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. For example, it has been known numerically that the threshold wavelength of the Gregory-Laflamme instability behaves like ~ √D at the large *D*. This behavior was actually proven by Asnin et. al. using the large *D* approximation.

I and collaborators have studied this large *D* limit in more detail and formulated the large D expansion method in more generic way. Using the large *D* expansion method, we obtained the dispersion relation of GL instability and the absorption probability of the scalar field with the black hole in the series of 1/*D*.

Large D analysis of the linear dynamics of the spherical black holes

The quasi-normal modes (QNM) are one of the basic property of the black hole. I and collaborators studied the QNM of the higher dimensional Schwarzschild black hole which is the simple extension of D=4 Schwarzschild solution. In the large D limit, the perturbation equation is simplified and therefore admits the analytical treatment.

We obtained the two type of QNMs, one of which is the decoupled modes which localize near the horizon and, another the non-decoupled mode which propagate from the near horizon to the asymptotic boundary. Such mode decoupling will be the basic property of the higher dimensional black holes. For the decoupled modes, we obtained the mode frequency up to 3rd order in 1/D which reproduces the numerics well.

Instability of the Myers-Perry Black Holes with Equal Angular Momenta

To show the universality of the large D limit, I and collaborators investigated the instability of the Myers-Perry black holes in the large D limit. Since Myers-Perry solutions have the cohomogeneity-2 in general, it will not be so easy even in the large *D* limit. Instead, to begin with, I and the collaborator studied the instability of the Myers-Perry solutions with equal angular momenta in the odd dimension, in which the spacetime has cohomogeneity-1.

We found that, by taking the large *D* limit, the leading order equation decouples to the several independent equations which are surprisingly simple. Then, the large *D* limit is now shown to be applicable even in the rotational case. We also found that this reflects the equivalence to the Schwarzschild metric in this limit.

By solving the equation order by order in terms of 1/*D*, we successfully obtained the quasinormal modes, and one of them was found to be unstable above the threshold rotation, which is consistent to the numerical calculation, at least up to the leading order in 1/*D*.