Power spectrum of the Cosmic Microwave Background radiation

Final presentation

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Goals and accomplishments

1. Simulation of the CMB temperature anisotropy
    - Generating only intensity map of CMB photons
    - Consider foreground effects and other distortions (eg. noise, lensing, etc.)
    - Optionally: Generate full-sky maps

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1. Simulation of the CMB temperature anisotropy
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2. Analysis of real observational data (eg. Planck)
   - Extract angular power spectrum from filtered/unfiltered intensity maps
   - Optionally: Explore and fit some (ideally 6) parameters of the ΛCDM model

Task 1: Simulation – Results

- All tasks - including the optionals - were accomplished
- Two completely different simulation method
  1. Naïve generation of all astrophysical components as individual layers
  2. Generating randomized HEALPix arrays of full-sky maps using the Fortran90 subroutine `synfast` and mapping them to an arbitrary projection.

Sample outputs of method I.

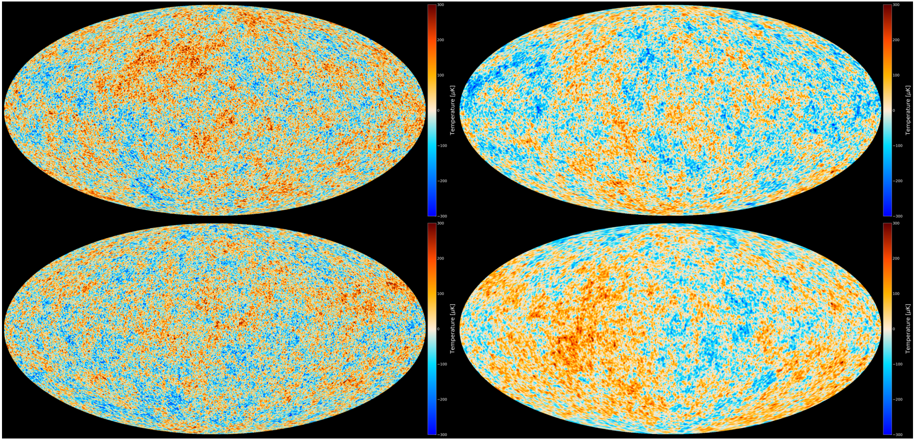


Figure 1: Randomly generated full-sky intensity maps of the CMB temperature anisotropy using HEALPix routines and conventions. The two images on the left side were generated with $\mathrm{FWHM}_{\mathrm{beam}} = 3\,\mathrm{arcmin}$ and with $\sigma_{\mathrm{beam}} = 0.5\,\mathrm{arcmin}$, while the images on the right side were generated with parameters $\mathrm{FWHM}_{\mathrm{beam}} = 30\,\mathrm{arcmin}$ and $\sigma_{\mathrm{beam}} = 15\,\mathrm{arcmin}$

Sample outputs of method II. - Pure maps

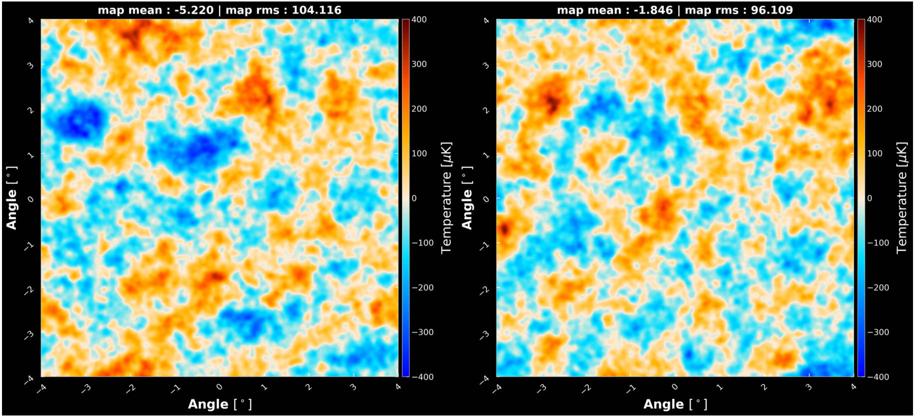


Figure 2: Randomly generated intensity maps of the pure CMB temperature anisotropy with two different random seeds.

Sample outputs of method II. - Foreground sources

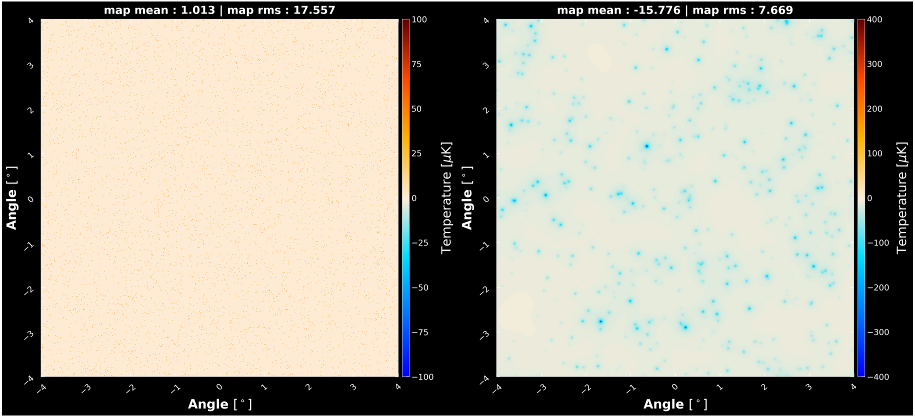


Figure 3: Randomly generated point sources (left) and the randomly generated map of the thermal component of the Sunyaev-Zeldovich effect (right).

Sample outputs of method II. - Beam size effect

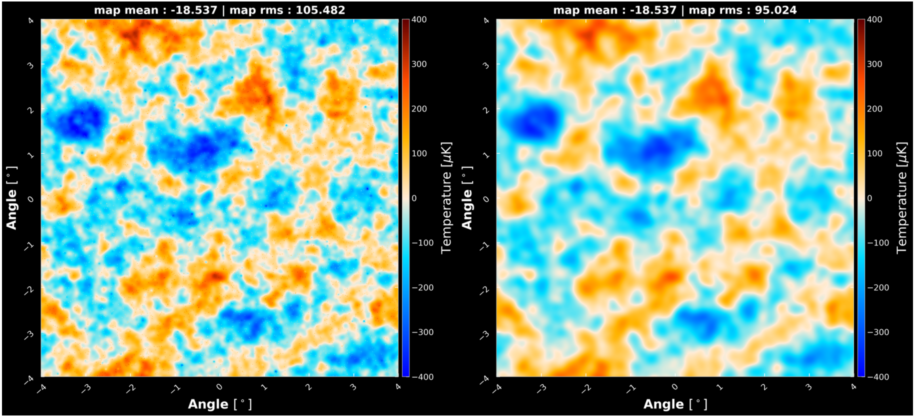


Figure 4: Effect of a beam with $\mathrm{FWHM}_{\mathrm{beam}} = 10\,\mathrm{arcmin}$ on a CMB map with foregrounds objects.

Sample outputs of method II. - Noises

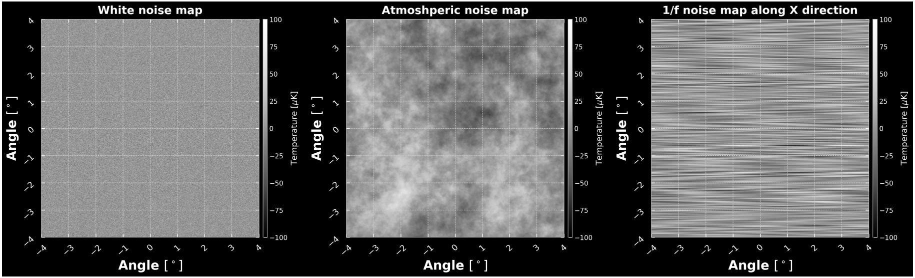
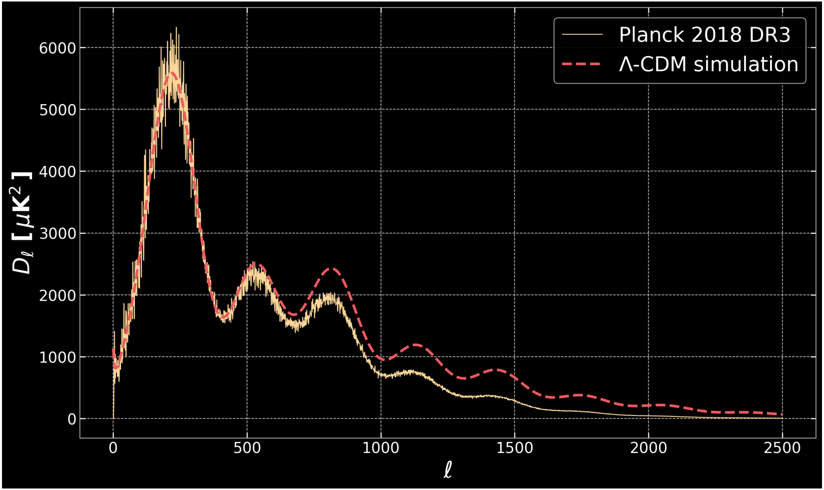


Figure 5: The different noise components in the simulation. All noises here are considered to be Gaussian.

Reconstructed angular power spectrum



MCMC algorithm tries to find cosmological parameters...