Available online at www.sciencedirect.com

ScienceDirect

Nuclear Physics B 905 (2016) 264–292

NUCLEAR PHYSICS B

www.elsevier.com/locate/nuclphysb

Supergravity background of λ-deformed model for $AdS_2 \times S^2$ supercoset

R. Borsato *, A.A. Tseytlin [1], L. Wulff

The Blackett Laboratory, Imperial College, London SW7 2AZ, UK

Received 4 February 2016; accepted 17 February 2016

Available online 23 February 2016

Editor: Leonardo Rastelli

Abstract

Starting with the $\widehat{F}/G$ supercoset model corresponding to the $AdS_n \times S^n$ superstring one can define the λ-model of arXiv:1409.1538 either as a deformation of the $\widehat{F}/\widehat{F}$ gauged WZW model or as an integrable one-parameter generalisation of the non-abelian T-dual of the $AdS_n \times S^n$ superstring sigma model with respect to the whole supergroup $\widehat{F}$. Here we consider the case of $n = 2$ and find the explicit form of the 4d target space background for the λ-model for the $PSU(1,1|2)/SO(1,1) \times SO(2)$ supercoset. We show that this background represents a solution of type IIB 10d supergravity compactified on a 6-torus with only metric, dilaton Φ and the RR 5-form (represented by a 2-form F in 4d) being non-trivial. This implies that the λ-model is Weyl invariant at the quantum level and thus defines a consistent superstring sigma model. The supergravity solution we find is different from the one in arXiv:1410.1886 which should correspond to a version of the λ-model where only the bosonic subgroup of $\widehat{F}$ is gauged. Still, the two solutions have equivalent scaling limit of arXiv:1504.07213 leading to the isometric background for the metric and $e^{\Phi} F$ which is related to the η-deformed $AdS_2 \times S^2$ sigma model of arXiv:1309.5850. Similar results are expected in the $AdS_3 \times S^3$ and $AdS_5 \times S^5$ cases.

* Corresponding author.
E-mail addresses: r.borsato@imperial.ac.uk (R. Borsato), tseytlin@imperial.ac.uk (A.A. Tseytlin), l.wulff@imperial.ac.uk (L. Wulff).

[1] Also at Lebedev Institute, Moscow.

http://dx.doi.org/10.1016/j.nuclphysb.2016.02.018

1. Introduction

There are two special integrable models that are closely associated with the superstring sigma model on $AdS_n \times S^n$. One is the η-model [1] – a particular integrable deformation of the $AdS_n \times S^n$ supercoset model generalising the bosonic Yang–Baxter sigma model of [2]. The other one is the λ-model [3,4] generalising the bosonic model of [5] (see also [6]). The λ-model is based on the $\widehat{F}/\widehat{F}$ gauged WZW model closely related to the $AdS_n \times S^n$ supercoset and may be interpreted as an integrable deformation of the non-abelian T-dual of the $AdS_n \times S^n$ supercoset action.

While for the η-model the corresponding target space background was found in [7–9] (but turns out not to be a supergravity solution [18]), in the case of the λ-model the GS sigma model action was so far not determined directly apart from the metric [11,12] and the dilaton [4,13]. Our aim below will be to find the full λ-model background (metric, dilaton *and* the RR field strength) from the λ-model action and also as a solution of the type II supergravity equations. We shall consider the simplest example of the $AdS_2 \times S^2$ model. The resulting background differs from the supergravity solution based on the metric and dilaton of the bosonic model that was found in [11].

Let us start with a brief review of the λ-model [4] (see also [13]). The λ-model may be interpreted as a unique integrable deformation of the first-order action that interpolates between the supercoset $AdS_n \times S^n$ superstring model and its non-abelian T-dual with respect to the full supergroup symmetry. In general, one may consider a model based on the supercoset $\frac{\widehat{F}}{G_1\times G_2} \supset \frac{F_1}{G_1} \times \frac{F_2}{G_2}$, where $\widehat{F}$ is a supergroup (e.g. $PSU(2,2|4)$ in the $AdS_5 \times S^5$ case or $PSU(1,1|2)$ in the $AdS_2 \times S^2$ case) and F_i and G_i are bosonic subgroups. The λ-model is defined by the action

$$\begin{aligned}\hat{I}_{k,\lambda}(f,A) = \frac{k}{4\pi}\Big(\int d^2x \ \mathrm{STr}\big[\tfrac{1}{2} f^{-1}\partial_+ f f^{-1}\partial_- f + A_+\partial_- f f^{-1} - A_- f^{-1}\partial_+ f \\ - f^{-1}A_+ f A_- + A_+A_-\big] - \tfrac{1}{3}\int d^3x\, \epsilon^{abc}\,\mathrm{STr}\big[f^{-1}\partial_a f f^{-1}\partial_b f f^{-1}\partial_c f\big] \\ + (\lambda^{-2}-1)\int d^2x \ \mathrm{STr}\big[A_+P_\lambda A_-\big]\Big)\,, \qquad (1.1)\end{aligned}$$

where $f \in \widehat{F},\ A_\pm \in \hat{\mathfrak{f}} = \mathrm{alg}(\widehat{F})$ and P_λ is a combination of $\mathbb{Z}_4$ projectors[2]

$$P_\lambda = P^{(2)} + \frac{1}{\lambda^{-1}+1}(P^{(1)} - \lambda P^{(3)})\,. \qquad (1.2)$$

All but the last term in (1.1) correspond to the $\widehat{F}/\widehat{F}$ gauged WZW model with integer coupling (level) k and λ is a "deformation" parameter. This action has no global symmetry but there is a local fermionic symmetry and a $G_1 \times G_2$ gauge symmetry which will be fixed by a condition on f after integrating out the gauge fields.

The direct limit $\lambda \to 1$ for fixed k leaves one with $\widehat{F}/\widehat{F}$ gauged WZW model. One can also consider another special limit of $\lambda \to 1$ combined with sending $k \to \infty$ and scaling the supergroup field $f \to 1$ as in [5]

$$f = \exp(-\tfrac{4\pi}{k}\, v) = 1 - \tfrac{4\pi}{k} v + \mathcal{O}(k^{-2})\,, \quad \lambda = 1 - \tfrac{\pi}{k} h + \mathcal{O}(k^{-2})\,, \quad k \to \infty\,, \qquad (1.3)$$

where $v \in \hat{\mathfrak{f}}$ and h are kept fixed. This leads to the following action

[2] Equivalently, $(\lambda^{-2}-1)A_+P_\lambda A_- = A_+(\Omega - 1)A_-$, where $\Omega = P^{(0)} + \lambda^{-2}P^{(2)} + \lambda^{-1}P^{(1)} + \lambda P^{(3)}$.