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## Early Universe with CMB B-mode and observational challenges

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The large-scale  $B$ -mode polarization of the Cosmic Microwave Background (CMB) holds immense potential for revealing high-energy physics from the early Universe. Detecting this signature would likely indicate the emission of primordial gravitational waves following the Big Bang, providing crucial insights into the physics that created them. However, observing this faint signal is extremely challenging due to the interference from  $B$ -mode-emitting Galactic foregrounds and the need for meticulous control over instrumental systematics. In this talk, I will outline the impact of these challenges on our observations, focusing on current and upcoming CMB experiments. I will also introduce innovative methods for foreground removal and discuss the characterization of various instrumental effects on the final cosmological signal.

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