# Research Plan

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I will develop my research further. In particular, I will try to understand the 2d-4d connection unifiedly and the relation with the integrable model.

**2d-4d connection**

I try to progress the research for 2d-4d(5d) connection based on the $q$-deformation of $W_n$ algebra. The conformal block and the instanton partition function are expressed as the series expansion labeled by the Young diagrams. Although the 2d-4d connection claims that these are equal, each term in this expansion are not necessarily. These are equal only in the special case $\beta = -\epsilon_1/\epsilon_2 = 1$. This is why the proof of the 2d-4d connection is difficult. Morozov and Smirnov have proposed to use the so-called generalized Jack polynomials in the expansion of the conformal block. The generalized Jack polynomials can be obtained as the eigenfunction of the deformed Hamiltonian of Calogero-Sutherland model. Then I will extend the polynomials to use for the 2d-5d connection and consider its root of unity limit for understanding 2d-4d connection unifiedly.

The generalized Jack polynomials were obtained by consideration of the gauge theory side. I will study the meaning of the deformation of the Hamiltonian in the CFT side and the algebraic structure. The Calogero-Sutherland Hamiltonian can be expressed by using the Dunkl operators included in the generators of Double Affine Hecke Algebra (DAHA). I will study the corresponding deformation of the Dunkl operator and discover the relation to the integrable models.

In addition, my research have concentrated the case of vanishing first Chern class so far. So I will extend to the non-vanishing case. I will also study about the connection between the conformal block in similar root of unity limit and the instanton partition function of four-dimensional $\mathcal{N} = 2$ gauge theories in the presence of surface operators by applying the different limiting procedure in 2d-5d connection.

**Matrix Model**

The USp matrix model is given from IIB matrix model by matrix orientifolding that preserves the maximal supersymmetries. My current research suggests that the four-dimensional spacetime emerges by the attractive force acting between the spacetime points in the USp matrix model. I will study spontaneous breaking of Lorentz symmetry for the matrix models by studying the the effect of fermionic part of the action, which has no physical meaning clearly. This study relates closely to the stability of emerging spacetime.

In addition, I would like to make the natural interpretation for the origin of usp algebras obvious. For this purpose, I will discuss the physical process from IIB matrix model to USp matrix model.

The above studies aim purely to clarify the spacetime structure in the USp matrix model. In addition, We will study the behavior of the matter in this spacetime. In order to introduce the matter, it is necessary to add the matrices belonging to the fundamental representation of the usp algebra to the model. The matter and spacetime are described in the same standpoint. That is, both relate mutually and intimately and then the matters affect spacetime and vice versa. After adding the matter fields, We will study the eigenvalue distribution and calculate the partition function etc. and then I want to study the influence of matter to spacetime structure.