

## Planck/LiteBird PhD Opportunity

This PhD project focuses on the physics of the Cosmic Microwave Background both from an observational and from a theoretical perspective. This PhD will be co-supervised by Martin Bucher and Ken Ganga at APC in Paris. It is also envisaged that the student will take part in exchanges with researchers at the University of Tokyo. Part of the project will involve studies to help prepare for the forthcoming LiteBird CMB polarization mission, whose aim is to detect primordial gravitational waves that were presumably generated during inflation.

The other part of this PhD project will involve investigating signs of parity violation in the CMB bispectrum. Historically, both theoretical and observational studies of parity violation have played a key role in the development of elementary particle physics, leading to the so-called Standard Electroweak model. In the early days of particle physics, it was tacitly assumed, perhaps more on grounds of simplicity rather than for any sound fundamental reason, that parity symmetry was respected by the laws of Nature. In the 1950s C.N. Yang and T.D. Lee undertook a theoretical study of the evidence for this symmetry in the weak interaction and concluded that based on the evidence then available, parity may or may not be respected by the weak interaction. They further proposed some experiments based on the angular dependence of decays of polarized nuclei to decide this question experimentally, and when C.S. Wu carried out one of these experiments, it was discovered that parity was indeed violated by the weak interaction.

The physics at play during Cosmic Inflation lies at energy scales many orders beyond the Standard Model. In formulating theories of the very Early Universe, but for a few exceptions, theorists have generally tacitly assumed that parity is conserved by this new physics, but this need not be the case and is rather a question that should be decided observationally. Most tests to date have involved the CMB power spectrum, in particular searching for a  $C_{TB}$  and  $C_{EB}$  power spectrum determined to be nonzero at a statistically significant level, which would require parity to be violated. This approach, however, is difficult given that B modes have not been yet detected. There is, however, another way to search for parity violation in the presently available CMB data. The CMB bispectrum may be divided into two components: a parity conserving (even) component and a parity violating (odd) part. So far almost all work on the CMB bispectrum has focused on the parity even part. The advantage of searching for parity violation using the bispectrum is that one does not rely on the presence of primordial B modes, which at best are present with a very small amplitude. The bispectrum of the much brighter temperature maps alone has a parity-odd component which might be nonzero.

As part of this thesis, the student recruited will study the parity-odd bispectrum both from an observational and a theoretical perspective. The student will develop a realistic estimator for extracting the parity-odd TTT bispectrum and will apply this estimator to the CMB temperature maps obtained from the ESA Planck mission to place constraints on possible parity violation in the very early universe, or perhaps even discover statistically significant evidence for parity violation. The student will also study and further develop theoretical models for the physics at play in the Early Universe that predict an observable level of parity violation.

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