

# Cosmological Evidences of Dark Matter through the CMB

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## 1 Introduction

Many astronomical and cosmological observations suggest that there is a missing form of matter that interacts gravitationally. Therefore, scientists have proposed the existence of a new form of matter that does not interact electromagnetically but gravitationally: Dark Matter. Nevertheless the fundamental nature of Dark Matter is not well understood, there are strong evidences for the existence of Dark Matter. One of the most important evidence for the existence of Dark Matter comes from the analysis of the Cosmic Microwave Background (CMB). The Cosmic Microwave Background is the electromagnetic radiation coming from the hot plasma of the early stages of the Universe. When the Universe, made of hot plasma, reached a temperature low enough to form stable hydrogen  $e^- + p^+ \rightarrow H + \gamma$ , the number density of the free electrons dropped, causing the Thomson scattering  $e^- + \gamma \rightarrow e^- + \gamma$  to be inefficient and the photons to decouple. They have since streamed freely through the universe and are today observed as the cosmic microwave background [1]

-practical Motivation for studying the cmb: nice spectrum black body spectrum: physics well known, very intense radiation  
which info can we get from the cmb: Big bang, matter and energy content of the universe—dark matter is a big part of the matter content it influenced the spectrum of the CMB — so it played a role.  
-structure of the paper

## 2 From the Discovery of the CMB to the Planck mission

The early Universe was made of a hot and dense plasma that cooled down as the Universe was expanding. At  $T = 100$  GeV particles receive their masses through the Higgs mechanism

-[2] brief thermal history of the universe and how to get to the cmb and what is it?

[3] -discovery of the cmb  
-filtering of the images  
-different missions

### 3 Content of the Universe

- Assumptions: working with the  $\Lambda$ CDM model
- General relativity
- Friedmann equations

### 4 CMB theo analysis

- hydrodynamics [4] page 14 eq 49 to page 17 eq 71  
skip doppler effect
- gravito acoustic oscillations page 19 up to eq 82 , justify briefly constant potential in page 20
- page 20 and 21 up to eq92 important comment
- baryonic effect

### 5 Comments on the results and plots of the CMB spectrum



Figure 1: The Universe

## 6 Conclusion

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## References

- [1] Lectures.pdf. <http://www.damtp.cam.ac.uk/user/db275/Cosmology/Lectures.pdf>.
- [2] Wayne Hu. <http://background.uchicago.edu/~whu/index.html>.
- [3] Martin Bucher. Physics of the cosmic microwave background anisotropy. January 2015.
- [4] Wayne Hu. Lecture Notes on CMB Theory: From Nucleosynthesis to Recombination. *arXiv:0802.3688 [astro-ph]*, February 2008.
- [5] Nikhil Padmanabhan and Douglas P. Finkbeiner. Detecting Dark Matter Annihilation with CMB Polarization : Signatures and Experimental Prospects. *Physical Review D*, 72(2), July 2005.