Contribution ID: **22** Type: **not specified**

IR finite correlation functions in de Sitter space, a smooth massless limit, and an autonomous equation

Thursday 31 October 2024 11:30 (20 minutes)

Currently, the study of cosmological correlation functions is extremely favored, and a large number of new techniques are being developed. I will discuss a less-fashioned but very efficient technique to calculate the loop corrections to the correlation function in the long-wavelength approximation. By employing the Yang-Feldman-type equation, we compute the two-point correlation function up to the three-loop level and the four-point correlation function up to the two-loop one. In contrast to the standard theory of a massive scalar field based on the de Sitter-invariant vacuum, we develop the vacuum-independent reasoning that may not possess de Sitter invariance but results in a smooth massless limit of the correlation function's infrared part. Our elaboration affords to calculate correlation functions of a free massive scalar field and to proceed with quantum corrections, relying only on the known two-point correlation function's infrared part of a free massless one. Remarkably, the two-point correlation function of a free massive scalar field coincides with the Ornstein-Uhlenbeck stochastic process's one and has a clear physical interpretation. We compared our results with those obtained with the Schwinger-Keldysh diagrammatic technique, Starobinsky's stochastic approach, and the Hartree-Fock approximation. At last, I will also discuss a way to generalize the obtained results to the non-perturbative case, as well as further prospects in this direction.

Based on arXiv: [2410.16226].

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