Available online at www.sciencedirect.com

ScienceDirect

Nuclear Physics B 902 (2016) 458–482

NUCLEAR PHYSICS B

www.elsevier.com/locate/nuclphysb

Implementing odd-axions in dimensional oxidation of 4D non-geometric type IIB scalar potential

Pramod Shukla

Universitá di Torino, Dipartimento di Fisica and I.N.F.N. – Sezione di Torino, via P. Giuria 1, I-10125 Torino, Italy

Received 6 September 2015; received in revised form 21 November 2015; accepted 24 November 2015

Available online 26 November 2015

Editor: Stephan Stieberger

Abstract

In a setup of type IIB superstring compactification on an orientifold of a $\mathbb{T}^6/\mathbb{Z}_4$ sixfold, the presence of geometric flux (ω) and non-geometric fluxes (Q, R) is implemented along with the standard NS–NS and RR three-form fluxes (H, F). After computing the F/D-term contributions to the $\mathcal{N}=1$ four dimensional effective scalar potential, we rearrange the same into 'suitable' pieces by using a set of new generalized flux orbits. Subsequently, we dimensionally oxidize the various pieces of the total four dimensional scalar potential to guess their ten-dimensional origin.

1. Introduction

String compactifications and gauged supergravities have quite remarkable connections via relating the background fluxes in the former picture with the possible gaugings in the later one [1–9]. Application of successive T-duality operations on three-form H-flux of type II orientifold theories results in various geometric and non-geometric fluxes, namely ω, Q and R-fluxes. Moreover, in a setup of type IIB superstring theory compactified on $\mathbb{T}^6/(\mathbb{Z}_2\times\mathbb{Z}_2)$, it was argued that additional fluxes are needed to ensure S-duality invariance of the underlying low energy type IIB supergravity, and in this regard, a new type of non-geometric flux, namely the P-flux, has been proposed as a S-dual candidate for the non-geometric Q-flux [9–11]. The resulting modular com-

E-mail address: pkshukla@to.infn.it.

http://dx.doi.org/10.1016/j.nuclphysb.2015.11.020

pleted fluxes can be arranged into spinor representations of $SL(2,\mathbb{Z})^7$, and the compactification manifold with T- and S-duality appears to be an U-fold [12–14] where local patches are glued by performing T- and S-duality transformations. Since fluxes can induce potentials for various four-dimensional scalars, the same are useful for moduli stabilization and constructing string vacua, and hence connections with gauged supergravity provide a channel to look into phenomenological window, see [15–17] and the references therein. Moreover, in recent years, non-geometric setups have been found to be useful for hunting de-Sitter solutions as well as for building inflationary models [18–23]. A consistent incorporation of various kinds of possible fluxes makes the compactification background richer and more flexible for model building.

Although the origin of all the geometric and non-geometric flux-actions from a ten-dimensional point of view still remains to be (clearly) understood, there have been significant amount of phenomenology oriented studies via considering the 4D effective potential merely derived by knowing the Kähler and super-potentials. However, some significant steps have been taken towards exploring the form of non-geometric 10D action via Double Field Theory (DFT) [24][1] as well as supergravity [8,28,29].[2] In this regard, toroidal orientifolds have been always in the center of attraction because of their relatively simpler structure. Moreover, unlike the case with Calabi Yau compactifications, the explicit and analytic form of metric being known for the toroidal compactification backgrounds make such backgrounds automatically the favorable ones for performing explicit computations. Therefore, the simple toroidal setups have served as promising toolkits for investigating the effects of non-geometric fluxes and also in studying their deeper insights via taking baby steps towards knowing their ten dimensional origin. For example the knowledge of metric has helped in anticipating the ten-dimensional origin of the geometric flux dependent [8] as well as the non-geometric flux dependent potentials [28,29]. Considering a general form of superpotential with the presence of H, ω, Q, R-fluxes in a simple $\mathbb{T}^6/(\mathbb{Z}_2\times\mathbb{Z}_2)$ toroidal orientifold of type IIA and its T-dual type IIB model, the subsequently induced four dimensional scalar potentials have been oxidized into a set of respective pieces of an underlying ten-dimensional supergravity action [28]. This *dimensional oxidation process* has suggested some peculiar flux combinations to be useful in the ten-dimensional picture, and the same have been further extended with the inclusion of P-flux, the S-dual to non-geometric Q-flux in [29]. *In addition, with recent attractions triggered in developing axionic models of inflation after BICEP2 and PLANCK [34–36], a generalization of [28,29] to include involutively odd axions B_2 and C_2 is desirable not only from the point of view of seeking better understanding of the non-geometric 10D action but also for axionic inflation model building.* For explicit construction of some type-IIB toroidal/CY orientifold examples with odd-axions, see [37–43].

Motivated by these aspects, in this article, we implement the presence of odd-axions in the dimensional oxidation process of [28] via considering the untwisted sector of type IIB superstring theory compactified on an orientifold of $\mathbb{T}^6/\mathbb{Z}_4$. *This setup happens to be nontrivial enough as compared to the mostly studied toroidal example of $\mathbb{T}^6/(\mathbb{Z}_2\times\mathbb{Z}_2)$-orientifold in two sense: (i) Having $h^{1,1}_-(X)=2$, it can accommodate the involutively odd axions, and hence can have the structure of usual flux orbits being corrected via B_2-axions similar to type IIA compactification on $\mathbb{T}^6/(\mathbb{Z}_2\times\mathbb{Z}_2)$-orientifold case [8,28]; and (ii) it can induce D-terms involving non-geometric R-fluxes also due to non-trivial even $(2,1)$-cohomology as $h^{2,1}_+(X)=1$.* On top of these, this

[1] For recent reviews and more details on flux formulation of DFT, see [25–27].

[2] Related to the study of ten-dimensional non-geometric action, see also [30–32] in β-supergravity framework as well as [33] for exceptional field theory.