

UNIVERSO PRIMORDIAL
Mestrado em Física Astronomia
2025-2026

Breakdown of a Joint Review Proceedings Book

The following breakdown in **List I** outlines potential topics for a joint review on the *physical processes that affect the observable properties of the Cosmic Microwave Background (CMB)*. Daniel Baumann's *Cosmology* book serves as the primary reference for these topics. Students are encouraged to consult the course coordinator for additional recommended references related to their areas of interest.

Students may choose to address a topic that is **not included** in the joint review proposal, selecting instead from the list of alternative topics provided, **List II**, below.

Alternatively, they may propose a new topic, provided it is relevant to the *Primordial Universe* course and receives prior approval from the course coordinator.

All students must **select their research topic** and **submit by email**, ajosilva@fc.ul.pt, **the title of their essay** to the course coordinator **by January 9, 2025**. Please note that the maximum length of each essay is **14 pages**, including figures, tables, and references.

List I - Breakdown of a Joint Review on the physics of CMB

A. The origin of perturbations

Baseline reference: Baumann Chapter 8: Quantum Initial Conditions

- **1 – Quantum fluctuations in the de Sitter space**
Section 8.1 (Inflationary Perturbations) + Section 8.2 (Quantum Fluctuations)
- **2 – Primordial Power Spectrum**
Section 8.3 (Primordial Power Spectrum) + Section 8.4 (Observational Constraints)

B. Cosmological perturbation theory

Baseline reference: Baumann Chapter 6: Relativistic Perturbation theory

- **1 – Linear Perturbations in GR**
Section 6.1 (Linear perturbations) + Section 6.2 (Initial Conditions) + OPTIONAL Section 6.3 (Gravitational Waves)
- **2 – Growth of perturbations**
Section 6.3 (Growth of matter perturbations) + Section 6.4 (Initial Conditions);

C. Cosmic Microwave Background Radiation

Baseline reference: Baumann Chapter 7: Relativistic Perturbation theory

- **1 – CMB basics and statistics**
Section 7.1 (Anisotropies in the first light) + Section 7.2 (Photons in a clumpy Universe) + Section 7.5 (understanding the Power Spectrum)
- **2 – Temperature Angular Power Spectrum**
Section 7.3 (Anisotropies from Inhomogeneities Growth) + Section 7.4 (Primordial Sound Waves)
- **3 (optional) – Polarization Angular Power Spectrum**
Section 7.6 (A Glimpse at CMB Polarization)

List II- Other topics suggestions (In alphabetical order)

- Baryogenesis models
- Beyond standard Big Bang Nucleosynthesis
- Big Bounce models: Solving the Primordial Big-Bang Singularity
- Boltzmann Equations (general covariant formalism) and their applications
- Cosmic Neutrino Background
- Dark Matter (alternative models, detection, observational constraints)
- Electroweak phase transition and the Higgs mechanism
- Grand Unification Theory phase transition
- Primordial Gravitational Wave Background
- Inflation: Alternative Models and Reheating
- Modified Gravity models in the Primordial Universe
- Quantum Cosmology: towards the Planck time
- QCD phase transition: the “origin” of protons and neutrons
- Primordial Non-Gaussianities
- Primordial Black Holes
- Structure Formation: Evolution of perturbations after inflation
- The Cosmological Constant in Quantum Field Theory
- ...