

Terms of Reference for the CMB Probe Science Analysis Group

A SAG from the Physics of the Cosmos Program Analysis Group

Next-generation cosmic microwave background (CMB) telescopes will address fundamental questions about our universe, including illuminating the physics that drove inflation at energy scales beyond the reach of terrestrial particle accelerators, shedding light on the epoch of reionization when the first stars turned on, improving constraints on the mass of neutrinos, and searching for the signature of additional light relic particles and other physics beyond the Standard Model. CMB instruments will have a profound impact on astrophysics by mapping and characterizing Galactic emissions, probing the structure of the universe through detection of tens of thousands of clusters and other sources, and tracking the variability of the sky at millimeter and sub-millimeter wavelengths. The importance of CMB science was emphasized by the 2020 Decadal Survey Report, *Pathways to Discovery in Astronomy and Astrophysics for the 2020s*, which recommended that the NSF and DOE continue the existing program of ground-based projects culminating in a Stage 4 Cosmic Microwave Background Observatory (CMB-S4) and that NASA invest \$100M in technology development this decade in preparation for a future Probe-scale space mission. Among various astrophysics sub-fields, Astro2020 recommended three topics as Probe priorities, far-IR, X-ray, and CMB. The Probe of Inflation and Cosmic Origins (PICO) mission concept submitted to the Decadal Survey panel laid out one possible architecture for a CMB Probe.

There have been significant developments in the CMB field since the 2020 Decadal Survey. DOE and NSF have announced that they are terminating their support for CMB-S4. Progress has been made in understanding the impact of Galactic foregrounds on inflationary science constraints. Technologies and launch capabilities relevant for a CMB Probe have progressed. The international landscape vis-a-vis a CMB space mission has evolved. All of these developments compel a critical re-evaluation of the role of a CMB Probe, both for a possible mid-decade review and in advance of upcoming Decadal Survey planning activities.

The goal of the proposed SAG would be to analyze and address the following questions:

1. What has changed in the science landscape relative to Astro2020? What guidance and conclusions do we draw from developments in understanding Galactic Foregrounds and delensing techniques?
2. What would be the role of a CMB Probe and how would it complement ground-based, balloon-borne, and other space projects? What would be the legacy value of such a Probe to a broad range of science?
3. Have there been significant developments in component technologies or launch capabilities that need to be studied in advance of the 2030 Decadal Survey? What technology development is still needed to enable a CMB Probe mission?

The SAG will have open membership. It is led by a Chair (Shaul Hanany, University of Minnesota) and two Co-Chairs (Brendan Crill, JPL and Tom Essinger-Hileman, Goddard) accompanied by a steering committee selected by the three leads. The SAG will submit its report by mid-2026.