Research Plan

One of the issues I should address is that the moduli is unstable in the points where the cosomological constant is suppressed. From a phenomenological point of view, it is desirable that the cosmological constant be small and the moduli be stabilized so that unobserved scalar fields do not appear. As for research plans, I will focus on investigating whether there exists a point where these two conditions are compatible.

- **Study in toroidal models**

  In [3], I analyzed the suppression of the cosmological constant and the stability of the moduli in nine-dimensional model. So, I would like to perform a more comprehensive analysis in lower dimensionnal models. Although the toroidal model is simple and can be easily constructed, the moduli can not be automatically fixed, and hence there are a lot of parameters to be considered. Therefore, I focus on the configurations of the moduli where the gauge symmetry is maximally enhanced. Since such points is known to correspond to extrema of the potential, it is natural to impose such a restriction. The procedure of the analysis would be as follows:

  1. For give moduli, identify all charges of the massless states
  2. Check whether a set of the charges obtained in step 1 satisfies the condition for suppression of the cosmological constant
  3. Calculate the Hessian matrix and check whether it is positive definite

  It is difficult to perform the above analysis by hand, so I plan to use a machine to do it. But, even if I use a machine, naive coding by iterators would take a huge amount of processing time on a typical computer. So, It is expected that the challenge will be how to reduce the calculation costs.

- **Study in orbifold models**

  As a next step, I would like to construct non-supersymmetric models whose a starting point of the construction is an orbifold model in which some supersymmetry is already broken. I plan to start from a study of simple orbifold models that is constructed with standard embedding and without discrete Wilson lines. The procedure of the analysis would be basically the same as in the toroidal models, but it is expected that characteristic contributions of orbifold models such as twisted sectors make a difference from the toroidal cases. After I complete the analysis of the simple models,

I would like to generalize the models by using non-standard embedding and turning on discrete Wilson lines, and move on to the analysis of more general cases.

[1] H. Itoyama and T. R. Taylor, "Supersymmetry Restoration in the Compactified O(16) x O(16)-prime Heterotic String Theory," Phys. Lett. B **186**, 129-133 (1987)

[2] H. Itoyama and S. Nakajima, "Exponentially suppressed cosmological constant with enhanced gauge symmetry in heterotic interpolating models," PTEP **2019**, no.12, 123B01 (2019) [arXiv:1905.10745 [hep-th]] .

[3] H. Itoyama and S. Nakajima, "Stability, enhanced gauge symmetry and suppressed cosmological constant in 9D heterotic interpolating models," Nucl. Phys. B **958**, 115111 (2020) [arXiv:2003.11217 [hep-th]] .

[4] H. Itoyama and S. Nakajima, "Marginal deformations of heterotic interpolating models and exponential suppression of the cosmological constant," Phys. Lett. B **816**, 136195 (2021) [arXiv:2101.10619 [hep-th]] .

[5] H. Itoyama, Y. Koga and S. Nakajima, "Target Space Duality of Non-Supersymmetric String Theory," [arXiv:2110.09762 [hep-th]] .

[6]

[6] S. Nakajima, "New non-supersymmetric heterotic string theory with reduced rank and exponential suppression of the cosmological constant," [arXiv:2303.04489 [hep-th]] .