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Supergravity background of the λ-deformed $AdS_3 \times S^3$ supercoset

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Abstract

We construct the solution of type IIB supergravity describing the integrable λ-deformation of the $AdS_3 \times S^3$ supercoset. While the geometry corresponding to the deformation of the bosonic coset has been found in the past, our background is more natural for studying superstrings, and several interesting features distinguish our solution from its bosonic counterpart. We also report progress towards constructing the λ-deformation of the $AdS_5 \times S^5$ supercoset.

1. Introduction

Integrability is a remarkable property, which has led to a very impressive progress in understanding of string theory over the last two decades (see [1] for review). While initially integrability was discovered for isolated models, such as strings on $AdS_p \times S^q$ [2], later larger classes of integrable backgrounds have been constructed by introducing deformations parameterized by continuous variables. The first example of such family, known as beta deformation [3], has been found long time ago [4], but recently two new powerful tools for constructing integrable string theories have emerged. One of them originated from studies of the Yang–Baxter sigma models [5–7], and it culminated in construction of new integrable string theories, which

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became known as η-deformations [8–12]. The second approach originated from the desire to relate two classes of solvable sigma models, the Wess–Zumino–Witten [13] and the Principal Chiral [14] models, and it culminated in the discovery of a one-parameter family of integrable conformal field theories, which has WZW and PCM as its endpoints [15–17].[1] This connection becomes especially interesting when the PCM point represents a string theory on $AdS_p \times S^q$ space, and the corresponding families, which became known as λ-deformations, have been subjects of recent investigations [19–22]. A close connection between the η and λ deformations has been demonstrated in [20]. In this article we study the λ-deformation for $AdS_3 \times S^3$ and $AdS_5 \times S^5$.

While the metrics for the λ-deformation of $AdS_p \times S^q$ have been constructed in [17,19], the issue of the fluxes supporting these geometries has not been fully resolved. Although the metric for the deformation can be uniquely constructed starting from the corresponding coset, there are two distinct prescriptions for the dilaton: one is based on a bosonic coset [17], and the other one uses its supersymmetric version [16]. In the first case the deformations for all $AdS_p \times S^q$ have been constructed in a series of papers [17,19], while in the second case, which is more natural for describing superstrings, only the result for $AdS_2 \times S^2$ is known [22]. In this article we construct the geometry describing the λ-deformed $AdS_3 \times S^3$ supercoset and report progress towards finding the deformed $AdS_5 \times S^5$ solution.

This paper has the following organization. In section 2 we review the procedure for constructing the λ-deformation, which will be used in the rest of the paper. In section 3 we use this procedure to construct the metric and the dilaton for the deformed $AdS_3 \times S^3$, but unfortunately construction of Ramond–Ramond fluxes requires a separate analysis. In section 3.3 we determine these fluxes by solving supergravity equations, and in sections 3.4–3.5 we find some interesting connections between the new background and solutions which exist in the literature. Section 4 reports progress towards constructing the λ-deformation for super-coset describing strings on $AdS_5 \times S^5$. Specifically, we determine the metric and the dilaton, but unfortunately we were not able to compute the Ramond–Ramond fluxes. The λ-deformation of $AdS_2 \times S^2$ constructed in [22] is reviewed in Appendix A, and its comparison with higher dimensional cases is performed throughout the article.

2. Brief review of the λ-deformation

We begin with reviewing the procedure for constructing the NS–NS fields for the λ-deformed cosets. Such deformation belongs to a general class of two-dimensional integrable systems with equations of motion in the form

$$\partial_\mu I^\mu = 0,$$
$$\partial_\mu I_\nu - \partial_\nu I_\mu + [I_\mu, I_\nu] = 0, \tag{2.1}$$

where currents I_μ take values in a semi-simple Lie algebra. Integrability of this system can be demonstrated by writing it as a zero-curvature condition for a linear problem[2]:

$$\mathcal{D}_\mu \Psi = 0, \qquad \mathcal{D}_\mu(\Lambda) = \partial_\mu + \frac{\Lambda^2}{\Lambda^2 - 1} I_\mu + \frac{\Lambda}{\Lambda^2 - 1} \epsilon_{\mu\rho} I^\rho,$$
$$[\mathcal{D}_\mu(\Lambda), \mathcal{D}_\nu(\Lambda)] = 0\,. \tag{2.2}$$

[1] See [18] for earlier work in this direction.

[2] We denote that spectral parameter by Λ instead of the conventional λ to avoid confusion with a variable governing the deformation.