Research Plan

Standard model of particle physics is still unsatisfactory because, for example, it does not contain gravity. The most promising candidate of such quantum gravity is string theory. However, it does not have predictive power yet for lack of nonperturbative formulation. **In my research, I hope to investigate candidates of nonperturbative formulation of string theory based on matrix models, and to gain fundamental understanding of birth of our universe or structure of space-time.** Below I enumerate main research plans. All of them would not be easy, but I intend to get meaningful results within three years. It would be possible because I have already got some partial results. Moreover, as I invited Prof. Mithat Ünsal who is an expert of resurgence to Nagoya University four years ago, I am willing to continue communicating and collaborating with researchers not only inside OCAM, but outside or abroad.

1. **Higher-genus correlation functions in supersymmetric matrix model via random matrix theory**

In our recent research, it has been revealed that **in a supersymmetric matrix model I have been studying for these years, we can give a systematic formula of correlation functions by using results of probability theory on the $1/N$ −expansion in the random matrix theory. I will analyze this formula and obtain expressions of multi-point correlation functions at arbitrary order.** Since our previous study suggests that our matrix model would be equivalent to a two-dimensional superstring theory, this result would give predictions of correlation functions at higher genus in corresponding superstring theory and **be useful for resolving ambiguity in calculation in the superstring side** like the problem of treatment of supermoduli on super Riemann surface.

2. **Analysis of spontaneous breaking of supersymmetry via resurgence**

Recently the idea of resurgence attracts much attention both mathematically and physically. Surprisingly it claims that **from perturbative solution one can obtain all nonperturbative ones in principle from consistency of theory** and in fact it has been applied to string theory. On the other hand, as mentioned in the previous item **1**, in our matrix model, we can derive perturbative expansion of correlation functions at arbitrary order. **Hence we apply resurgence to this series and extract information on nonperturbative effect from it.** In fact, **it was proved that in our matrix model, supersymmetry is spontaneously broken by nonperturbative effect.** Thus from analysis of resurgence, we get information of a nonperturbative object like tension or the number of collective modes and then **from them we clarify physical picture of spontaneous breaking of supersymmetry as what kind of brane is generated or condensed.**

3. Analysis of motion of string, random walk in gravitational field

Although it is well known that there is equivalence between propagation of scalar field and the random walk, **we do not have such description for propagation of a string. It is because we do not know a framework in which propagation of a random surface is described in general space-time.** In fact, this problem is closely related the long-standing problem of the upper critical dimension of gauge theory. One the other hand, there is a possibility that behavior of a string near the Hagedorn temperature is described as the random walk in gravitational field. By noticing that a string is an extended object and hence its time evolution can happen locally along it, I will clarify its relationship to the Schwinger-Dyson equation, stochastic quantization, and the loop equation in gauge theory and **determine (differential) equations which describe motion of a general random surface in gravitational field.**

Furthermore, **since I had been studying "Algebraic Number Theory" with my colleague until two years ago, I intend to initiate research on classical and quantum chaos as a researcher who is familiar with both algebraic number theory and the random matrix theory.**