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Enhancing Complex Langevin with Lefschetz Thimble-Based Regularizations

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The complex Langevin (CL) method is a promising tool for addressing the numerical sign problem.- Depending on the specific system, CL may produce unreliable results, which necessitates the use of ad-hoc stabilization methods. Building on the connection between CL and Lefschetz thimbles, we develop weight regularizations to enable correct convergence by deforming thimbles in systems with compact domains. This approach ensures success when a single compact thimble dominates the regularized system. Additionally, we introduce a bias correction procedure to recover results for the original theory where unregularized CL fails. We validate our method using several models, including the cosine model and the SU(2) and SU(3) Polyakov chains, for which CL previously was plagued by wrong convergence. Finally, we discuss the implications and potential applications of the insights gained by this technique to lattice field theories.

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