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A qubit regularization of asymptotic freedom without fine-tuning

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Other than the commonly used Wilson's regularization of quantum field theories (QFTs), there is a growing interest in regularizations that explore lattice models with a strictly finite local Hilbert space, in anticipation of the upcoming era of quantum simulations of QFTs. A notable example is Euclidean qubit regularization, which provides a natural way to recover continuum QFTs that emerge via infrared fixed points of lattice theories. A non-trivial question is whether such regularizations can also capture the physics of ultraviolet fixed points. Specifically, can we recover massive continuum QFTs which are free in the UV but contain a marginally relevant coupling?

In this talk, I will discuss a novel regularization of the asymptotically free massive continuum QFT that emerges at the BKT transition through a hard core loop-gas model. Our proposed model offers several advantages compared to traditional regularizations. Firstly, without the need for fine-tuning, it can reproduce the universal step-scaling function of the classical lattice XY model in the massive phase as we approach the phase transition. Secondly, our approach exhibits reduced finite size effects for certain universal quantities at the BKT transition compared to the traditional XY model. Lastly, our model serves as a prime example of Euclidean qubit regularization of an asymptotically free massive QFT and helps understand the emergence of asymptotic freedom as a relevant perturbation at a decoupled fixed point without fine-tuning.

Topical area

Theoretical Developments

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