Research Plan

Objectives : Study of higher dimensional black holes in the Large D limit

The Einstein equation is the non-linear partial differential equation, which is quite difficult to solve in general. In the large D limit, however, when the gradient along the horizon is moderate, the Einstein equation reduces to the more tractable effective membrane equation with one fewer inhomogeneity. My research objective is to study the property and dynamics of higher dimensional black holes in more general shapes and with various matter fields and modified gravity theory by the large D limit. I also investigate the large D limit in non-vacuum cases with charges and other matter fields as well as that for the modified theories of gravity.

Research Plan

I plan to develop and extend the application of the large D limit in several directions.

(i) Search for higher dimensional black holes

The large D limit greatly simplifies the Einstein's equation to the large D effective theory, which makes the analysis with fewer symmetries easier. Recently, we have developed a technique to study the dynamics of compact black holes easily by implementing them as 'blob' on the brane setup. This technique will help mapping out the entire solution space. The study of black holes with the charges and other matter sources and even with the modified gravity will be also important topics.

(ii) Physics beyond effective theory: radiation, topology-change, critical collapse

The conventional effective theory approach cannot be applied for the physics involving large gradients. Since the general framework has been not yet established, it is challenging and fruitful to tackle this problem. We have shown the Einstein's equation reduces to the Ricci flow equation with the large space gradient, giving the analytical treatment for the topology-changing transition [1]. Similar setup in the time domain also gives similar heat flow type equation [2], in which the critical collapse will be described. These results will be a great hint to find out the general treatment for the physics beyond the effective theory.

(iii) Large D limit and Extremal limit

With a fixed horizon radius, the large D limit leads to the black hole horizon with the temperature of $\mathcal{O}(D)$. However, the extremal limit leads to the vanishing temperature which competes with the large D behavior. Recently, Kachru and Shyani has paved a way to treat both limits in a controllable manner by tuning the extremal parameter to give the finite temperature at $D \to \infty$ [3]. Hinted by this work, I will investigate the large D limit of the extremal limit.

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[1] R. Emparan and R. Suzuki, JHEP **1907**, 094 (2019)
[2] M. Rozali and B. Way, JHEP **11**, 106 (2018)
[3] S. Kachru and M. Shyani, arXiv:2010.03560 [hep-th].