Backreaction in Swiss Cheese models

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Outline

- Introduction and motivation
- Swiss Cheese theorem
- A different model
- Summary

Motivation

The standard way of dealing with inhomogeneities:

- Take a background FRW-universe
- Add 'small' perturbations on top
- Evolution of the background is independent of the inhomogeneities by construction!

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- In perturbation theory, also $\langle\theta\rangle \simeq \theta_b$
- Backreaction is identically zero
- Can we do anything else?

Swiss Cheese models

Embed a LTB (or Szekeres) solution into a background FRW

$$ds^2 = -dt^2 + \frac{R'(t,r)^2}{\sqrt{1+E(r)}}dr^2 + R^2(t,r)d\Omega^2$$

- Solves Einstein equations exactly (Darmois junction)
- Only dust $\rightarrow$ singularities
- Can have many holes, as long as they do not overlap
- Can be made statistically homogeneous and isotropic

SC theorem

Under the following conditions, $\langle \theta_{\mathrm{hole}} \rangle \simeq \theta_b$

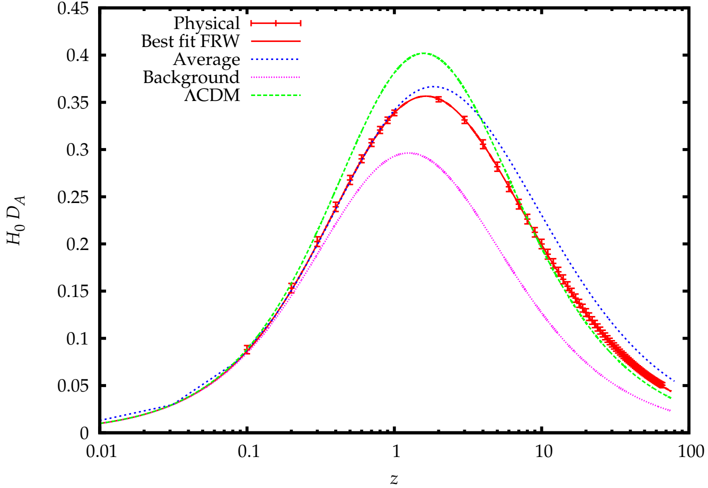
1. There exists a coordinate r for the LTB solution, for which $R(t, r = 0) = 0$ at all times,
2. $R(t, r)$ is a monotonous function of r,
3. Today (t_0) all regions are approximately equally old, $t_{B\mathrm{max}} - t_{B\mathrm{min}} \ll t_0$ and they have no singularities before today,
4. The LTB solution can be matched continuously to an FRW spacetime at the boundary,
5. The holes are small compared to the curvature radius of the universe.

Tardis?

$R' = 0$? What happens?

- Boundary layers on shells with $R' = 0$
- $\rightarrow$ no longer a dust-only solution
- Can be understood as a weird embedding of multiple LTB solutions
- If we allow $\langle \theta_{\rm hole} \rangle \neq \theta_b$, the real volume of holes is different from the embedding region $\rightarrow$ "larger from the inside"
- If we disregard the boundary layers, everything behaves well

Results


Physical
Best fit FRW
Average
Background
ΛCDM
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.01
0.1
1
10
100
$H_0 D_A$
z

Summary

- Swiss Cheese models are very limited by their construction
- Under some physical conditions, backreaction must be small
- Breaking the conditions can lead to interesting effects