The QUIJOTE CMB Experiment

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Abstract We present the current status of the QUIJOTE (Q-U-I JOint TEnerife) CMB Experiment, a new instrument which will start operations early in 2009 at Teide Observatory with the aim of characterizing the polarization of the CMB and other processes of galactic and extragalactic emission in the frequency range 10–30 GHz and at large angular scales. QUIJOTE will be a valuable complement at low frequencies for the PLANCK mission, and will have the required sensitivity to detect a primordial gravitational-wave component if the tensor-to-scalar ratio is larger than $r = 0.05$. 

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1 Introduction

The study of the Cosmic Microwave Background (CMB) anisotropies is one of the main pillars of the Big Bang model. With the latest results from WMAP satellite [5], and the information provided by ground-based experiments such as VSA [3], ACBAR [13] or CBI [12], it has been possible to determine cosmological parameters with accuracies better than 5% (see e.g. [4]).

However, the CMB contains far more information encoded in its polarization signal. Since the first detection of polarization by the DASI experiment [8], other experiments have started to measure the angular power spectrum of the polarization. Although those measurements are still having a relatively poor signal-to-noise, they show excellent agreement with the predictions of the standard ΛCDM model.

The standard theory predicts that the CMB is linearly polarized, the physical mechanism responsible for its polarization being Thomson scattering during the recombination or reionization epochs. Generally speaking, the polarization tensor can be decomposed in terms of a E-field (gradient) and a B-field (rotational) components [6, 17]. Due to parity conservation, this implies that we have three angular power spectra to describe the polarization field: the TE (cross-correlation of temperature and E mode), the EE and BB power spectra. All the other combinations (TB and EB) should be zero.

If the fluctuations in CMB intensity are seeded by scalar perturbations (i.e. fluctuations in the density alone), one would only expect primordial E modes in the CMB polarization. However, vector and tensor perturbations, like those due to gravitational waves in the primordial Universe (e.g. [11]), are mechanisms that could generate primordial B-modes in the polarization on large angular scales. Therefore if we can measure these modes we may have a unique way to carry out a detailed study of the inflationary epoch. In particular, the energy scale $V$ at which inflation occurred can be expressed in terms of $r$, the ratio of tensor to scalar contributions to the power spectrum, as [9]

$$r = 0.001 \left( \frac{V}{10^{16} \text{ GeV}} \right)^4.$$  

(1)

The current upper limit of $r \lesssim 0.3$ from WMAP data [7] translates into $V \lesssim 4 \times 10^{16} \text{ GeV}$.

Because of the importance of detecting primordial gravitational waves [2, 10], there is a huge interest to develop ground-based experiments to measure (or constrain) the amplitude of B-modes power spectrum of the CMB polarization. Here we present one of these efforts.

The QUIJOTE (Q-U-I JOint TEnerife) CMB Experiment is a scientific collaboration between the Instituto de Astrofísica de Canarias, the Instituto de Física de Cantabria, the IDOM company, and the universities of Cantabria, Manchester and Cambridge, with the aim of characterizing the polarization of the CMB, and other galactic and extragalactic physical processes in the frequency range 10–30 GHz and...