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Fractional-wrapped branes with rotation, linear motion and background fields

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Abstract

We obtain two boundary states corresponding to the two folds of a fractional-wrapped Dp-brane, i.e. the twisted version under the orbifold $\mathbb{C}^2/\mathbb{Z}_2$ and the untwisted version. The brane has rotation and linear motion, in the presence of the following background fields: the Kalb–Ramond tensor, a $U(1)$ internal gauge potential and a tachyon field. The rotation and linear motion are inside the volume of the brane. The brane lives in the d-dimensional spacetime, with the orbifold-toroidal structure $T^n \times \mathbb{R}^{1,d-n-5} \times \mathbb{C}^2/\mathbb{Z}_2$ in the twisted sector. Using these boundary states we calculate the interaction amplitude of two parallel fractional Dp-branes with the foregoing setup. Various properties of this amplitude such as the long-range behavior will be analyzed.

1. Introduction

By using the boundary state formalism all properties of the D-branes can be extracted. In this formalism a D-brane can be completely represented in terms of all closed string states, internal fields, tension and dynamical variables of the brane. Hence, a D-brane appears as a source for emitting (absorbing) all closed string states. The D-branes interaction is obtained by overlap of two boundary states, associated with the branes, through the closed string propagator. Thus, this adequate formalism has been applied for various configurations of the D-branes [1–21].

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Among the different configurations of branes the setups with fractional D-branes have some appealing behaviors [17–24]. The fractional branes appear in the various parts of string and M- theories. For example, they are useful tools for demonstrating the gauge/gravity correspondence [24], and the dynamical fractional branes prepare an explicit starting point for defining Matrix theory [25,26]. On the other hand, we have the compactified D-branes which have a considerable application in string theory. Besides, there are D-branes with background fields which possess various interesting properties. For example, these fields drastically control the interactions of the branes [8–15], and they influence the emitted and absorbed closed strings by the branes. The fractional branes, wrapped branes and the background fields motivated us to study a configuration of the dynamical fractional-wrapped branes with background fields.

In this paper we use the method of boundary state to obtain the interaction amplitude between two parallel fractional-wrapped bosonic Dp-branes with background fields and dynamics. We introduce the background field $B_{\mu\nu}$, internal $U(1)$ gauge potentials and internal open string tachyon fields in the worldvolumes of the branes. In addition, the branes of our setup are dynamical, i.e. they rotate and move within their volumes. For the background spacetime in the twisted sector $\mathcal{T}$ we shall apply the following topological structure

$$T^n \times \mathbb{R}^{1,d-n-5} \times \mathbb{C}^2/\mathbb{Z}_2 \ , \ \ n \in \{0, 1, \ldots, d-5\}.$$

An arbitrary torus from the set $\{T^n | n = 0, 1, \ldots, d-5\}$ will be considered. Therefore, our configuration represents a generalized setup. We shall demonstrate that the twisted sector does not contribute to the long-range force, i.e. the interaction of the distant branes completely comes from the untwisted sector $\mathcal{U}$.

This paper is organized as follows. In Sec. 2, we compute the boundary states corresponding to a rotating and moving fractional-wrapped Dp-brane with background and internal fields. In Sec. 3.1, the interaction amplitude for two parallel Dp-branes will be acquired. In Sec. 3.2, the contribution of the massless states of closed string to the interaction amplitude will be extracted. Section 4 is devoted to the conclusions.

2. The boundary states corresponding to a Dp-brane

We start by calculating the boundary states, associated with a fractional-wrapped Dp-brane. The d-dimensional background spacetime contains a toroidal compact part, and for the twisted sector includes a non-compact orbifold part $\mathbb{C}^2/\mathbb{Z}_2$. The $\mathbb{Z}_2$ group acts on the orbifold directions $\{x^a | a = d-4, d-3, d-2, d-1\}$. We begin with the string action

$$S = -\frac{1}{4\pi\alpha'} \int_{\Sigma} d^2\sigma \left(\sqrt{-g} g^{ab} G_{\mu\nu} \partial_a X^\mu \partial_b X^\nu + \epsilon^{ab} B_{\mu\nu} \partial_a X^\mu \partial_b X^\nu\right)$$
$$+ \frac{1}{2\pi\alpha'} \int_{\partial\Sigma} d\sigma \left(A_\alpha \partial_\sigma X^\alpha + \omega_{\alpha\beta} J_\tau^{\alpha\beta} + T^2\left(X^\alpha\right)\right) , \qquad (2.1)$$

where $\alpha, \beta \in \{0, 1, \ldots, p\}$ represent the worldvolume directions of the brane, the metrics of the worldsheet and spacetime are g_{ab} and $G_{\mu\nu}$, Σ indicates the worldsheet of closed string and $\partial\Sigma$ is its boundary. Here we take the flat spacetime with the signature $G_{\mu\nu} = \eta_{\mu\nu} = \mathrm{diag}(-1, 1, \ldots, 1)$ and a constant Kalb–Ramond field $B_{\mu\nu}$. The profile of the tachyon field is chosen as $T^2(X) = \frac{1}{2} U_{\alpha\beta} X^\alpha X^\beta$ with the constant symmetric matrix $U_{\alpha\beta}$ [27,28]. For the internal gauge potential

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