L'énergie noire en tant qu'artefact de l'époque de la virialisation

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- when/where should ΛCDM, EdS fail?

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- Newton $\neq$ Einstein $\Rightarrow$ ΛCDM, EdS should fail at $\ll 3\ h^{-1}$ Gpc and $z < 3$

beyond the homogeneous model

- what parameter can measure the expected failure of the homogeneous models?

beyond the homogeneous model

- $f_{\rm vir}(z) :=$ fraction of virialised matter (large-scale structure, clusters, galaxies)

beyond the homogeneous model

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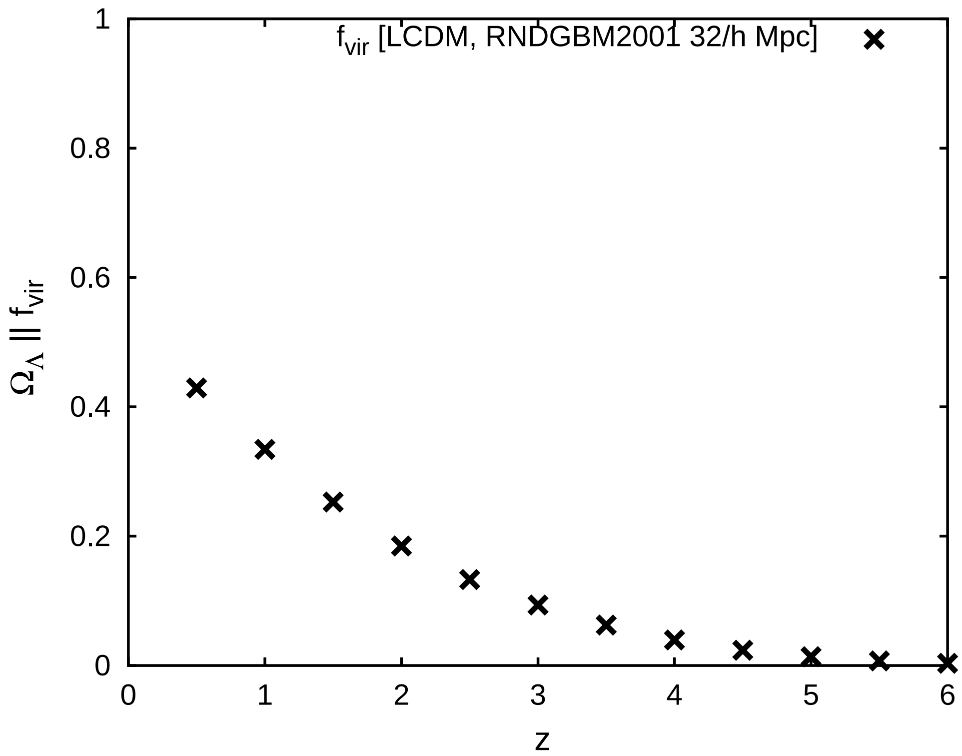

Roukema, Ninin, Devriendt, Bouchet, Guiderdoni & Mamon (2001)

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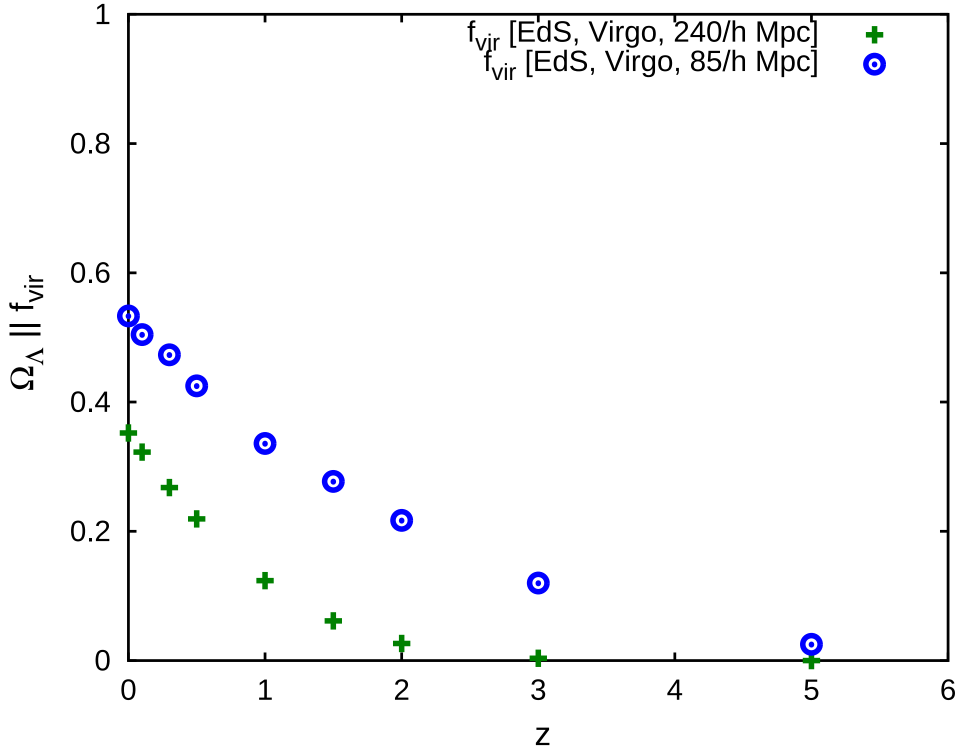

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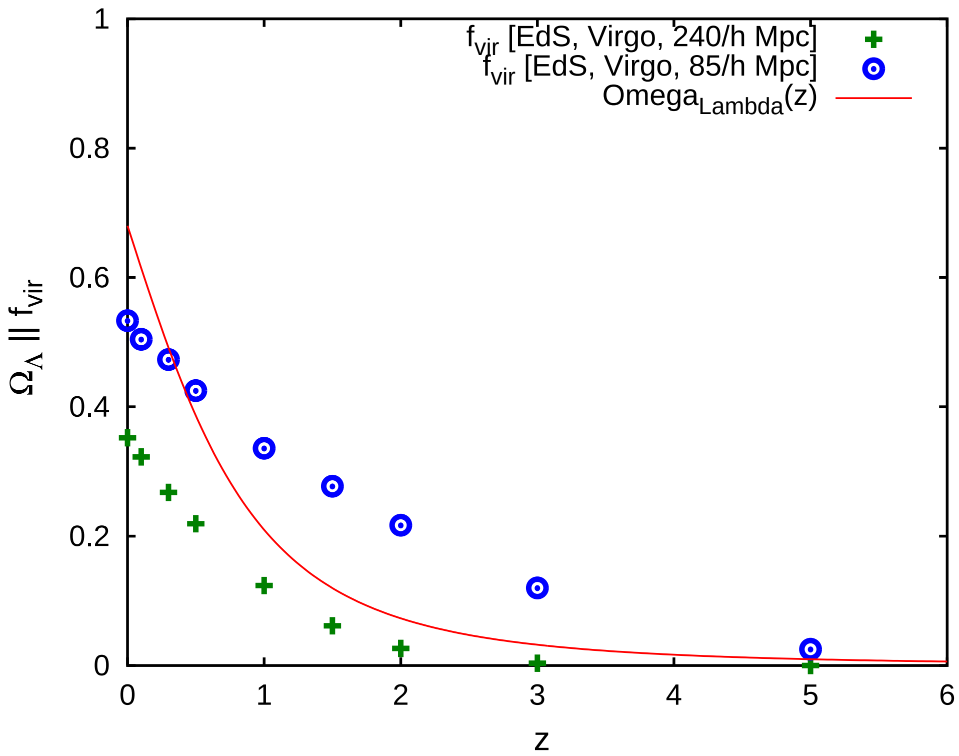

Roukema, Ostrowski, Buchert, 2013, JCAP, 10, 043

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- Is $\Omega_\Lambda(z)$ an artefact of ignoring virialisation?

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$$\Omega_{\rm m} + \Omega_\Lambda + \Omega_{\rm k} = 1.$$

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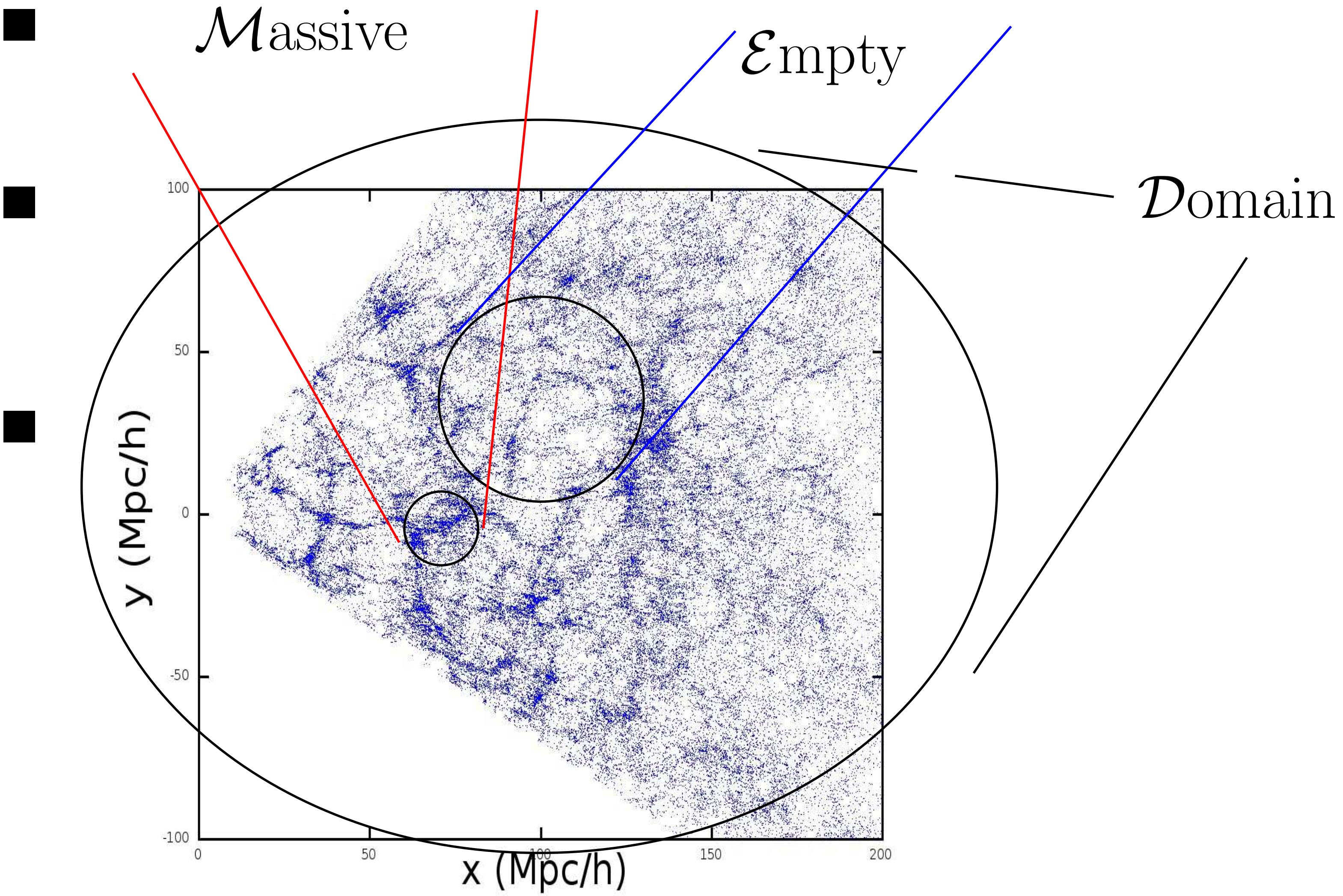

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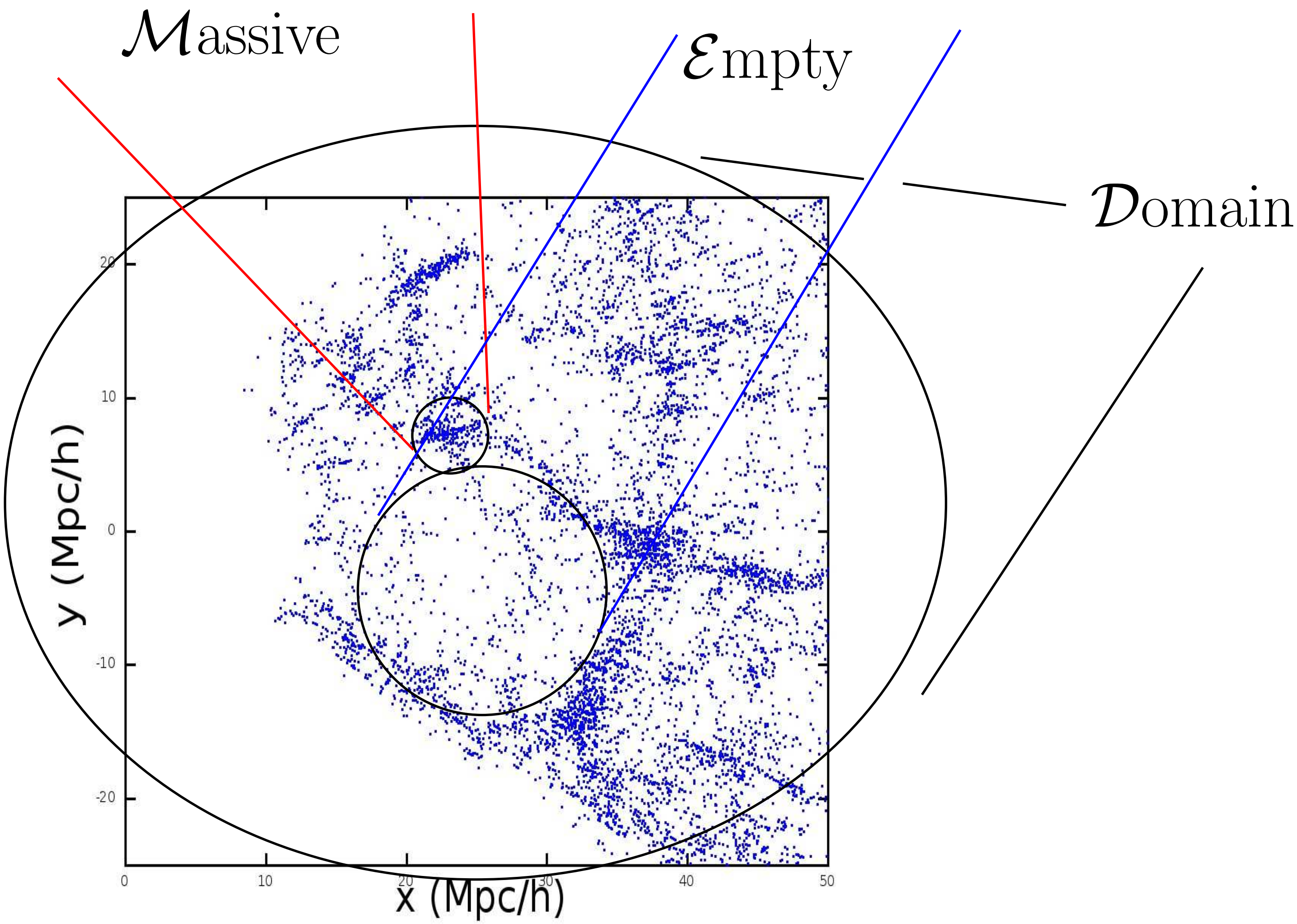

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  generalised Friedmann equation (Hamiltonian constraint):
  $$\Omega^{\mathcal{F}}_{\rm m} + \Omega^{\mathcal{F}}_\Lambda + \Omega^{\mathcal{F}}_{\mathcal{R}} + \Omega^{\mathcal{F}}_{\mathcal{Q}} = \frac{H^2_{\mathcal{F}}}{H^2_{\mathcal{D}}} \ , \quad \text{where } \mathcal{F} \in \{\mathcal{M}, \mathcal{E}, \mathcal{D}\}$$

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- assume $\Omega_\Lambda^{\mathcal{F}} = 0$
- assume $|\Omega_{\mathcal{Q}}^{\mathcal{F}}| \ll 1$

EdS + virialisation

- early: V(voids) : V(structures) $\sim 1 - f_{\rm vir} : f_{\rm vir}$

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- late : V(voids) : V(structures) $\sim 1 - f_{\mathrm{vir}}/\Delta_{\mathrm{vir}} : f_{\mathrm{vir}}/\Delta_{\mathrm{vir}}$
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$$\Omega^{\mathcal{D}}_{\rm m} = \lambda_{\mathcal{M}}\Omega^{\mathcal{M}}_{\rm m} + (1-\lambda_{\mathcal{M}})\,\Omega^{\mathcal{E}}_{\rm m}$$
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$\Rightarrow \Omega^{\rm eff}_{\rm m}(z)$ drops when $f_{\rm vir}(z)$ grows

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$\Rightarrow \Omega^{\rm eff}_{\rm m}(z)$ drops when z drops

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$\Rightarrow$ curvature more negative when z drops

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(Riess et al. 2011; Freedman et al. 2012)

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(Riess et al. 2011; Freedman et al. 2012)

$$R_{\rm C}^{\rm eff}(z) = \frac{c}{aH^{\rm eff}(z)\,\sqrt{\Omega_{\mathcal{R}}^{\rm eff}(z)}}$$

effective metric

$$\mathrm{d}s^2 \;=\; -\mathrm{d}t^2 + a^2(t)\left[\mathrm{d}{\chi^{\mathrm{eff}}}^2 + {R_{\mathrm{C}}^{\mathrm{eff}}}^2\left(\sinh^2\frac{\chi^{\mathrm{eff}}}{R_{\mathrm{C}}^{\mathrm{eff}}}\right)(\mathrm{d}\theta^2 + \cos^2\theta\,\mathrm{d}\phi^2)\right]$$

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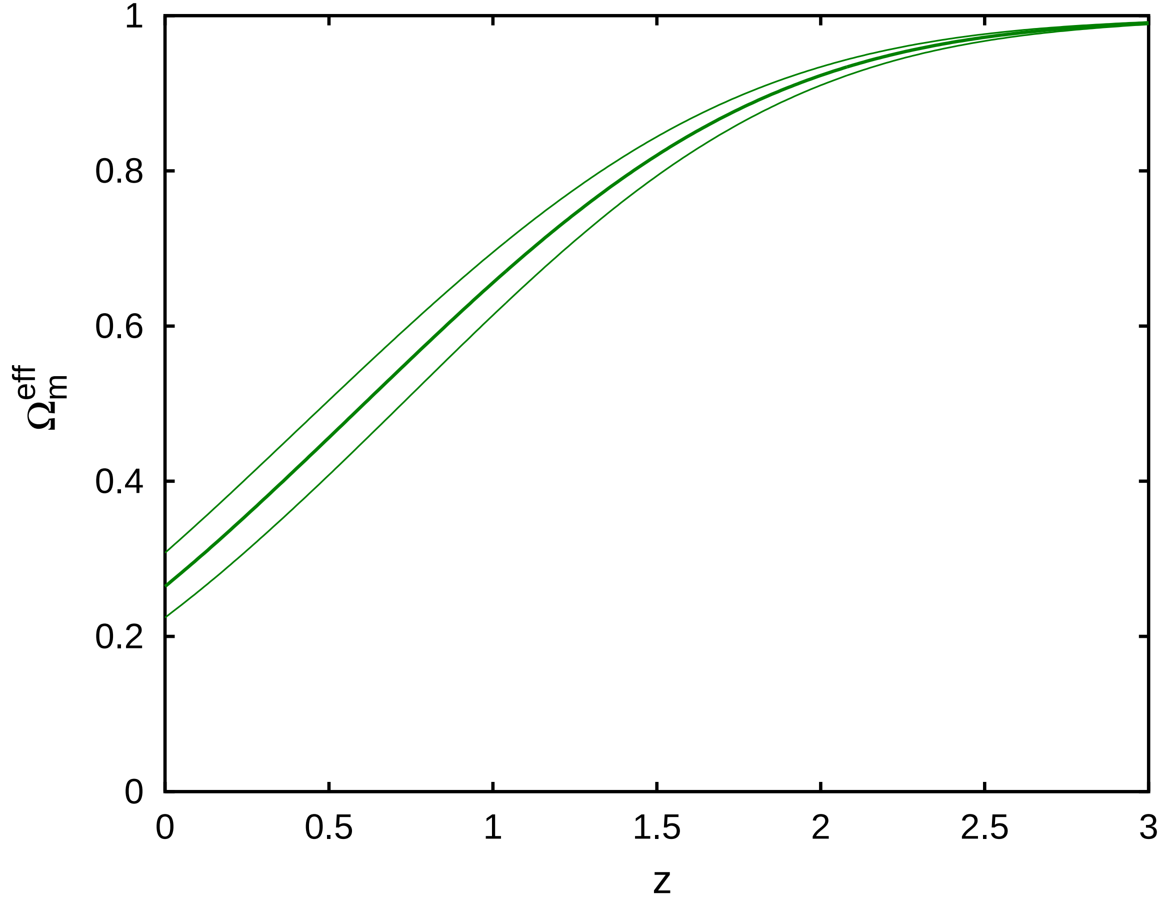
$$d_L^{\mathrm{eff}} = (1+z)R_{\mathrm{C}}^{\mathrm{eff}}\sinh\frac{\chi^{\mathrm{eff}}}{R_{\mathrm{C}}^{\mathrm{eff}}}$$

EdS + virialisation



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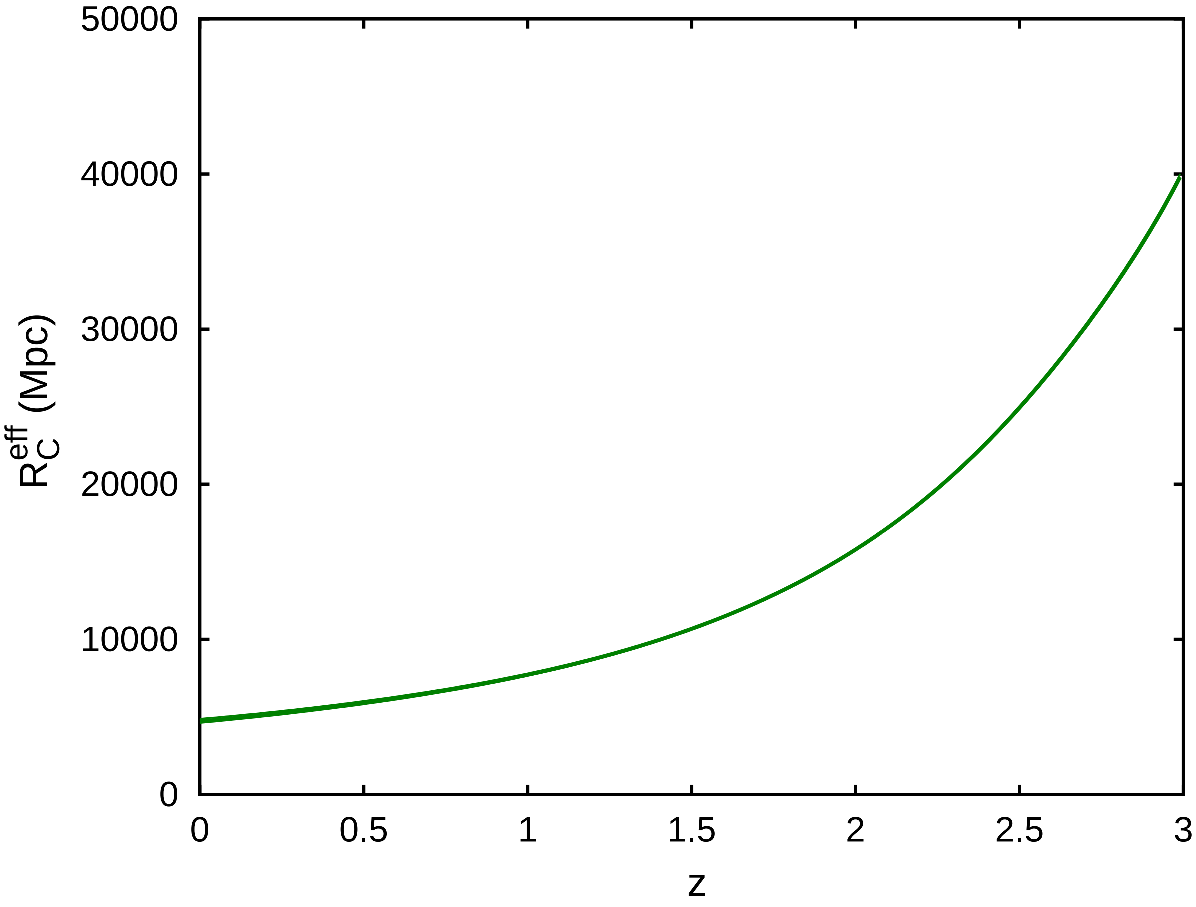

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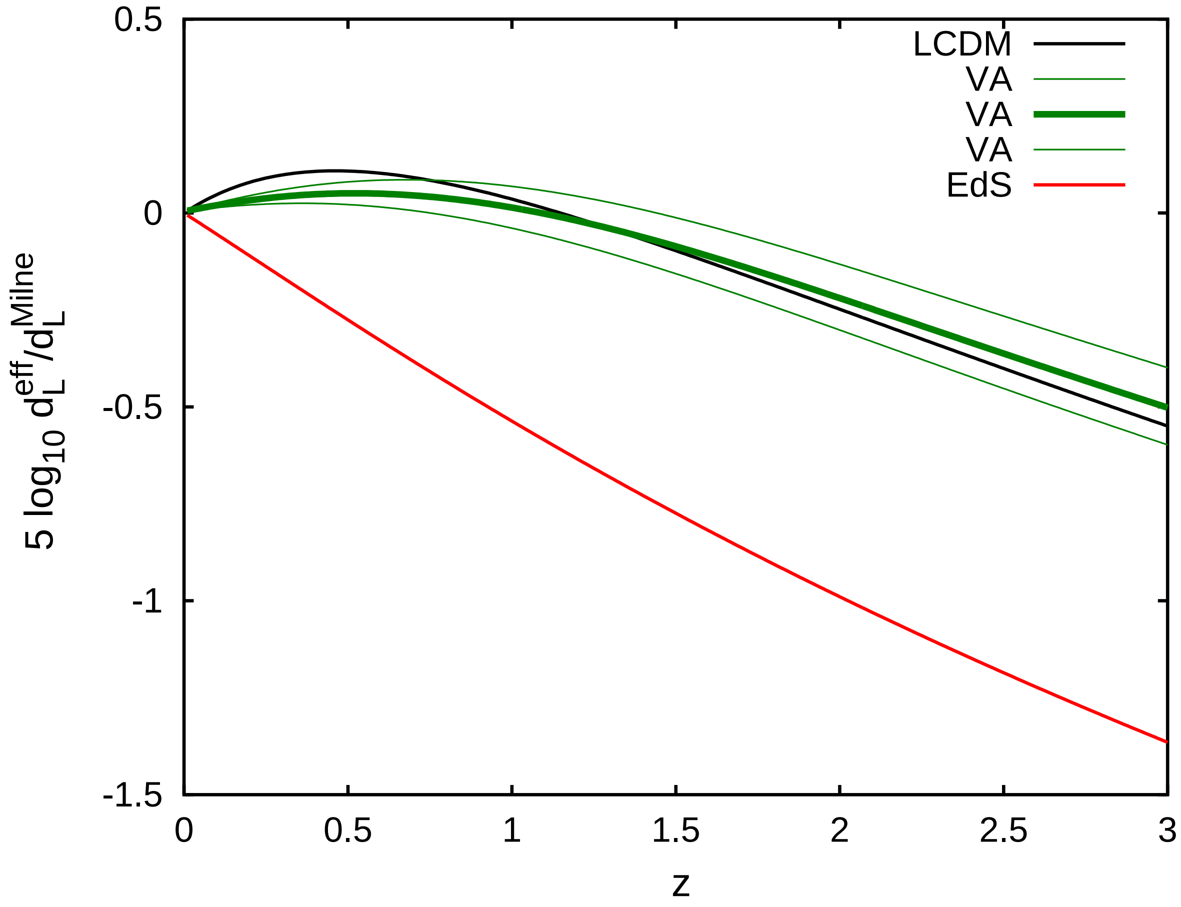

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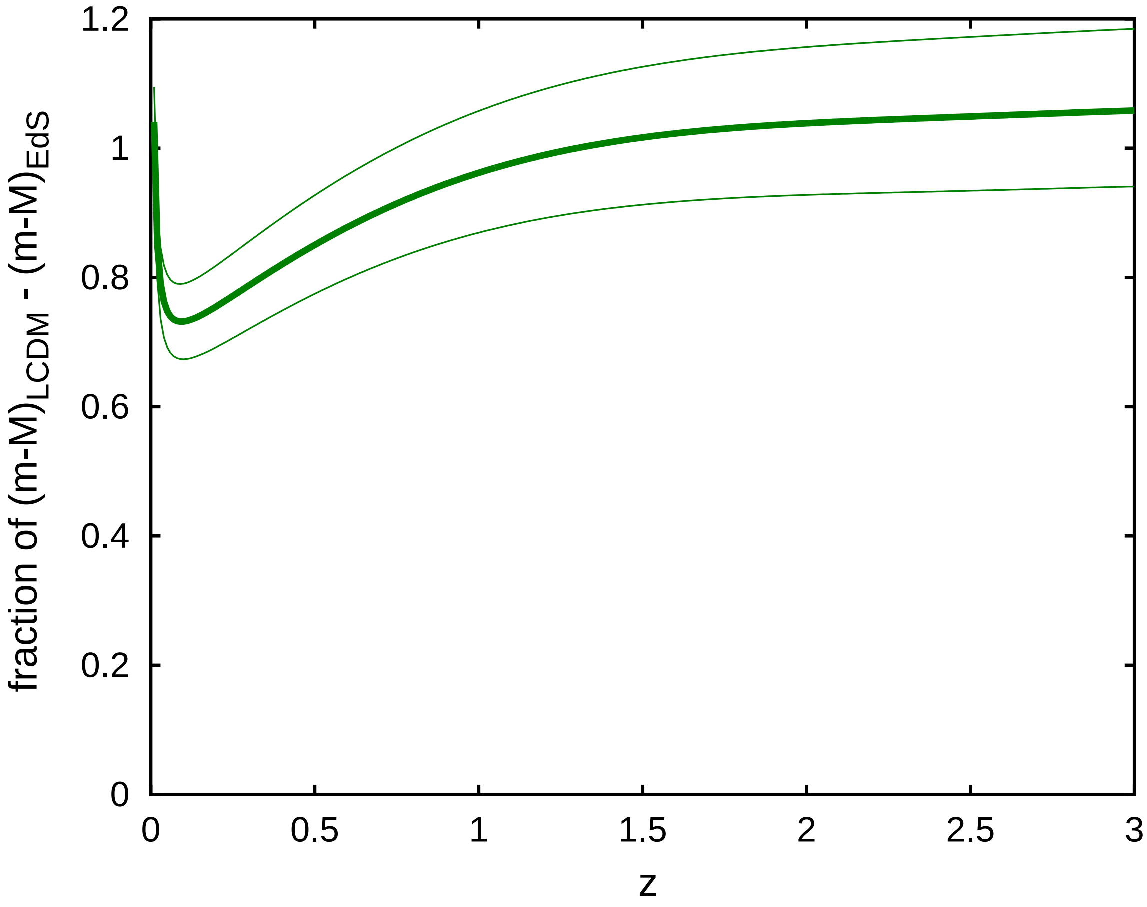

Summary

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  $\Rightarrow$ void-dominated neg. curvature + inhomogeneous expansion $\Rightarrow$
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  distance modulus $m - M$ vs z : EdS+VA $\sim \Lambda$CDM

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