Available online at www.sciencedirect.com

ScienceDirect

Nuclear Physics B 891 (2015) 106–127

NUCLEAR PHYSICS B

www.elsevier.com/locate/nuclphysb

Supergravity backgrounds for deformations of $AdS_n \times S^n$ supercoset string models

O. Lunin [a,*], R. Roiban [b,c], A.A. Tseytlin [d,1]

[a] *Department of Physics, University at Albany (SUNY), Albany, NY 12222, USA*
[b] *Department of Physics, The Pennsylvania State University, University Park, PA 16802, USA*
[c] *Kavli Institute for Theoretical Physics, University of California, Santa Barbara, CA 93106, USA*
[d] *The Blackett Laboratory, Imperial College, London SW7 2AZ, UK*

Received 12 November 2014; received in revised form 29 November 2014; accepted 4 December 2014

Available online 11 December 2014

Editor: Herman Verlinde

Abstract

We consider type IIB supergravity backgrounds corresponding to the deformed $AdS_n \times S^n \times T^{10-2n}$ supercoset string models of the type constructed in arXiv:1309.5850 [2] which depend on one deformation parameter κ. In $AdS_2 \times S^2$ case we find that the deformed metric can be extended to a full supergravity solution with non-trivial dilaton, RR scalar and RR 5-form strength. The solution depends on a free parameter a that should be chosen as a particular function of κ to correspond to the deformed supercoset model. In $AdS_3 \times S^3$ case the full solution supported by the dilaton, RR scalar and RR 3-form strength exists only in the two special cases, $a = 0$ and $a = 1$. We conjecture that there may be a more general one-parameter solution supported by several RR fields that for particular $a = a(\kappa)$ corresponds to the supercoset model. In the most complicated deformed $AdS_5 \times S^5$ case we were able to find only the expressions for the dilaton and the RR scalar. The full solution is likely to be supported by a combination of the 5-form and 3-form field strengths. We comment on the singularity structure of the resulting metric and exact dilaton field.

* Corresponding author.
E-mail addresses: olunin@albany.edu (O. Lunin), radu@phys.psu.edu (R. Roiban), tseytlin@imperial.ac.uk (A.A. Tseytlin).
1 Also at Lebedev Institute, Moscow.

http://dx.doi.org/10.1016/j.nuclphysb.2014.12.006
0550-3213/

1. Introduction

Integrability of string sigma model is a key feature that allows to determine the string spectrum in non-trivial curved backgrounds. The study of integrable deformations of the most-symmetric $AdS_5 \times S^5$ model underlying AdS/CFT correspondence [1] is thus an important avenue of research that may also shed light on hidden symmetries of dual gauge theories. Recently, a novel one-parameter integrable deformation of the $AdS_5 \times S^5$ supercoset model was constructed in [2] (see also [3–8]). This model generalizes some previously known low-dimensional bosonic integrable models [9–13].

The corresponding target space type IIB supergravity background has no space-time supersymmetry and the bosonic isometry is reduced from $SO(2,4) \times SO(6)$ to its Cartan subgroup $[SO(2)]^3 \times [SO(2)]^3$, i.e. most of the symmetry of the original $AdS_5 \times S^5$ space becomes hidden (or "q-deformed"). Starting with a specific parametrization of the bosonic part of the deformed supercoset model [2] the corresponding 10d metric and B-field were found explicitly in [3]. However, extracting the associated RR field strengths that should promote the deformed metric to an exact supergravity solution from the fermionic part of the supercoset action turns out to be challenging even in the simpler low-dimensional $AdS_2 \times S^2$ and $AdS_3 \times S^3$ models [4].

Our aim here will be to find the deformed $AdS_n \times S^n$ type IIB backgrounds by (i) starting with the deformed metric as given by the bosonic part of the supercoset model and (ii) solving the supergravity equations directly to find the expressions of all other fields required to support this metric as an exact solution. Finding "matter" fields supporting a given metric via Einstein equations is not a standard GR problem; the solution may not exist or, if it exists, it may not be unique. The present case is complicated also by the absence of supersymmetry and non-abelian isometries. We shall see that the solutions will have a rather unusual feature: while the string-frame metric is a direct sum of the deformed AdS_n and S^n parts, this will no longer be so for the dilaton and the RR fields – they will not factorize and thus "tie" the AdS_n and S^n parts together (as what fermion part of supercoset model does).

Having found a supergravity solution with the required deformed $AdS_n \times S^n$ metric, one is still to decide if it is the one that actually corresponds to the integrable deformed supercoset model of [2]. As we shall see below, the solution for the dilaton and RR fluxes supporting a given deformed metric is not unique: in $AdS_2 \times S^2$ case there is a one-parameter a-family of solutions, and the same is expected to be the case also in the $AdS_3 \times S^3$ and $AdS_5 \times S^5$ cases. One is then to choose a as a function of the deformation parameter κ[2] in order to match the supercoset model. This choice may be aided by consideration of the two special limits discussed in [4]:

(i) $\kappa = \infty$ or "maximal deformation limit": in this case the deformed $AdS_n \times S^n$ supercoset model becomes T-dual to "double Wick rotation" of the undeformed $AdS_n \times S^n$ model, i.e. it has $dS_n \times H^n$ target space supported by an imaginary n-form RR flux;

(ii) $\kappa = i$ (combined with a rescaling of coordinates and string tension) or "pp-wave limit": in this case the target-space metric becomes of pp-wave type and the problem of finding the supporting dilaton and fluxes simplifies.

[2] We shall follow [3] and use $\kappa = \frac{2\eta}{1-\eta^2}$ as the deformation parameter, where η is the parameter used in [2].