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 and S-matrix theory

- Entanglement of scattering particles and the AdS/CFT correspondence
  Quantum entanglement is a very intriguing phenomenon in quantum mechanics. Inspired by recent developments on entanglement entropy (EE), which are the replica method for calculating EE by Cardy *et al* and the holographic EE by Ryu-Takayanagi, many theorists are studying EE eagerly. And the ER=EPR conjecture by Maldacena-Susskind is also interesting. They have suggested that there exists an Einstein-Rosen bridge (or a wormhole) which connects an Einstein-Podolsky-Rosen pair. For examples supporting the ER=EPR conjecture, Jensen-Karch studied a pair of accelerating quark and anti-quark, and we [18]* studied a pair of scattering gluons in the AdS/CFT correspondence. A natural question in order is how the change of entanglement of two particles are caused by interaction in a scattering process. Since it is well-known that the S-matrix theory is useful for analyzing a scattering process, we [19,20] formulated the EE of scattering particles by the S-matrix theory.
  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 scattering particles and experiments
  We [20] found the formula for the EE of two particles in an elastic scattering process. 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 should like to evaluate the EE actually by the experimental data of colliders. The proton-proton scattering in LHC would be a reasonable playground to apply that formula.

(2) String theory and entanglement

- 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 coompute 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.

*See "List of publications".