Massive Bosonic conformal zero-mode in the spatially compactified FLRW spacetimes and its detection

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Abstract

We examine a massive scalar field in the $(1+1)$- dimensional, spatially compactified Friedmann-Robertson-Walker (FRW) cosmological spacetimes. We consider both twisted and untwisted fields. The issue of the massive conformal zero mode arises for the untwisted field whenever the effective mass vanishes at early or late times. More precisely we show that this occurs whenever the zero-momentum mode of the untwisted field reduces to a massive conformal zero-mode in the corresponding asymptotic region(s). To resolve this issue, we develop a new scheme for quantizing the zero-momentum mode. This new quantization scheme introduces a family of two real parameters for every zero-momentum mode with an associated two-real-parameter set of in/out initial (resp. final) state(s). Moreover, we show that the zero-momentum starting state (resp. final state) wave function corresponds to a family of two-real parameter complex Gaussian wave packets. For applications, we examine the finite-time detector's response to a massive scalar field in the $(1+1)$-dimensional, spatially compactified Milne spacetime. Explicit analytic results are obtained for the comoving and inertially non-comoving trajectories. Numerical results are provided for the comoving trajectory. The numerical results suggest that when the in-state of the field system is chosen to be very far from the conventional Minkowski vacuum state, then it contains particles. As result, spontaneous excitation of the comoving detector occurs.

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