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Infinite (continuous) spin fields in the frame-like formalism

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Abstract

In this paper we elaborate on the gauge invariant frame-like Lagrangian description for the wide class of the so-called infinite (or continuous) spin representations of Poincaré group. We use our previous results on the gauge invariant formalism for the massive mixed symmetry fields corresponding to the Young tableau with two rows $Y(k,l)$ ($Y(k+1/2,l+1/2)$ for the fermionic case). We have shown that the corresponding infinite spin solutions can be constructed as a limit where k goes to infinity, while l remain to be fixed and label different representations. Moreover, our gauge invariant formalism provides a natural generalization to (Anti) de Sitter spaces as well. As in the completely symmetric case considered earlier by Metsaev we have found that there are no unitary solutions in de Sitter space, while there exists a rather wide spectrum of Anti de Sitter ones. In this, the question what representations of the Anti de Sitter group such solutions correspond to remains to be open.

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0. Introduction

Besides the very well known finite component massless and massive representations of the Poincaré algebra there exists a number of rather exotic so-called infinite (or continuous) spin ones (see e.g. [1,2]). In dimensions $d \geq 4$ they have an infinite number of physical degrees of freedom and so may be of some interest for the higher spin theory. Indeed, they attracted some attention last times [3–8] (see also recent review [9]). One of the reason is that such representation being massless nevertheless are characterized by some dimensionful parameter μ, which may play important role in the possibility to construct interactions with such fields.

It has been already noted several times in different contexts that such infinite spin representations may be considered as a limit of massive higher spin ones where spin goes to infinity, mass goes to zero while their product $ms = \mu$ remains to be fixed and provides this dimensionful parameter that characterizes the representation. A very nice Lagrangian realization for this idea has been given recently by Metsaev in [10] for the bosonic case and in [11] for the fermionic one (see also [12]). Namely, he has shown that the very same gauge invariant formalism that was previously used for the description of massive higher spin bosonic [13] and fermionic [14] particles can be used to provide Lagrangian gauge invariant formulation for the infinite spin cases. It is interesting that even in flat Minkowski space there exist unitary models that resemble the so-called partially massless models for the finite spin particles in de Sitter space. Recall that one of the nice features of such gauge invariant formulation for the massive higher spins is that it perfectly works not only in flat Minkowski space but in (Anti) de Sitter spaces as well, giving a possibility to investigate all possible massless and partially massless limits. The same holds for the infinite spin cases as well and it appeared that while there are no unitary infinite spin models in de Sitter space there exists quite a lot of different unitary solutions in Anti de Sitter space though till now it is not clear what representations of the Anti de Sitter group they correspond to.

Naturally, the most important open physical question is the possibility to have consistent interacting theories containing such infinite spin fields. A very important step in this direction was recently made by Metsaev [15], who using light-cone formalism provided a classification of cubic interaction vertices for one massless infinite spin field with two massive finite spin ones as well as for two massless infinite spin fields with one massive finite spin one (see also [16] for the interaction of two massive scalars with one massless infinite spin field).

In general, the classification of the infinite spin representations is provided by the representations of the so-called short little group $SO(d-3)$ [1,2]. It is clear that in $d = 3$ and $d = 4$ dimensions this short little group is trivial so we have just one bosonic and one fermionic infinite spin representation whose description is based on the completely symmetric (spin-)tensors. But in dimensions higher than 4 we face a huge number of such representations. For example, in $d = 5, 6$ such representations are labeled by the parameter l that can take integer or half-integer values for the bosonic and fermionic cases respectively. It seemed natural to assume that the Lagrangian formalism for such representations can be obtained starting with the gauge invariant description for the massive mixed symmetry fields corresponding to the Young tableau with two rows $Y(k,l)$ ($Y(k+1/2, l+1/2)$ for the fermionic case) if one takes a limit where k goes to infinity, while l being fixed and labels different representations. In this paper using our previous results [17–20] we show that it appears to be the case. As in the completely symmetric case our gauge invariant formalism provides an extension to (Anti) de Sitter space and we also found that there are no unitary solutions in de Sitter space while there exists a number of unitary ones in Anti de Sitter space. Let us stress ones again that what representations of the Anti de Sitter group such solutions correspond to is still an open question.