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Efficient Multilevel Sampling of Lattice Field Theory Near Criticality

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We present a hierarchical generative framework for efficient sampling of scalar field configurations near criticality. The method leverages a multiscale structure where coarse and intermediate fields are sampled via conditionally constructed Gaussian Mixture Models (GMMs). Normalizing Flows (NFs) refine these samples through invertible transformations that match the target distribution. This approach enables high Effective Sample Size (ESS) and mitigates critical slowing down. Our results demonstrate improved scalability and accuracy over traditional and superresolution-based methods.

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