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 in inelastic scattering

  Using S-matrix theory, Peschanski and I [20,21] found the formula for the Entanglement Entropy (EE) of two particles in an elastic scattering process at high energy. Extending this understanding, I should like to consider entanglement in an inelastic scattering. I focus on two in more than three particles appearing in the final state of the inelastic scattering, and formulate their entanglement entropy in terms of the density matrix given by the S-matrix theory. Also I shall calculate relative entropy, mutual information, tripartite information *etc.* for three particles in the final state.

- Entanglement of strings

  The S-matrix theory is 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 [20,21] 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 [20,21].

(2) String amplitudes by new gauge-fixing

- Open string amplitudes

  So far it has been trusted that the two-point amplitude of open strings vanishes, because the volume of residual gauge symmetry diverges. However, Erbin *et al.* have pointed out that this divergence is canceled by the infinity, $\delta(0)$, which originates from the energy-momentum conservation, and they have obtained a non-zero two-point string amplitude. They have proved it in the path integral formalism. On the other hand, Takahashi and I [22] have derived the same non-zero amplitude of open strings in the operator formalism. In this derivation we introduced a novel mostly BRST exact operator for gauge fixing, and obtained the two-point amplitude from the three-point function including this operator. In this research plan, I should like to prove that an n-point amplitude is, in general, given by an $(n+1)$-point function including the mostly BRST exact operator. Then, applying this method, I shall clarify one and zero-point amplitudes.

- 2-point amplitude in closed string theory

  Although we have tried a simple application of the mostly BRST exact operator in the open string theory to the closed string theory, currently we have not succeeded in obtaining a non-zero two-point amplitude of closed strings. In order to solve this problem, I shall consider a new way of gauge fixing in the closed string theory and derive a non-zero two-point amplitude of closed strings.