URSI GASS 2023, Sapporo, Japan, 19 – 26 August 2023

The Next Generation Cosmic Microwave Background Experiment – CMB-S4

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The Cosmic Microwave Background Stage Four project (CMB-S4) is the next generation ground-based cosmic microwave background experiment.[1] It is designed to cross critical thresholds in our understanding of the origin and evolution of the Universe, from the highest energies at the dawn of time through the growth of structure to the present day.

The CMB-S4 science case includes the search for primordial gravitational waves as predicted from inflation and the imprint of relic particles including neutrinos, unique insights into dark energy and tests of gravity on large scales, elucidating the role of baryonic feedback on galaxy formation and evolution, opening up a window on the transient Universe at millimeter wavelengths, and even the exploration of the outer Solar System. The CMB-S4 sensitivity to primordial gravitational waves will probe physics at the highest energy scales and cross a major theoretically motivated threshold in constraints on inflation. The CMB-S4 search for new light relic particles will shed light on the early Universe 10,000 times farther back than current experiments can reach. Finally, the CMB-S4 Legacy Survey, covering 60% of the sky with unprecedented sensitivity and angular resolution from centimeter- to millimeter-wave observing bands, will have a profound and lasting impact on Astronomy and Astrophysics and provide a powerful complement to surveys at other wavelengths, such as the Vera Rubin Observatory (VRO) Legacy Survey of Space and Time and those conducted by the Nancy Grace Roman Space Telescope, Euclid, and others yet to be imagined. CMB-S4's key science goals are beyond the reach of any current or projected precursor experiment by a significant margin CMB-S4 has been endorsed as a priority large project in the Astro2020 decadal survey.[2]

To meet its ambitious goals, CMB-S4 plans to have small-aperture (0.55-meter) and large-aperture (6-meter) telescopes located both in the Chilean Atacama desert (to access a large fraction of the sky) and at the South Pole (for targeted deep-field observations). Over 500,000 superconducting detectors will be distributed across these telescopes, enabling the necessary leap in sensitivity. The instrument and experimental designs draw on the combined experience of the CMB community, through the CMB-S4 collaboration, which includes over 320 members, representing at least 114 institutions in 19 countries on 6 continents, including 27 US states. Advances in systematic control, optical design, survey optimization, and other key technical aspects of the experiment build on this experiment, and provide a firm basis for forecasting CMB-S4's science reach.

In this talk, we will present an overview of the CMB-S4 project, its organization, technical design, construction plans, and predicted performance. We will highlight some specific synergies and relations to other cosmological and radio surveys and Commission J activities.

References

[1] Abazajian, K. et al., "CMB-S4 Science Case, Reference Design, and Project Plan", *arXiv e-prints*, July 2019, doi:10.48550/arXiv.1907.0447.

[2] National Academies of Sciences, Engineering, and Medicine, 2021, *Pathways to Discovery in Astronomy and Astrophysics for the 2020s*. Washington, DC: The National Academies Press. https://doi.org/10.17226/26141.