

Diffusion Sampler For Lattice Field Theory

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Sampling algorithms for lattice field theories face persistent efficiency challenges near the continuum limit, including critical slowing down and, in certain fermionic theories, poor ergodicity across degenerate vacua. Generative diffusion models, recently shown to correspond to stochastic quantization, offer a promising alternative and have been demonstrated for scalar and pure gauge theories; their extension to fermionic systems, central to full QCD with dynamical quarks, has remained largely unexplored.

We present a diffusion-based sampler for the two-dimensional Gross-Neveu model, a four-fermion lattice theory. The sampler is combined with an exact Monte Carlo correction step, guaranteeing unbiased sampling from the target distribution. We validate the method in the asymptotically free regime and across the finite-volume crossover, with observables cross-checked against an independent reference implementation. This work extends diffusion-based sampling to the fermionic sector and suggests a possible route toward accelerating simulations with dynamical fermions.

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