論文の内容の要旨

Six-Dimensional Superconformal Field Theories and Their Torus Compactifications

(6 次元超共形場理論とそのトーラスコンパクト化)

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Abstract In this thesis, we study six-dimensional superconformal field theories (SCFTs), brane engineerings of them, and circle/torus compactifications of them.

In the former half, we summarize some of known results about 6d $\mathcal{N}=1$ SCFTs. Since a 6d SCFT sits on UV side of renormalization group flows among 6d theories and is generally strongly coupled, we cannot probe those theories with perturbative methods. However, a tensor branch effective field theory which describes the near IR regime captures some aspects of the strongly coupled UV physics, for example the anomaly polynomial. We will first review the general near IR 6d $\mathcal{N}=1$ physics and the calculation of the anomaly polynomial. Then, we look at brane/singularity engineerings of some specific 6d SCFTs in string/M-theory, which guarantees the existence of 6d SCFTs.

In the latter half, we focus on the circle/torus compactifications of 6d SCFTs. We consider compactifications of two classes of 6d SCFTs. One is very-higgsable theories and the other is theories higgsable to $\mathcal{N}=(2,0)$ theories. We find general properties of such compactifications, as well as identifying 4d theories obtained by torus compactification for some examples. The 4d theories obtained by the considered compactifications tend to be described by a class S theory or a combination of different class S theories.

Structure of the thesis and rough summary Here we explain the structure of the thesis and roughly summarize the result. This thesis contains four chapters: the first one is this introduction, the second one is devoted to reviewing known result (containing slightly new considerations) on 6d SCFTs, the third one includes the main contents about compactifications of 6d SCFTs, and we conclude in the last. The main chapter is further split into three sections. Each section corresponds to one of the author's and his collaborators' paper:

- Section 3.1: "6d $\mathcal{N}=(1,0)$ theories on T^2 and class S theories: Part I" [1]
- Section 3.2: "S^1/T^2 compactifications of 6d $\mathcal{N}=(1,\,0)$ theories and brane webs" [2]
- Section 3.3: "6d $\mathcal{N}=(1,0)$ theories on T^2 and class S theories: Part II" [3]

Some amount of the results in [1] is also dissolved into Chapter 2.

In Section 3.1, we will consider the torus compactification of a 6d $\mathcal{N}$=(1,0) SCFT $\mathcal{T}$ which satisfies a condition we call "very-higgsable". The main result there is

The torus compactification ${}^{4d}\mathcal{T}$ of a very-higgsable 6d theory $\mathcal{T}$ has a strongly coupled 4d $\mathcal{N}$=2 SCFT fixed point. The 4d central charge can be calculated from 6d anomaly polynomial. The torus modulus τ is not *a marginal deformation of the 4d SCFT ${}^{4d}\mathcal{T}$, but it is irrelevant.*

This is a generalization of well-known relation between the 6d E-string theory and the E_8 theory of Minahan and Nemeschansky. Note that in this case the torus modulus τ is not a marginal deformation of the 4d theory, as opposed to the case of $\mathcal{N}$=(2,0) theory explained above. This means that the story of class S theory [4] cannot be naively imported into the whole $\mathcal{N}$=(1,0) theories.

In Section 3.2, we investigate concrete examples of very-higgsable 6d theories, which are higgsable to E-string theory. There we will find

For a theory in the class of very-higgsable theories we consider, the torus compactification is identified with a class S theory whose Gaiotto curve C is a three-punctured sphere.

We will extensively use the method of 5d brane webs [5], generalizing the analysis of [6].

In Section 3.3, we study 6d theories which are "higgsable to $\mathcal{N}$=(2,0) theories". An example of a "higgsable to an $\mathcal{N}$=(2,0) theory" is an $\mathcal{N}$=(2,0) theory itself. Those theories are not very-higgsable, and thus the above result for very-higgsable theories are not applied. The result can be roughly summarized as follows:

For a 6d theory $\mathcal{T}$ which is higgsable to an $\mathcal{N}$=(2,0) theory, its torus compactification ${}^{4d}\mathcal{T}$ does not generally have a fixed point composed of single coupled 4d SCFT (without turning on Wilson lines along the torus). Rather, in some examples the 4d theory ${}^{4d}\mathcal{T}$ has a fixed *point containing two class S theories coupled with each other by IR free gauges fields. The torus modulus τ is a marginal deformation of one of them. In some special cases, one of two class S theories happens to be trivial, and the fixed point is a single class S theory.*

A $\mathcal{N}$=(2,0) is included in the "some special cases" mentioned above, and there are infinitely many other $\mathcal{N}$=(1,0) theories in it. Therefore, we hope many properties of class S theories can be generalized to those cases when we put on those theories on general Riemann surfaces, though it is far from the scope of this thesis.

References

[1] K. Ohmori, H. Shimizu, Y. Tachikawa, and K. Yonekura, "6d $\mathcal{N} = (1,0)$ theories on T^2 and class S theories: Part I," *JHEP* **07** (2015) 014, `arXiv:1503.06217 [hep-th]`.

[2] K. Ohmori and H. Shimizu, "S^1/T^2 compactifications of 6d $\mathcal{N} = (1, 0)$ theories and brane webs," *JHEP* **03** (2016) 024, `arXiv:1509.03195 [hep-th]`.

[3] K. Ohmori, H. Shimizu, Y. Tachikawa, and K. Yonekura, "6d $\mathcal{N} = (1, 0)$ theories on S^1 /T^2 and class S theories: part II," *JHEP* **12** (2015) 131, `arXiv:1508.00915 [hep-th]`.

[4] D. Gaiotto, "$N = 2$ dualities," *JHEP* **08** (2012) 034, `arXiv:0904.2715 [hep-th]`.

[5] O. Aharony, A. Hanany, and B. Kol, "Webs of (p, q) five-branes, five-dimensional field theories and grid diagrams," *JHEP* **01** (1998) 002, `arXiv:hep-th/9710116 [hep-th]`.

[6] F. Benini, S. Benvenuti, and Y. Tachikawa, "Webs of five-branes and N=2 superconformal field theories," *JHEP* **09** (2009) 052, `arXiv:0906.0359 [hep-th]`.