Lattice Supersymmetry: Successes and Opportunities

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Supersymmetric theories play a prominent role in efforts to understand strong dynamics, quantum gravity and a variety of extensions to the the Standard Model of particle physics. Of particular interest is $\mathcal{N}=4$ super Yang-Mills theory. This possesses a conformal phase containing a line of critical points which are believed to map into each other under a strong-weak coupling duality. It is also thought to be holographically equivalent to type IIb string theory in an anti-de Sitter background, at least in the limit of an infinite number of colors and for strong 't Hooft coupling. Far less is understood as the 't Hooft coupling and number of colors is reduced corresponding to the incorporation of classical and quantum string corrections.

A lattice formulation of the theory would allow us to study these less well understood limits from first principles testing both the holographic principle and potentially yielding insight into the non-perturbative structure of both string theory and quantum gravity. Work over the last twenty years has resulted in a suitable lattice formulation of this theory which preserves both gauge invariance and a fraction of the continuum supersymmetries [1]. These symmetries are already sufficient to constrain the form of the quantum corrected lattice action and indicate that a maximum of one marginal operator will need to be tuned to take the continuum limit [2]

Numerical work has already revealed the existence of the conformal phase and shown that the Wilson loops of the theory exhibit a behavior consistent with the predictions of holography [3, **?**]. These calculations need to be extended to larger lattices where the issue of tuning will need to be addressed. Calculations have been proposed which will provide a check on the strong-weak coupling duality and will allow computation of anomalous dimensions of non-BPS operators such as the Konishi operator away from the large N limit. Such calculations will require substantial but achievable computational resources that can be estimated reliably from current simulations.

This research area ties together many different branches of theory - from lattice gauge theory to string theory, the conformal bootstrap and amplitudes programs and work on quantum gravity. It also exhibits significant connections to the Computational Frontier.

References

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