Research plan

I would like to continue my research on string theory. Some of interesting research topics are listed and explained in the following.

The dynamics of M2-branes

I will continue to study M2-branes and try to understand their properties more deeply. Current collaboration with Sanefumi Moriyama is expected to become more fruitful and therefore should be proceeded further. So far, we have clarified the details of the partition function of M2-branes in M-theory on an orbifold. The partition function is expected to contain a lot of information. I will try to find techniques to extract it. One possible way to do this is to specify a topological string theory corresponding to the Fermi gas system we used to calculate the partition function, and to investigate its properties. It should be noted that, although such a way was successful for ABJM theory, the presence of a topological string theory is not obvious at all. Up to now, we need more information on three-dimensional gauge theories which enables us to discuss its existence. There are several orbifold backgrounds in M-theory in addition to the one we studied recently. I am interested in extending our research to the other orbifold backgrounds. The results from various orbifold cases will give us an insight on the M2-brane partition function, which then gives us a key to understand the properties of M2-branes.

Matrix models of Chern-Simons-matter theories

Recently, I have concentrated on the study of M2-branes mentioned above, and the study on matrix models was not proceeded enough. Since the latter is also an interesting research topic, I would like to continue the research on matrix models related to Chern-Simons-matter theories. So far, I found that the matrix models can be solved rather generally, and the properties of the solution are encoded in a Fuchsian system of ordinary differential equations. The Fuchsian system, however, cannot be written down explicitly so far, and only the monodromy realized by it is known. It is apparently difficult to extract necessary information from the Fuchsian system with such limited knowledge, but I expect that at least some partial information on the properties of the solution of the matrix models could be extracted. This is because I noticed that the information important in the context of AdS/CFT correspondence can be obtained from the local behavior of the solution of the Fuchsian system. Therefore, I would like to try investigating the local behavior of the solution in detail in order to clarify the properties of the gravity theory which is assumed to be described by a Chern-Simons-matter theory.

Toward an M5-brane effective theory

ABJM theory and related three-dimensional gauge theories are expected to describe the dynamics of M2-branes, and have been studied intensively. In addition, since M2-branes can interact with M5-branes, these theories have been studied for the purpose of investigating M5-branes. Up to now, M5-branes are less understood than M2-branes,

but the understanding of M5-branes is equally important in understanding M-theory. I would like to study ABJM theory and others in the presence of a boundary, with the hope that it will lead us to the construction of an effective theory describing M5-branes. The interaction with M5-branes occurs at the boundary of M2-branes, suggesting that the boundary terms in ABJM theory would describe the interaction. By understanding the allowed structure of the boundary terms, I expect to gain some insights into the structure of an M5-brane effective theory.