Available online at www.sciencedirect.com
ScienceDirect
Nuclear Physics B 804 (2008) 193–222
NUCLEAR PHYSICS B
www.elsevier.com/locate/nuclphysb

Heterotic AdS_3/CFT_2 duality with (0, 4) spacetime supersymmetry

Stefan Hohenegger, Christoph A. Keller, Ingo Kirsch *

Institut für Theoretische Physik, ETH Zürich, CH-8093 Zürich, Switzerland

Received 11 June 2008; accepted 16 June 2008

Available online 1 July 2008

Abstract

We discuss the AdS_3/CFT_2 duality of a heterotic three-charge model with (0, 4) target space supersymmetry. The worldsheet theory for heterotic strings on the $AdS_3 \times S^3/\mathbb{Z}_N \times T^4$ near-horizon geometry was constructed by Kutasov et al. [D. Kutasov, F. Larsen, R.G. Leigh, String theory in magnetic monopole backgrounds, Nucl. Phys. B 550 (1999) 183, hep-th/9812027]. We propose that the dual conformal field theory is given by a two-dimensional (0, 4) sigma model arising on the Higgs branch of an orbifolded ADHM model. As a non-trivial consistency check of the correspondence, we find that the left- and right-moving central charges of the infrared conformal field theory agree with those predicted by the worldsheet model. Moreover, using the entropy function formalism, we show that to next-to-leading order the central charge can also be obtained from an α'-corrected supergravity theory.

1. Introduction

Recently, several authors [1–7] have studied the possibility of an AdS_3/CFT_2 duality for the fundamental *heterotic* string. Heterotic strings are dual to type I D1-branes whose low-energy effective field theory is expected to be conformally invariant. The dual near-horizon geometry of the heterotic string should therefore contain an AdS_3 factor. This was confirmed in [8] (see also [9]) in which an $AdS_3 \times S^2$ factor was found in a $\mathcal{N} = 2$, $d = 5$ R^2-corrected supergravity solution corresponding to heterotic strings in five dimensions.

* Corresponding author.
E-mail addresses: stefanh@phys.ethz.ch (S. Hohenegger), kellerc@phys.ethz.ch (C.A. Keller), kirsch@phys.ethz.ch (I. Kirsch).

0550-3213/$ – see front matter
doi:10.1016/j.nuclphysb.2008.06.020

In general, heterotic string setups may contain additional charged objects such as NS5-branes and Kaluza–Klein monopoles. Such setups generically have $(0,4)$ target space supersymmetry. Recently, it has been found that in the absence of some or all of these additional charges the target space supersymmetry is enhanced to $(0,8)$ [2,4–6] (see also [10]). Such theories are expected to be very different from those with only $(0,4)$ supersymmetry. For one thing, there are no linear superconformal algebras with more than four supercurrents. Indeed, it has been argued in [5,6] that the global supergroup of the boundary CFT is $Osp(4^*|4)$, whose affine extension is given by a *nonlinear* $\mathcal{N}=8$, $d=2$ superconformal algebra. For another, it is not clear if these theories possess unitary representations.

In this paper we take a step back and address the construction of a heterotic AdS/CFT duality with only $(0,4)$ target space supersymmetry. For this we revisit a heterotic three-charge model previously studied by Kutasov, Larsen and Leigh (KLL) in [11]. The setup consists of p fundamental strings embedded in the worldvolume of N' NS5 branes and N Kaluza–Klein (KK) monopoles. In [11] KLL work out the worldsheet theory for string theory on the corresponding near-horizon geometry $AdS_3 \times S^3/\mathbb{Z}_N \times T^4$. The worldsheet CFT turns out to be essentially the product of an $SL(2)$ WZW model and a "twisted" $SU(2)$ WZW model corresponding to the asymmetric orbifold $S^3/\mathbb{Z}_N$. In contrast, not much is known about the dual conformal field theory on the boundary of the AdS_3 space.

The first part of this paper is therefore devoted to the construction of the dual two-dimensional boundary conformal field theory. We first apply heterotic/type I duality to map the three-charge configuration to an intersection of p D1-branes and N' D5-branes plus N KK monopoles in type I string theory. In the absence of any KK monopoles the low-energy effective theory corresponds to Witten's ADHM sigma model of Yang–Mills instantons [12], as shown by Douglas in [13]. To also include KK monopoles, which have a $\mathbb{C}^2/\mathbb{Z}_N$ near-core geometry, it is natural to construct a $\mathbb{Z}_N$ orbifold theory of the massive ADHM sigma model. (Refs. [14,15] also use an orbifold construction to obtain the boundary CFT dual to *type II* string theory on $AdS_3 \times S^3/\mathbb{Z}_N \times T^4$.)

Our proposal is that the sought-after boundary conformal field theory arises on the Higgs branch of the orbifolded ADHM model, which corresponds to the bound state phase of the D-brane setup. We will perform a consistency check for the proposal by the following line of reasoning. Lambert has shown in [16] that, even though the ADHM model is classically not conformal, it is ultraviolet finite to all orders in perturbation theory. There is no renormalisation group flow, and anomalous conformal dimensions are absent [16]. The conformal Higgs branch theory can therefore be obtained by integrating out the massive degrees of freedom in the ADHM model [17]. Moreover, the central charges of the Higgs branch theory can be determined by counting the massless degrees of freedom of the ultraviolet theory. In other words, they are given by the dimension of the instanton moduli space of the ADHM model. Repeating these steps for the orbifold version of the ADHM model, we determine the central charges of the low-energy theory of the three-charge model and match them to those predicted by the worldsheet theory.

The second part of the paper is devoted to the construction of a higher-derivative correction of the near-horizon supergravity solution of the KLL setup. In fact, for a dual setup a full solution of the $\mathcal{N}=2$ off-shell completion of four-derivative supergravity in five dimensions was constructed already in [8]. Here we will use six-dimensional corrections to the heterotic string action [18,19] and employ the entropy function formalism [20,21] to find the corrected near-horizon geometry. To first order, the latter correctly reproduces the expected central charges of the boundary CFT via the Brown–Henneaux formula [22].