T–DUALITY AND THE TYPE–II SUPERSTRING

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ABSTRACT

We derive the T–duality transformations that transform a general $d = 10$ solution of the type–IIA string with one isometry to a solution of the type–IIB string with one isometry and vice versa.

1. Introduction

Duality symmetries[1] play an important role in string theory. The simplest example is the well–known $R \rightarrow 1/R$ duality which states that a type–I string compactified on a 1–torus with radius R is equivalent to a type–I string compactified on a 1–torus with radius $1/R$. In the low–energy effective action this kind of duality manifests itself as a noncompact

$$SO^{\uparrow}(1,1) \times \mathbb{Z}_2 \tag{1}$$

symmetry. The $SO^{\uparrow}(1,1)$–part corresponds to a diffeomorphism in the torus–direction while the $\mathbb{Z}_2$–part leads to the Buscher's duality rules[2].

Recently, it has been found that duality symmetries of type–II strings have a number of interesting and unusual features[3]. In this talk I would like to discuss some properties of duality symmetries in the context of the type–II superstring in nine and ten dimension, and the relation of these to eleven–dimensional supergravity.

2. Nine Dimensions

The relevant supergravity theory to consider is $N = 2, d = 9$ supergravity. We find that the theory has a non–compact

$$SL(2,\mathbb{R}) \times SO^{\uparrow}(1,1) \tag{2}$$

symmetry[4]. The absence of the $\mathbb{Z}_2$–part, corresponding to the $R \rightarrow 1/R$–duality in the case of the type–I string, is consistent with the observation[5] that the type–IIA string compactified on a torus with radius R is equivalent to the type II–B string compactified on a torus with radius $1/R$. In other words, the duality provides a map from one theory to another and therefore does not correspond to a non–compact symmetry after compactification.

3. Ten Dimensions

In order to describe the type–II T–duality one has to decompactify the nine–dimensional theory in two different ways. One decompactification leads to the type–IIA superstring, the other "dual" decompactification leads to the type–IIB superstring. In this way we have been able to write down the explicit form of the type–II T–duality rules[4]. These rules reduce to the usual Buscher's rules after setting all the Ramond–Ramond fields equal to zero.

4. Eleven Dimensions

Of all duality symmetries we find in ten dimensions only the usual type–I T–duality rules lead to a duality in eleven dimensions[4]. For a membrane compactified on a two–torus it leads to a generalization of the $R \to 1/R$ duality. In particular, we find the following family of self–dual two–torii:

$$R_1 = R\,, \qquad\qquad R_2 = \frac{1}{R^2}\,. \tag{3}$$

It would be interesting to see in which sense this family of two–torii plays a special role in membrane dynamics. One conclusion seems to be that the membrane does not lead to the notion of a minimal length scale.

5. Acknowledgements

I wish to thank Chris Hull and Tomas Ortín for their collaboration on this project and the physics department of QMW college for its hospitality. This work has been made possible by a fellowship of the Royal Netherlands Academy of Arts and Sciences (KNAW).

6. References

1. See, e.g., A. Giveon, M. Porrati and E. Rabinovici, *Phys. Rep.* **244** (1994) 77.
2. T. Buscher, *Phys. Lett.* **159B** (1985) 127.
3. C.M. Hull and P.K. Townsend, *Nucl. Phys.* **B438** (1995) 109.
4. E. Bergshoeff, C.M. Hull and T. Ortín, *Duality in the type–II superstring effective action*, preprint UG–3/95, QMW–PH–95–2, hep–th/9504081.
5. J. Dai, R.G. Leigh and J. Polchinski, *Mod. Phys. Lett. A*, **Vol. 4** (1989) 2073; M. Dine, P. Huet and N. Seiberg, *Nucl. Phys.* **B322** (1989) 301.