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Supersymmetric extended string field theory in NS^n sector and NS^{n-1}–R sector

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Abstract

We construct a class of quadratic gauge invariant actions for extended string fields defined on the tensor product of open superstring state space for multiple open string Neveu–Schwarz (NS) sectors with or without one Ramond (R) sector. The basic idea is the same as for the bosonic extended string field theory developed by the authors [1]. The theory for NS^n sector and NS^{n-1}–R sector contains general n-th rank tensor fields and $(n-1)$-th rank spinor–tensor fields in the massless spectrum respectively. In principle, consistent gauge invariant actions for any generic type of 10-dimensional massive or massless tensor or spinor–tensor fields can be extracted from the theory. We discuss some simple examples of bosonic and fermionic massless actions.

1. Introduction

In the previous paper [1], the authors constructed an extended string field theory (ESFT) which describes massless higher spin fields accompanied with a tower of massive fields, in hoping that it may give a possible ultraviolet completion of the higher spin gauge theory. There the key ingredient is a tensor product of open string state space which naturally gives higher spin fields at a massless level provided with the proper restriction of the states as an extension of the

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$L_0 - \bar{L}_0 = 0$ condition for the closed string. Although the interaction is still to be studied, both the gauge-invariant and the gauge-fixed free actions of the various types of higher rank tensor fields are systematically extracted from the quadratic action of ESFT.

In the present paper, we extend the above mentioned construction to include fermionic fields i.e. higher rank spinor–tensor fields as well as bosonic pure tensor fields, especially in a supersymmetric way. Thus we use the NSR formalism with GSO projection to setup building blocks of open string state space. For the sake of brevity we only consider the simplest supersymmetric case where the tensor product space consists of only two sectors, namely NS $\otimes \cdots \otimes$ NS and NS $\otimes \cdots \otimes$ NS $\otimes$ R sectors, so that the resultant theory has $\mathcal{N} = 1$ supersymmetry. If we could include interactions, we would have to consider not only these two sectors but also all other possible sectors with arbitrary number of R factors. One may also think that the simplest tensor product with $\mathcal{N} = 1$ is a heterotic-type construction, namely the theory with (Bosonic)$^{n-1} \otimes$ NS and (Bosonic)$^{n-1} \otimes$ R sectors. For the heterotic-type case, however, we have to properly treat extra 16-dimensions and thus we will have many lower-spin massless modes. Therefore we restrict ourselves to the above mentioned case with NS^n and NS^{n-1}–R sectors and try to understand the structure of the free minimal supersymmetric theory with massless higher-rank spinor–tensor fields as well as tensor fields.

This paper is organized as follows. In the next section, we briefly review the free covariant open superstring field theory for NS and R sectors. We then show that the 'a-gauges,' which is a class of covariant gauge fixing conditions valid for bosonic string field theory [2,3], can be extended to the superstring field theory in both sectors. In the main section 3, we construct free extended string field theory for NS^n and NS^{n-1}–R sectors and discuss the properties of the actions. Massless spectrum of these sectors generally includes higher-spin fields since it is given by the n-th rank tensor field and the $(n-1)$-th rank spinor–tensor field respectively. We see that the basic structure of the actions for NS^n and NS^{n-1}–R sectors does not depend on n. We then explicitly see the massless part of the actions and give some examples of gauge invariant actions for several types of tensor or spinor–tensor fields. We close the section by giving some comments. In the final section 4, we give summary and some discussions. In Appendix A, we summarize the basic properties of open superstring states and operators.

2. Quadratic action of superstring field theory in NS and R sectors

In this section, we first recall the quadratic action of covariant open superstring field theory in NS and R sectors. We then see how the a-gauges [2,3] can be extended to the gauge invariant action in NS and R sectors.

2.1. State space and the gauge invariant action

The state spaces for NS and R sectors we use have the form

$$\mathcal{H}_{(\mathrm{NS})} = \tilde{\mathcal{F}}^{(\mathrm{NS})} + c_0 \tilde{\mathcal{F}}^{(\mathrm{NS})}, \qquad \mathcal{H}_{(\mathrm{R})} = \tilde{\mathcal{F}}^{(\mathrm{R})} + (\gamma_0 + c_0 \tilde{G}_0)\tilde{\mathcal{F}}^{(\mathrm{R})}. \tag{1}$$

Here the spaces $\tilde{\mathcal{F}}^{(\mathrm{NS})}$ and $\tilde{\mathcal{F}}^{(\mathrm{R})}$ consist of states with arbitrary number of non-zero modes of matter (α, ψ) and ghost (b, c, β, γ) oscillators operated respectively on the ghost number 1 ground states

$$\begin{aligned} &|0, p; \downarrow; -1\rangle_{\mathrm{NS}} \ (= |0, p\rangle \otimes |\downarrow\rangle \otimes |-1\rangle\,), \\ &|0, p, a; \downarrow; -\frac{1}{2}\rangle_{\mathrm{R}} \ (= |0, p, a\rangle \otimes |\downarrow\rangle \otimes |-\frac{1}{2}\rangle\,). \end{aligned} \tag{2}$$