

Research proposal

I have focused on two approaches to supersymmetric (SUSY) theory: (1) extensions of the gradient flow to supersymmetric theory, and (2) extensions of the minimal supersymmetric standard (MSSM). These researches relate to various topics including renormalization, numerical calculations, string theory, and the anti-de Sitter/conformal field theory (AdS/CFT) correspondence. In addition to continuing the previous research described in the attached sheet, I am interested in exploring other areas of research as well.

1. Supersymmetric gradient flow in supersymmetric theory

In previous work, we showed that the two-point correlation functions generated by the gradient flow are finite at the one-loop level [1]*. In the case of the Yang-Mills gradient flow, it is shown that 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, our results suggest that manifest SUSY may be significant to gradient flow. As a further study, it would be interesting the perturbation theory with manifest SUSY and different regularization schemes.

Gradient flow has also been applied to various studies: (1) the universal formulation of physical quantities independent of regularization schemes, (2) the construction of an exact renormalization group that is manifestly gauge-invariant, and (3) the new approach to the AdS/CFT correspondence. Applying these studies to SUSY theory would clarify the structure of gradient flows and supersymmetry theory and facilitate a variety of related applied research. We will also approach the methodology of constructing the flow equation appropriate to certain theories from the viewpoint of geometric flow and work on extensions to $\mathcal{N} = 2, 4$ supersymmetric theories.

2. The MSSM extended to mixed Majorana-Dirac mass

First, we will analyze more precisely the mass matrix and interactions in general supersymmetric theories obtained from the partially SUSY breaking $\mathcal{N} = 2$ to 1. This analysis will confirm the existence of massless fermions, which is guaranteed by the Nambu-Goldstone theorem. We will also discuss the physical consequences of interactions with supersymmetric particles. These analyses are for general effective theory with $\mathcal{N} = 1$ SUSY.

After analyzing the general case, we will also work on extensions of the minimal supersymmetric standard model (MSSM). Specifically, as an application of the partial SUSY breaking of $\mathcal{N} = 2$ to 1, we will investigate a model in which $\mathcal{N} = 1$ SUSY is dynamically broken on a metastable vacuum. Such a theory has already been constructed by Itoyama and Maru. The model has a new mechanism of spontaneous SUSY breaking and contains a mixed Majorana-Dirac mass term. By analyzing the properties of this model, we extend the MSSM and elucidate the mechanism of SUSY breaking.

*[] is the paper number in the attached list.