AdS_3 and $N = 3$ Superconformal Field Theory

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Abstract

In this paper some aspects related to N=3 SCFT in the context of AdS_3 have been reviewed. In particular recent developments for N=3 SCFT dual to string theory on background $AdS_3 \times (S^3 \times S^3 \times S^1)/\mathbb{Z}_2$ has been reviewed. Moreover review of the SCFT dual to $AdS_3 \times S^3 \times S^3 \times S^1$ has also been carried out.

1 Introduction

With the discovery of AdS/CFT correspondence[1], huge developments have taken place in the last two decades in this direction. In [1] five examples were given and one of them was the AdS_3/CFT_2. It is very interesting example but has not been established completely so far. There is a range of issues related to this. In this paper our main focus will be only on reviewing a particular version of this duality, that is the N=3 SCFT dual to the string theory on the background $AdS_3 \times (S^3 \times S^3 \times S^1)/\mathbb{Z}_2$ as well as the N=4 SCFT dual to string theory on the background $AdS_3 \times S^3 \times S^3 \times S^1$.

In section 2 we will briefly review the developments of N=3 in the context of AdS_3. In section 3 a new N=3 SCFT dual to string theory on $AdS_3 \times (S^3 \times S^3 \times S^1)/\mathbb{Z}_2$ as well as N=4 SCFT dual to string theory on $AdS_3 \times S^3 \times S^3 \times S^1$ has been reviewed. Finally we will give summary and conclusions.

2 Review on $N = 3$ SCFT in the context of AdS_3

In this section we will give a brief review of the work that has been done in the direction of N=3 AdS_3/CFT_2.

In [2] superstring theory on AdS_3 was studied and effort was made to invertigate spacetime N=3 superconformal generators in terms of WZW model. Various investigations have been carried out for N=4 spacetime SCFT in AdS_3 models [3-6]. However there are some unclear points for spacetime less supersymmetry models. In [2] development of a concrete applicable method to construct less supersymmetry models in AdS_3 has been given. In [2] the study is basically in the direction of establishing the

AdS_3/CFT_2 correspondence in less supersymmetry models and to use it to various additional examples that are of interest in the different contexts.

In [7], cases in which $\mathcal{N}$ as a coset manifold unlike the specific examples on $AdS_3 \times \mathcal{N}$ where $\mathcal{N}$ is a group manifold [5,8] or an orbifold of a group manifold [2,9], have been studied. This turns out to be an interesting generalization of the AdS/CFT which has been studied in higher dimensional cases. In [7] focus is on those cases in which the dual two-dimensional theory(aslo refered to as the spacetime CFT) has an extended superconformal symmetry. Coset models giving us N=2 are simply obtained as specific cases of the general construction of [10], where $\mathcal{N}$ factorizes as a $U(1)$ factor times a Kazama-Suzuki model[11]. Interestingly there are no seven dimensional coset manifolds giving us N=4 supersymmetry in spacetime (other than the cases [5,8]) where the cosets are basically group manifolds. In [7], cases where spacetime CFT has N=3 supersymmetry have been studied.

In [7] computation of spacetime spectrum of the N=3 supersymmetric dual CFT using standard worldsheet techniques has been carried out. N=3 coset examples discussed in [7] can be considered as the intermediate examples between the most symmetric N=4 case for which the symmetric product ansatz for $\mathcal{M}_{\mathbb{Y}}$ works and the generic N=2 cases where such an ansatz does not have meaning.

There is another model that has got the similar spacetime symmetry structure, that is $AdS_3 \times S^3 \times S^3 \times S^1$ /$\mathbb{Z}_2$[2] that is a $\mathbb{Z}_2$ orbifold of the model with large N=4 superconformal symmetry [5]. A natural question that appears in connection between this model and the two models discussed in [7]. To be more precise whether or not these models have the same moduli space has been discussed in [7].

The exceptional status of the AdS_3/CFT_2 duality in the AdS/CFT point of view arises from the reality that the virasoro generators of the boundary CFT is constructed perfectly from the operators in string theory on an $SL(2,\mathbb{R}) \times \mathcal{N}$ worldsheet CFT. Necessary conditions have been found for the internal CFT $\mathcal{N}$, imposed by the existence of N=2,3,4 SCFT in the boundary dual of the string theory on $AdS_3 \times \mathcal{N}$(Table 1 of [12])

3 Recent Devlopments of $N = 3$ SCFT Dual to Strings on $AdS_3 \times S^3 \times S^3 \times S^1$

In this section latest developments in the context of AdS_3/CFT_2 have been reviewed with the focus on N=3 SCFT dual to string theory on background of $AdS_3 \times (S^3 \times S^3 \times S^1)/\mathbb{Z}_2$ as well as the N=4 SCFT dual to string theory on $AdS_3 \times S^3 \times S^3 \times S^1$.

New examples of the holographic correspondence of the string theory on AdS_3 backgrounds have been constructed recently. On one side, we have Large N=(4,4) duality proposed in [13] for type IIB string theory on $AdS_3 \times$

$S^3 \times S^3 \times S^1$, building on the previous developments[5,14-18]. The CFT dual proposed is the symmetric product orbifold of $\mathcal{S}_k$ CFTs that explains the σ-model on $\times S^3 \times S^1$. On the other side, a new family of N=(2,2) dualities is conjectured in [19,20] by taking into account Type IIB string theory over quotient backgrounds $AdS_3 \times (S^3 \times T^4)/D_n$ and $AdS_3 \times (S^3 \times K3)/\mathbb{Z}_2$, here D_n is the dihedral group.

Along these lines new example of the AdS_3/CFT_2 duality with less supersymmetry has been studied in [21] by using the construction of Yamaguchi et. al. [2] and string theory on the orbifold background $AdS_3 \times (S^3 \times S^3 \times S^1)/\mathbb{Z}_2$ has been studied. The implementation of $\mathbb{Z}_2$ orbifold is done by exchange of two 3-spheres and reflection of circle S^1. This implementation could be achieved provided the spacetime supersymmetry is decreased from large N=4 to either N=1 or N=3. In [21], latter case has been considered for study of string theory on $AdS_3 \times (S^3 \times S^3 \times S^1)/\mathbb{Z}_2$ background construction with N=(3,3) supersymmetry. Proposal is made that the string theory on this background is dual to the symmetric product orbifold of $\mathcal{S}_0/\mathbb{Z}_2$ where $\mathcal{S}_0$ is a theory of four free fermions and one free boson. BPS spectra exact matching of the two sides of the duality has been shown. Moreover, elliptic genus of the dual CFT has been computed and that of the supergravity limit of string theory has been computed and the matching has been shown, therefore giving non-trivial backing to the holographic conjecture. Further, this agreement lends substantial new support for the conjecture in [13] that string theory on $AdS_3 \times S^3 \times S^3 \times S^1$ is dual to the symmetric product of $\mathcal{S}_k$, at least in the situation when two spheres possess the same size.

4 Summary and Conclusions

In this paper we tried to put the things in perspection in the beginnig. Then we presented a brief review on N=3 SCFTs in the context of AdS_3. Then in section 3 recent devlopments of $N = 3$ SCFT dual to strings on $AdS_3 \times (S^3 \times S^3 \times S^1)/\mathbb{Z}_2$ were reviewed. Its relevence and connection with AdS_3 and N=4 SCFT in the context of AdS_3/CFT_2 was aslo discussed. Along these lines it would be interesting to study the string duality on $AdS_3 \times (S^3 \times S^3 \times S^1)/\mathbb{Z}_2$ backgrounds with N=(3,1), (1,3), and (1,1) supersymmetries further.

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