Some Topics in Superstring Theory

Hyeonjoon Shin

String theory is known as a strong candidate for the theory of quantum gravity. What I have pursued is to understand the theoretical structure of string theory via possible supersymmetric states and to uncover various features to distinguish string theory from the usual quantum field theory based on particle viewpoint. Below, I introduce some topics in string theory which I have considered.

For many years, I have focused on the matrix model for M-theory. The M-theory is defined as the eleven dimensional theory whose low energy limit is described by an eleven dimensional supergravity and dimensional reduction along a circle leads to the ten dimensional superstring theory. Although we have its definition, we do not yet know its full covariant description through an action in a conventional sense. However, it has turned out that the matrix model may describe the M-theory in a particular frame, the infinite momentum frame, or in the context of discrete light cone quantization. Although it is not a covariant one, it opens up a way of studying M-theory or non-perturbative string theory. The basic idea is that a set of matrix variables can be used to describe every state in M-theory (e.g., graviton, membrane, and fivebrane). I have investigated the low energy dynamics between these states, which has shown to agree well with the results expected from the eleven dimensional supergravity. Though successful, there is a problem in that the analytical calculation based on the matrix model is limited to the eikonal approximation. But, hopefully, some new idea or methodology will overcome this problem and we will be able to make further progress.

Secondly, the construction of string actions and the possible supersymmetric string states in a given background have been an area of my concern. In connection with the holography, the identification and quantization of supersymmetric string configuration in the anti de Sitter space-time is especially important since they are the basic elements for establishing the holography itself. I have been interested in a particular string configuration, which is expected to be related to the Wilson line operator in the field theory side, and have investigated the fluctuating modes along the configuration which have been shown to form an expected supersymmetry multiplet structure. Another issue that I have considered is the construction of full superstring action in a less supersymmetric background. The superstring action should contain a given number of fermionic coordinates regardless of the number of supersymmetries of background. I have shown how to construct such an action starting from the well known plane-wave background.

Last but not least is the application of string theory to field theory problems in the context of holography. Nowadays, it is an exciting research area and leads to the chance of connecting string theory to other disciplines, such as hadron physics and condensed matter physics. From the string theoretical viewpoint, one major challenge is to develop the holography away from the conformal fixed point basically because the theory for a given physical system is usually not a conformal field theory. This requires us to understand the fully back-reacted background corresponding to a given field theory. With respect to this, I have collaborated with JRG members sharing common interests.

Hyeonjoon Shin is a research professor at Physics Department of POSTECH and an adjunct professor at the Asia Pacific Center for Theoretical Physics (APCTP). He received his Ph.D. in theoretical particle physics from Korea Advanced Institute of Science and Technology (KAIST) in 1995. He was a postdoctoral research associate at Sogang University, Seoul National University, and Korea Institute for Advanced Study (KIAS). He also worked at Sungkyunkwan University as a research professor and at Sogang University as an assistant professor.