

Thesis

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Part I

Cosmological Context

Chapter 1

Standard Model of Cosmology

From Dodelson

- 1.1 The expanding Universe
- 1.2 The fundamental equations of Cosmology
- 1.3 History of the Universe
- 1.4 Problems of the Standard Model

Chapter 2

CMB, Inflation, and B-modes

- 2.1 Inflation theory
- 2.2 Cosmic Microwave Background
- 2.3 CMB polarisation
- 2.4 CMB contamination: astrophysical foregrounds
- 2.5 CMB past and future observations

Part II

QUBIC instrument: the first bolometric interferometer for cosmology

Chapter 3

Bolometric Interferometry and QUBIC

- 3.1 Classical telescope for CMB physics: Imager**
- 3.2 Innovative approach: Bolometric Interferometer**
- 3.3 QUBIC Collaboration**
- 3.4 Instrumental Design**

Chapter 4

Bolometric Interferometry to Spectral Imaging

4.1 Synthesized Beam

4.2 Spectral Imaging

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Chapter 5

GPS for Self-Calibration

Part III

Map-Making

Chapter 6

Forward Map-Making

6.1 Frequency Map-Making

6.2 Component Map-Making

6.3 Realistic TOD Simulation

6.3.1 How to define Realistic TOD

6.3.2 Convolution approximation

6.3.3 TOD convergence problem: Pixelisation vs Number of Frequency

6.3.4 Effect of $N_{\text{sub,TOD}} = N_{\text{sub,rec}}$

6.3.5 External data addition effect (Planck)

6.3.6 Simulation hyperparameters optimisation: N_{sub} , $N_{\text{pointings}}$, N_{iter} , N_{loop} (CMM), ...

Chapter 7

Inverse Map-Making

7.1 Neural Network Map-Making

Chapter 8

Atmospheric Mitigation

Chapter 9

QUBIC Forecasts

9.1 Studied Cases

- 9.1.1 CMB without foregrounds: QUBIC raw sensitivity
- 9.1.2 CMB + Dust (d_0, d_1, d_6, \dots): Simple forecasts
- 9.1.3 CMB + Dust (d_0, d_1, d_6) + Synchrotron (s_0, s_1): Realistic forecasts

9.2 Results

- 9.2.1 Compare QUBIC configurations
- 9.2.2 Dual bands without spectral imaging: “Imager case”
- 9.2.3 Dual bands with spectral imaging: “BI case”
- 9.2.4 Ultra-wide band: “Extreme BI case”
- 9.2.5 Successive mono-band case: “Conservative case”

9.3 Compare QUBIC’s map-making algorithms

- 9.3.1 FMM: Cross-spectra Analysis
- 9.3.2 NN-FMM: Cross-spectra Analysis
- 9.3.3 CMM: Parametric Analysis
- 9.3.4 NN-CMM: Parametric Analysis
- 9.3.5 CMM: Blind Analysis
- 9.3.6 Addition of external data for component separation
- 9.3.7 Exploring exotic models

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