Plan of Research

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From the viewpoint of the gauge theory/matrix model correspondence, I have been studying matrix models that have connections with supersymmetric gauge theories. I will continue to study matrix models and related topics.

1. Multi-critical points of the unitary matrix models and Argyres-Douglas theories

As an example of the gauge theory/matrix model correspondence, the relationship between the multi-critical unitary matrix models and four-dimensional supersymmetric theories of Argyres-Douglas type has been studied. In the limit where the matrix size N goes to infinity, this correspondence manifests as an isomorphism between the spectral curve of the matrix model and the Seiberg-Witten curve of the gauge theory. It is known that the multi-critical unitary matrix models exhibit a third-order phase transition in the large N limit. Recently, it has been shown that double scaling limits toward their multi-critical point correspond to the limit where the gauge theories approach the Argyres-Douglas superconformal fixed point.

As a next research topic, I will try to study the correspondence for finite N. For finite N, the gauge theory/matrix model correspondence is expected to be refined to the correspondence between the partition functions of the matrix models and the Nekrasov partition functions of the gauge theories. At first, I will try to determine the finite N corrections and the instanton corrections on the matrix model side.

Furthermore, the simplest case of the multi-critical model is the Gross-Witten-Wadia (GWW) model (with a logarithmic potential term). The partition function of the GWW model can be interpreted as the tau function of the Painlevé III equation. I would also like to consider what kind of integrable systems are involved in more general cases.

2. Higher dimensional gauge theories and their algebraic structures

When a four-dimensional supersymmetric gauge theory is obtained as the low energy limit of the S^1-compactified five-dimensional gauge theory, there is sufficient merit in considering the lifted five-dimensional theory itself. In the gauge theory/matrix model correspondence, the five-dimensional lift corresponds to the q-deformation on the matrix model side. I would also like to consider whether the unitary matrix model can be q-deformed. These are related to q-deformed two-dimensional field theories and are expected to have the q-Virasoro or q-W algebra as their symmetry algebra.

Also, the q-Virasoro or q-W algebra is a certain Hopf algebra, called the Ding-Iohara-Miki algebra, with special type of structure function. This algebra can be further deformed by introducing an additional parameter p and by extending the structure function, to the elliptic Ding-Iohara-Miki algebra. It seems natural to expect that the correlation functions and corresponding matrix models, which have elliptic Virasoro algebra or elliptic W algebra as their symmetry are related to partition functions of the six-dimensional $\mathcal{N} = (2,0)$ superconformal field theories. I would like to investigate these correspondences in detail.