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Causality Bounds on the Primordial Power Spectrum

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Effective field theories (EFTs) parametrize our ignorance of the underlying UV theory through their Wilson coefficients. However, not all values of these coefficients are consistent with fundamental physical principles. In this talk, I will talk about recent work where we explore the consequences of imposing causal propagation on the comoving curvature perturbation in the EFT of inflation, particularly its impact on the primordial power spectrum and the effective sound speed $c_s^{\rm eff}$. We investigate scenarios where $c_s^{\rm eff}$ undergoes a transition, remaining consistent with CMB constraints at early times but later experiencing a drastic change, becoming highly subluminal. Such scenarios allow the primordial power spectrum to grow at small scales, potentially leading to the formation of primordial black holes or the generation of scalar-induced gravitational waves. We find the generic feature that in a causal theory, luminal sound speeds imply a free theory, effectively constraining the dynamics. Additionally, we obtain that when considering natural values for the Wilson coefficients, maintaining the validity of the EFT and the weakly coupled regime, and enforcing causal propagation of the EFT modes, the power spectrum cannot increase drastically. This imposes significant constraints on the parameter space of models aiming to produce such features.

Primary author: CESPEDES, Sebastian (Imperial College London)

Presenter: CESPEDES, Sebastian (Imperial College London)

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