Lattice BSM Summary

USQCD AHM 2023

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Why use lattice methods for BSM?

- A lot of physics is missing from the Standard Model: gravity, inflation, dark matter, matter-antimatter asymmetry, neutrino masses, …

- Parts of the Standard Model are still not well-understood: Higgs naturalness, Higgs potential, W boson mass, …

- New strongly-coupled physics could play a role in any of these areas.

- In some areas, we can already adapt the techniques used in Lattice QCD to other theories.

- In other areas like gravity, inflation, fields in curved spacetimes, new approaches to "lattice" discretization are needed.

Current Lattice BSM on USQCD Resources (I)

- *From walking and emergent dilatons to α_s in QCD at the Z-pole,* J. Kuti (PI)

  - Gradient-flow based running coupling, competitive with other lattice QCD methods. Can also be used to study BSM theories (N_f=10) at strong coupling.

  - Dilaton EFT analysis in SU(3) sextet model.

- *Renormalization of critical ϕ^4 theory on $\mathbb{S}^2$ and $\mathbb{S}^2 \times \mathbb{R}$,* E. Owens (PI)

  - Initial plan was to study critical ϕ^4 theory at various couplings λ.

  - Evolved into finding a solution for the Ising model on a sphere using affine-transformed lattices as intermediate result. arXiv:2209.15546

- C. Wong and E. Owen gave talks at 2022 AHM.

Current Lattice BSM on USQCD Resources (II)

- *Near-conformal composite Higgs physics with two representations* (continuation), Neil (PI)

  - Project nearing completion. Seems theory is inside conformal window. First ever measurement of baryon operator anomalous dimension. Sadly, probably not viable candidate for partial compositeness. Preprint shortly.

  - Some resources were used to study running couplings in SU(3) N_f=10 Wilson with PV regulator. Max $g^2 \sim 10 \rightarrow 20$. Work in progress.

- *Gradient flow renormalization scheme for N_f=3 QCD*, Hasenfratz (PI)

  - While initially a QCD-oriented proposal, non-perturbative schemes for computing running couplings in the strong coupling regime are important for studying near-conformal BSM theories as well.

Proposed BSM on USQCD Resources

- *From BSM to α_s in QCD at the Z-pole* (continuation), J. Kuti (PI)

  - Primarily focused on completing QCD calculation. Tests of method in strong coupling QCD will also help with future BSM studies.

- *Gradient flow renormalization scheme* (continuation), A. Hasenfratz (PI) [Talk]

- *The non-perturbative renormalization group β-function of eight-flavor SU(3) gauge theory*, C. Peterson (PI) [Talk]

- *Novel phases and emerging fixed points in SU(2) gauge systems*, A. Hasenfratz (PI), S. Catterall, …

  - SU(2) N_f=8 might have a phase which chiral symmetry is unbroken but fermions still acquire mass. First step in a possible construction of chiral gauge theory.

Other BSM Projects by USQCD Members

- LSD Collaboration studying light scalars in SU(3) N_f=8. Update this month. Plans for updating S, T parameter calculation relevant for W mass.

- LSD studying composite scalar baryon dark matter based on SU(4) gauge theory, including thermodynamics, gravity waves, self-interaction, nuclei?…

- S. Catterall et al. studying Euclidean dynamical triangulation , confirming earlier results by J. Laiho. arXiv:2207.12642 [hep-lat]

- S. Catterall, J. Geidt et al. studying N=4 SUSY connecting to results from holography. arXiv:2303.16025

- QFE Collaboration: conformal 4pt function in critical ϕ^4 theory on $\mathbb{S}^2 \times \mathbb{R}$. PoS LATTICE2022 (2023) 370

- Several projects exploring lattice theories on hyperbolic spaces: Catterall, Brower, Unmuth-Yockey, …