The step scaling function of 2 flavor sextet SU(3) fermions

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We investigate the discrete β function of the 2-flavor SU(3) sextet model using the gradient flow scheme. This renormalized quantity should agree between different fermion formulations, offering a test of universality. Staggered fermion investigations[1,2] suggest that the system is chirally broken, following earlier Schrödinger functional studies with Wilson fermions[3] that were consistent with conformality. Our results, using improved Wilson fermions and the gradient flow RG scheme, are in tension with the staggered fermion results. Considering the potential phenomenological impact of this model, it is important to resolve this disagreement.

Numerical details

- Wilson fermions with nHYP smearing and NDS term ($\gamma = 0.075$) to reduce lattice artifacts[4]
- 3000-8000 MDTU at 11 gauge couplings, 7 volumes (10^4 - 24^4), tuned to $m_{\rm AWI} \approx 0$, in "volume squeezed phase"
- (Present mass tuning is insufficient for 28^4 configurations - they are in "mass deformed" phase)
- Use t-shift improved gradient flow coupling[5]

$$g^2_{\rm GF}(\mu = \frac{1}{\sqrt{8t}}) = \frac{1}{\mathcal{N}} t^2 \langle E(t+\tau_0)\rangle$$

- Measure the discrete β function with scale change s

$$\beta_s(g_c^2) = \frac{g_c^2(sL) - g_c^2(L)}{\log(s^2)}$$

where $g_c^2(L) = g^2_{\rm GF}(\mu = 1/cL)$, $s = 1.5$, $c \equiv \sqrt{8t}/L = 0.35 - 0.45$

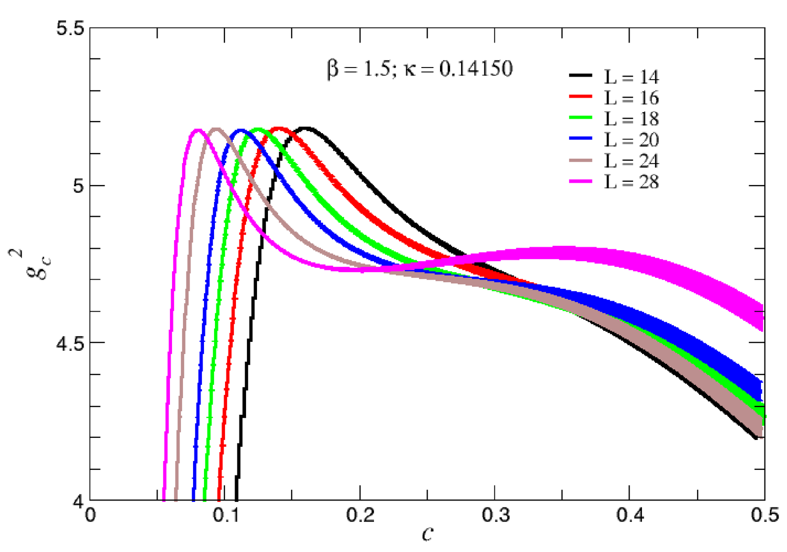
Challenges

- Tuning to κ_c has to be very precise, especially on large volumes and strong couplings
- Any mistuning will give upper bound to the step scaling function
- Continuum extrapolation should be taken reliably

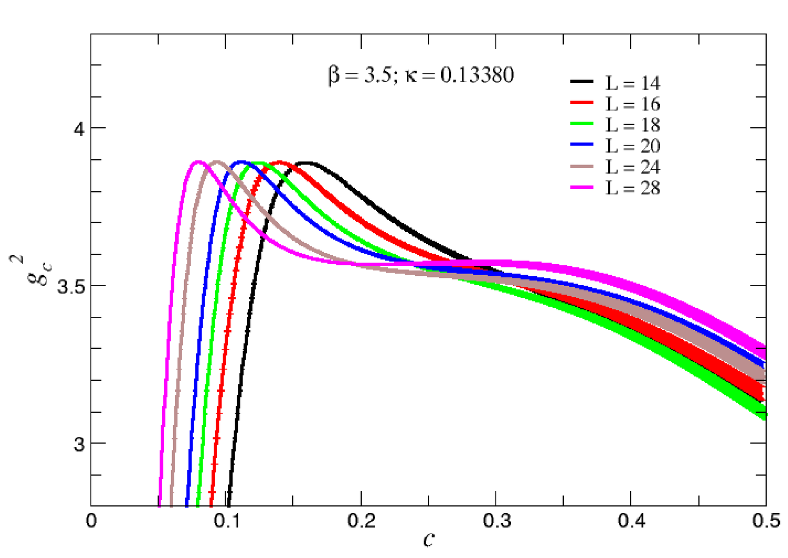
Volume dependence

Goal: tune κ such that $m_{\rm AWI} \ll 1/L$ (volume squeezed phase)

Mistuning: 28^4 configurations at some of the couplings are in mass deformed phase



At $\beta = 1.5$ the $L = 28$ volume is in different phase

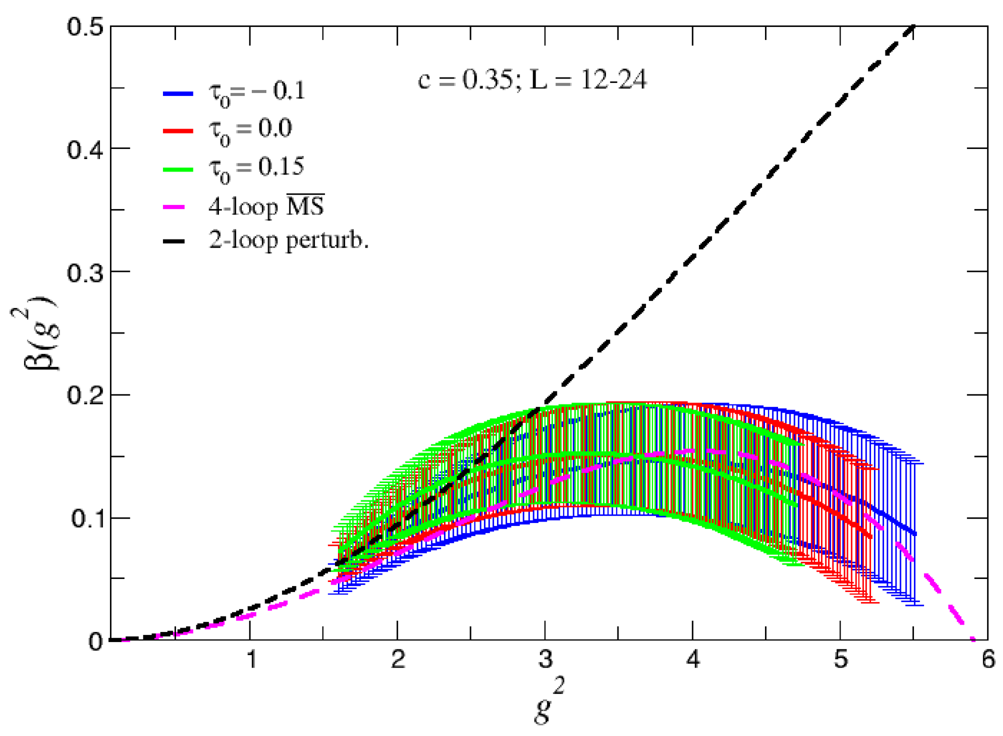


At $\beta = 3.5$ the $L = 10 - 28$ volumes are consistent

Analysis

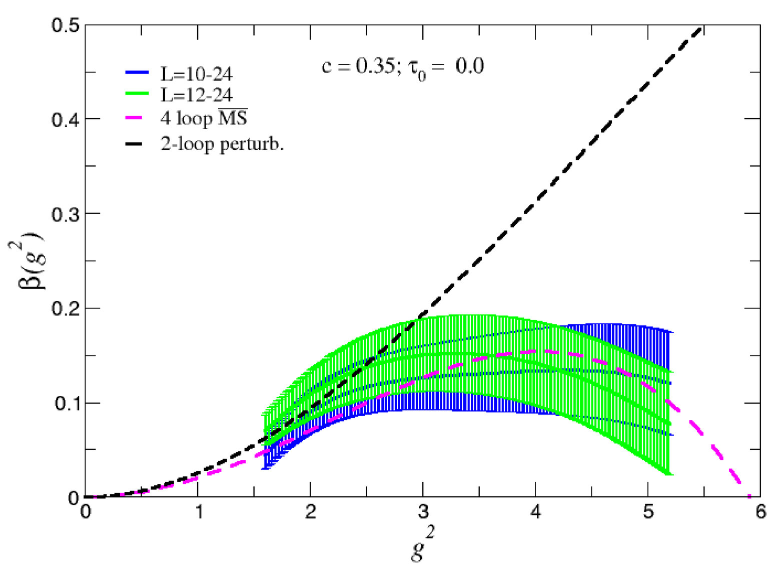
- Tune $\kappa \approx \kappa_{cr}$ so $0 \le am_{\rm AWI} \lesssim 0.003$
- Interpolate
  - $g_c^2(L;\beta,\kappa)$ in $1/L$, $L = 10 - 24$ (reduces errors considerably)
  - $\beta_{3/2}(g_c^2)$ step scaling function with a 5th order polynomial
- Extrapolate to continuum limit in $(a/L)^2$
- Use large c values (0.35 - 0.45) to reduce cut-off effects
- Use t-shift to improve continuum extrapolation ($\tau_0 = -0.1, 0, 0.15$)
- Use volumes $L \le 24$ only
- Compare $1/L^2$ extrapolation for $L \ge 10$ and $L \ge 12$

Results and conclusions

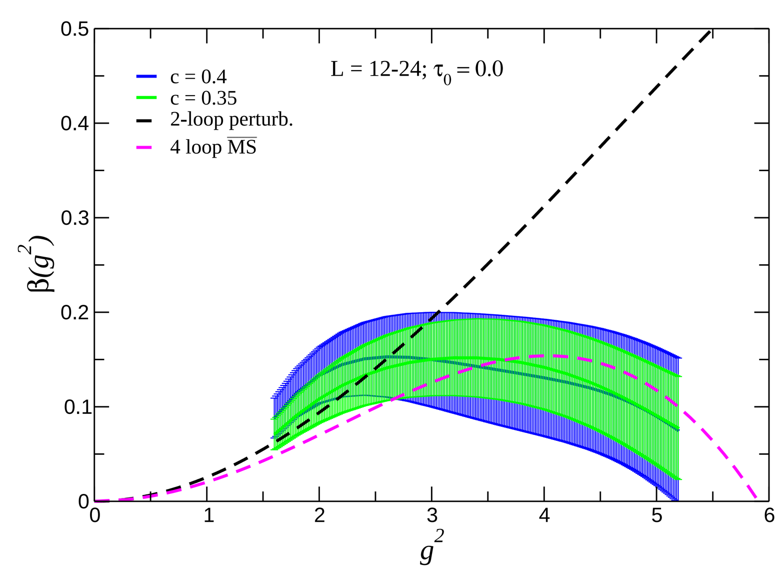


- Continuum extrapolated $\beta_{3/2}(g^2)$ with $c = 0.35$, $\tau_0 = -0.1$, 0.0, 0.15 are consistent
- $\beta_{3/2}$ is smaller than universal 2-loop at strong couplings, consistent with a possible IRFP at $g_c^2 \approx 6.0$
- $\beta_{3/2}$ is in tension with recent continuum limit extrapolated staggered fermion results[2] at $g_c^2 \gtrsim 4.0$

Further consistency checks:



Continuum extrapolations with $L \ge 10$ and 12 are consistent



$\beta_{3/2}(g^2)$ with $c = 0.35$ and $c = 0.40$ are consistent

The errors are dominated by statistic and κ mistuning

[1]arXiv:1502.00028; [2]arXiv:1506.06599; [3]arXiv:1201.0935; [4]arXiv:1407.4201; [5]arXiv:1404.0984