Expression of Intent to Propose a B-Polarization Satellite Mission (B-Pol) Aimed at Detecting Primordial Gravitational Waves Generated During Inflation

We announce our intention to submit a proposal for a Class M space mission aimed at detecting the primordial gravitational waves generated during inflation, in response to the Call for Proposals released 5 March 2007 as part of ESA Cosmic Vision 2015-2025.

The quest to understand the origin of the tiny fluctuations about a perfectly homogeneous and isotropic universe lies at the heart of both modern cosmology and high-energy physics. Inflationary theory offers the most satisfying and plausible explanation for the initial conditions of the universe. Inflation is a phase of superluminal expansion of space itself, within 10^{-35} s of the Big Bang, during which quantum fluctuations are stretched to cosmological scales. Results from Cosmic Microwave Background (CMB) experiments, in particular the space missions COBE and WMAP, have established that the universe is almost spatially flat, with a nearly Gaussian, scale-invariant spectrum of primordial adiabatic perturbations. These characteristics are all consistent with the simplest models of inflation.

By providing accurate measurements of the E-mode (gradient component) polarization of the CMB, the ESA mission Planck will offer more stringent tests of the inflationary paradigm. Nevertheless, even with such an accurate characterization of the scalar perturbations, a decisive confirmation of inflation will be lacking, and large uncertainties in the allowed inflationary potentials will persist.

Inflation predicts the existence of primordial gravitational waves on cosmological scales. Their detection would establish firmly the existence of a period of inflationary expansion in the early universe, and confirm the quantum origin of cosmological fluctuations that led to the large scale structure observed today. The search for primordial B-mode (curl component) polarization of the CMB provides the only opportunity to detect in the foreseeable future the imprint of these gravitational waves.

Measuring the amplitude of these tensor perturbations at one length scale would fix the energy scale of inflation and its potential. Measuring their amplitude at more than one length scale would provide a powerful consistency check of a broad class of inflationary models.

If, as suggested by recent CMB and large scale galaxy surveys, the power spectrum of primordial perturbations is not exactly scale invariant, then in a wide class of inflationary models the level of gravitational waves will be within the range accessible to B-Pol.

The B mode polarization is a clean probe of gravitational waves, since primordial scalar perturbations do not contribute to B-modes, and the effects due to intervening gravitational lenses are calculable and of order 5 μK·arcmin , which sets the sensitivity target of B-Pol.

A confirmation of inflation and determination of the inflationary potential would have profound implications for fundamental physics by providing new experimental data on the physics near the Planck scale. This is indispensable for model building in string and M theory. The energy scales probed by B-Pol lie many orders of magnitude beyond any conceivable accelerator experiment. Consequently, the quest for primordial gravitational waves from inflation constitutes a unique window for constraining the new physics near the Planck scale, which will help understand how quantum gravity is unified with the other three fundamental interactions.

Due to its high sensitivity and accuracy, B-Pol will make substantial contributions in several other areas of astrophysics, such as Galactic magnetic fields, interstellar dust and gas properties, gravitational lensing of the CMB, and cosmological reionization.

The bulk of the statistical weight for detecting inflationary B modes is concentrated at two angular scales on the sky: firstly, at the reionization bump at multipoles ℓ = 2-10 and secondly at the multipole region from about 20 to 100 (corresponding to angles larger than ~ one degree on the sky). Given that most of the signal lies on large angular scales, a full-sky survey with exquisite stability and control of systematic errors, of both instrumental and astrophysical origin, is required, hence the need to go to space.

To achieve this primary science objective of detecting and characterizing the primordial gravity waves generated during inflation, we propose a medium class satellite, with broad frequency coverage using several bands at millimetre and sub-millimetre wavelengths to enable removal of galactic foreground contamination, with a sensitivity for the final cleaned map of 5 μK·arcmin , and with a resolution of about 30 arcmin at 90 GHz.

This measurement would nominally require more than 100 years of Planck integration time and much better control of systematics in polarization. The required improvement in sensitivity over Planck will be provided by the new generation of high sensitivity detector arrays, such as low temperature bolometers (<200mK), massively increasing the number of detectors in the focal plane to overcome inherent limitations due to the photon noise from the CMB itself. The control of potential systematic effects is the other design driver of this mission.

We are in the process of developing a detailed proposal using the experience acquired with Planck, the CNES SAMPAN mission study, the ASI COFIS study, and lessons from other CMB polarization experiments like Archeops, BARSport, BOOMERanG, CLOVER, SPORT…
The preliminary costing study of CNES indicated that it is possible to conceive a CMB polarization mission compatible with a class-M mission.

This proposal currently involves teams from Denmark, France, Germany, Ireland, Italy, Norway, Portugal, Romania, Spain, Sweden, and the United Kingdom, and is open to further international collaborators. The proposing teams, involving several research institutes in each country, have considerable experience and expertise in the critical technologies and data analysis challenges essential to the success of this mission.

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