

My principal research object is as for superstring theory, in particular, its non-perturbative description. In the framework of the superstring theory, each elementary particle is described as not point-particle but the oscillation of a string. Then, the graviton which is the gauge particle mediating the gravity is naturally included in the theory as one of the oscillation modes and the superstring theory can become, therefore, the principal candidate of the unified theory.

• Matrix model

The matrix model is given as one of the models which formulate non-perturbatively superstrings. There are three kinds of matrix model for the superstring theory, which are called as matrix theory, IIB matrix model and USp matrix model.

• Compactification

Because the superstring theory is defined on ten-dimensional spacetime, so are the matrix models. In conclusion, if we would like to obtain the models which describe realistic world, the compactification of spacetime to four-dimensions are required. In particular, I studied about the USp matrix model which defines non-perturbatively type I superstrings, compactified by $\mathbb{C}^3/\mathbb{Z}_3$ and then I succeeded in enumerating all possibilities to be able to be consistently defined.

• Calculation of partition function

I calculated the partition functions of reduced matrix models for various gauge groups by using the prescription of Moore-Nekrasov-Schatchashvili(MNS). Here, the word “reduced” means that the matrix models are given by the dimensional reduction of higher dimensional supersymmetric Yang- Mills theory to zero-dimension. In addition, I have showed that the USp matrix model can be rewritten to the form to which the prescription of MNS can be applied.

• Effects of matrix orientifolding and four-dimensional spacetime

In matrix model, Spacetime points are described by the eigenvalues of the bosonic matrices and then the coordinates are treated as dynamical variables. The distribution of the eigenvalues is, therefore, a very interesting research object and the matrix model has possibility to describe the spacetime where we live. By calculating the one-loop effective action for the eigenvalues I studied the effect of orientifolding to matrix model and showed that the spacetime directional asymmetry of attractive force between eigenvalues appears. The spacetime points are eventually attracted to an imaginary four-dimensional surface. Moreover I calculated two-loop corrections and found that in the case of short distance the interaction between eigenvalues is turned to repulsive. In the USp matrix model, the spacetime points are stabilized near above mentioned four-dimensional plane and then the four-dimensional spacetime are produced.

• AdS/CFT correspondence

The AdS/CFT correspondence, which was proposed by Maldacena, shows that there exist the deep relation between the type IIB superstring theory in $AdS_5 \times S^5$ background and the four-dimensional $\mathcal{N} = 4$ supersymmetric Yang-Mills theory. According to this correspondence, both are related by exchanging strong and weak coupling each other. It enables us to understand the theory beyond the perturbative theory. In particular, I studied the AdS side, that is the superstring theory in $AdS_5 \times S^5$ background. Here, $AdS_5 \times S^5$ is the product space with the Anti de Sitter spacetime (AdS_5) and the five-dimensional sphere (S^5).

• Lagrangian in the generalized light-cone gauge

The superstring theory in curved spacetime can be described by Green-Schwartz action. In order to carry out the research of this action, one must fix its gauge invariance and I adapted the generalized light-cone gauge. In addition, the theory is the constrained system and one must solve the some constrain conditions. So far the Lagrangian obtained after gauge-fixing is written by the first-order form. Then, I succeeded in converting the Lagrangian to that in the Lagrange formalism, that is I obtained the Lagrangian written by the fields and their derivatives. Moreover, we showed that the obtained Lagrangian becomes the correct form in flat space limit.