Forecasting for Future CMB Searches for Primordial Magnetic Fields
Literature Review

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27th May 2016

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1 Abstract

2 Introduction

The cosmic microwave background (CMB) is the oldest light in the Universe. It was formed around 300,000 years after the Big Bang, during the era of recombination. During this time the Universe was still hot and dense, emitting high energy photons through black body radiation. However, the Universe had cooled sufficiently to allow electrons and protons to form neutral hydrogen, making space transparent to light. The photons from this era have since been cosmologically redshifted into the microwave frequency band. The temperature of the CMB photons is 2.7K, which is currently the equilibrium temperature of the Universe.

As a relic of the early Universe, the CMB is a powerful tool for probing high energy physics, piecing together the history of the Universe and mapping out large scale strucutres. The discovery of the CMB was a landmark success for verifying the Big Bang Theory and is still studied to test ΛCDM Cosmology. Since its discovery in 1964, the CMB has been studied extensively. In 1989 COBE launched and found the CMB matches the blackbody spectrum with a temperature of 2.725 ± 0.002K as well as detecting anisotropies to one part in 100,000. In 2001 WMAP began its 9 year run, solidifying ΛCDM parameters and beginning the era of precision cosmology. In

2.1 Large Scale Magnetic Fields

Galaxies, Galaxy clusters and the Intercluster medium all exhibit weak magnetic fields on the order of microgauss coherent over kiloparsecs or megaparsecs

2.2 Primordial Magnetic Fields

- seed magnetic field produced in the early universe - undetected - predicted magnitude of ¡ 1 nG. - evolves through magnetohydrodynamical processes

2.3 CMB Polarisation

¡ 'borrow' from lit review? ¿

2.4 CMB-S3

- stage 3 of CMB experiments operating from 2016 to 2020. - n detectors, m detector years - primary science goal is to detect PGW from cosmic inflation through B-modes. - could also make a detection of PMFs.

2.4.1 SPT-3G

- South Pole Telescope - n detectors - starting/fishishing dates - area - etc.

2.4.2 Advanced ACTPol

2.4.3 The Simons Array

2.5 CMB-S4

- stage 4 CMB experiments still in planning stages - nothing concrete yet. - n detectors, m detector years - running through the 2020s

3 Theory

3.1 More Primordial Magnetic Fields

Observations of Faraday rotation in the polarisation of radio signals reveal the existence of weak coherent magnetic fields over large scales. Magnetic fields have strengths of order microgauss coherent over kPc scales. Similarly the intracluster medium possesses microgauss fields over tens of kPc. In addition, the voids between galaxy clusters are believed to have coherent nanogauss fields.

The origin of these fields is not explained in ΛCDM cosmology. [why]. A solution to this problem are seed magnetic fields produced early in the Universe. These seed fields would be amplified through galactic dynamos and magnetohydrodynamics into the magnetic fields we observe in the present day.

Primordial Magnetic Fields (PMFs) are a candidate for the seed magnetic fields. PMFs would have been produced during the early Universe. They may have been a result of conformal symmetry breaking during inflation, or during a phase transition - QCD to weak, say. The Biermann battery is the most standard mechanism for PMF production.

3.2 Biermann Batteries

3.3 Other Methods of PMF Generation

3.4 Effect of PMFs on the Cosmic Microwave Background

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6.1 Discussion

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References

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