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Research Plan

As a long time perspective, I would like to understand the nonperturbative aspects of superstring theory, especially a kind of which can determine the true vacuum of it, through the study regarding its relationship with matrix models and AdS/CFT correspondence. The research plan I have in my mind now is to understand the dynamical aspects of matrix models and its relationship with the properties of superstring theory, and to obtain profound understandings on Wilson loop operators in the framework of AdS/CFT correspondence.

Here, I will present some concrete plans.

Spontaneous symmetry breaking in matrix models Spontaneous symmetry breaking in matrix models under large-N limit is studied. This is motivated by the fact that the type IIB matrix model is believed to be a constructive definition of superstring theory. Thus, after the spontaneous symmetry breaking occurs, the residual symmetry can be regarded as the symmetry of the true vacuum of superstring theory, which is interesting from a phenomenological point of view. Here, with the scope of the analysis for this IIB matrix model, I would like to start with simpler models and to develop the technique to deal with the symmetry breaking on as rigours footings as possible.

Before taking the large-N limit, the matrix models are the systems of finite degrees of freedom and then they won't exhibit symmetry breaking. On the other hand, it can be expected that some matrix models show symmetry breaking under the large-N limit. This fact has been studied using numerical analysis or an improved mean field approximation, and it turned out that, for the matrix models of Yang-Mills type, the model would show the spontaneous symmetry breaking of its rotational symmetry if the model possesses degrees of freedom.

I would like to start with the simplest kind of bosonic matrix model and to develop the tool to determine whether this model exhibits the symmetry breaking rigorously, and will apply this technique developed here to the supersymmetric matrix models of interests.

Wilson loop operators in AdS/CFT correspondence Wilson loop operators play an important role in gauge theories not only as gauge invariant nonlocal operators, but also as being more fundamental degrees of freedom of the theory because of the fact that the set of Schwinger-Dyson equations of loop operators, known as the loop equations, can reproduce the dynamics of gauge theory. Having this fact in my mind, I would like to give more profound understanding on Wilson loops in AdS/CFT correspondence. The loop equations have a clear geometrical meaning that they describe the deformations of Wilson loops, and, on the string theory side, the Wilson loop has also a clear geometrical meaning as a boundary of a fundamental string, and thus I am aiming to establish a clear relationship between these two pictures. I will try to understand the properties of the Wilson loop of circular shape on the string/supergravity side. On the gauge theory side, this circular Wilson loop preserve a part of the superconformal symmetry and then the perturbative calculation of the vacuum expectation of this operator boils down to evaluating large-N Gaussian matrix model. It is well known that most of quantities in large-N matrix model can be calculated immediately once the eigenvalue density is known. AdS/CFT correspondence asserts that on the string side there is a quantity that corresponds to the quantity of interest in gauge theory, and one can compute it using string theory if the appropriate boundary condition is imposed. Thus, I am interested in this problem, namely, how to compute the quantity like the eigenvalue density from string theory.

And I would mention that I am also interested in the formulation of the complete set of the loop equations in both string and gauge theory.