Polyakov loop correlations

The untraced Polyakov loop

$$L(\vec{x}) = \prod_{\tau} U_4(\vec{x}, \tau)$$

is related to the color-averaged free energy of a quark-antiquark pair[1]

$$F_{q\bar{q}}(r, T) = -T \log \left\langle \frac{1}{9} \operatorname{tr} L(\vec{x}) \operatorname{tr} L(\vec{y})^\dagger \right\rangle \qquad r = |\vec{x} - \vec{y}|.$$

Also of interest to us will be color-singlet free energy[2]

$$F_1(r, T) = -T \log \left\langle \frac{1}{3} \operatorname{tr} L(\vec{x}) L(\vec{y})^\dagger \right\rangle .$$

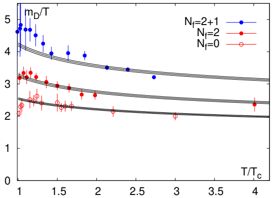
[1] L. D. McLerran and B. Svetitsky, Phys. Rev. D, 24.2, 450–460 (1981).
[2] S. Nadkarni, Phys. Rev. D, 34.12, 3904–3911 (1986).

Debye mass m_D

- $r_D = 1/m_D$ characterizes distance at which in-medium modifications of quark-antiquark interaction dominate (color screening)
- Extract m_D from large r behavior of quark-antiquark free energy

$$F_1(r,T) \sim \frac{\alpha(T)}{r} e^{-r\, m_D(T)}$$

- m_D dependence on T and N_f can be seen, e.g. in lattice simulations[3]



QUESTION: How does m_D depend on m_ℓ?

[3] O. Kaczmarek, PoS(CPOD07), 043 (2008).

Deconfinement criteria

Pure SU(N_c) and quenched QCD:

- Polyakov loop is the order parameter
- At finite N_s, the susceptibility peaks near $\beta_c(N_s)$
- Can use this to extract the critical temperature T_c

Finite quark mass:

- Peaks no longer contain information on deconfinement
- One may not find a peak anyway

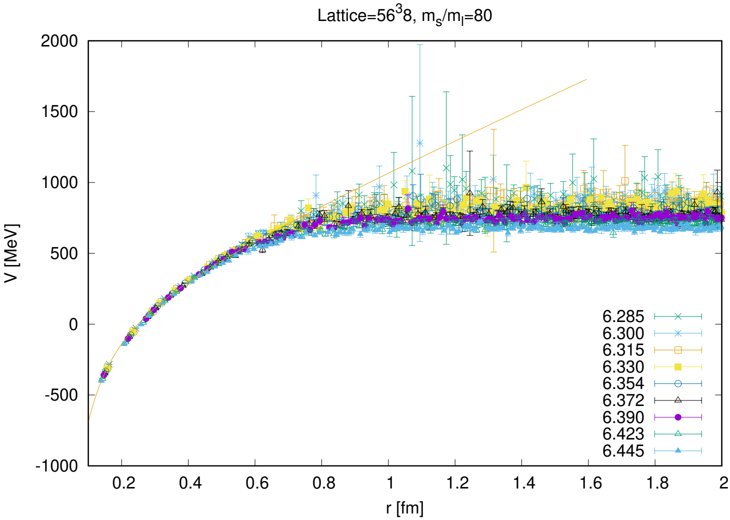
GOAL: Also examine these observables as a function of m_ℓ

Debye mass: Additional details

- F_1 measured in Coulomb gauge; gauge fixing with OR
- Free energies renormalized using qq-scheme[4]
- Scale is set with r_1
- m_D extracted from long-distance ($rT \gtrsim 1$) behavior of F_1
- But F_1 tends to be noisy at large distances
- IDEA: smooth using gradient flow to improve the signal

[4] O Kaczmarek et al., Phys. Lett. B, 543.1-2, 41–47 (2002).

Preliminary: T dependence of F_1



Preliminary: m_ℓ dependence of different Fs