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Functional determinants and lifetime of the Standard Model

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Accurately computing the decay rate of metastable vacua in quantum field theory hinges on a precise evaluation of functional determinants arising from quantum fluctuations. In this presentation, we explore recent advances in the regularisation and evaluation of these determinants. The first part introduces a streamlined method to regularize functional determinants for fields of spin 0, 1/2, and 1 in four-dimensional Euclidean space, by using familiar Feynman diagrammatic techniques with a double expansion in interactions and masses, together with dimensional regularisation in momentum space. After a Fourier transform to coordinate space, we end up with a simple regularisation prescription in terms of single integrals over the Euclidean radius of field-dependent masses and their derivatives. We demonstrate the effectiveness of this procedure with a full treatment of the Standard Model. In the second part, we refine the electroweak vacuum decay rate by revisiting the one-loop prefactor, focusing on gauge field contributions. Using group theory, we correct an overcounting in the transverse gauge modes, leading to a 6% shift in their contribution and a slightly reduced—but still cosmologically safe—vacuum lifetime. Together, these results offer improved theoretical control over vacuum decay calculations and broader insights into functional determinant techniques in gauge theories.

Secondary track

T01 - Astroparticles, Gravitation and Cosmology

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