



ID de Contribution: 57

Type: **Talk**

From cosmological experiments to sensitive cryogenic detectors : a cool road to CMB

mardi 31 mars 2026 15:13 (13 minutes)

Have you ever looked up at the night sky and wondered where our world came from, or how it all began? These are the fundamental questions that astrophysicists and cosmologists strive to answer. We now know that the Big Bang is the most robust theory explaining the origin and evolution of our Universe.

Thanks to numerous ground and space experiments, we have observed a relic signal from the dawn of time: the Cosmic Microwave Background, first discovered in 1965.

This relic radiation behaves like a black body at roughly 3 K and contains tiny temperature fluctuations, or anisotropies, on the scale of a few nanokelvins.

Within these fluctuations lies the signal's polarization, categorized into E-modes and B-modes, according to their shape and origin. While E-modes have been extensively mapped, B-modes are the ultimate goal of modern cosmology. They carry crucial information regarding the amplitude of primordial gravitational waves, multi-messenger astronomy, gravitational lensing and more. Because the B-mode signal is incredibly faint compared to the temperature anisotropies we must use hundreds of thousands of the most sensitive detectors and readout systems available.

To capture such subtle signals, our detectors must be cooled to cryogenic temperatures, often as low as 100 mK. Operating at these extremes minimizes thermal noise and allows us to use superconducting materials, which are sensitive enough to register the tiniest variations in cosmic temperature. Indeed those materials exhibit a sharp superconducting to normal transition and are used as very sensitive thermometers.

Determination of performances in terms of sensitivities and bandwidth of such ultra sensitive detectors (transition edge sensors) require the development of methodologies of measurements and analysis. I'm focusing on the reconstruction of transition of the resistance as a function of temperature behind these superconducting sensors. Their response to a step signal is also an interesting tool to recover many dynamic sensor parameters. Finally, I'm building a noise model of these sensors taking into account the evolution of their operating point in the superconducting transition. This study would ease the on-site characterization of large arrays of transition edge sensors.

Speaker information

PhD 2nd year

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Classification de Session: PhD Talks

Classification de thématique: Physics of the Universe