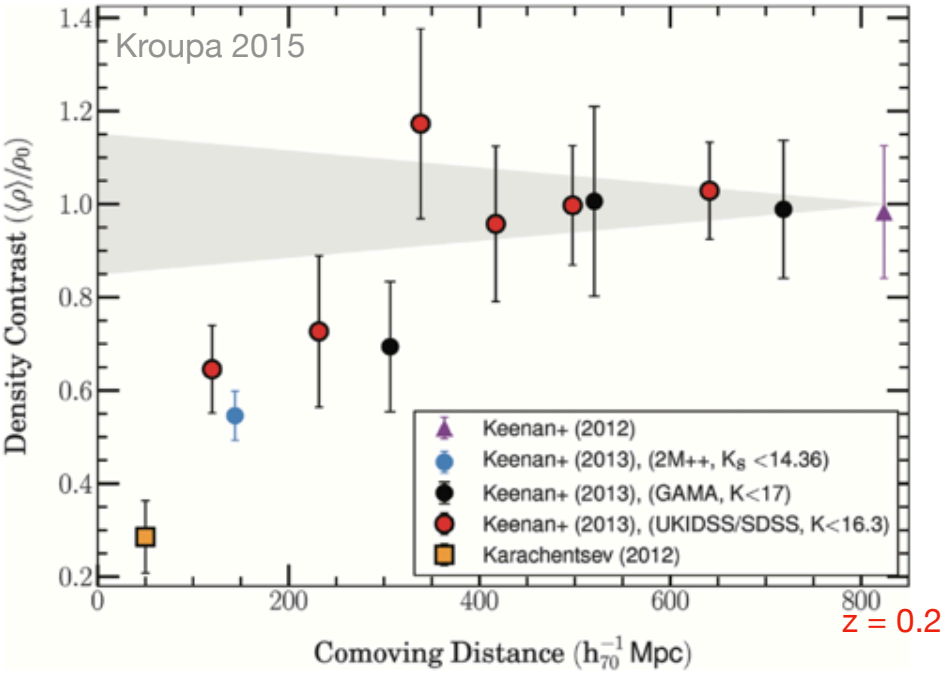

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Additionally :

Strong evidence for highly significant over- and under-densities in galaxy-cluster data

Migkas & Reiprich (2018); Migkas et al. (2021)

4.9 sigma exclusion of cosmological principle based on distribution of 10^6 quasars Secrest + Sarkar et al. (2021)

The observed KBC Void
is in 5sigma tension with the SMoC
and
automatically and naturally
accounts for the "Hubble Tension" !

Haslbauer et al. (2020)

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MOND : || generalised Poisson equation

$$\mu = \mu \left(\frac{|\vec{\nabla}(\phi)|}{a_0} \right)$$ Bekenstein & Milgrom(1984)

$|\vec{\nabla}(\phi)| \gg a_0 \rightarrow \mu \approx 1$ || corresponds to the p=2 p-Laplacian

$|\vec{\nabla}(\phi)| \ll a_0 \rightarrow \mu \approx \frac{|\vec{\nabla}(\phi)|}{a_0}$ || corresponds to the p=3 p-Laplacian

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MOND correctly describes all observed dynamical phenomena on the scale of galaxies

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Analytical calculations suggest the nuHDM model correctly accounts for the KBC void (thus *no Hubble Tension*) and El Gordo and Bullet Clusters.

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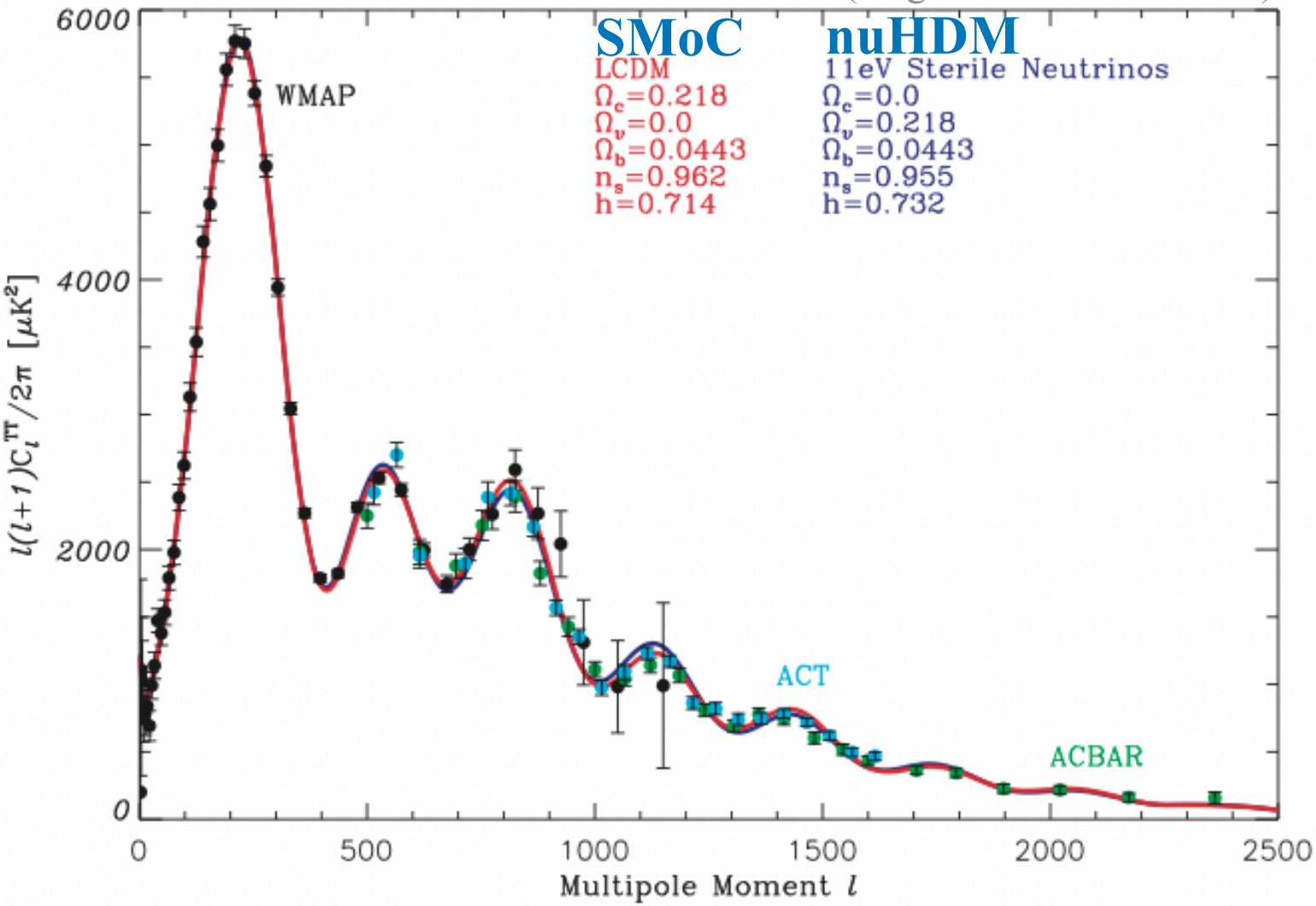


Figure 1. The CMB angular power spectrum for our cosmological model (blue line), compared with the ΛCDM model (red line). The data points come from *WMAP* 7 year (black), Atacama Cosmology Telescope (ACT) (turquoise) and ACBAR (green).

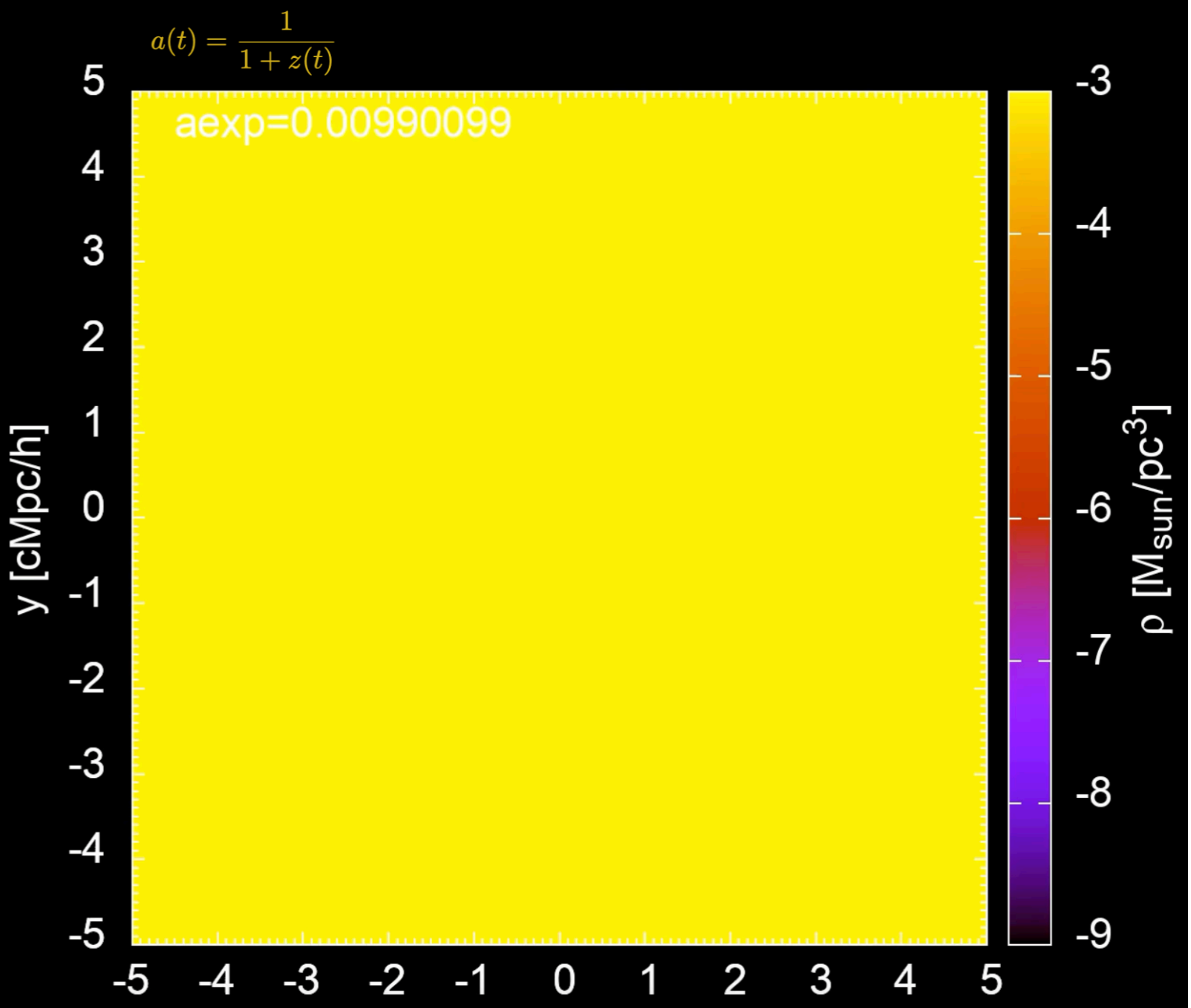
Begin with :

Comparison calculation using *LCDM fluctuations* in baryon density field at z = 100

Nils Wittenburg

nuHDM / LCDM initial conditions

without EFE



Nils Wittenburg

nuHDM / LCDM initial conditions

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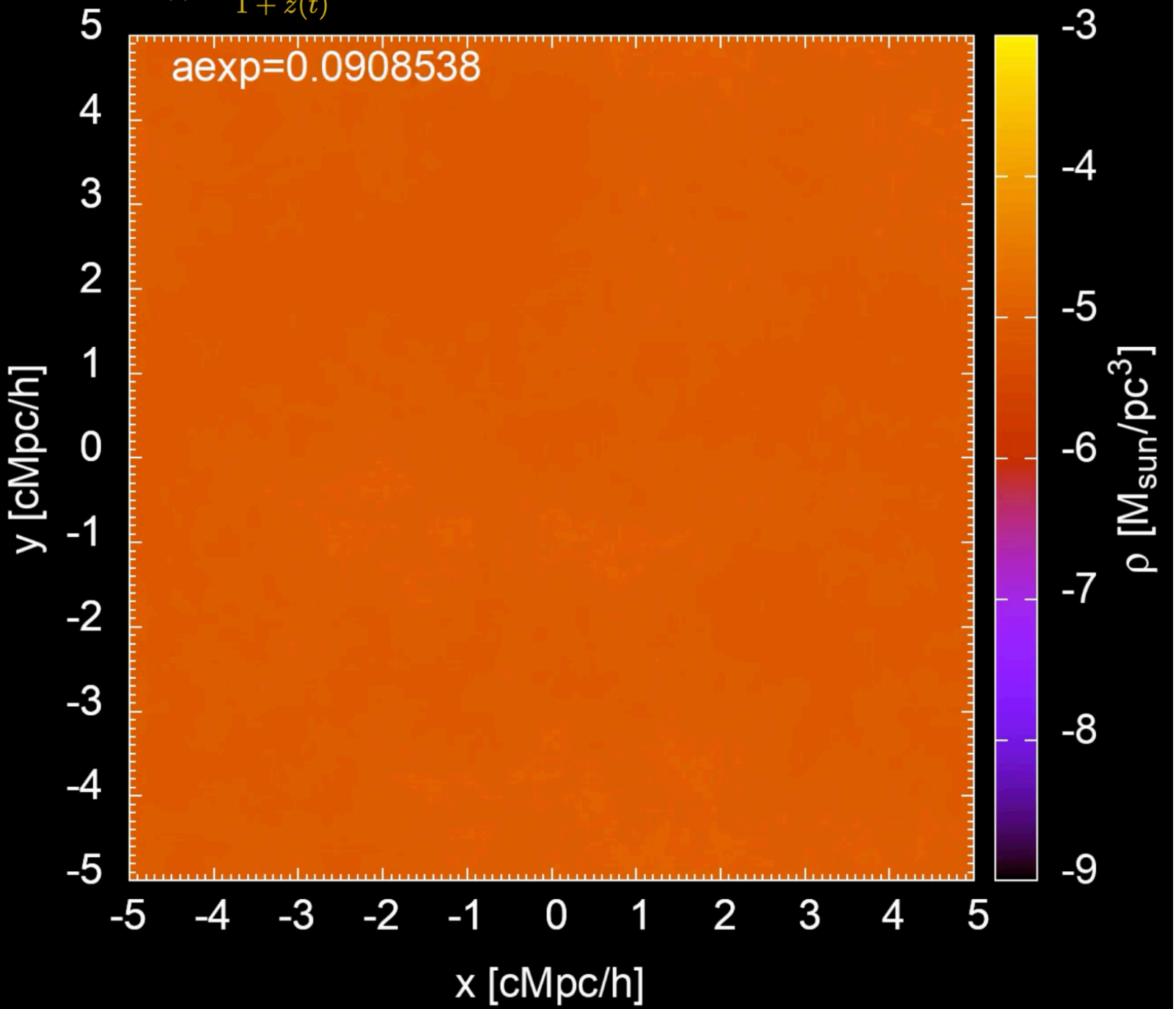
without EFE



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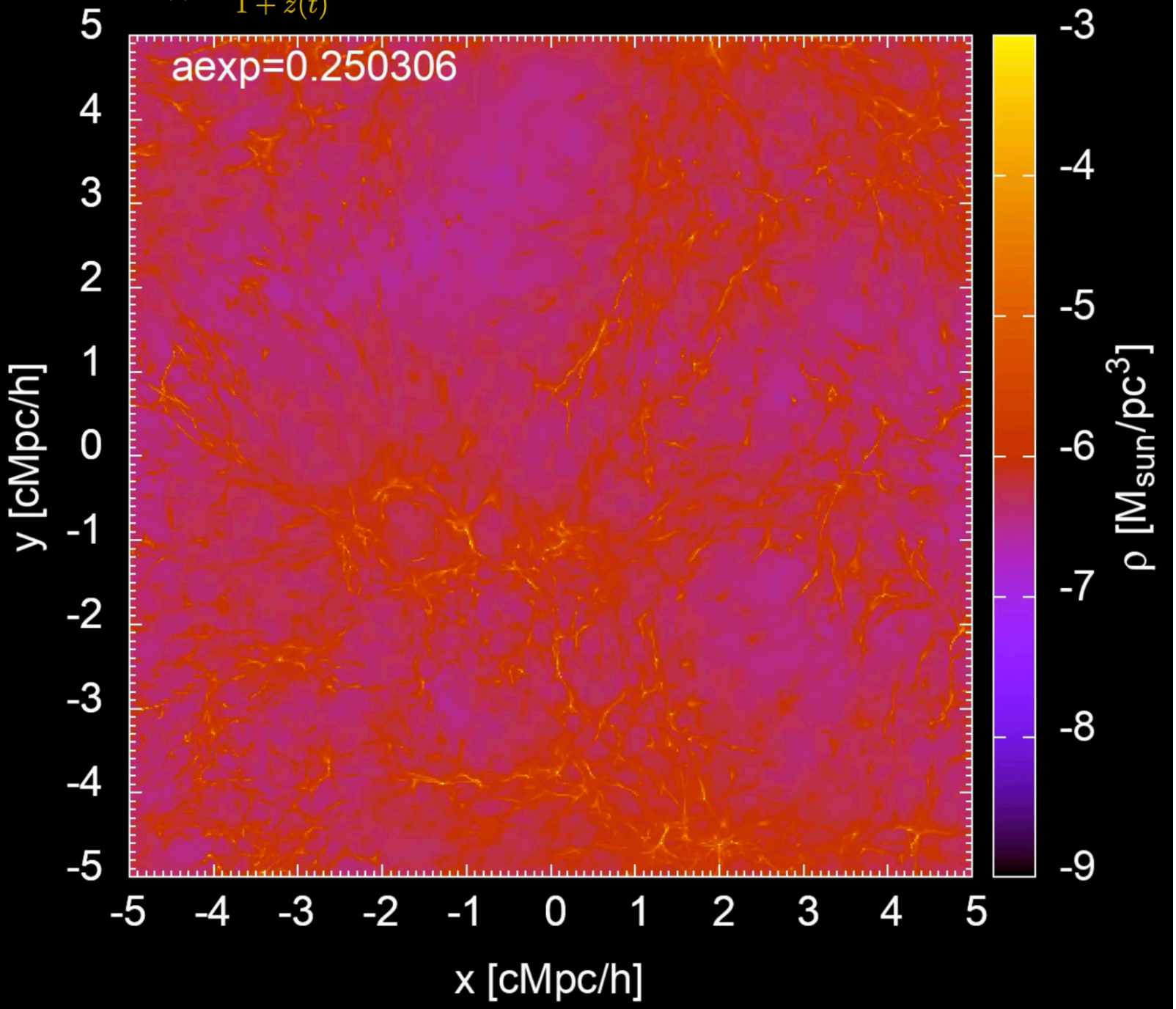

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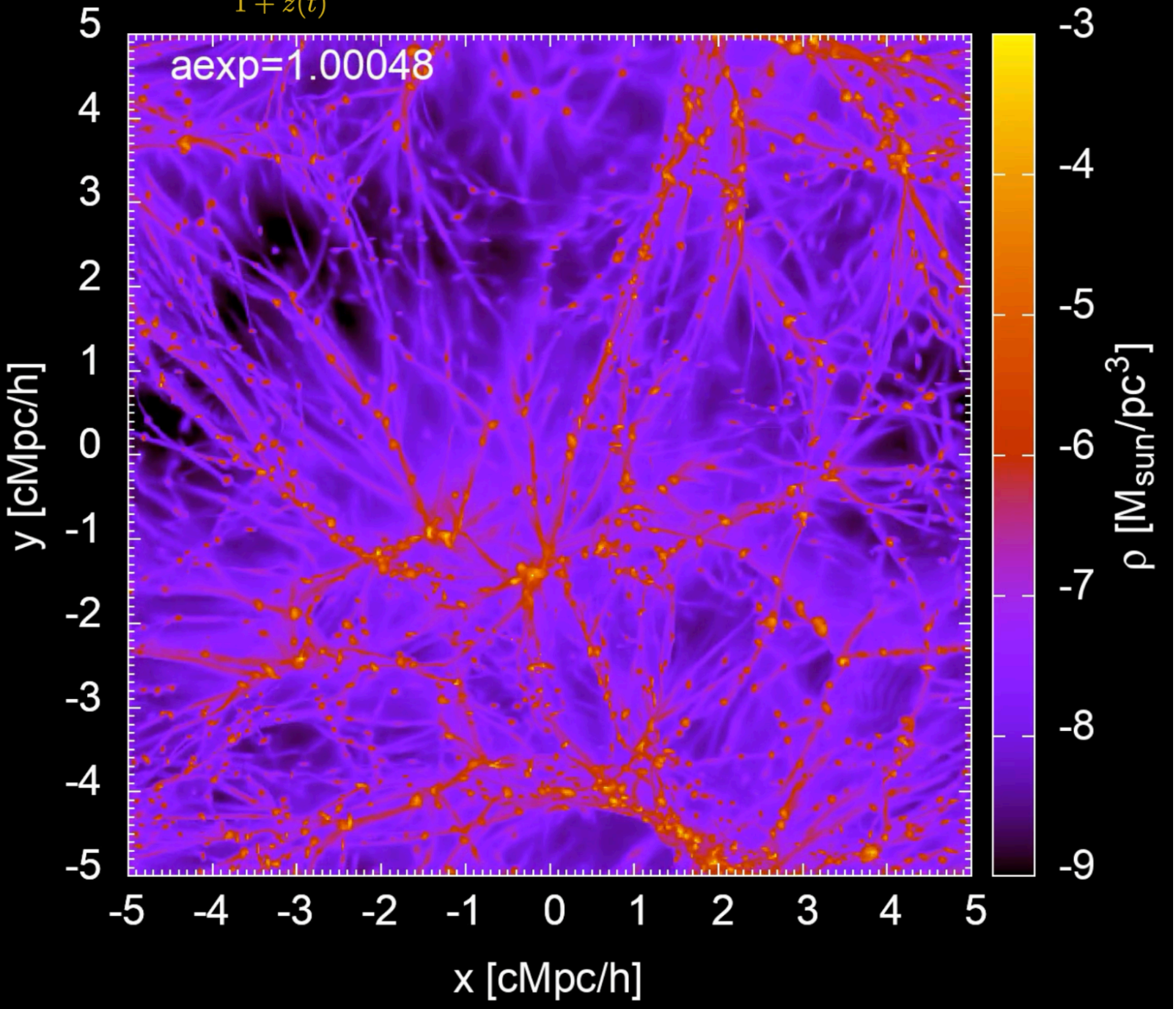

Mass function of galaxies comes out to agree with the observed one

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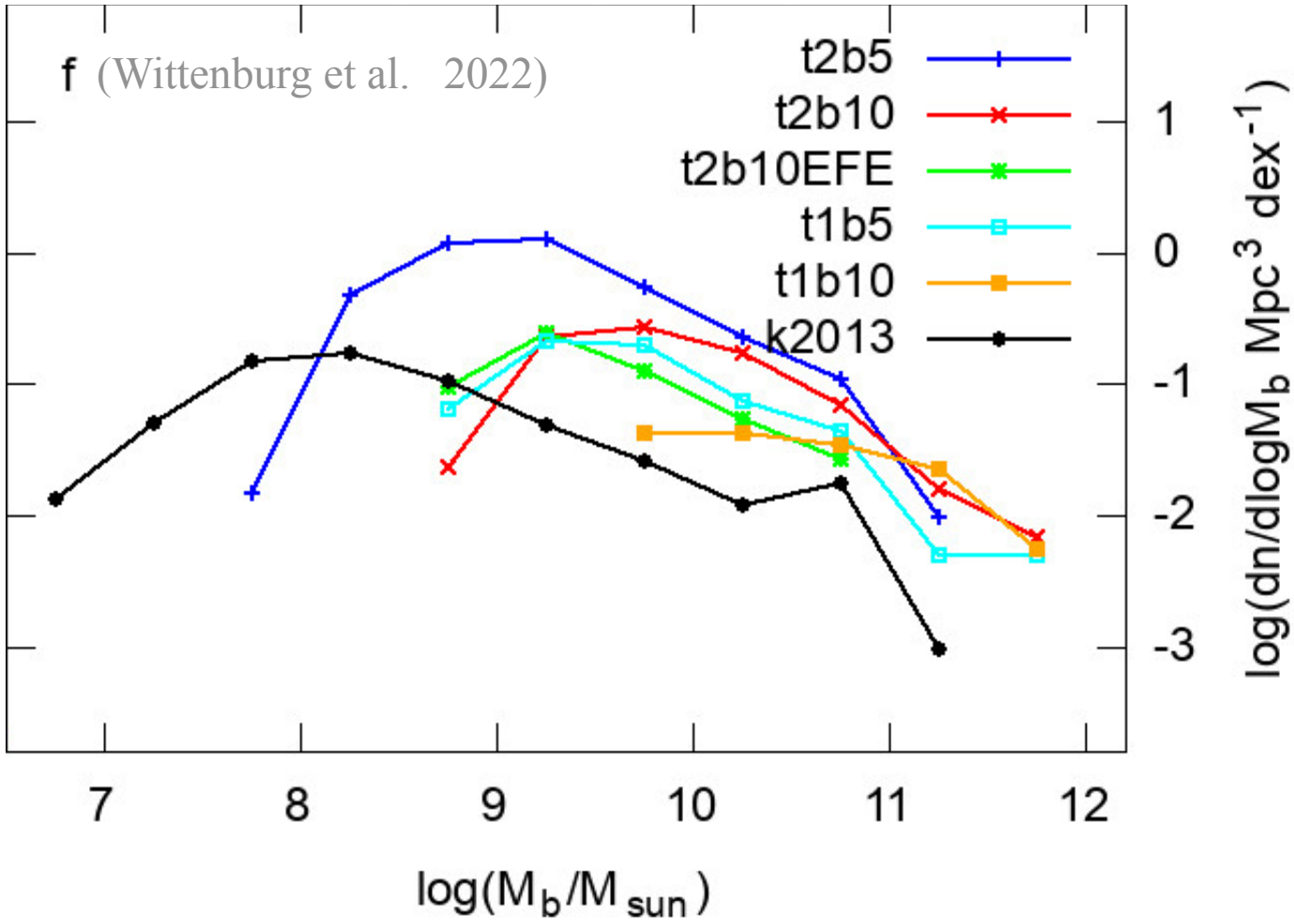
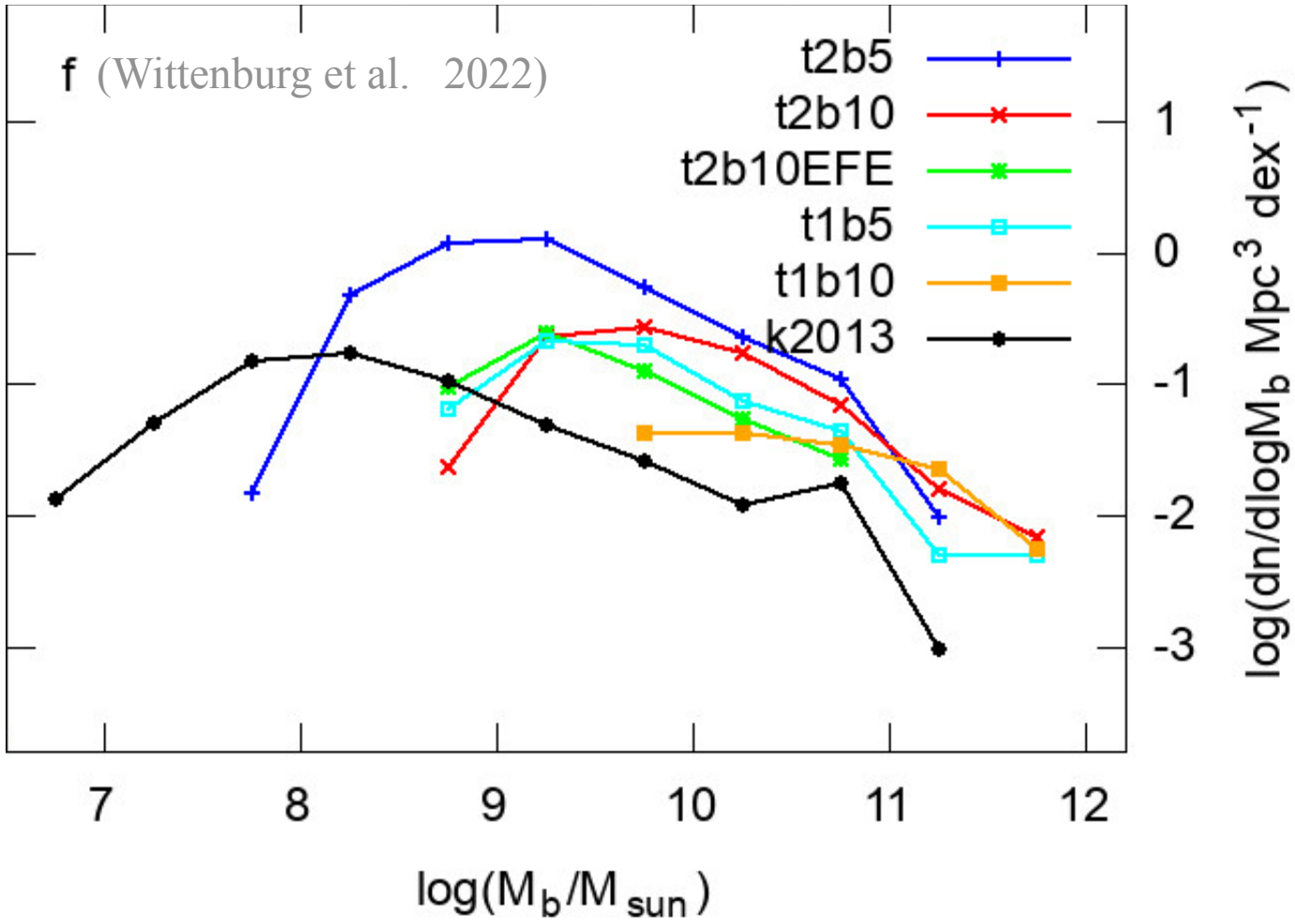


Mass function of galaxies comes out to agree with the observed one

Note the effect of the KBC void.



Use Phantom of Ramses to evolve the nuHDM model to $z = 0$

for correct initial density fluctuations

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nuHDM / Angus09 cosmological model

(see Haslbauer et al. 2020 for details)

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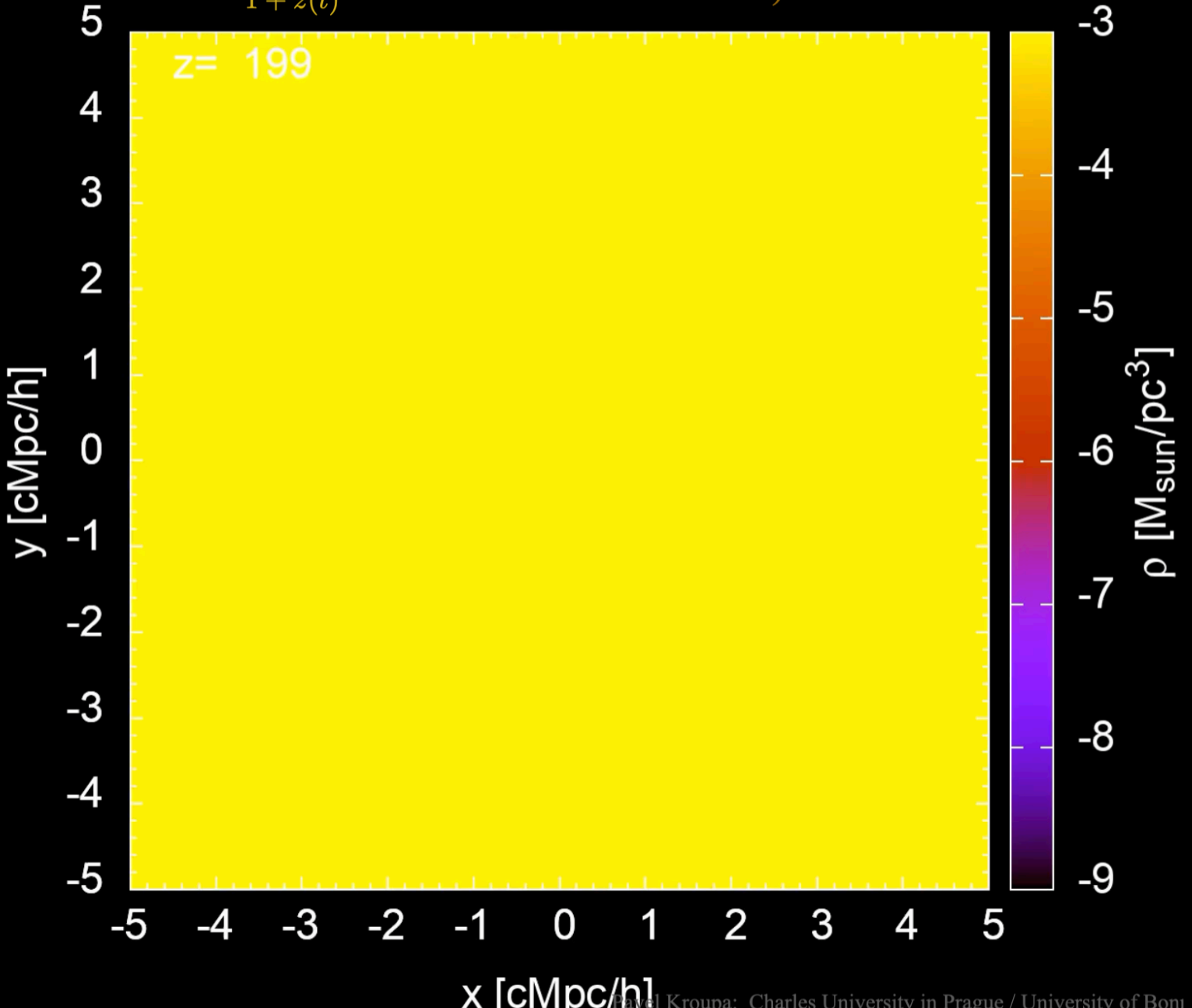

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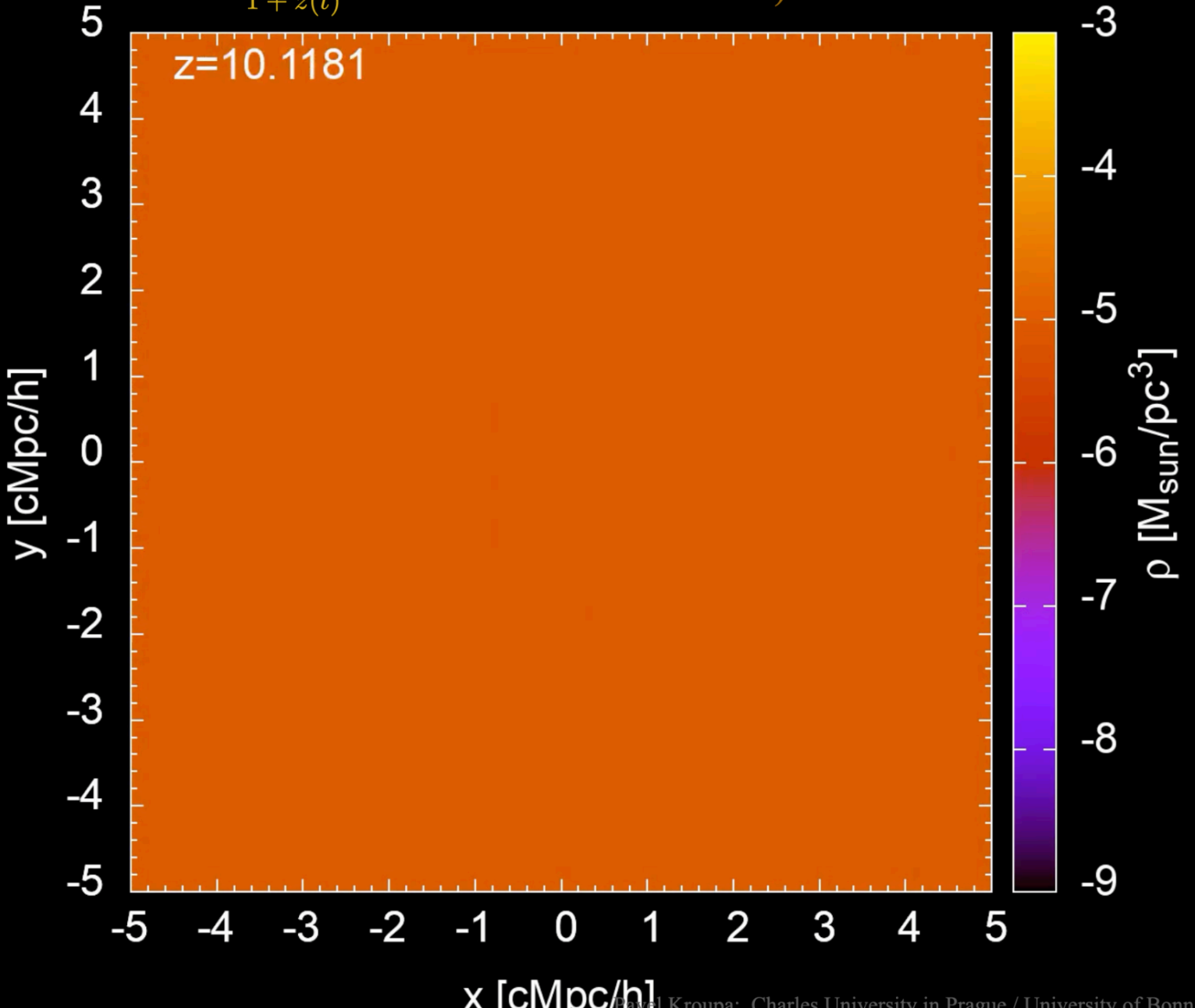

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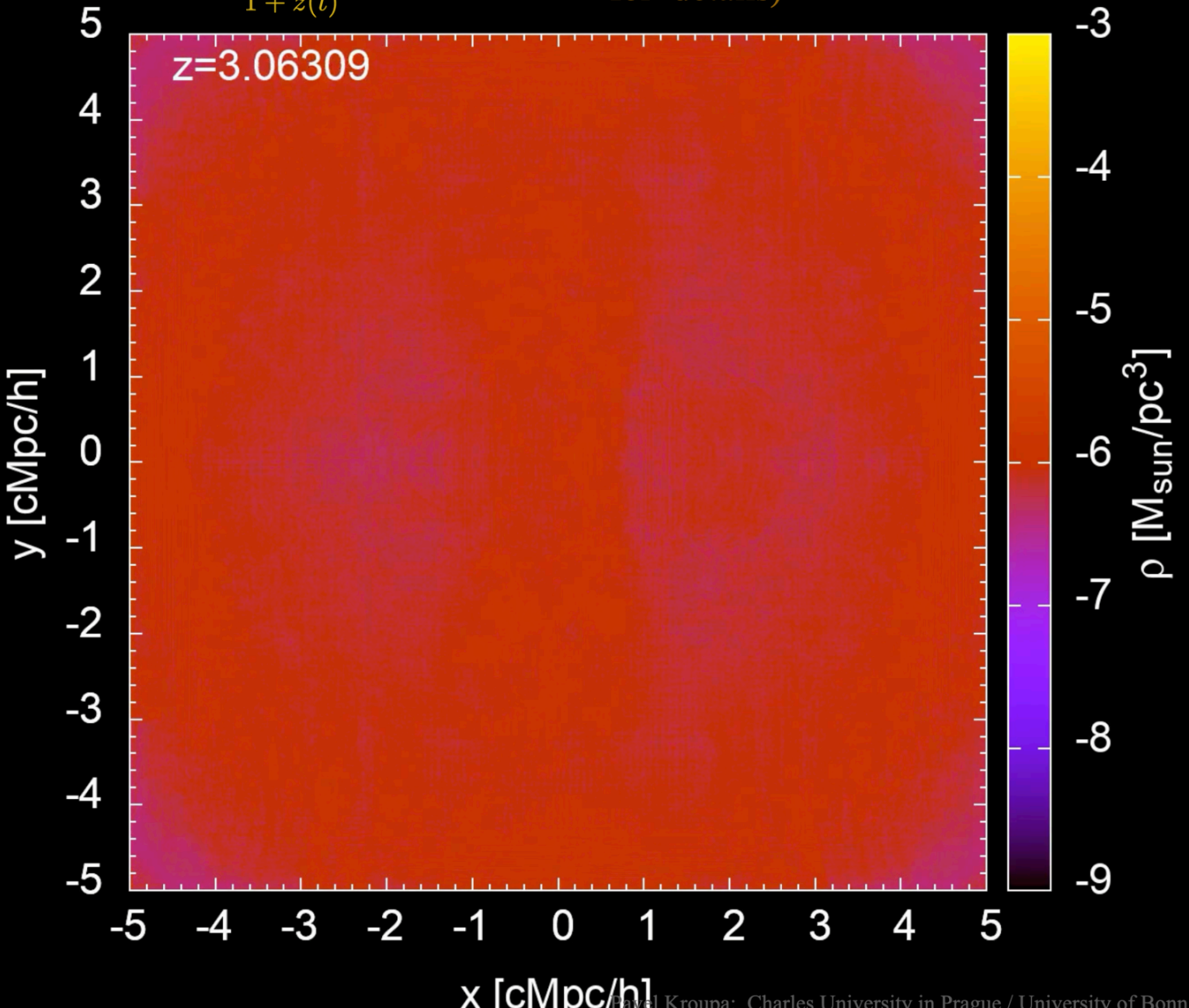

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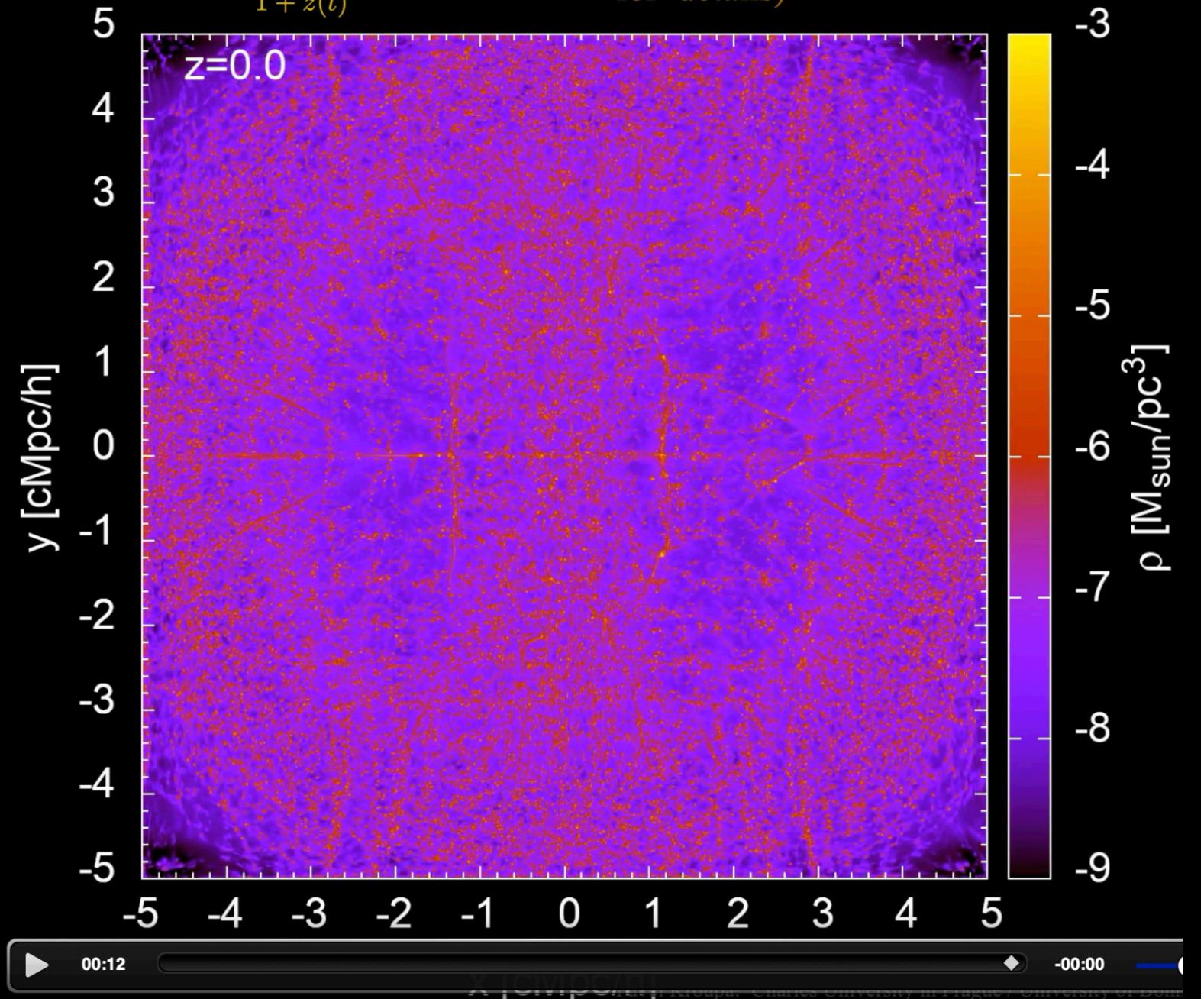

Thus, nuHDM cannot (?) form structures that resemble the observed galaxies

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Why ?

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Calculate transfer function to obtain initial conditions at $z = 200$

944 *G. W. Angus and A. Diaferio* 2011

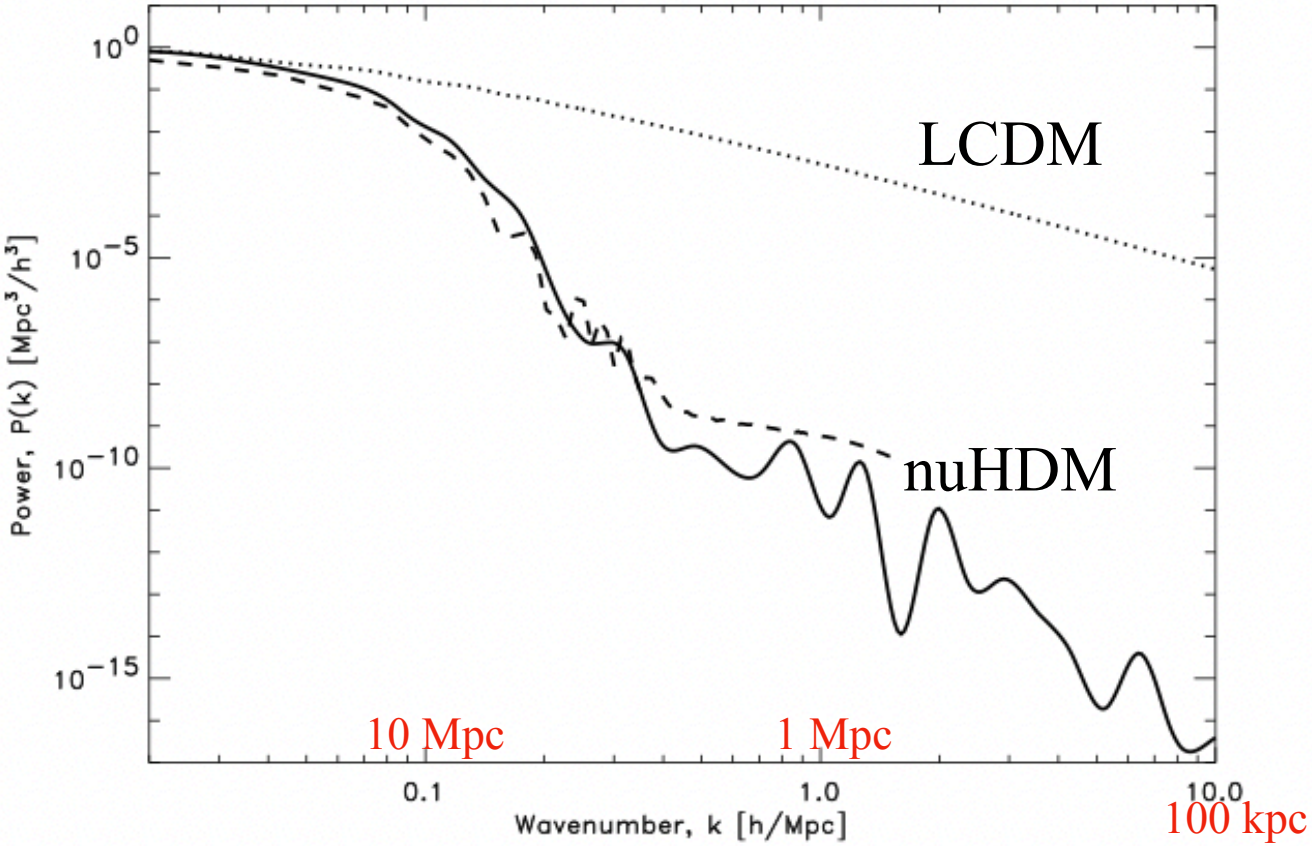

Figure 2. The power spectrum of our N-body realization (dashed) at $z = 254.1$, the expected power spectrum from the CAMB package (solid) for that model as well as the power spectrum for the ΛCDM model (dotted line).

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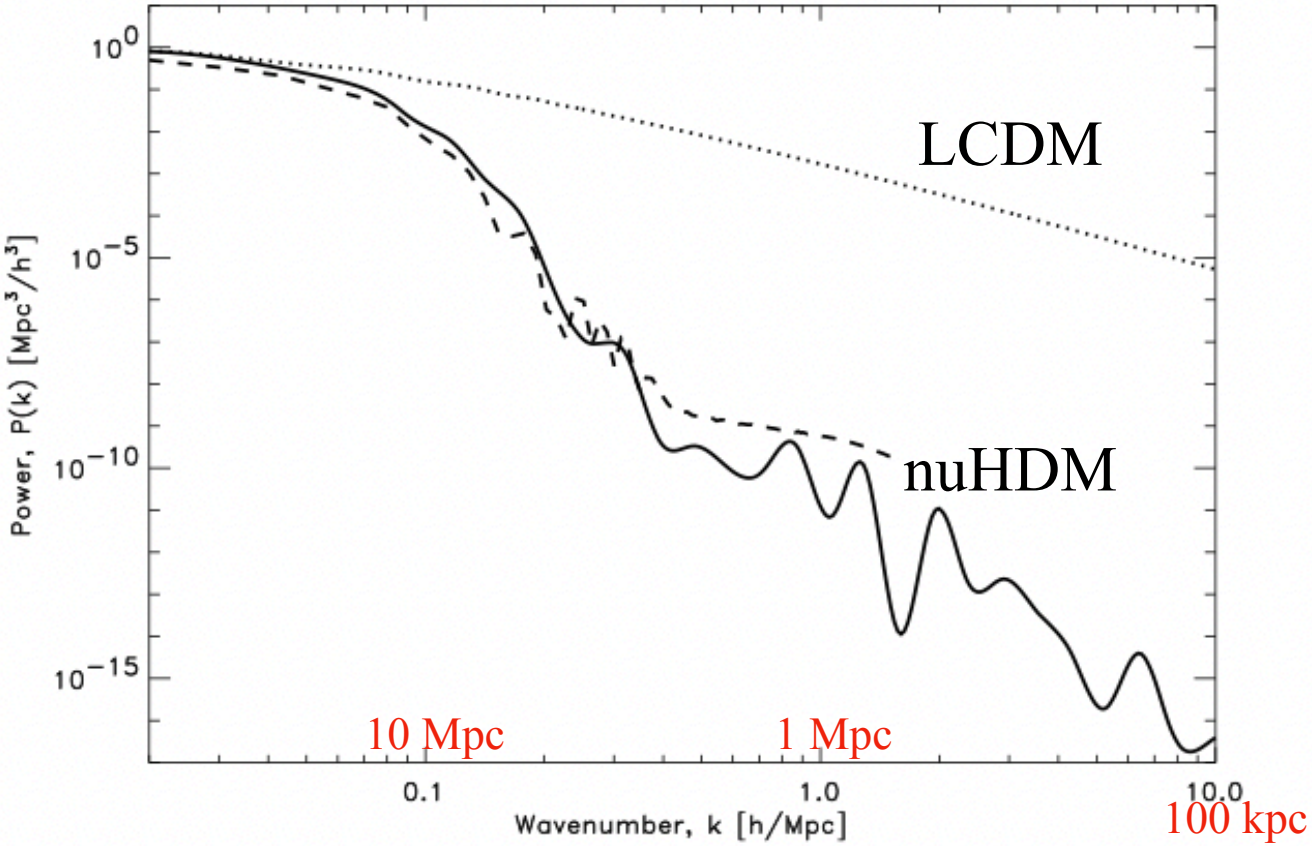

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nuHDM model has $<10^{-7}$ times less power on scales < 1Mpc than the SMoC (LCDM)

Try larger-scale simulation box

Nils Wittenburg

nuHDM / Angus09 cosmological model

(see Haslbauer et al. 2020 for details)

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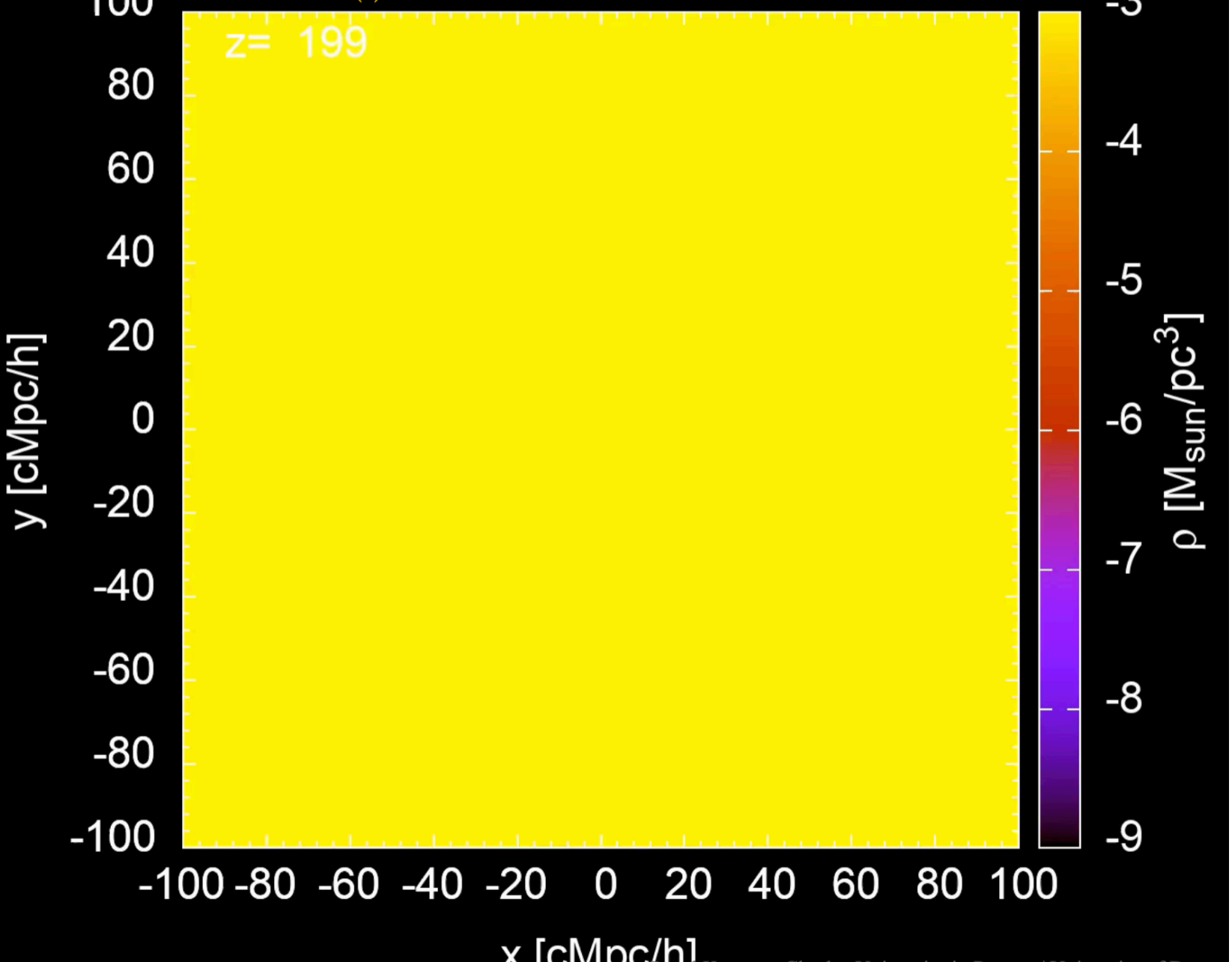

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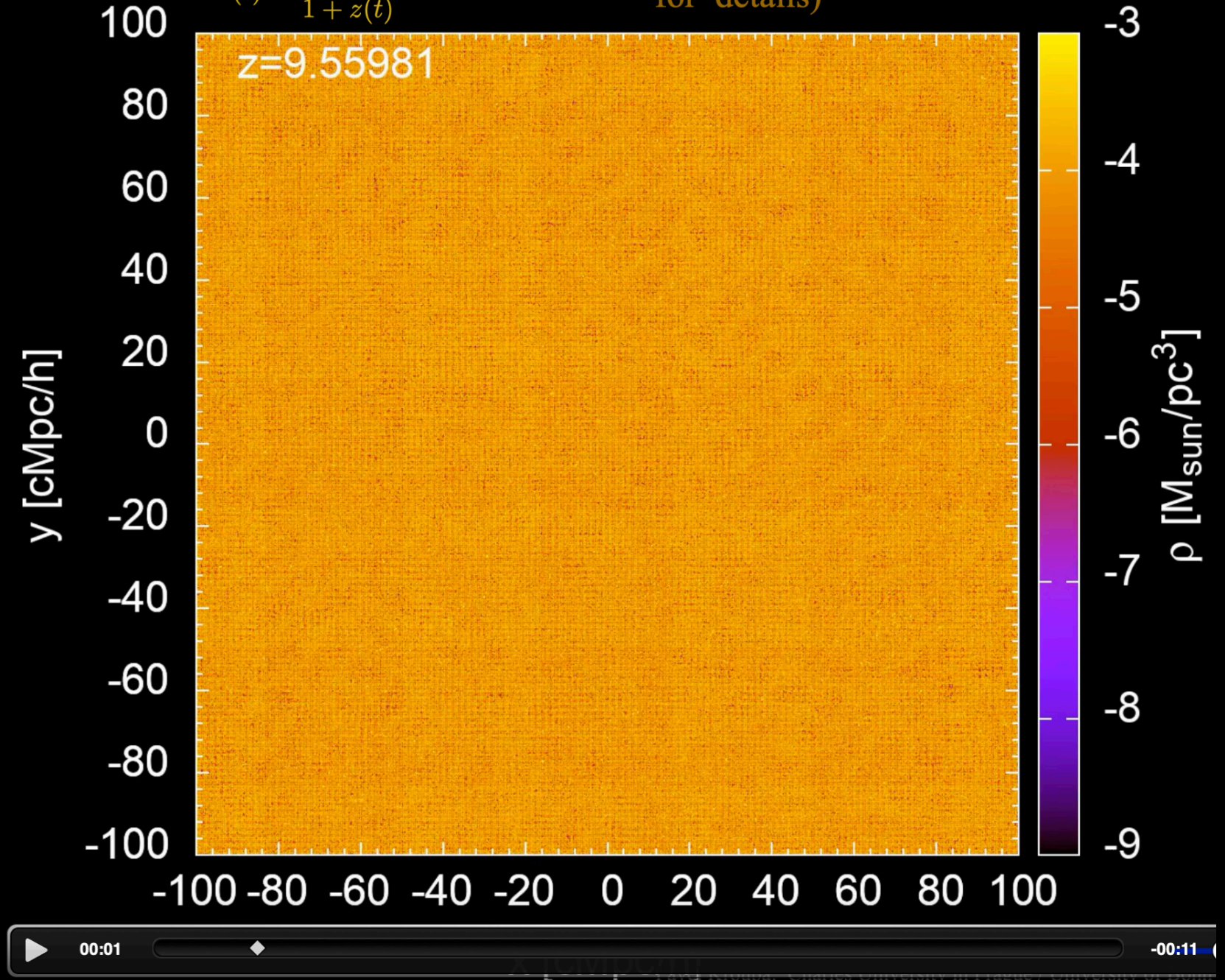

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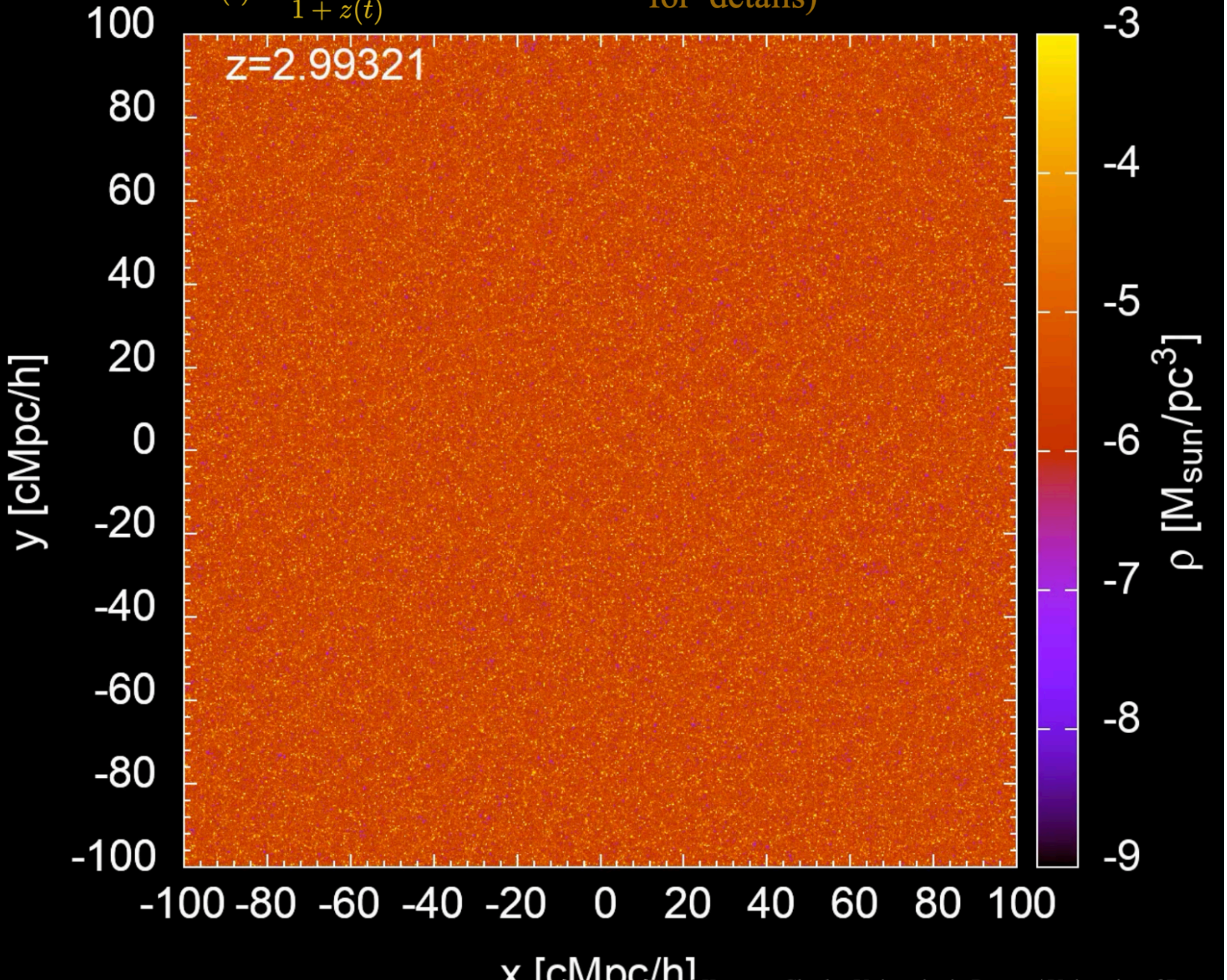

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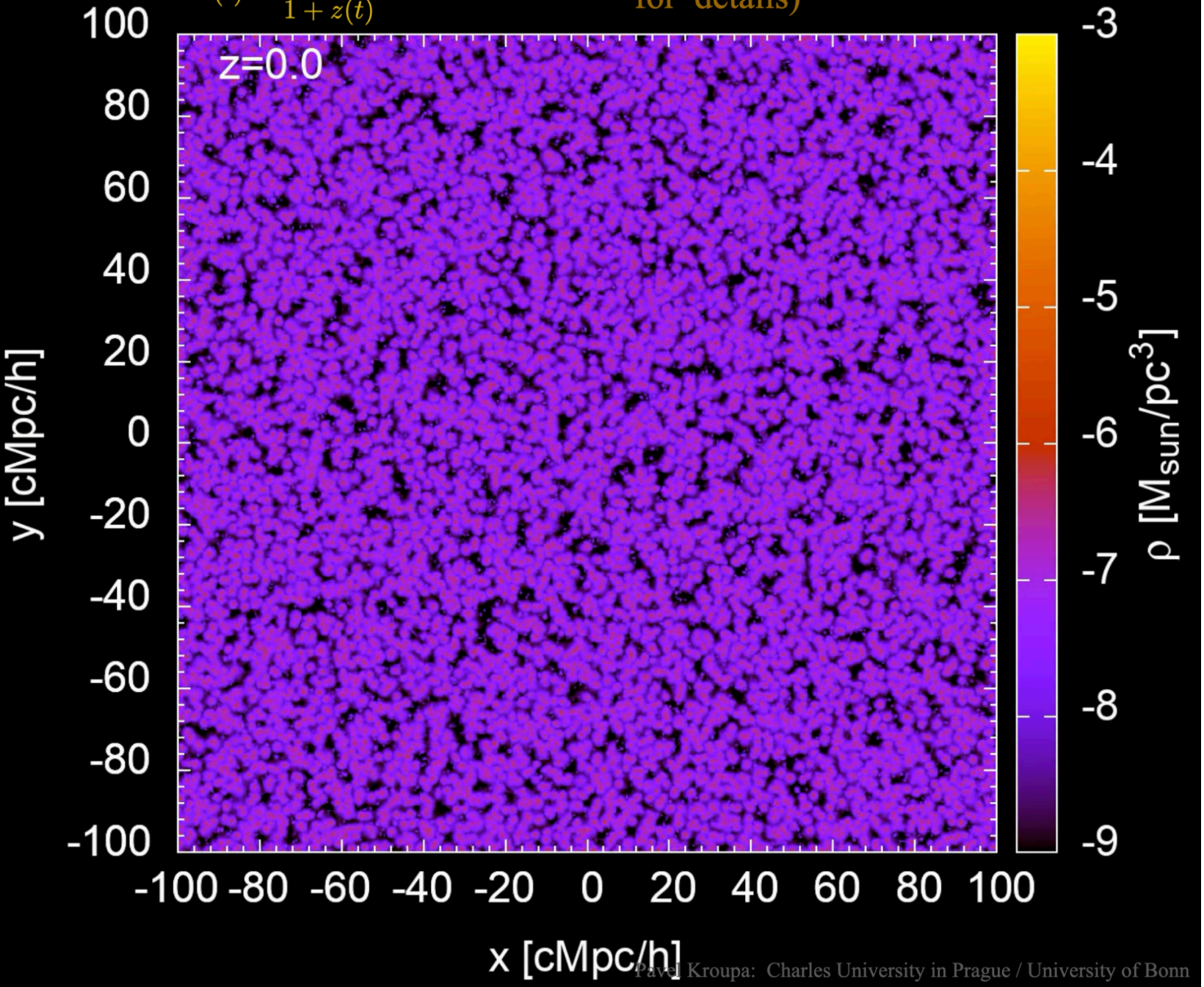

Apparently too many too massive objects (groups of galaxies)

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Consistent with previous results by
Angus & Diaferio (2011) and
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Next steps :

Revisit the physical contents of

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purely speculative

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Dark Energy started a new era of inflation about 5 Gyr ago
dark energy has unphysical properties

- Peacock [1999] : the negative-pressure equation of state of the vacuum makes it a source of unlimited energy allowing any region to inflate arbitrarily at a constant energy density.
- Total misfit to QFT vacuum energy.

Be brave
be bold & radical :
be Bohemian !

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Inflation Hot Big Bang Dark Energy

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The Bohemian model of cosmology

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. . . already partially developed

core ingredients: ....--scale physics
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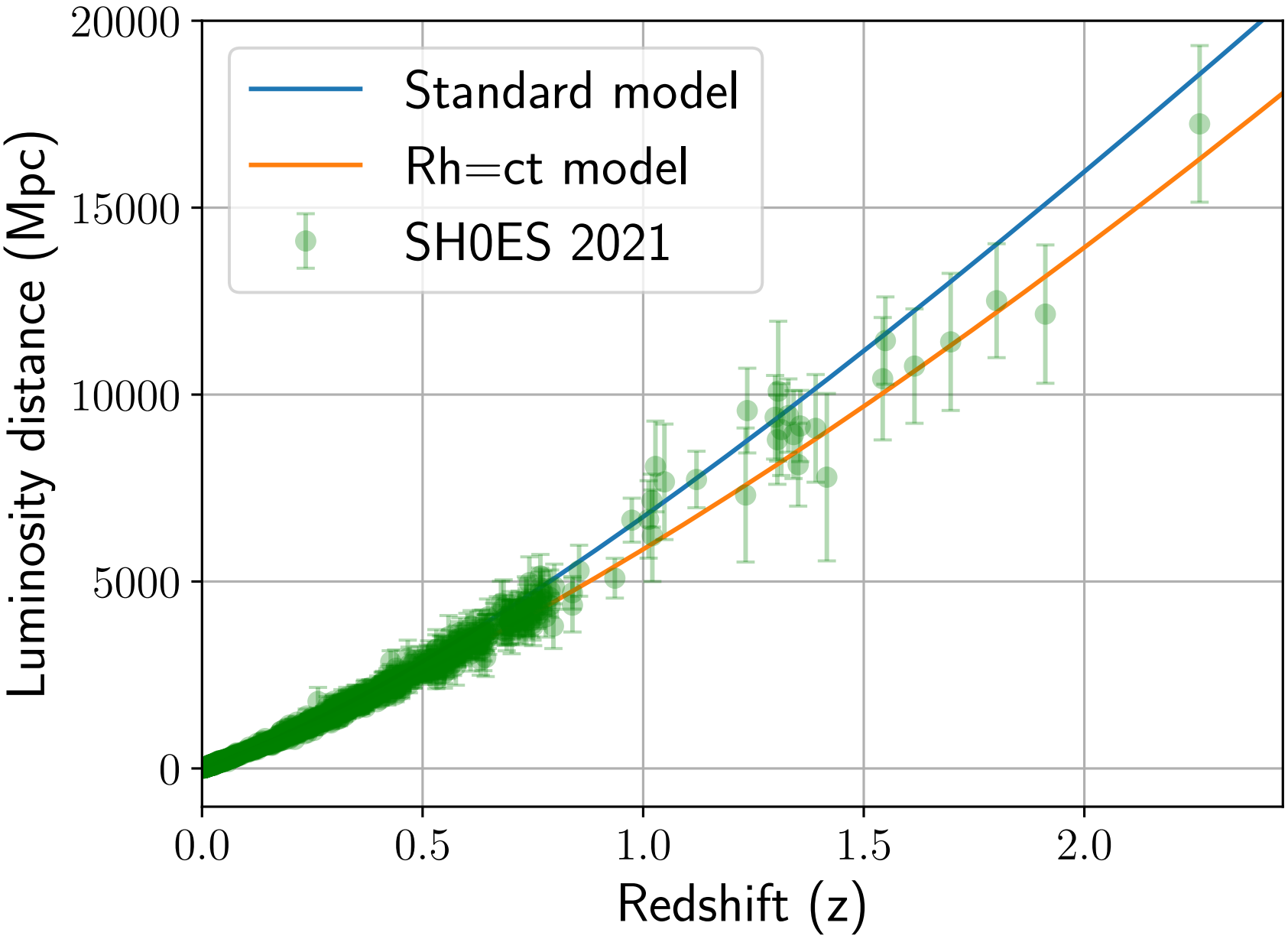
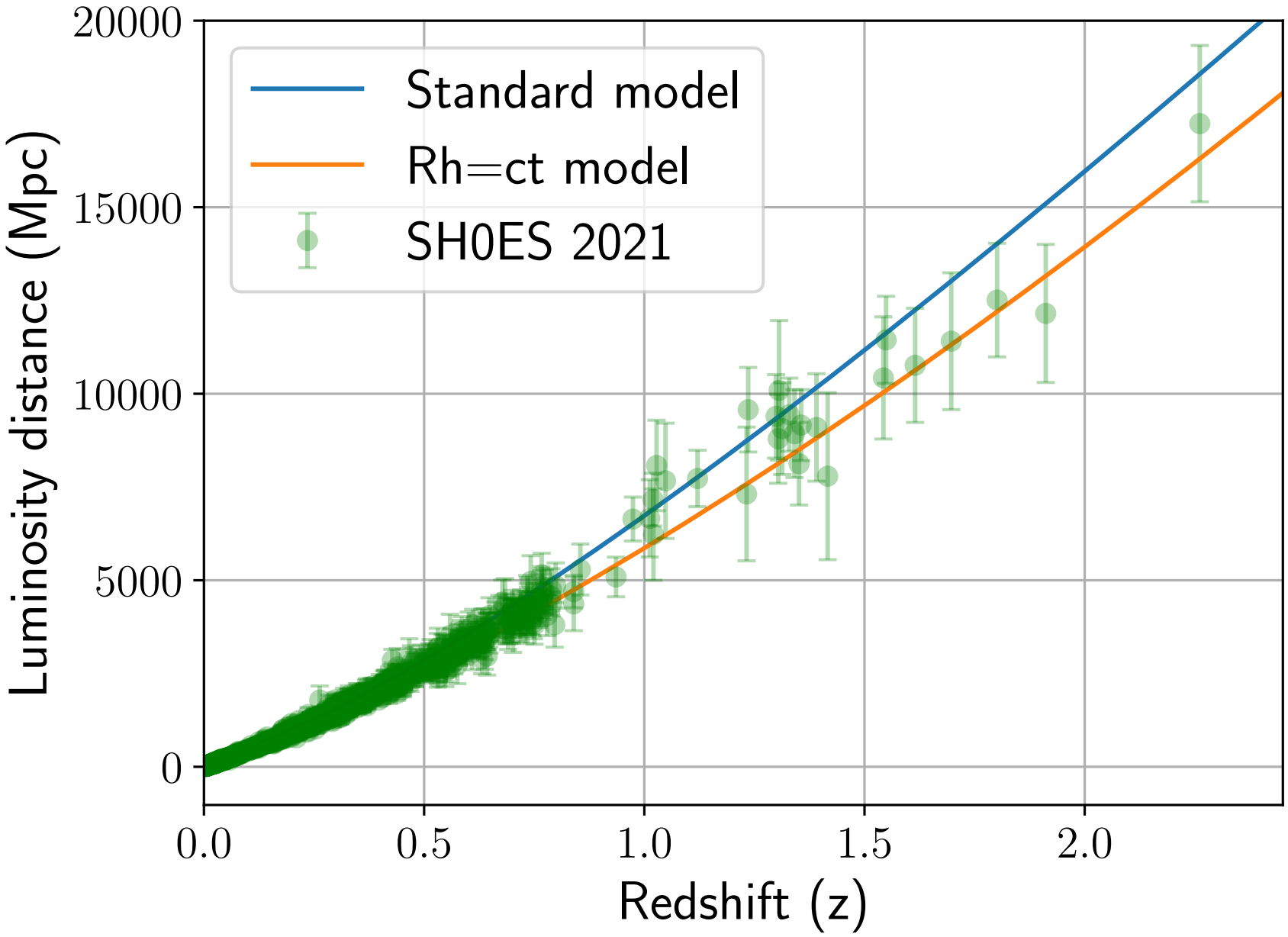
expansion rate = c



1701 SN1a from Riess et al. 2022, ApJ

Important : SMoC = LCDM standard model has been adjusted to fit by varying 3 parameters

$\chi^2 = 0.96$



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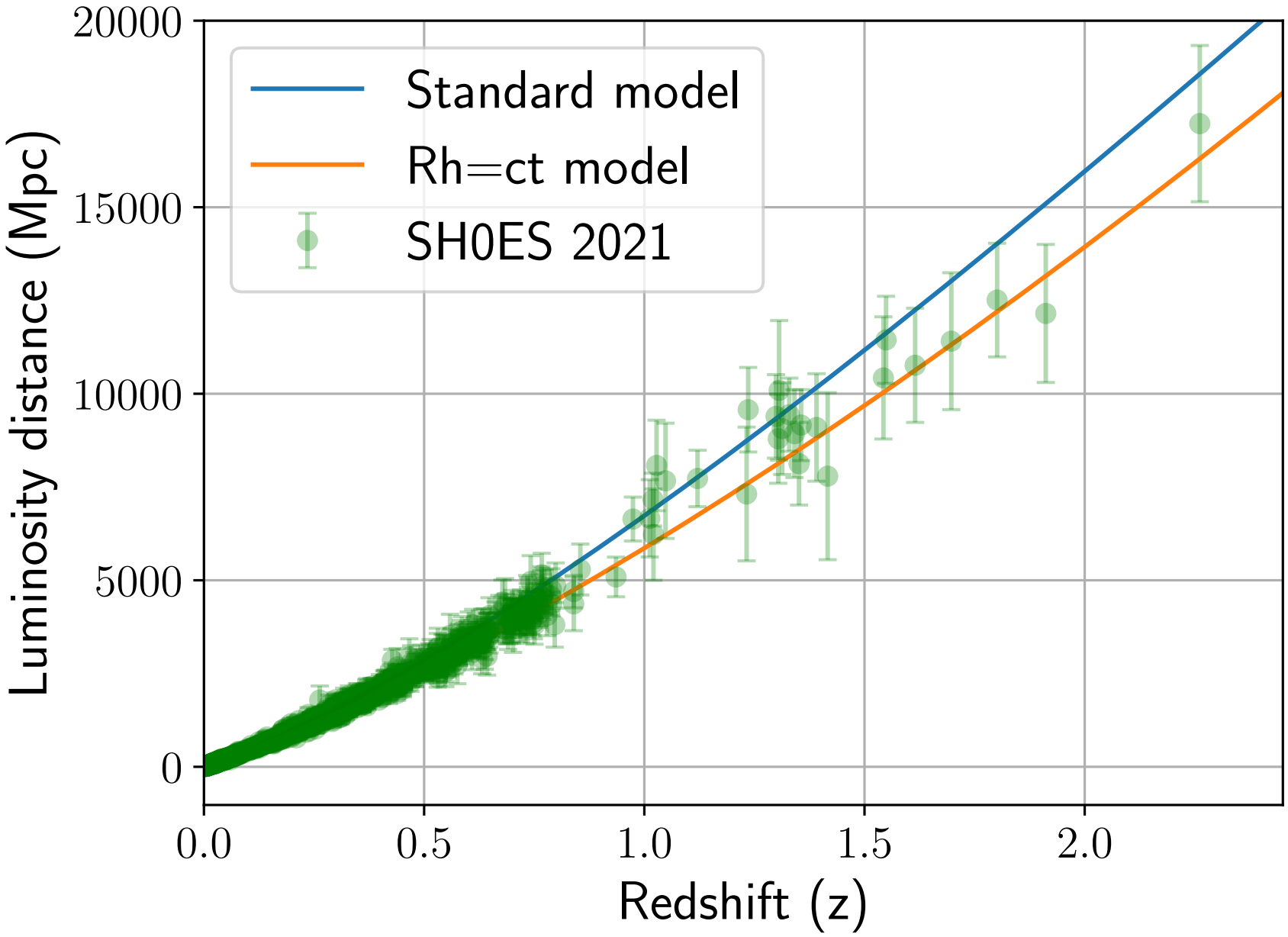

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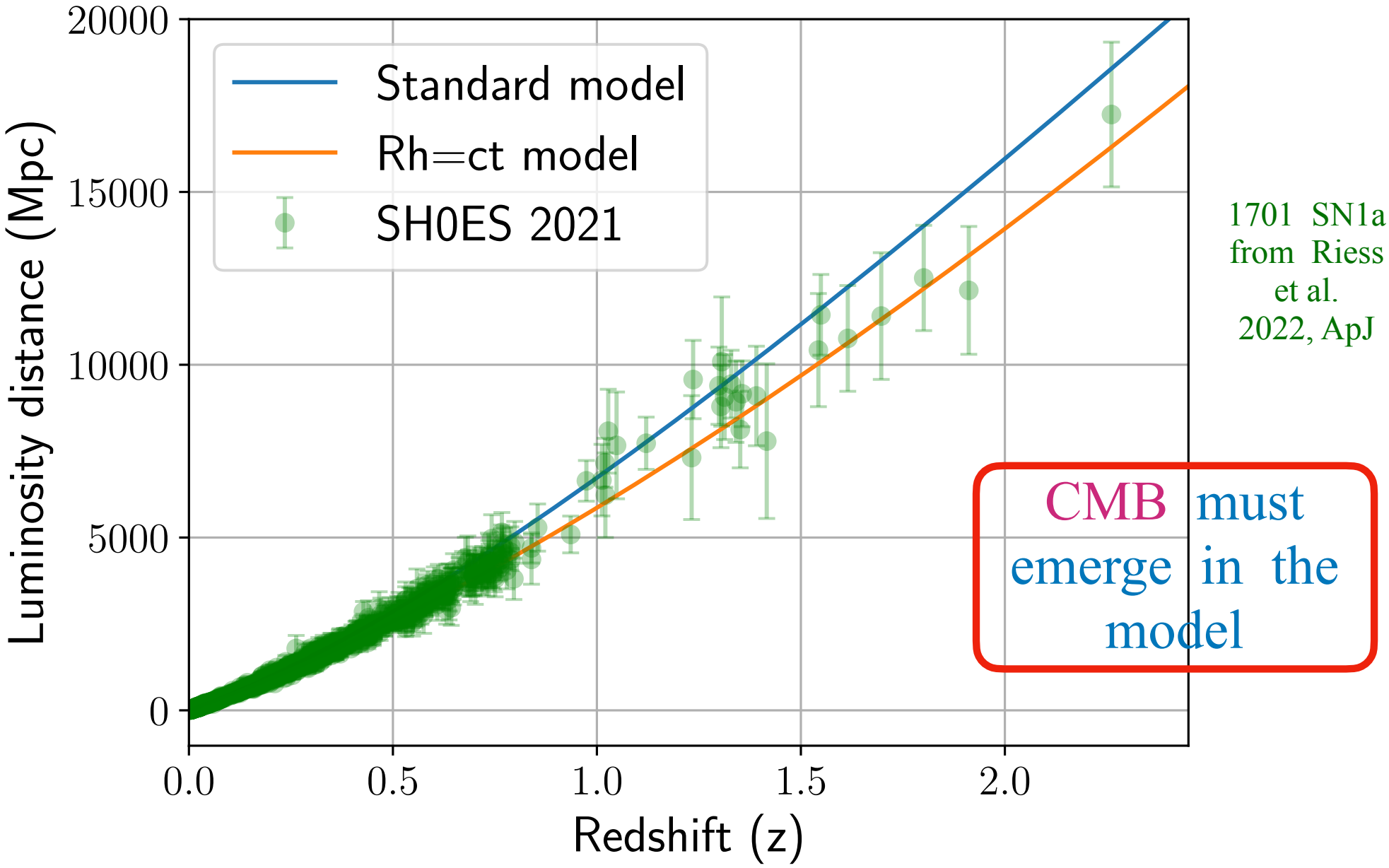

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CMB must emerge in the model

In conclusion :

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The Bohemian model (constant expansion, MOND) has no free parameters, and is being studied now. Looks promising & is very natural.

END