A test for Dynamic Stabilization of complex Langevin: the XY-model

[G. Aarts, F. Attanasio, B. Jäger, CM]

Complex Langevin offers the possibility of simulating field theories that suffer from the complex action problem.

$$Z = \int D[\phi] e^{-S[\phi]}, \qquad S[\phi] \in \mathbb{C}$$

Idea:

- the fields are complexified $\phi \rightarrow \phi^R + i\phi^I$
- a time θ is introduced and the fields evolve according to the equations

$$\frac{\partial \phi^R(\theta)}{\partial \theta} = K^R + \eta(\theta) , \qquad \frac{\partial \phi^I(\theta)}{\partial \theta} = K^I$$

- expectation values are computed as noise averages of observables.

Problem of complex Langevin: **convergence to the wrong limit**.

The XY-model

XY-model

$$S = -\beta \sum_x \sum_{\nu=1}^3 \cos(\phi_x - \phi_{x+\nu} - i\mu\delta_{\nu,3}) , \quad \phi_x \in [0, 2\pi]$$

- phase transition at $\beta_c \sim 0.45$ and $\mu = 0$

- at $\mu \neq 0$ the model suffers from the **complex action problem**

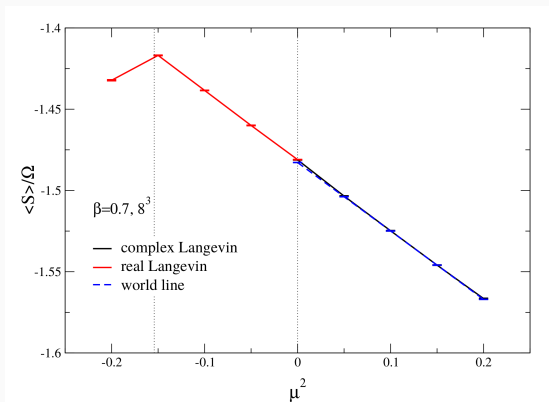- there exists a sign problem free worldline representation

[Banerjee and Chandrasekharan, Phys. Rev. D**81** (2010)]

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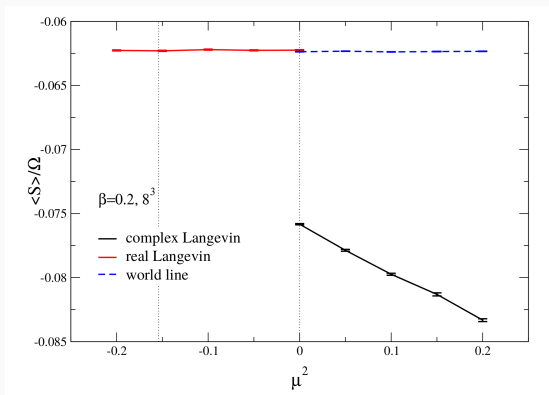
[Aarts and James, JHEP**08** (2010)]

In the ordered phase complex Langevin agrees with the worldline results

The XY-model

XY-model

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[Aarts and James, JHEP**08** (2010)]

In the disordered phase complex Langevin fails

Dynamic Stabilization

The main idea is to add a force to the Langevin dynamics. The imaginary part of the drift is modified by the addition of a force

$$K^I \rightarrow K^I + \alpha_{DS} F_{DS} \ , \qquad \alpha_{DS} \in \mathbb{R}.$$

The aim of adding this force is to suppress excursions into the complex direction to ensure improved convergence to the correct limit.

[Aarts, Attanasio and Jäger, Acta Phys. Polon. Supp. **9** (2016)]

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...come to the poster session to see the results