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MCRG study of 8 and 12 fundamental flavors with mixed fundamental-adjoint gauge action in strong coupling

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I explore the behavior of the beta function of SU(3) gauge theories with 8 and 12 flavors of fundamental fermions using Monte Carlo Renormalization Group (MCRG) techniques.

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1. Introduction

The behavior of strongly coupled ...

Our groups MCRG analysis is part of a broader study of SU(3) gauge theories with 8 and 12 flavors of fundamental fermions. Other characterstics of these theories that we have studied include the finite temperature phase diagram, eigenvalues, and mass spectra. Understanding how the beta function runs is very importaint in determining basic characteristics of a theory. Several other groups are also interested in these theories, many of whome have also calculated the step scaling function using schrodinger functional (other ways).

2. Two Lattice MCRG Matching

For a more detailed description of two lattic matching see[**?**]. The fundamental idea of two lattice matching is to geneate pairs of couplings (β, β') such that the lattice correlation lenght obeys $\xi(\beta) = 2\xi(\beta')$. Here we define the step scaling function, the analogue of the RG β function, as $s_b = \lim_{n_b \to \infty}(\Delta\beta = \beta\beta')$. Two blocked actions are identical if all blocked observables' expectation values are identical. The action matching process is summarized in two steps:

1. *Matching:* Match a given operator measured on two lattices blocked down to the same size L_b, where $L_b = \frac{L}{2^{n_b}}$

$$\Delta\beta(\beta; n_b, L_b) = \beta - \beta' \tag{2.1}$$

$$< O(\beta; n_b, L_b) >=< O(\beta'; n_b - 1, L_b) > \tag{2.2}$$

2. *Optimization:* Tune the blocking parameter such that consecutive steps yield the same $\Delta\beta$

$$\Delta\beta(\beta; n_b, L_b, \alpha_{optimal}) = \Delta\beta(\beta; n_b - 1, L_b, \alpha_{optimal}) \tag{2.3}$$

To accomplish this end I generate three lattices sizes over a variety of β values. We used a blocking factor of two and three volume sizes to do finite volume corrected two lattice matching: 24^3x48, 12^3x24, 6^3x12. All of our volumes were blocked down to a volume of 3^3x6 at which point we performed matching with the 24^3x48 and 12^3x24 as well as the 12^3x24 and 6^3x12. This gives me two values of $\Delta\beta$. To optimize the block transformation we tune a blocking parameter α; $\alpha_{optimal}$ is the value of α for which the two values of $\Delta\beta$ for the $24^3x24 \to 3^3x6$ matching and the $12^3x24 \to 3^3x6$ matching are identical. Once we have optimized the blocking, s_b can be approximated as $\Delta\beta_{optimal}$.

A great feature of MCRG is that it is fairly insensitive to finite volume effects since we are always comparing measurmetns on the same lattice size. Because we are using expectation values of observables to compare actions this feature also allows us to work at small lattice sizes and still achieve good results. Additionally because we are comparing local operators the statistical accuracy is generally good even with modest datasets. Finally MCRG is a nice method for determining the step scaling function because it does not require special lattices. The lattices used to generate this MCRG result are the same lattices that were used throughour program of study.

3. 8 Flavor Results

Our results for 8 flavors shows a step scaling function that is running

4. 12 Flavor Results

Our resutls for 12 flavors

5. Wilson Flow

6. Wilson Flow and MCRG...a shotgun wedding

7. Conclusion

8. Acknowledgments

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References

[1] ....