Large-Scale Structure Science

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Towards a next space probe for CMB observations and cosmic origins exploration
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Census of the Baryons

• How do baryons flow from gas to stars and back within the cosmic web?

• **Census of the baryons**
  • Where are they: relation to dark matter
  • What are they doing: gas, dust, star formation, etc.
  • *Feedback is key, but not well understood*

• Missing info on gas, dust, mass at critical epochs
LSS Science Case

- Sub/millimeter well suited to answer this question:
  - tSZ traces gas
  - CMB lensing traces mass
  - Far-IR traces dust and star formation rate
  - Millimeter traces AGN

- Halo properties (1-halo term)
  - Binning on objects by type and redshift
  - Halo masses via CMB lensing

- Larger-scale distribution (2-halo term, filaments)
  - Cross-correlations
Implications for feedback: gas pushed out to $R_{500} < R < 5R_{500}$
Population Studies: QSOs

Verdier et al. (2016): Planck

Tracer of SF

tSZ at z>3!

Constraints on QSO feedback

See also Crichton et al. (2016): ACT
CMB Halo Lensing

- CMB: Much broader lensing kernel
- Reach critical high-z epochs
CMB Halo Lensing

- Stack on selected objects

1-sigma filter noise (Melin & Bartlett 2015)
Cross Correlations

- SPT CMB lensing
- Dark Energy Survey SV galaxies
- Tomography
  - Galaxy bias
  - Structure growth rate (neutrino mass, dark energy, modified gravity)

Giannantonio et al. (2016)
Cross-Correlations

tSZ $\times$ WFIRST lensing convergence (4 arcmin FWHM)

Credit: C. Hill
Unique Science

- Probe critical epochs of galaxy formation: $z \sim (1–8)$
Unique Science

- Probe critical epochs of galaxy formation: $z \sim (1–5)$
- Trace hot gas phase over critical epochs
  - Feedback mechanism running thermal cycle
  - **Recall: galaxy formation is inefficient: Why?**
- Trace dust during critical epochs
  - Metal production
  - Star formation activity
- Trace dark matter
  - Host halos
  - Larger-scale distribution
Impact on Mission

- Frequency coverage for tSZ and Dust
  - Population studies: +resolution
  - Large-scale distribution: e.g., CIB/SZ separation
- Resolution for CMB halo lensing
CMB Halo Lensing

COre+ mission concepts

$\Delta T \text{ [}$\mu$K$.arcmin$]$

COre telescope diameter [m]

$LSS$ Science CMB$@$CERN 2016

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Frequency Coverage

- QSO study with: 70, 100, 143 & 217 GHz
- Loose dust information
- Bias SZ signal
- Need high frequencies
Work

• Sell science case
  • Outside our community

• CMB halo lensing
  • Minimum variance estimator

• Sensitivities for SZ, dust & mass stacks

• Cross-correlation predictions

• Studies for different mission profiles
Work

Astronomy & Astrophysics manuscript no. core1ss
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**COre+: Large-Scale Structure Science**

The COre+ Collaboration
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Received : accepted

**ABSTRACT**

This is the abstract.

**Key words.** Large-Scale Structure

1. Introduction
2. Census of the Baryons
3. Halo Lensing
4. Cross-Correlations
5. Conclusion

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