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Thermodynamic Consistency as a Reliability Test for Complex Langevin Simulations

Tuesday 4 November 2025 18:00 (1h 30m)

The complex Langevin method (CLM) is a promising tool to address the sign problem in quantum field theories with complex actions. However, it can converge to incorrect results even when simulations appear stable, highlighting the need for robust diagnostics. Existing checks, such as monitoring drift distributions, are useful but indirect. We propose a complementary test based on the configurational temperature, constructed from the gradient and Hessian of the complex action. Unlike drift-based criteria, this estimator directly probes thermodynamic consistency and provides a physically interpretable cross-check of CLM dynamics. Using one-dimensional PT-symmetric models, we show that it reproduces the input temperature with high precision and sensitively detects algorithmic errors, step-size artifacts, and incomplete thermalization. While demonstrated in simple systems, the method extends naturally to higher-dimensional scalar and gauge theories. Since temperature is tied to the bare coupling in many lattice theories, configurational monitoring can also provide an independent check on coupling-dependent observables. Our results indicate that configurational temperature can enhance CLM reliability across a broad range of applications, including lattice QCD at finite density.

Parallel Session (for talks only)

Theoretical developments and applications beyond Standard Model

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