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ScienceDirect
New Astronomy Reviews 51 (2007) 260–265
New Astronomy Reviews
www.elsevier.com/locate/newastrev

A design study of a CMB polarization satellite SAMPAN and bolometric camera developments ☆

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Available online 11 January 2007

Abstract

There is a strong theoretical case for measuring the primordial gravitational wave background that is expected in inflation-based Big Bang scenario. A promising route is via the polarization B-modes of the CMB anisotropies. We discuss a recent design study called SAMPAN for a moderate angular resolution (20 arcmin. at 217 GHz) but highly sensitive (5 μK arcmin.) polarization mapper satellite. In parallel, we describe recent efforts in France to build bolometric cameras.

Keywords: Cosmic microwave background; Polarization; Bolometric detectors; Cosmology

Contents

1. A design study for a B-mode satellite

After the ground-breaking results from the first generation satellite COBE (Smoot et al., 1992) and from the more recent second generation satellite WMAP (Bennett et al., 2003), the ESA PLANCK mission should provide an even more precise characterization of the CMB primary anisotropies in 2008 (The PLANCK Collaboration, 2006). This satellite should also make cosmic variance limited measurements of the E-mode polarization of the CMB. These E-modes, produced primarily by scalar perturbations at recombination, are closely linked to the temperature anisotropies and will provide stringent consistency checks and break degeneracies among some of the cosmological parameters.

On the other hand, primordial B-modes can only be produced by tensor perturbations, most notably gravitational waves (Kamionkowski et al., 1997,). They have been shown to provide unique information about the inflationary phase

☆ This article summarizes work done by many contributors, including B. Belier, A. Benoit (DCMB leader), F.R. Bouchet (SAMPAN leader), M. Bucher, Ph. Camus, Ph. Desmet, L. Dumoulin, Y. Jin, J. Michaud (CNES study leader), M. Piat, N. Ponthieu, D. Santos, S. Triqueneaux, S. Yates

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doi:10.1016/j.newar.2006.11.047

of the Universe (Bond and Efstathiou, 1984), most notably the energy scale of inflation. Although PLANCK can already set valuable limits on the tensor-to-scalar power spectrum ratio $r = \frac{T}{S}$ at the level of 10^{-1}, we have here designed a satellite dedicated to CMB polarization measurements with the aim of reaching limits of $r \sim 10^{-3}$, which is a natural target for GUT motivated inflation models. This phase 0 design study in 2005, named SAMPAN (Bouchet et al., 2005) was commissioned by CNES (the French space agency) in order to study its feasibility, cost and critical technologies, with significant industrial contributions by Alcatel Alenia Space and Air Liquide.

In order to obtain that goal which translates into measuring the polarization of the CMB at the nanoKelvin level on large scales, we devise the following requirements: (1) a full sky survey, which can only be done from space, (2) a strict control of foreground polarized emissions hence at least four frequency bands, typically 100, 143, 217 to 353 GHz, (3) an angular resolution of 20 arcmin at 217 GHz, (4) sensitivity (see below) (5) a strict control of systematic effects (see Figs. 1 and 2).

Bolometer arrays are chosen because they offer the highest sensitivity at millimeter wavelengths, as exemplified by PLANCK HFI with respect to WMAP. PLANCK HFI bolome-

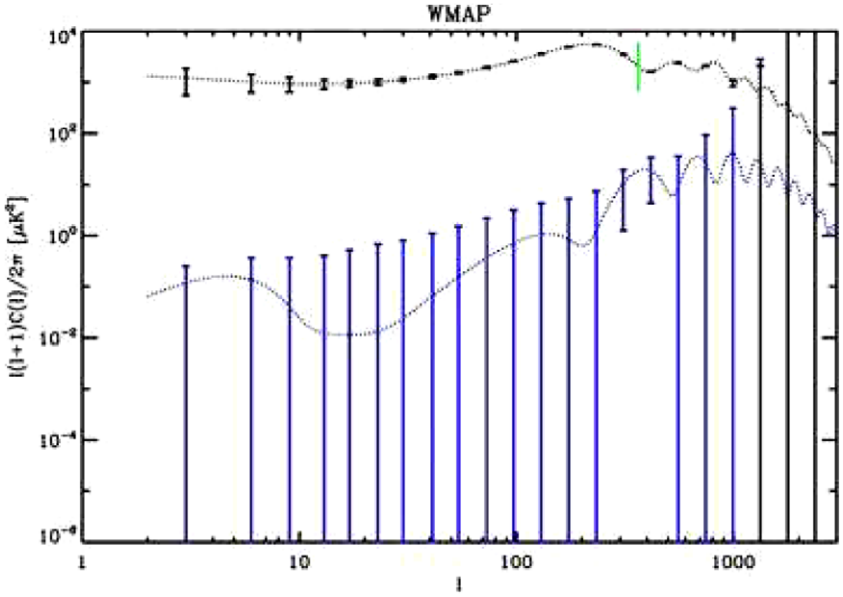

Fig. 1. WMAP one year sensitivity to TT and EE power spectra.

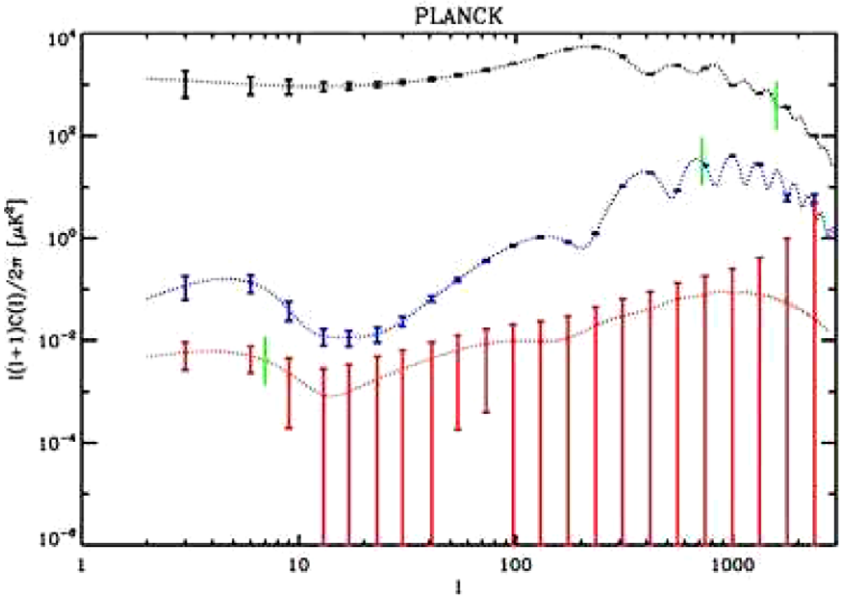

Fig. 2. PLANCK one year sensitivity to TT, EE, BB power spectra.