



The CMB Landscape for the Next 25 Years

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Abstract :

The Cosmic Microwave Background (CMB) has played a central role in the development of modern cosmology, transforming the field into a precision science. Yet, more than sixty years after its discovery, the CMB is far from having exhausted its scientific potential. The next twenty-five years are expected to bring new momentum to the way we observe and exploit this extraordinarily powerful cosmological probe.

I will discuss the emerging CMB landscape, from the experiments of the coming decade to the scientific opportunities that may define the field towards 2050. LiteBIRD will mark a major milestone, providing all-sky, multi-frequency polarization measurements primarily designed to search for the imprint of inflationary gravitational waves through primordial B modes, while also offering the potential for breakthroughs in other areas of fundamental physics, most notably through tests of fundamental symmetries. At the same time, increasingly sensitive ground-based experiments will push measurements of small-scale anisotropies and CMB lensing to unprecedented precision, targeting neutrino masses, light relics, the growth of structure, and new physics beyond the standard cosmological model.

Looking further ahead, the ESA Voyage 2050 programme provides a natural horizon for considering the next generation of space-based CMB science. Future missions could move beyond the traditional measurement of temperature and polarization anisotropies, combining exquisite control of polarized foregrounds with high-resolution observations, CMB lensing, and measurements of the frequency spectrum of the microwave sky. CMB spectral distortions, in particular, offer access to largely unexplored epochs of cosmic history and could open a qualitatively new observational window on the early Universe.

The CMB of the 2030s and 2040s will also increasingly become part of a much broader cosmological ecosystem. Cross-correlations with large-scale structure, galaxy and weak-lensing surveys, line-intensity mapping, and other tracers of the evolving Universe will turn the microwave sky into an increasingly powerful probe of both fundamental physics and cosmic structure.

I will conclude by looking towards the middle of the century and asking what the CMB landscape might look like by then: which of today's fundamental questions we can realistically expect to have answered, which new observables may have become central to the field, and whether the next major breakthrough will come from improved measurements of familiar CMB signals—or from aspects of the microwave sky that we have only begun to explore.