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

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- Motivation
- Effective Polyakov loop potential
- Chiral properties
- Summary and outlook

GEFÖRDERT VOM

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HIC for FAIR
Helmholtz International Center

Motivation

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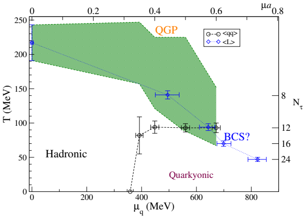
effective Polyakov loop potential

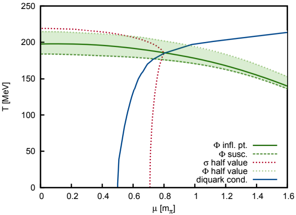
- influence of quarks on Polyakov loop potential
- compare to effective model descriptions
- two-color QCD as QCD-like theory where finite density is accessible

chiral properties

- scale setting
- scaling behavior



Boz, Cotter, Fister, Mehta, Skullerud [1303.3223]



Strodthoff, von Smekal [1306.2897]

Effective Polyakov loop potential

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- per-site probability distribution $P(l)$ via histogram
- per-site “constraint” effective potential:

$$V_0(l) = -\log P(l)$$

- obtain the actual per-site effective potential via Legendre transform

$$W(h) = \log \int dl \exp\left(-V_0(l) + hl\right)$$

$$V_{\text{eff}}(\hat{l}) = \sup_h \left(\hat{l}h - W(h)\right)$$

Polyakov Loop distributions and effective potentials at $\beta = 2.577856$

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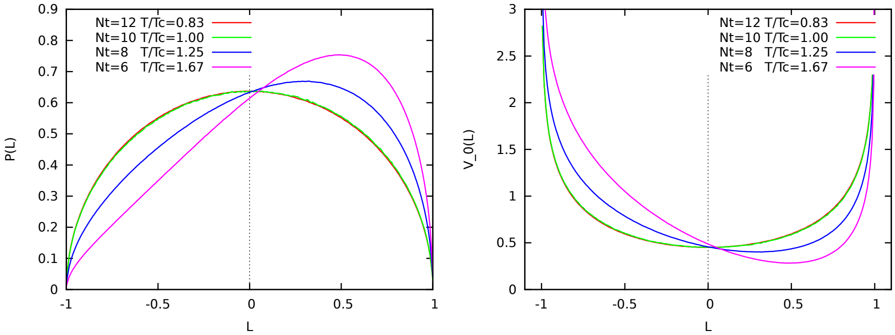

- pure gauge results by Smith, Dumitru, Pisarski, von Smekal [1307.6339]
- fixed scale

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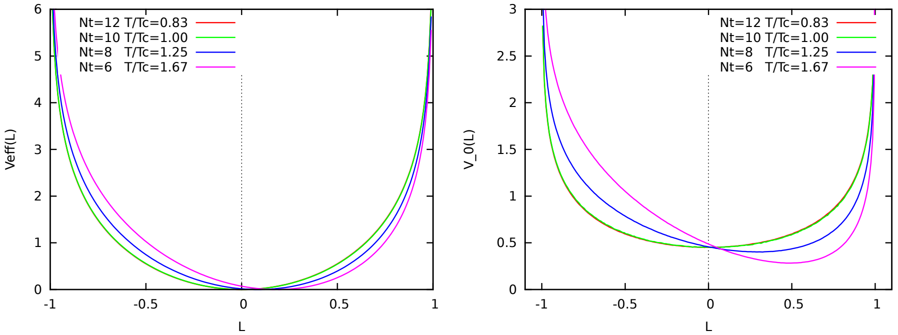

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Polyakov Loop distributions at $\beta = 2.577856$

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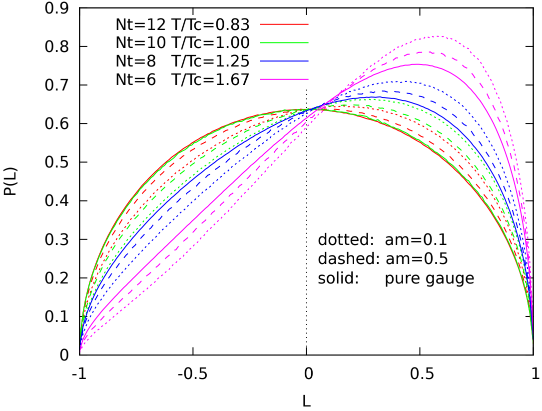

- add $N_f = 2$ staggered quarks
- neglect scale change through quark masses

▸ $\beta = 2.635365$

Polyakov Loop effective potential at $\beta = 2.577856$

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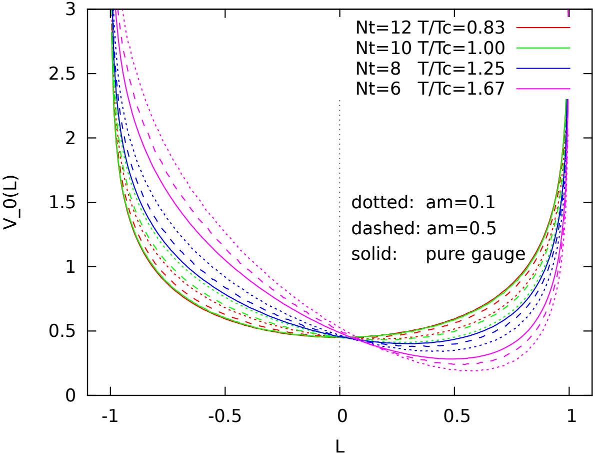

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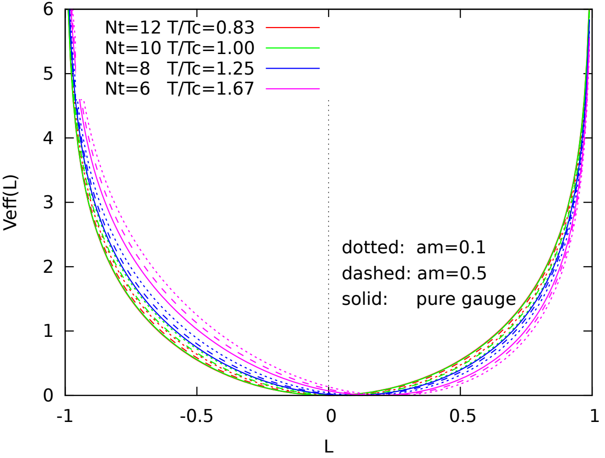
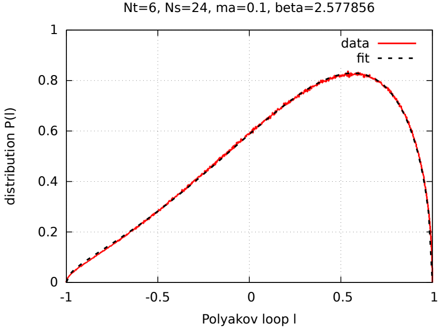


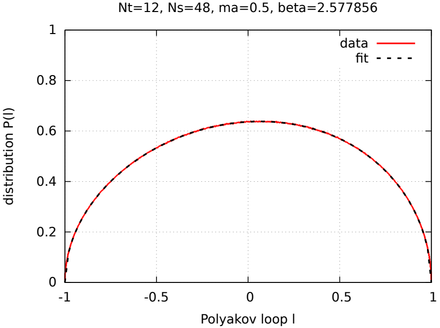
Modeling the distributions and potentials
Fit coefficients at $\beta = 2.577856$

- pure gauge: for $T \leq T_c$: Vandermonde potential:

$$V_0^{(T_c)}(l) = -\frac{1}{2}\log(1-l^2) - C \qquad P^{(T_c)}(l) = \frac{2}{\pi}\sqrt{1-l^2}$$

- ansatz for $T > T_c$: $$V_0(l) = V_0^{(T_c)}(l) + a(T) - b(T)l + c(T)l^2$$





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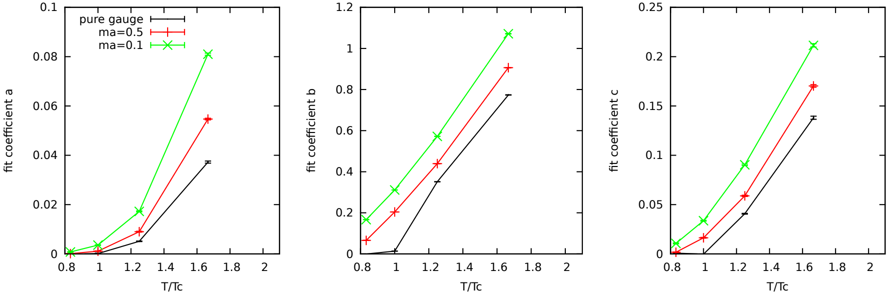

▸ $\beta = 2.635365$

Chiral properties
Simulation setup

- $N_f = 2$ staggered quarks via RHMC
- $N_t = 4, 6, 8$ with aspect ratio $N_s/N_t = 4$
- several masses $am = 0.005, 0.01, 0.02, 0.1, \ldots$
- finite temperature: vary β

symmetry breaking

- continuum: $SU(2N_f) \to Sp(N_f)$
- staggered: $SU(2N_f) \to O(2N_f)$, here: $SU(4) \simeq O(6) \to O(4)$

Order parameters

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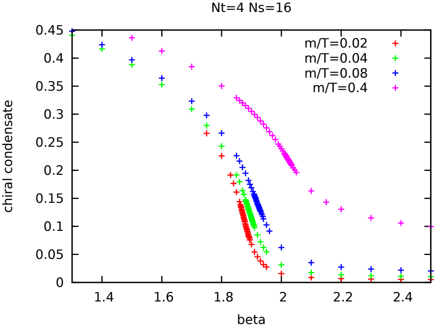

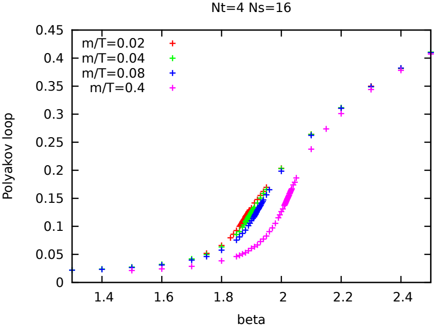

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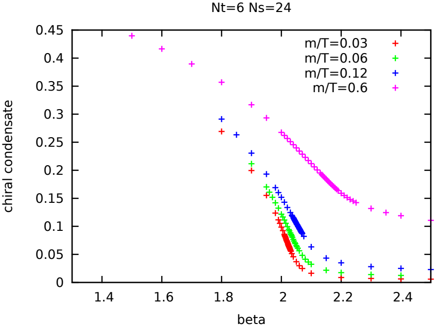

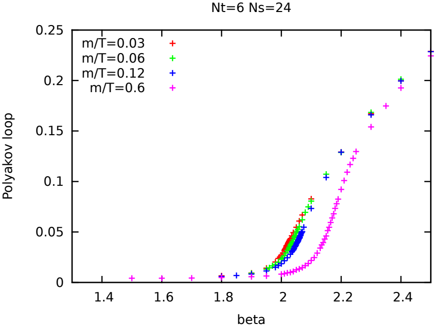

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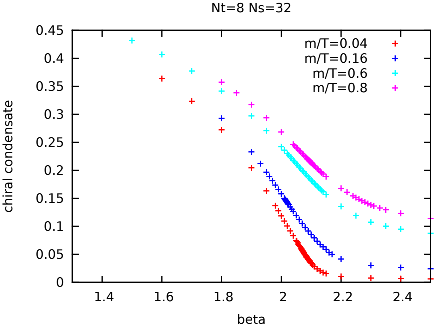
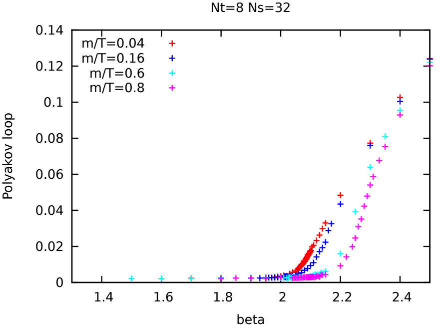
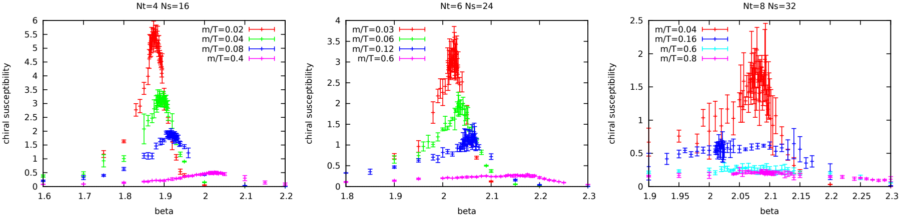
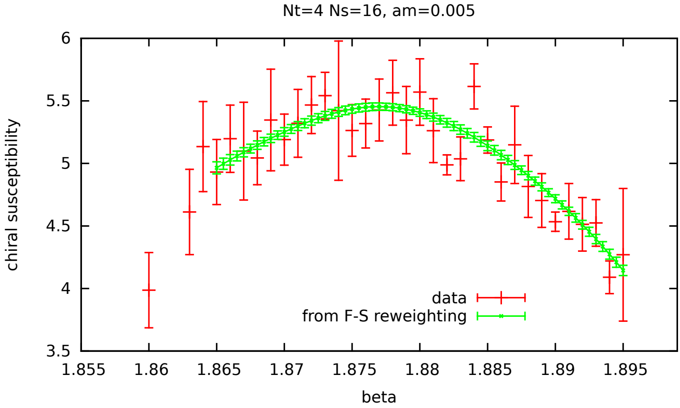




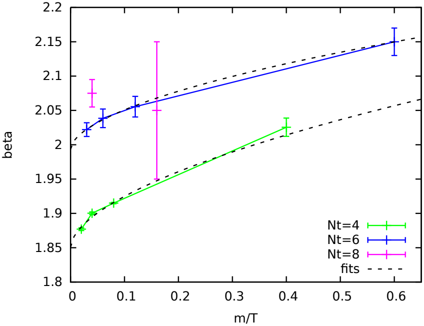
Chiral susceptibilities



Chiral susceptibilities



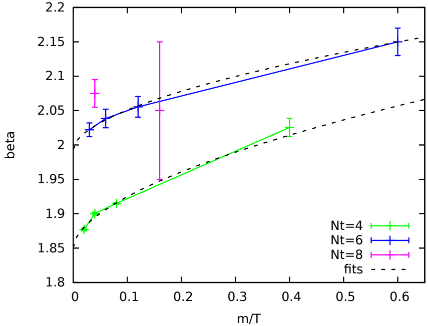
Temperature scale

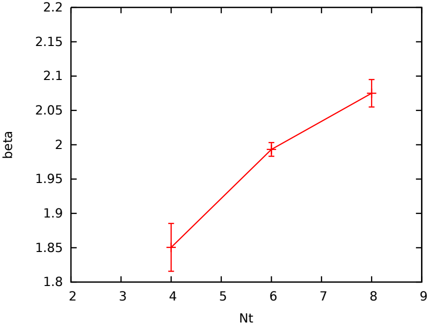


chiral extrapolation

$$\beta_{pc}(m, N_t) = \beta_c(N_t) + b \cdot am^c$$

Temperature scale





chiral extrapolation

$$\beta_{pc}(m, N_t) = \beta_c(N_t) + b \cdot am^c$$

Temperature scale

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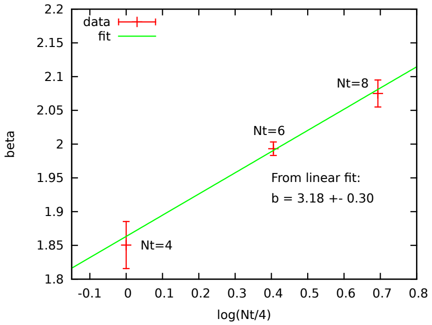
leading scaling behavior:

$$\frac{T}{T_c} = \exp\{b(\beta - \beta_c)\}$$



magnetic scaling

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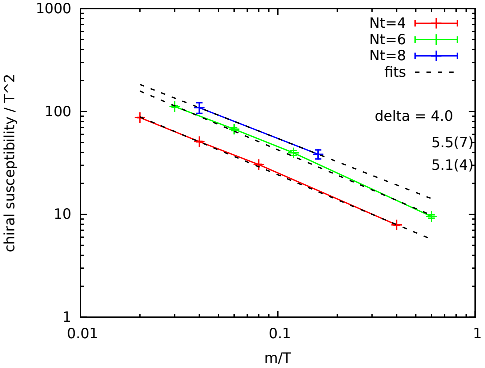
$$\chi_{max} \sim m^{1/\delta - 1}$$



Summary and outlook

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Summary

- unquenched effective Polyakov loop potentials
- began scale setting and determine critical exponents

Outlook

- continue: chiral properties need more work, especially at $N_t = 8$
- main goal: effective Polyakov loop potentials at finite density
- possible direction: adjoint representation

Backup Slides

Fixed scale parameters

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- pure gauge analysis: Smith, Dumitru, Pisarski, von Smekal [hep-lat/1307.6339]

β	$a\sqrt{\sigma}$	N_t	T/T_c
2.577856	0.140	12	0.83
		10	1.00
		8	1.25
		6	1.67
2.635365	0.116	12	1.00
		10	1.20
		8	1.50
		6	2.00

$$T(N_t) = \frac{1}{N_t a}$$

β	am
2.577856	0.5
	0.1
2.635365	0.414
	0.083

Polyakov Loop distributions at $\beta = 2.635365$

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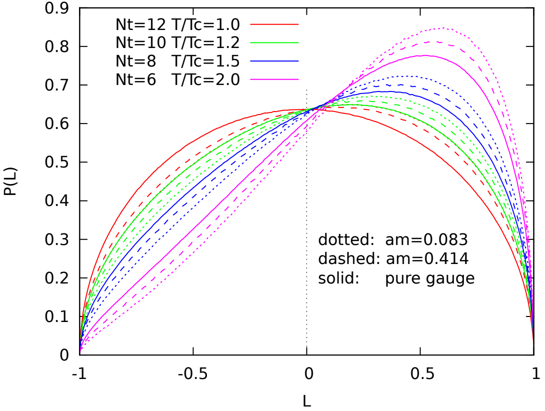
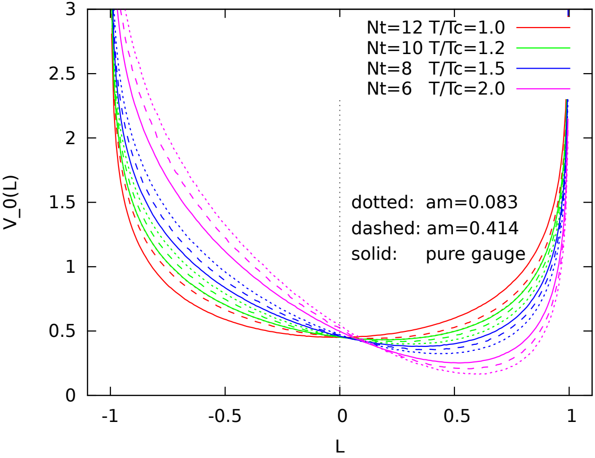


◂ $\beta = 2.577856$

Polyakov Loop effective potential at $\beta = 2.635365$



$\beta = 2.577856$

Fit coefficients at $\beta = 2.635365$

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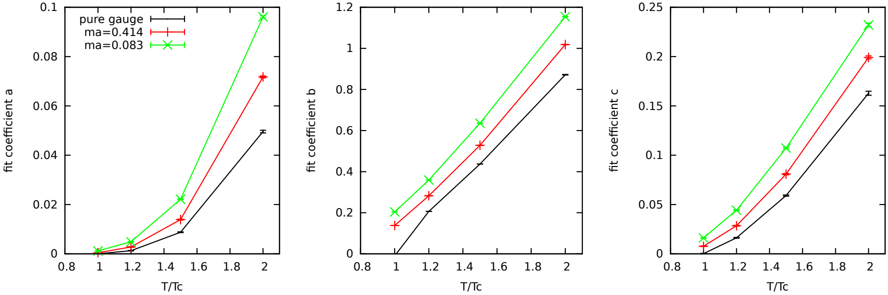
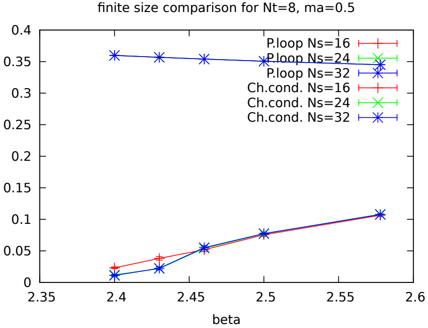


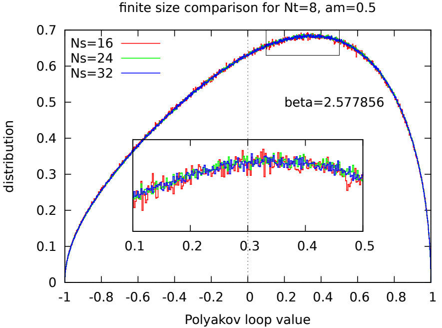
$$V_0(l) = V^{(T_c)}(l) + a(T) - b(T)l + c(T)l^2$$

◂ $\beta = 2.577856$

Finite volume test

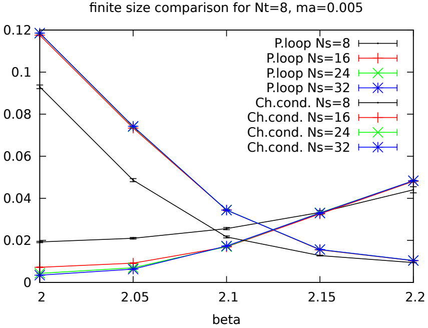
$N_t = 8, am = 0.5$

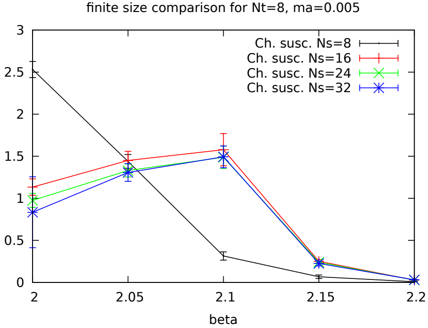




Finite volume test

$N_t = 8, am = 0.005$





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