Research proposal

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The applicant has conducted research in particle physics, with a focus on supersymmetry and gradient flow. This research relates to various topics including renormalization, numerical calculations, string theory, and AdS/CFT correspondence. In addition to continuing the previous research described in the attached sheet, the applicant is interested in exploring other areas of research as well.

Supersymmetric Gradient Flow in SQCD

In previous work, we examined the perturbation theory and divergence structure of supersymmetric gradient flow in four-dimensional $\mathcal{N}=1$ supersymmetric quantum chromodynamics (SQCD) [1]. However, this investigation was limited to the one-loop level for two-point functions in the Wess-Zumino gauge. In the case of Yang-Mills flow, it is shown that UV-divergences are absent in any flowed correlation function at all orders of perturbation theory. We aim to prove the result of [1]. Additionally, while the Wess-Zumino gauge does not preserve manifest supersymmetry, the results of [1] suggest that manifest supersymmetry is recovered. As a further study, it would be interesting to explore the perturbation theory using the superfield formalism, a supersymmetric gauge-fixing, and different regularization schemes.

Numerical Applications in SQCD

One notable aspect of gradient flow is the ability to derive new gauge-invariant physical quantities using the UV-finiteness and small flow time expansion. This enables the examination of physical quantities obtained with different regularization schemes. We aim to formulate observables using SQCD flow , and to apply this to numerical calculations.

Other applications and extension of supersymmetric flow

Gradient flow has also been applied in the study of the AdS/CFT correspondence, which claims a profound relationship between a D-dimensional conformal field theory and a $(D+1)$-dimensional supergravity theory. In an attempt to understand the correspondence from a different perspective, a method for defining the geometry of $(D+1)$-dimensions from D-dimensional gauge theories using gradient flow equations has been proposed.

Another area of interest is the construction of an exact renormalization group (ERG) which is manifestly gauge-invariant. While the ERG provides a framework for studying quantum field theories beyond perturbation theory, the momentum cutoff makes it difficult to preserve gauge symmetry. The gradient flow can propose a gauge-invariant ERG.

Applying these studies to supersymmetric theories will enhance our understanding of gradient flow and supersymmetry, and facilitate a variety of related applied research. To achieve this, we plan to also work on extending supersymmetric flow theory to $\mathcal{N}=2,4$ supersymmetric theories.