Chiral restoration and deconfinement in two-color QCD with two flavors of staggered quarks

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Motivation
• understand phases of strong-interaction matter under extreme conditions in temperature and density
• develop reliable methods for finite baryon density where fermion sign problem prevents direct lattice Monte-Carlo simulations
• detox: QCD-like theories without fermion sign problem

This project: chiral properties
• preparations for finite density
• setting of (relative) temperature scale
• determine (unusual) chiral scaling behavior

Two-Color QCD
• Dirac operator has antinuimutary symmetry → no fermion sign problem
• extended flavor symmetry
• color-singlet diquarks: bosonic baryons
• would-be Goldstone bosons: pions and diquarks
• BEC-BCS crossover in diquark condensation phase

Chiral Symmetry Breaking Pattern
• continuum: SU(2Nf) →O(2Nf), here: SU(4) ≃O(6) →O(4)
• staggered: SU(2Nf) →O(2Nf), here: SU(4) ≃O(6) →O(4)

Simulation Details
• Nf = 2 staggered quarks

\[ g = \frac{1}{2a} \sum_{L} \phi(x) \left( U_{aL}(x) \delta_{\alpha,\beta} - U_{aL}(x) \delta_{\beta,\alpha} \right) + m \delta_{\alpha,\beta} \]

with staggered phases \( \phi(x) = (-1)^{x_{1}+x_{2}+x_{3}} \).
• \( Nf = 4, 6, 8 \) with aspect ratio \( Ns/Nf = 4 \)
• finite temperature: vary coupling \( \beta \)
• various masses for chiral extrapolation

Results

Order Parameters

Temperature Scale

Chiral extrapolation:

\[ \beta_{pc}(m, Nf) = \beta_{pc}(Nf) + a \cdot m^{2} \]

leading scaling behavior:

\[ T = \exp\left( \frac{m}{\beta - \beta_{pc}} \right) \]

Magnetic Scaling

determination of a critical exponent via susceptibility peak height:

\[ \chi_{max} \sim m^{1/2} \]

Outlook

• main goal: Polyakov loop potentials at finite density
• longer runs necessary at \( Nf = 8 \)
• lines of constant physics, scale setting