Plan of Research

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Focusing mainly on the gauge theory/matrix model correspondence, we conduct research on supersymmetric gauge theories and corresponding matrix models, as well as related themes, including the following.

1. Multicritical points in unitary matrix models and their correspondence with Argyres-Douglas theories

As an example of the "gauge theory/matrix model correspondence," one can cite the correspondence between multicritical unitary matrix models and four-dimensional supersymmetric theories of Argyres-Douglas type. We have already analyzed this correspondence in detail in the large-N limit, where the matrix size N goes to infinity. Building on this, we aim to investigate in depth how the correspondence behaves for finite N, beyond the large-N limit. For finite N, the "gauge theory/matrix model correspondence" is expected to be refined into a precise matching between the partition function on the matrix model side and the Nekrasov partition function on the gauge theory side. First, we aim to clarify the form of finite-N corrections and instanton corrections on the matrix model side. Furthermore, the simplest case of such a multicritical unitary matrix model is the unitary matrix model obtained by adding a logarithmic potential to the Gross-Witten-Wadia (GWW) model. It is known that the partition function of this model can be regarded as a tau function of the Painlev'e III equation. We would also like to explore what kind of integrable systems are associated with more general cases.

2. Higher-dimensional gauge theories and algebraic structures

When a four-dimensional supersymmetric gauge theory arises as the low-energy limit of a five-dimensional gauge theory compactified on S^1, there is significant value in studying the five-dimensional theory itself after lifting. In the "gauge theory/matrix model correspondence," the operation on the matrix model side that corresponds to this five-dimensional lift is expected to be the q-deformation. We also plan to examine whether unitary matrix models can be q-deformed. These are related to q-deformed two-dimensional field theories and are expected to possess symmetries such as the q-Virasoro algebra or q-W algebra. Moreover, the q-Virasoro and q-W algebras are known to be related to a Hopf algebra called the Ding-Iohara-Miki (DIM) algebra with a specific structure function. This algebra can be extended to the elliptic Ding-Iohara-Miki algebra by introducing an additional parameter p and modifying the structure function accordingly. It is a natural conjecture that correlation functions (or corresponding matrix models) possessing the elliptic Virasoro algebra or elliptic W algebra as symmetries are related to the partition function of the six-dimensional $\mathcal{N} = (2, 0)$ superconformal field theory. We would like to investigate these correspondences in greater detail.