Galaxy Clusters and Cosmology /hen there is light, there is also shadow

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outline



- 2 Planck & the SZ-effect
- **3** Structure formation and Dark Energy
- 4 Clusters at high-z
- 5 Summary

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Constructing a full-sky tSZ-map

(Waizmann & Bartelmann 2009)

In a nutshell

- Works also for w(z) models
- Method is fast compared to numerical simulations
- Assume hydrostatic equilibrium (M-T relation)
- Model clusters as β-profiles
- Constructed observed sky maps including foregrounds and instrumental noise
- Fed observations into our filtering pipeline





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Introduction

The Planck Cluster Catalogue (Melin et al. in prep.)



What can we expect of the PCC?

We can expect from Planck to detect 1000-2000 clusters at a purity of 90%. Preliminary results!!! from WG5 cluster challenge

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Structure growth & dark energy

(Pace, Waizmann & Bartelmann in prep.)

How do structures grow when dark energy is present?

 5×10^{-1} , $\delta_{i} = a_{i}$, δ_{i} to be searched.

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Galaxy Clusters and Cosmology, When there is light, there is also shadow

$$\begin{split} & \int \delta' - \frac{4}{3} \frac{\delta'^2}{1+\delta} - \frac{3}{2} \frac{\Omega_{\rm m}}{a^5 E^2(a)} \delta(1+\delta) = 0 \\ & \delta'' + \left(\frac{3}{a} + \frac{E'(a)}{E(a)}\right) \delta' - \frac{3}{2} \frac{\Omega_{\rm m}}{a^5 E^2(a)} \delta = 0 \end{split}$$

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How do structures grow when dark energy is present?

$$\delta'' + \left(\frac{3}{a} + \frac{E'(a)}{E(a)}\right)\delta' - \frac{4}{3}\frac{\delta'^2}{1+\delta} - \frac{3}{2}\frac{\Omega_{\rm m}}{a^5E^2(a)}\delta(1+\delta) = 0$$
$$\delta'' + \left(\frac{3}{a} + \frac{E'(a)}{E(a)}\right)\delta' - \frac{3}{2}\frac{\Omega_{\rm m}}{a^5E^2(a)}\delta = 0$$

IC: $a_i = 5 \times 10^{-5}$, $\delta' = a_i$, δ_i to be searched.

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Getting δ_c for DE models

(Pace, Waizmann & Bartelmann in prep.)



Getting δ_c for DE models

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Equation of state Linear density contrast 1.70 0.2 1.68 1.66 0.0 1.64 -0.2 1.68 1.62 1.68 (∑) ≥ -0.4 ្លា1.67 1.58 -0.6 1.66 1.56 1.66 -0.8 1.65 2EXP 2EXF 1.54 AS CNR CNR 1.65 INV1 INV 1.52 INV2 -1.0 IÑV2 collapse redshift z. SUGRA SUGRA EDE 1.50 ⊾ 0.0 10° 10^{2} 10^{4} 10 1.0 20 3.0 40 5.0 scale factor a collapse redshift z

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gh-z) Summary

Cluster Cosmology in our Dreams



Using simulations to study cluster evolution



Refinement scheme

(Waizmann, lapichino & Bartelmann in prep.)



Follow the leader

(Waizmann, lapichino & Bartelmann in prep.)

Summary



Follow the leader

(Waizmann, lapichino & Bartelmann in prep.)



(Waizmann, lapichino & Bartelmann in prep.)

Summary



Summary & Conclusions

Structure formation and Dark Energy

- We can compute $\delta_{
 m c}$ for a range of DE models
- Impact on non-linear structure formation is neglible
- Probably modified gravity and/or clustered DE change this

Z cluster sample & mapmaking

eo, 1000-2000 clusters from Planck

& point source contamination make life hard

need many clusters for cosmology

will be high-redshift clusters

onhigh-z cluster evolution is needed

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Cluster cosmology

- We need many clusters for cosmology
- Future missions will probe high-redshift clusters
- Better understanding of high-z cluster evolution is needed

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