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Influence of spatial curvature in cosmological particle production

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Abstract

We analyze cosmological particle production driven by spacetime expansion in the early universe for homogeneous and isotropic cosmologies with positive, negative, and zero spatial curvature. We prioritize analytical results to gain a deeper understanding of curvature-induced effects. Specifically, for a conformally coupled scalar field, we model the inflationary epoch as an exact de Sitter phase followed by a transition to a static universe. Both instantaneous and smooth exits from inflation are considered, the latter being implemented via the adiabatic vacuum prescription. Starting from an initial Bunch-Davies vacuum, we derive the associated mode functions carefully adapted to each curvature sign. Using the Bogoliubov formalism, we non-perturbatively compute the number density of produced scalar particles. Our results demonstrate that spatial curvature significantly impacts the resulting particle spectra, particularly for light fields, where the deviation from the flat-space scenario is most prominent and can reach several orders of magnitude.

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