

論文 / 著書情報
Article / Book Information

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種別(和文)	論文要旨
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論文要旨

THESIS SUMMARY

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要旨 (英文 800 語程度)

Thesis Summary (approx.800 English Words)

In this thesis, we propose a new calculation method of the superconformal index by using the Anti-de Sitter (AdS)/Conformal Field Theory (CFT) correspondence.

AdS/CFT is a correspondence between a four-dimensional conformal field theory (CFT) and type IIB string theory on $AdS_5 \times M_5$ (AdS), where M_5 is a five-dimensional compact manifold. This correspondence is the strong/weak duality, and one can use AdS/CFT to study the strongly coupled field theories from the theory on the AdS side. There are many AdS/CFTs depending on the compact manifold M_5 . The simplest example is $M_5=S^5$, and the corresponding CFT is N=4 U(N) supersymmetric Yang-Mills (SYM) theory. There are also AdS/CFTs in which the Lagrangian on the CFT side is not known. An interesting example is AdS/CFT between a Z_k S-fold theory and type IIB string theory on $AdS_5 \times S^5/Z_k$, where the S-fold theory is an N=3 superconformal field theory (SCFT) and always strongly coupled. In this case, AdS/CFT is a powerful tool to study the S-fold theories. To understand strongly coupled field theories, the study of theories for which the Lagrangian is unknown is essential.

It is possible to understand AdS/CFT from D3-branes in type IIB string theory, where the D3-brane is a 3+1-dimensional object. A rank N CFT is realized on the worldvolume of N D3-branes, while D3-branes produce the AdS geometry. This is the origin of AdS/CFT. In the large N limit, the AdS side is well described by classical gravity, and there are many applications to the analysis of strongly coupled theories, even for the theories for which the Lagrangian is not known. On the other hand, if N is finite, it is believed that the theory on the AdS side is described by quantum gravity. Since no one knows quantum gravity, people think it is difficult to calculate the physical quantities on the CFT side from the AdS side when N is finite.

However, it may be possible to calculate the superconformal index by using AdS/CFT due to the simplification by the supersymmetry even though N is finite. The superconformal index has the information of the BPS operator spectrum of a given SCFT and is independent of the coupling constant. The BPS operator is an operator annihilated by a certain supercharge in the theory. Thus, if we calculate the superconformal index for an SCFT, one can immediately obtain the non-trivial information of the SCFT even though the Lagrangian is not known. In fact, the calculation method of the superconformal index on the AdS side in the large N limit is already known, and the application to S-fold theories has also been performed by using AdS/CFT. Furthermore, the candidates contributing to the superconformal index on the AdS side in the finite N region are known: the D3-branes wrapped on three-cycles in the compact manifold M_5 .

Inspired by these previous researches, we develop the calculation method of the superconformal index on the AdS side when N is finite.

To achieve this purpose, we adopt the following strategy. First, we use the well-known AdS/CFT: the correspondence between $N=4$ $U(N)$ SYM and type IIB string theory on $AdS_5 \times S^5$. Then, we focus on the BPS partition function, which also has the BPS operator information of the theory and a simpler structure than the superconformal index. In this case, the BPS partition function is calculable using the Lagrangian on the CFT side. The results then provide us a hint to search for the calculation method of the BPS partition function on the AdS side in the finite N region. Concretely, we analyze the single-wrapped D3-branes and compare the results with the CFT results. Then, we propose the calculation method of the BPS partition function on the AdS side in the finite N region. Actually, since this new method is applicable even for the superconformal index, we can calculate the superconformal index on the AdS side even though N is finite. We see that our results agree with the CFT results up to contributions from the multiple wrapped D3-branes. Although we use CFT results as a hint to search the correct calculation method of the superconformal index on the AdS side, the agreement suggests that AdS/CFT correspondence may hold even in the finite N region.

Second, we apply our method to S -fold theories. Then, we can predict the superconformal index of the finite rank S -fold theories from the AdS side. Since it is expected that the rank one and two S -fold theories are equivalent to $N=4$ SYM, we can carry out the consistency check. Besides this check, recently, the superconformal index of the rank three Z_3 S -fold theory was calculated using the renormalization group flow, and we can confirm the correctness of our method for this case. All the results given in this thesis are consistent with the known facts.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

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