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Quantum-to-classical transition of leading-order background fluctuations

Understanding the emergence of classical behavior from a quantum theory is vital towards establishing the quantum origin for the temperature fluctuations observed in the Cosmic Microwave Background (CMB). This talk presents how a real-space approach can comprehensively address this problem even in the leading order of curvature perturbations. Spatial bipartitions of quantum fluctuations are tested for three different indicators of classical behavior: i) decoherence, ii) peaking of the Wigner function about classical trajectories, and iii) relative suppression of non-commutativity in observables. These signatures are obtained from the covariance matrix of a multi-mode Gaussian state and addressed primarily in terms of entanglement entropy and log-classicality. Through a phase-space stability analysis of such states, we ascertain that the underlying cause for the dominance of classicality signatures is the occurrence of gapped inverted mode instabilities. We demonstrate that the absence of decoherence preempts a quantum-to-classical transition of scalar fluctuations in an expanding background in (1+1)-dimensions using two examples: i) a Tanh-like expansion and ii) a de-Sitter expansion. We then extend the analysis to leading order fluctuations in (3+1)–dimensions to show that a quantum-to-classical transition occurs in the de-Sitter expansion and discuss the relevance of our study in distinguishing cosmological models.

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