論文内容の要旨

Semiclassical Strings on $AdS_5 \times S^5/\Gamma$ and Operators in Orbifold Field Theories

$AdS_5 \times S^5/\Gamma$ 上の半古典的な弦と オービフォールド場の理論の演算子

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We studied the AdS/CFT correspondence of orbifold models. The original model before orbifolding is the correspondence between $\mathcal{N} = 4$ $U(N)$ SYM and type IIB superstring on $AdS_5 \times S^5$. Recently, there are big progress in the study of this correspondence. Firstly, it was found that the planar $\mathcal{N} = 4$ SYM can be regarded as a spin chain system. Concretely, the anomalous dimension matrix of the field theory is mapped to the Hamiltonian of the spin system. This spin system is shown to be integrable by the Bethe ansatz. So, spectrum of the planar $\mathcal{N} = 4$ SYM is obtained by solving the Bethe equations. In long chain limit, the Bethe equations can be explicitly solved. This means that some spectrum of states with large charge in the field theory is obtained. On the other hand, superstring on $AdS_5 \times S^5$ can be treated appropriately at semiclassical level if some charges which the superstring has are very large. Such string configurations have been found and their spectrum has been compared with the spectrum of the field theory. This comparison has shown a beautiful agreement between both sides, at least at one-loop level of the field theory. Furthermore, this agreement could be generalized to action (equations of motion) level. In this process, the integrabilities of both theories, the superstring on $AdS_5 \times S^5$ as well as $\mathcal{N} = 4$ SYM, have been revealed and have played a important role in the exciting agreement. This quantitative agreement strongly suggests the validity of the AdS/CFT correspondence of the $\mathcal{N} = 4$ model.

We have studied whether the above integrabilities and quantitative correspondence can be seen in other models. We investigated orbifold model. This model has less supersymmetry than $\mathcal{N} = 4$. In this sense, this model is more realistic and is very interesting to study. In the orbifold model, the correspondence is between the four-dimensional quiver gauge theory and type IIB superstring on $AdS_5 \times S^5/\Gamma$ background, where Γ is an orbifold group. This group is a discrete subgroup of global symmetry $SO(6)$ of $\mathcal{N} = 4$ SYM. First, we show the integrability of the quiver gauge theory. For this theory, there exist new classes of states (operators) other than the sector of states inherited from the original theory. We call the former classes twisted sectors and the latter an untwisted sector. The spin chain system corresponding to the untwisted sector is the same as that of $\mathcal{N} = 4$ SYM and integrable by the Bethe ansatz. This spin chain has a periodic boundary condition. On the other hand, the spin chain system corresponding to the twisted sector does not have the periodic b.c. but twisted b.c.. Even with the twisted b.c., this system is integrable by the Bethe ansatz method. We show this fact by both the coordinate Bethe ansatz and the

algebraic Bethe ansatz. The algebraic one gives more precise explanation of the integrability than the other. Then, we solve the Bethe equations in some cases and obtain some spectrum. For the superstring theory on $AdS_5 \times S^5/\Gamma$, we find some classical solutions of the string configuration. In the large charge region, the semiclassical treatment is validated and the classical solutions are appropriate objects. Then, the spectrum of this solutions are compared to the the spectrum of the quiver gauge theory and we can see an agreement between them. This observation is done at the one-loop level of the field theory. Finally, we generalize this agreement to the action level.

Our work clarified the validity of the AdS/CFT duality of the less supersymmetric model. In this process, the integrabilities both of the quiver gauge theory and the string theory on $AdS_5 \times S^5/\Gamma$ is shown in some sectors. This encourages further studies of these theories.