Current Progress

Background

Recent progress on higher dimensional black holes reveals there are a vast number of black hole phases, unexpected from the four dimensional spacetime. In D = 5, there found various explicit solutions as Myers-Perry black holes, black rings, black saturns, etc. for now. The discovery of these solutions greatly owes to the solution generating techniques which were only found for D = 5 stationary spacetime. On the other hand, in D > 5, the only known explicit soluitons are Myers-Perry solutions. Since it is difficult to directly solve the Einstein equation and obtain an explicit solution with less symmetries, some approximation techniques should help us.

Large D Limit of General Relativity

In some gravitational phenomenon in higher dimensions, it is known that there exists a certain limit when we take the *dimension D* sufficiently large. I and collaborators have studied this large *D* limit in more detail and formulated the large D expansion method in more generic way.

Large D analysis of the linear dynamics of black holes

The quasi-normal modes (QNM) are one of the basic property of the black hole. I and collaborators studied the QNM of several higher dimensional black holes. In the large D limit, the perturbation equation is simplified and therefore admits the analytical treatment. Especially, we studied:

- Instability of black strings (Gregory-Laflamme instability)
- Instability of rotating black holes (Myers-Perry black holes)
- Quasi-local modes of (A)dS Schwarzshild black holes

We obtained the analytic formulas of dispersions for each black holes written in the inverse dimension expansion. Including higher order corrections, the formulas reproduce the numerical results well up to the relevant order of 1/D.

Exploring black hole solutions in the large D limit

Our works revealed that the large D limit is the good approximation, at least, in the linear order analysis. However, this is also useful approximation in solving the Einstein equation nonlinearly. Since the decoupling property in this limit comes from the following fact that, in the large D limit, the near horizon spacetime varies mainly in the radial direction and the gradient in other directions can be ignored, and therefore the equation decouples into the radial part and the other parts. After the radial dependence is solved, the remaining equations reduce to the differential equation with one less inhomogeneity, which makes the analysis of the non-uniform solution easier. I and collaborators studied the analytic form of the following non-uniform solutions:

- Non-uniform black strings (NUBS)
- Non-uniform rotating black holes (Bumpy black holes)
- Localized AdS black holes

For NUBS, I and collaborators studied the thermodynamical property, and reproduced the phase diagram and the critical phenomenon in the dimensionality consistent with the numerical calculations.