THE UPPER RIGHT CORNER OF THE COLUMBIA PLOT WITH STAGGERED FERMIONS

Ruben Kara
and
S. Borsányi, J. N. Guenther, P. Parotto, A. Pásztor, D. Sexty

Quark Matter 2022
Columbia plot

"Columbia group" 10.1103/PhysRevLett.65.2491. Fig. from Forcrand et. al. 1702.00330.

Quenched QCD

- Latent heat in conti. lim. Shirogane: [1605.02997], Borsányi: [2202.05234] \(\Rightarrow\) 1st order
- Decreasing quark masses \(\Rightarrow\) transition gets weaker
- Investigations for \(N_f = 2\) Wilson fermions Cuteri: [2009.14033]
- Goal: Determination of the critical mass \(m_c\) for \(N_f = 3\)
Observables for $\mathbb{Z}_3$ symmetry breaking

Observables: Polyakov loop and its susceptibility

$$P = \frac{1}{N_s^3} \sum_{\vec{x}} P_{\vec{x}} = \frac{1}{N_s^3} \sum_{\vec{x}} \text{tr} \left[ \prod_{\tau} U_4(\vec{x}, \tau) \right]$$

$$\chi = N_s^3 \left( \langle |P|^2 \rangle - \langle |P| \rangle^2 \right)$$

Precise peak determination

- Cubic spline of $\langle |P| \rangle (\beta)$ and $\chi(\beta) \rightarrow \chi(\langle |P| \rangle)$
- Simpler form allows us to perform precise low order polynomial fits
Finite size scaling and comparison to the quenched case

L.h.s.: Quenched case

Borsányi: [2202.05234]

R. Kara (BUW)
Volume scaling of $\chi_{\text{max}}^{-1}$

Infinite volume limit for $N_t = 6$ and $N_t = 8$

- $N_t = 6: 28^3, 32^3, 42^3, 48^3, (64^3)$
- $N_t = 8: 32^3, 40^3, 48^3, 64^3$
Determination of the critical mass $m_c$

Critical region

- $\chi_{\text{max}}^{-1}$ follows a power law near the transition
- $m_q$ represents symmetry breaking field

$$\chi_{\text{max}}^{-1}(LT_c \to \infty) = A \cdot (m_c - m)^\gamma$$

| $N_t$ | $w_0 \cdot T_c$     | $m_{PS}/T_c$       |
|-------|---------------------|--------------------|
| 6     | 0.2531(2)           | 19.2271(9)         |
| 8     | 0.2477(4)           | 20.2090(4)         |