Equation of state from complex Langevin simulations

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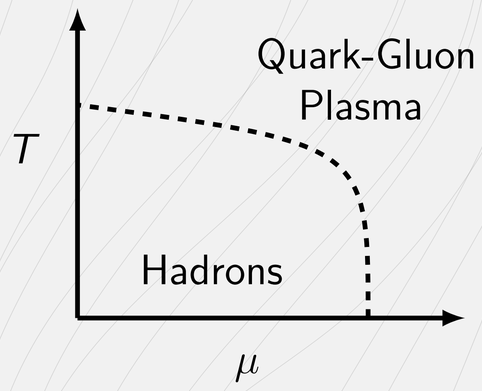
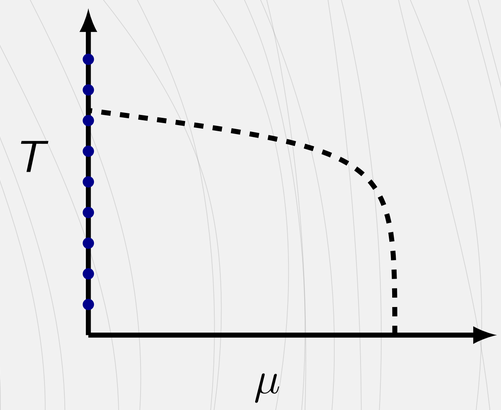
QCD phase diagram



Overview

- Goal: QCD phase diagram
- QCD @ $\mu \neq 0$ has SIGN problem
- Standard lattice can do small μ
- Here: Complex Langevin
- Based on arXiv 2203.13144

Standard lattice



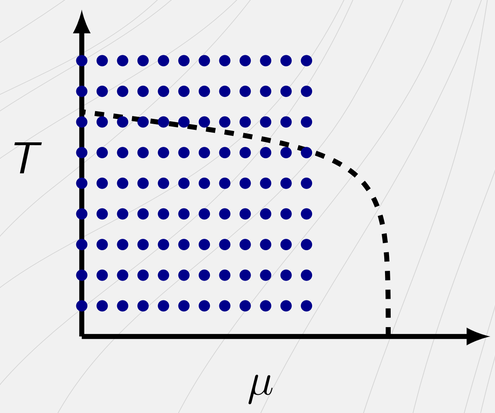
Complex Langevin

- Complexify

  $x \to z = x + iy$

  $SU(3) \to SL(3, \mathbb{C})$
- Langevin Equation

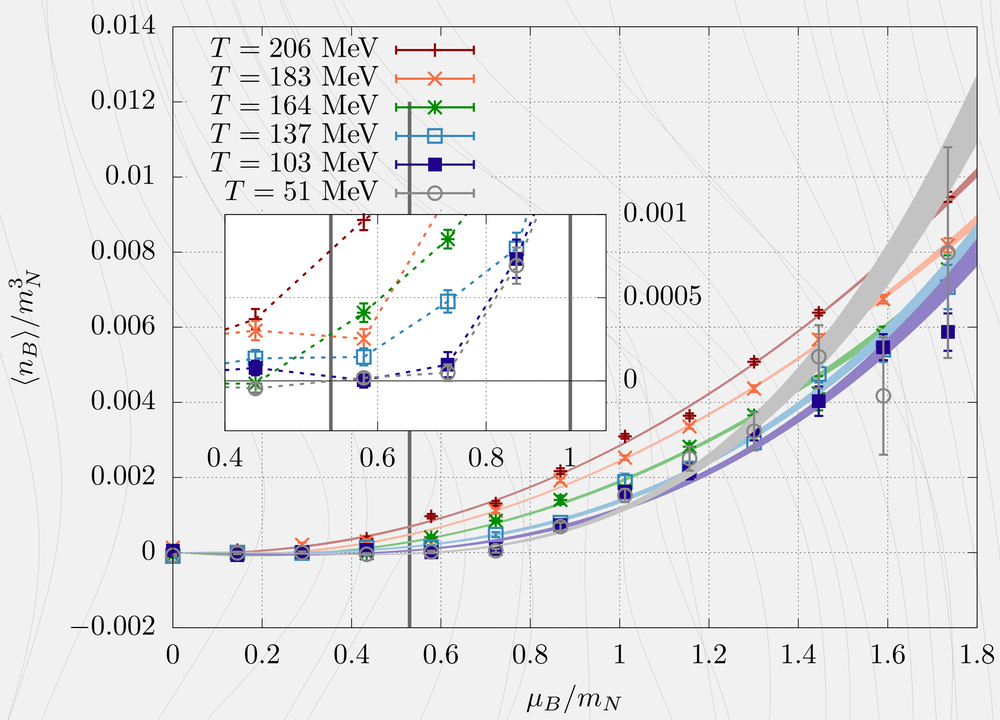
  $$\frac{\partial z}{\partial \theta} = \frac{\partial S}{\partial z} + \eta(\theta)$$



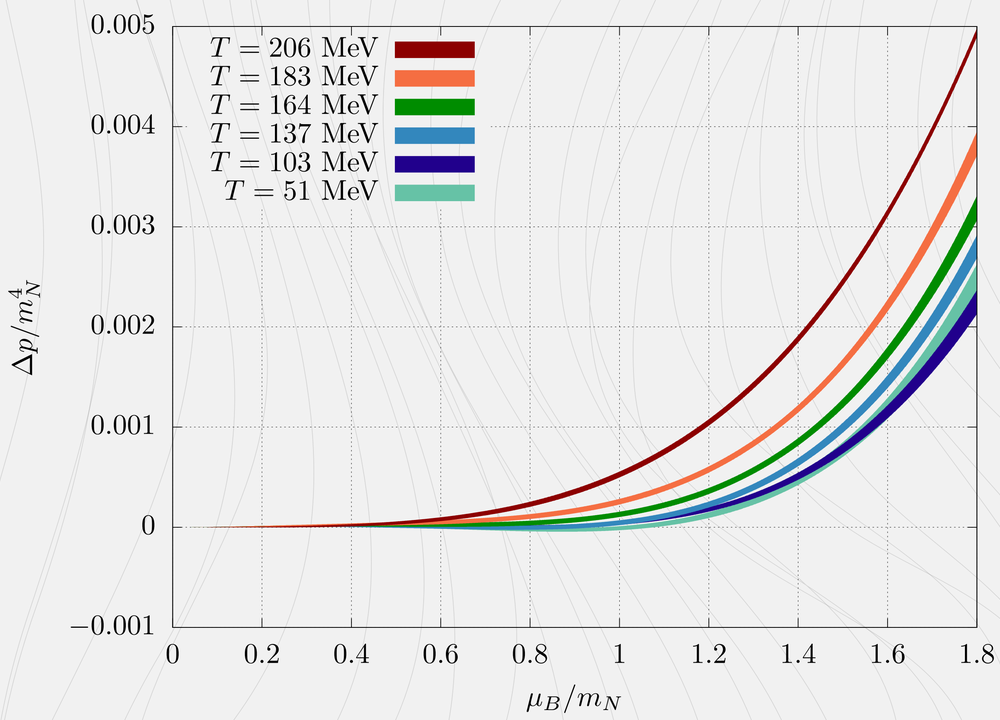
Current Setup

- Wilson plaquette action
- Pion mass $m_\pi \sim 500$ MeV
- Two flavour $N_f = 2$
- Volume $V = 24^3$
- Naive Wilson $c_{SW} = 0$
- Temperatures $T = 25 - 800$ MeV
- Density $\mu = 0 - 6500$ MeV
- Strange quark density $\mu_s = 0$

Fermion density vs. μ



Pressure vs. μ



Future Setup

- Lüscher-Weisz action
- Pion mass $m_\pi \to m_\pi^{\text{phys.}}$
- Three flavour $N_f = 2 + 1$
- Volume $V = 32^3$
- Wilson Clover $c_{SW} \neq 0$
- Temperatures $T = 12 - 800$ MeV
- Density $\mu = 0 - 6500$ MeV
- Strange quark density $\mu_s \neq 0$

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