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Fermionic higher-spin triplets in AdS

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Abstract

We derive a metric-like Lagrangian and equations of motion, in *AdS* space, for multiplets of fermionic fields with spin ranged from $\frac{1}{2}$ to s, from their frame-like formulation.

1. Introduction

Systems of massless higher spin fields which are transformed under a reducible representation of the Lorentz group have attracted a great deal of attention (see e.g. [1–23]), since, as was shown 30 years ago [1,2], they arise in a tensionless limit of string theory in a flat background and may, therefore, shed light on a possible relation between string theory and higher spin gauge theory. The simplest of these systems consists of three symmetric tensor fields of rank s, $s-1$ and $s-2$. This motivated Francia and Sagnotti [6] to call them *higher-spin triplets*. The simplest massless bosonic triplets form reducible multiplets of physical fields with even or odd spins (or helicities) running, respectively, from 0 or 1 to s, while the fermionic triplets consist of physical fields with

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half-integer spins running from 1/2 to s.[1] More complicated systems involve tensor fields of mixed symmetry. Since 1986 higher-spin triplets have been studied from different perspectives (see e.g. [1–27]). For a review and references on difference aspects of higher spin theory (see e.g. [12,28–38]).

Fermionic triplets of tensor-spinor fields were introduced in [3] and independently in [6]. Their origin from a tensionless limit of a Ramond–Neveu–Schwarz string was studied in detail in [7]. The Lagrangian formulations (i.e. the actions and equations of motion) for bosonic triplets are known in flat and anti de Sitter spaces, both in metric-like and frame-like formulations of the higher spin fields. For the fermionic triplets, however, the metric-like actions and equations of motion have been constructed only in flat space-time, while the generalization of this construction to the anti-de Sitter spaces encountered obstacles [7,10] and have not been fulfilled by now. On the other hand, in the frame-like formalism the Lagrangian description of reducible fermionic higher-spin systems in AdS was constructed in [13] and it was outlined therein that the metric-like Lagrangian formulation of the fermionic triplets in AdS can be obtained from the frame-like one by a certain redefinition of fields.

The purpose of this note is to accomplish this goal and to derive an explicit form of the metric-like action, equations of motion and local symmetries of the fermionic triplets in AdS from their frame-like counterparts. In passing we will clarify a subtlety regarding a physical spin-1/2 field one should deal with when relating the reducible fermionic frame-like higher-spin system to the metric-like fermionic triplet. A motivation for presenting these results is that having got the gauge invariant metric-like Lagrangian formulation of the fermionic (and bosonic) higher-spin triplets in AdS one can perform its BRST analysis (already carried out in the bosonic case in [7]) with the aim of understanding whether and how these systems may be obtained by taking a tensionless limit of a String Theory in an AdS background.

Our main notation and conventions are given in Appendix A.

2. Fermionic triplets in flat space-time

2.1. Metric-like formulation

In the metric-like formulation in D-dimensional space-time a fermionic higher-spin triplet consists of three symmetric tensor-spinor fields $\Psi_\alpha^{\mu_1\ldots\mu_r}$, $\chi_\alpha^{\mu_1\ldots\mu_{r-1}}$ and $\lambda_\alpha^{\mu_1\ldots\mu_{r-2}}$, where $\mu_i = 0, 1, \ldots, D-1$ are D-dimensional space-time indices, α is a spinor index which we will usually skip, and $r = s - \frac{1}{2}$ with s denoting the highest spin in the spectrum of the triplet fields. In flat space-time they satisfy the following equations of motion [6]

$$\begin{aligned}
\not\partial\Psi^{\mu_1\ldots\mu_r} + i\partial^{(\mu_1}\chi^{\mu_2\ldots\mu_r)} &= 0,\\
\partial_\nu\Psi^{\nu\mu_1\ldots\mu_{r-1}} - \partial^{(\mu_1}\lambda^{\mu_2\ldots\mu_{r-1})} + i\not\partial\chi^{\mu_1\ldots\mu_{r-1}} &= 0,\\
\not\partial\lambda^{\mu_1\ldots\mu_{r-2}} + i\partial_\nu\chi^{\nu\mu_1\ldots\mu_{r-2}} &= 0\,,
\end{aligned} \tag{2.1}$$

which are invariant under the gauge transformations

[1] The conventional notion of spin and helicity are associated with irreducible representations of the four-dimensional Poincaré group. In what follows we will formally use this terminology also in higher-dimensional theories associating the "spin" with the rank of symmetric tensor-spinors which transform under irreducible representations of the $SO(1, D-1)$ Lorentz group.