Research Plan

Recently string theory and the AdS/CFT correspondence (also called the gauge/gravity correspondence or holography) have been tightly connecting particle theory with various research areas of physics and mathematics, for example, information theory and condensed matter theory. Since I have been studying various topics as I mentioned in "Research History", I shall engage myself in interdisciplinary researches. Here I should like to show some concrete topics that I am now interested in.

(1) Quantum entanglement

- Entanglement of scattering particles and experiments

  We [20] found the formula for the Entanglement Entropy (EE) of two particles in an elastic scattering process at high energy. It is of interest also in particle phenomenology and experiments. Since this formula describes the EE in terms of physical observable, *i.e.*, cross sections and a maximal impact parameter, I shall evaluate the EE actually by the experimental data of colliders. For example, there are the data on the proton-proton (or anti-proton) scattering by LHC, Tevatron *etc.* I should like to develop this entanglement as a tool for clarifying physical properties of those particles through that formula.

- Relation with the AdS/CFT correspondence

  The holographic EE tells us that the EE between two regions is associated with the area of a minimal surface embedded into an anti-de Sitter space. On the other hand, the AdS/CFT correspondence allows us to calculate the scattering amplitude from the area of another minimal surface. Therefore I should like to understand the relation between the EE in a scattering process and the scattering amplitude from the geometric viewpoint of the minimal surfaces in the AdS/CFT correspondence.

- Entanglement of strings

  The S-matrix theory is also historically in close relation with string theory. Therefore I should like to study the entanglement between strings. I consider a scattering process of strings in which two strings appear in a final state. Since I can obtain the S-matrix by calculating the string scattering amplitude, I apply the formulation developed by [19,20] to this S-matrix, and compute the EE between two strings in the final state. I shall clarify a stringy property of the EE in the string scattering, comparing with the EE in the particle scattering by [19,20].

  Extending this research, I should like to study the process in which a light string is emitted from a heavy string. How are the heavy and light strings entangled in the final state? This emission process is an analogy for black hole radiation. Hence to study the entanglement of such strings might shed light on several issues about the entanglement between black hole and radiation.

- Entanglement of D-branes

  A D-brane also plays a fundamental role in string theory. I should like to understand the entanglement between two D-branes separately located. Since D-branes have interaction caused by the exchange of closed strings, one can naturally guess that this interaction generates the entanglement of D-branes. In order to analyze the EE of D-branes I may use boundary states which describes the D-branes.

(2) AdS/CFT correspondence in lower dimensions

- SYK model and AdS_2/CFT_1 correspondence

  So far ones have been studying the AdS/CFT correspondences in various dimensions and their applications in many ways as I mentioned above. However the AdS_2/CFT_1 (2-dim. AdS/1-dim. CFT) correspondence has not been known well. Recently SYK model has been proposed as a candidate of the AdS_2/CFT_1 correspondence and draws much attention. This model employs a disorder average, which is well known in condensed matter theories. On the other hand, a quantum field theory, which is popular in particle theories, is not familiar to the disorder average. Therefore, referring to the SYK model, I should like to study, in the context of a field theory, an SYK-like model or any other models which would be candidates of the AdS_2/CFT_1 correspondence.