Shoichi Kawamoto

Description of research plan

I am interested in particle physics and quantum gravity, and particularly in superstring theory as a unified theory. My aim is to elucidate that superstring theory satisfies the requirements for theory to be unified theory, that is, whether or not it reproduces the properties of known elementary particles and describes all the interactions such as electromagnetic and gravitational forces in a unified way. In the study of superstring theory, this will be carried out through the study of the vacuum structure of superstring theory. Through my research I would like to provide the answers of very fundamental questions of particle physics, such as "Why is our world four dimensional?" or "Why do we observe four kinds of forces?" etc.

There are two problems in the current situation of superstring theory to answer these questions; one of those is that there are actually infinitely many classical solutions to the equations of motion of string theory and the other is that superstring theory is only written in terms of perturbation theory. Though perturbation theory is a powerful tool to analyse quantum field theory and string theory, it is helpless to answer the question which vacuum is most plausible among many vacua, so at this moment superstring theory is not capable of providing any answer to the questions. In order to overcome it we have to go beyond perturbation theory, and to go into nonperturbative study.

There have been several attempts to go over nonperturbative study of superstring theory. One of the most promising approach is using large N matrix models. Supersymmetric versions of matrix model have been proposed as nonperturbative definition of superstring theory, which are expected to reproduce all the known result of perturbative superstring theory and to admit nonperturbative study. The most well known examples are BFSS model and IKKT model and they are the models I would like to dissect. I am especially interested in IKKT model, also known as the IIB matrix model, and I would like to develop a technique to extract an exact, and physically interesting, quantity from it.

Based on these background, I will work on general large N matrix models. I would like to elucidate their dynamical behaviour under the large N limit and obtain some insights on physical aspects of them. I first would like to study the symmetry breaking, such as rotational symmetry or supersymmetry breaking, of matrix models under the large-N limit.

Here I have concentrated on superstring theory and matrix models, but I have also wider interest on whole theoretical physics and am especially interested in the dynamics of gauge theory. Since through the large-N reduction large-N matrix model has very deep relationship with Yang-Mills theory, I also hope to develop a nonperturbative technique which can be applied to gauge theories and hope to clarify the nonperturbative dynamics of gauge theory in the planar limit.

Based on my own previous research and the plan I describe here, I would like to develop new research.