The QCD phase diagram at strong coupling including auxiliary field fluctuations

Research talk about severity of the sign problem at strong coupling to investigate the QCD phase diagram on a large size lattice.

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Finite chemical potential region

- The sign problem
  - Caused by chemical potential
  - Complexity of the weight
  - Weight cancellation
  - Difficulty in studying finite chemical potential region

Avoiding or weakening the sign problem

- Ways to study finite chemical potential region
  - Reweighting Z. Fodor, S. D. Katz, (2002)…
  - Taylor expansion C. R. Allton *et al* (2002,2005) R. V. Gavai,S. Gupta (2008), S. Ejiri et al., (2010) …
  - Imaginary chemical potential M. G. Alford et al,. (1999). P. de Forcrand and O. Philipsen, (2002)…
  - Complex Langevin Matsui and Nakamura (1987) G. Aarts et al. (2010) …
  - Canonical approach Miller and Redlich (1987) Engels et al. (1999) A.Li, Meng et al.(2010) …
  - Strong coupling
  - ……etc.

Sign problem & Strong coupling lattice QCD

- Characteristics
  - Starting from lattice QCD
  - $1/g^2$expansion
    - Expansion by inverse coupling

$$S_{\mathrm{LQCD}} = S_{\mathrm{F}} + S_{\mathrm{G}}$$

$$\frac{1}{g^2} \square U \sim F_{\mu\nu}^2$$

- No sign problem in the mean field approximations
  - Chiral transition

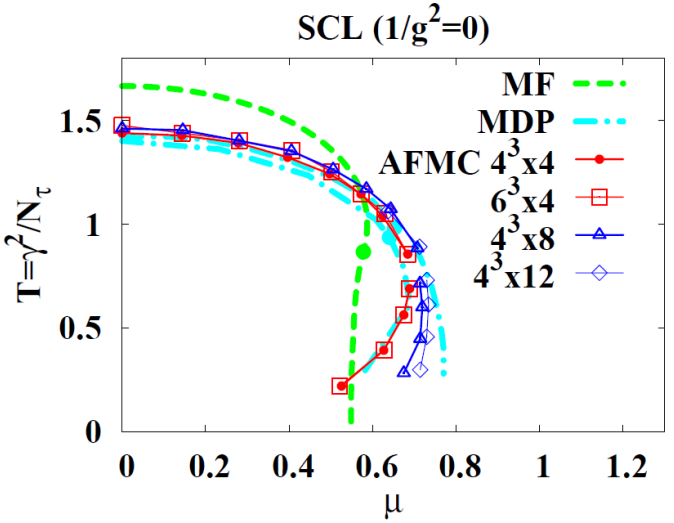
    N. Kawamoto and J. Smit (1981), P. H. Damgaard, N. Kawamoto and K. Shigemoto(1984) etc.
  - The QCD phase diagram

    Bilic, Karsch, Redlich ('92), Fukushima ('04), Nishida ('04) etc.
- "The sign problem" with fluctuations
  - Monomer-Dimer-Polymer simulations

    W. Unger, Ph. de Forcrand,

    J. Phys. G: Nucl. Part. Phys. **38** 124190 (2011)
  - Auxiliary field Monte-Carlo method

    A. Ohnishi, T. I. and T. Z. Nakano : arXiv:1211.2282



Purpose

- To discuss the source of “the sign problem” in Auxiliary field Monte-Carlo (AFMC) method
- To explore the possibility of applying AFMC method on a large lattice