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Critical Phenomena on Bethe Lattice

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We investigate the critical behaviour of a $\mathbb{Z}_2$ -symmetric scalar field theory defined on Bethe lattices (the tree limit of regular hyperbolic tessellations) using both lattice perturbation theory and the non-perturbative functional renormalization group. Owing to the hyperbolic nature of such graphs, the Laplacian lacks a zero mode and exhibits a spectral gap, which is an external scale in the system, hindering the computation of critical exponents. Closing the spectral gap by adding a negative mass to the bare Laplacian is therefore essential to access a nontrivial fixed point, whose critical exponents are governed by the spectral dimension, which is three, corresponding to the Wilson–Fisher universality class. This behavior stands in stark contrast to the nearest-neighbor Ising model on Bethe lattices, which has mean-field critical exponents. To our knowledge, this constitutes the first explicit demonstration that a ϕ^4 theory and the discrete Ising model may flow to distinct fixed points on the same underlying lattice. We further comment on possible reasons for such deviations and propose future work to better understand critical phenomena on more general hyperbolic spaces.

Parallel Session (for talks only)

Theoretical developments and applications beyond Standard Model

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