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Complex Langevin analysis of the spontaneous breaking of 10D rotational symmetry in the Euclidean IKKT matrix model

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The IKKT matrix model is a promising candidate for a nonperturbative formulation of superstring theory, in which spacetime is conjectured to emerge dynamically from the microscopic matrix degrees of freedom in the large-N limit. Indeed in the Lorentzian version, Monte Carlo studies suggested the emergence of (3+1)-dimensional expanding space-time. Here we study the Euclidean version instead, and investigate an alternative scenario for dynamical compactification of extra dimensions via the spontaneous symmetry breaking (SSB) of 10D rotational symmetry. We perform numerical simulations based on the complex Langevin method (CLM) in order to avoid a severe sign problem. Furthermore, in order to avoid the singular-drift problem in the CLM, we deform the model and determine the SSB pattern as we vary the deformation parameter. From these results, we conclude that the original model has an SO(3) symmetric vacuum, which is consistent with previous results obtained by the Gaussian expansion method (GEM). We also apply the GEM to the deformed matrix model and find consistency with the results obtained by the CLM.

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