

# Research Plan

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The nonperturbative features of superstrings are studied based on my research that has been done so far. Matrix model is very interesting because it is constructive formulation of superstring theory and treats nonperturbatively superstrings. The principal aim is to find out the informations for the nonperturbative nature of superstrings by using the matrix model. The spacetime coordinates appear as the eigenvalues of matrices, and the spacetime structures are decided by the distributions of the eigenvalues. Emergence of four-dimensional spacetime and unified treatment of elementary particles are consequently the central target. Moreover, I will apply the matrix model to gauge/gravity correspondence. The content is indicated as follows.

- **Compactification**

My interest is to generate four-dimensional spacetime in the matrix model. Since the matrix models are usually defined in ten-dimensional spacetime, we must compactify the spacetime to four dimensions. Then, we must demand the conditions for compactifications from outside. So far, I have studied about the matrix models compactified by  $\mathbb{C}^3/\mathbb{Z}_3$ -orbifolding. In similar way, I continue to study the other compactified models. On the other hand, I will study spontaneous breaking of ten-dimensional Lorentz symmetry for the matrix models without compactifying spacetime by hand.

- **Generation of four-dimensional spacetime**

USp matrix model was proposed as the constructive definition of  $T^6/\mathbb{Z}_2$  compactified type I superstring theory. The model is given from IIB matrix model by matrix orientifolding that preserves the maximal supersymmetries. Because the interaction between two spacetime points depend on the direction, the spacetime structures of this model have also the same feature. In addition, it is suggested that there is a four-dimensional object from the research of the Berry phase.

In order to firm these results, I will calculate the distributions of the eigenvalues and the distance between two eigenvalues by using computers. The numerical estimations by the computer are adopted to the researches and I will search for the possibility of emergence of four-dimensional spacetime in the matrix model.

- **Calculation of partition function (free energy)**

I want to estimate exactly the partition function of the USp matrix model. In order to perform this calculation, I use the prescription of Moore-Nekrasov-Shatashvili. In this procedure, matrix models transform to CohFT (Cohomological Field Theory) and the calculation of partition function becomes more easy. Indeed, I calculated the partition function of four-dimensional reduced matrix model by using its prescription as mentioned in “Research Result”. I want to apply the methods thought out in these simpler models to the USp matrix model. It becomes possible to examine the stability of generated spacetime.

- **Large- $N$  limit**

While the above mentioned studies are for researching the spacetime structures, the purpose here is its application to gauge/gravity duality. The matrix model obtained by dimensionally reducing gauge theory to zero-dimensional is equivalent to the original gauge theory in the limit that the size of matrices is large (Large- $N$  limit, planar limit). In consequence, because one can treat the gauge theory nonperturbatively by the matrix model, I will apply the matrix model to the research of the duality.