Mode-sum construction of the graviton two-point function in de Sitter space-time

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Quantum fields on de Sitter space-time received increasing attention in the last decades due to its relevance to inflationary cosmology. Yet, the existence of a de Sitter-invariant vacuum state for free gravitons is still a matter of contention in the literature. This thirty-year long controversy has its roots in the infrared (IR) behaviour of the free graviton field modes in the conformally flat (Poincaré) patch of the de Sitter space. Here we approach this problem by constructing the graviton two-point function for a two-parameter family of linear covariant gauges in n-dimensional de Sitter space. The construction is performed via the mode-sum method in the Bunch-Davies vacuum in the Poincaré patch, and we introduce a Fierz-Pauli mass term as an IR regulator. The resulting two-point function is de Sitter invariant and free of IR divergences in the massless limit, although analytic continuation with respect to the mass for the pure-gauge sector of the two-point function is necessary. However, if one starts with strictly zero mass theory, the IR divergences are absent only for a specific value of one of the two parameters, with the other parameter left generic.