Research Statement

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In previous work, I have investigated theoretical research on particle physics. In particular, I have focused on supersymmetric gauge theory and gradient flow method, investigating the perturbation theory of supersymmetric gradient flow in supersymmetric quantum chromodynamics (supersymmetric QCD, SQCD).

Background

In particle physics, supersymmetry, a symmetry that relates fermions and bosons under generalized spacetime transformations, is still significant. There is also the potential for using supersymmetry to approach quantum gravity through the exact solution of supersymmetric theory on a discretized lattice space, but there is a challenge in relating supersymmetry and translational symmetry. It is also difficult to directly define the energy-momentum tensor (EMT) on the lattice because of the violation of translational invariance.

The gradient flow, primarily used in lattice gauge theory, defines a flow equation through the gradient of the action and discusses a smeared gauge field. In the case of Yang-Mills theory, any correlation function generated by the gradient flow for a positive flow-time becomes ultraviolet (UV)-finite after renormalizing the boundary theory. This is because the flow equation behaves like a diffusion equation and reduces UV-divergence. The gradient flow's ability to renormalize allows for the local products of the flowed field to be used to compare physical quantities obtained through different regularizations. The gradient flow can also represent the EMT in terms of the flowed field, and this representation has been utilized in lattice QCD simulations. Additionally, the gradient flow suggests the possibility of constructing supersymmetric theory as a continuous limit from the lattice.

Supersymmetric flow in SQCD

One natural application is to construct supersymmetric flow equation. As an extension of the supersymmetric flow equation, the applicant, with Kadoh, Maru, and Ukita, has been working on four-dimensional $\mathcal{N}=1$ SQCD, interacting with matter fields. In particular, In particular, we solved iteratively the flow equations for all component fields in the Wess-Zumino gauge and investigating the divergence structure of the two-point functions generated by each flowed field at the one-loop level [1]. As a result, the gauge multiplet is found to be UV-finite by renormalizing the boundary SQCD. The matter multiplet requires additional wave function renormalization, which is also found to be common to the component fields. These results can be regarded as a naive extension of non-supersymmetric flow theory and suggest the potential for further research on gradient flow and supersymmetry. To validate the results of [1] in all orders of perturbation, we have also constructed a $(D+1)$-dimensional action equivalent to D-dimensional flow theory.