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Towards a fully stringy computation of Yukawa couplings on non-factorized tori and non-abelian twist correlators (I): The classical solution and action

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Abstract

We consider the simplest possible setting of non-abelian twist fields which corresponds to $SU(2)$ monodromies. We first review the theory of hypergeometric function and of the solutions of the most general Fuchsian second order equation with three singularities. Then we solve the problem of writing the general solution with prescribed $U(2)$ monodromies. We use this result to compute the classical string solution corresponding to three $D2$ branes in $\mathbb{R}^4$. Despite the fact that the configuration is supersymmetric the classical string solution is not holomorphic. Using the equation of motion and not the KLT approach we give a very simple expression for the classical action of the string. We find that the classical action is not proportional to the area of the triangle determined by the branes intersection points since the solution is not holomorphic. Phenomenologically this means that the Yukawa couplings for these supersymmetric configurations on non-factorized tori are suppressed with respect to the factorized case.

1. Introduction and conclusions

Since the beginning, D-branes have been very important in the formal development of string theory as well as in attempts to apply string theory to particle phenomenology and cosmology. However, the requirement of chirality in any physically realistic model leads to a somewhat

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restricted number of possible D-brane set-ups. An important class of models are intersecting brane models where chiral fermions can arise at the intersection of two branes at angles. Most of these computable models are based on $D6$ branes at angles in T^6 or its orbifolds.

To ascertain the phenomenological viability of a model the computation of Yukawa couplings and flavor changing neutral currents plays an important role. This kind of computations involves the computations of (excited) twist fields correlators. Besides the previous computations many other computations often involve correlators of twist fields and excited twist fields. It is therefore important and interesting in its own right to be able to compute these correlators. The literature concerning orbifolds (see for example [1,2]) intersecting D-branes on factorized tori (see for example [3]), magnetic branes with commuting magnetic fluxes (see for example [4]) or involving "abelian" twist fields in various applications (see for example [5]) is very vast. These results are mainly based on the so-called stress–tensor method [1] and concerns mainly non-excited twists even if results for excited twists [6] were obtained. Some of the previous results were also obtained in the infinite charge formalism and boundary state formalism [7]. Within the Reggeon framework (see for example [8,9]) the generating functions for the three point correlators were also obtained in a somewhat complex way. Finally in [10] and [11] based on previous results [12] and a mixture of the path integral approach with the Reggeon approach the generating function of all the correlators with an arbitrary number of (excited) twist fields and usual vertices was given in the case of abelian twist fields. These computations boil down to the knowledge of the Green function in presence of twist fields and of the correlators of the plain twist fields. In this way the computations were made systematic differently from many previous papers where correlators with excited twisted fields have been computed on a case by case basis without a clear global picture. The same results were then recovered using the canonical quantization approach in [13].

Until now only the case of factorized tori has been considered at the stringy level. It is clear that the non-factorized case is more generic and technically by far more complex. It concerns the so-called non-abelian twists for which only a handful papers can be found in the literature of the last 30 years [14]. It is therefore interesting to try to understand how special the results from the factorized case are and to try to clarify the technical issues involved.

In this very technical paper we start the investigation of these configurations. We start considering the case of three $D6$ branes embedded in $\mathbb{R}^{10}$.[1] The relevant configuration can be effectively described by three euclidean $E2$ branes in $\mathbb{C}^2 = \mathbb{R}^4$. We can think of embedding the first $E2$ brane as $\Im Z^1 = \Im Z^2 = 0$. Then the second and third $E2$ branes are generically characterized by a $SO(4)$ matrix (or more precisely by an equivalence class, i.e. a point in the Grassmannian $SO(4)/SO(2) \times SO(2)$) which describes how they are embedded with respect to the first one. However we limit our analysis to the simplest case where these matrices are characterized by an equivalence class of $SU(2)$. If these two matrices commute then we are in the abelian case if not we deal with the by far more difficult non-abelian case. Even if we do not consider the most general case it is however interesting enough to start grasping the issues involved. Moreover this configuration is supersymmetric since there are spinors invariant under the other $SU(2)$ of the "internal" rotation $SO(4) \equiv SU(2) \times SU(2)$.

Due to the technicality of the computations involved we have preferred to write down the details therefore the paper has grown in dimension making necessary to split it into different parts.

[1] It is obviously possible to extend the analysis to configurations on $\mathbb{R}^6 \times T^4$ alone the lines of [15]. It would also be interesting to see in which way the results in this paper improve the conclusion of [16] as far as the moduli stabilization without fluxes.