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On the magical supergravities in six dimensions

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Abstract

Magical supergravities are a very special class of supergravity theories whose symmetries and matter content in various dimensions correspond to symmetries and underlying algebraic structures of the remarkable geometries of the Magic Square of Freudenthal, Rozenfeld and Tits. These symmetry groups include the exceptional groups and some of their special subgroups. In this paper, we study the general gaugings of these theories in six dimensions which lead to new couplings between vector and tensor fields. We show that in the absence of hypermultiplet couplings the gauge group is uniquely determined by a maximal set of commuting translations within the isometry group $SO(n_T, 1)$ of the tensor multiplet sector. Moreover, we find that in general the gauge algebra allows for central charges that may have nontrivial action on the hypermultiplet scalars. We determine the new minimal couplings, Yukawa couplings and the scalar potential.

MSC: Supergravity; Exceptional groups; Gauge theories; Central charges

1. Introduction

There exists a remarkable class of supergravity theories in $D = 3, 4, 5, 6$, known as magical supergravities [1,2] whose geometries and symmetries correspond to those the Magic Square of

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Table 1
Scalar target spaces of magical supergravities in 6, 5, 4 and 3 dimensions.

$D=6$		$D=5$		$D=4$		$D=3$
$\frac{SO(9,1)}{SO(9)}$	$\longrightarrow$	$\frac{E_{6(-26)}}{F_4}$	$\longrightarrow$	$\frac{E_{7(-25)}}{E_6\times SO(2)}$	$\longrightarrow$	$\frac{E_{8(-24)}}{E_7\times SU(2)}$
$\frac{SO(5,1)}{SO(5)}$	$\longrightarrow$	$\frac{SU^*(6)}{USp(6)}$	$\longrightarrow$	$\frac{SO^*(12)}{U(6)}$	$\longrightarrow$	$\frac{E_{7(-5)}}{SO(12)\times SU(2)}$
$\frac{SO(3,1)}{SO(3)}$	$\longrightarrow$	$\frac{SL(3,\mathbb{C})}{SO(3)}$	$\longrightarrow$	$\frac{SU(3,3)}{SU(3)\times SU(3)\times U(1)}$	$\longrightarrow$	$\frac{E_{6(+2)}}{SU(6)\times SU(2)}$
$\frac{SO(2,1)}{SO(2)}$	$\longrightarrow$	$\frac{SL(3,\mathbb{R})}{SO(3)}$	$\longrightarrow$	$\frac{Sp(6,\mathbb{R})}{U(3)}$	$\longrightarrow$	$\frac{F_{4(+4)}}{USp(6)\times USp(2)}$

Freudenthal, Rozenfeld and Tits [3–5]. In five dimensions these theories describe the coupling of $N=2$ supergravity to 5, 8, 14 and 26 vector multiplets, respectively, and are the unique *unified* Maxwell–Einstein supergravity theories with symmetric target spaces. In $D=6$ they describe the coupling of a fixed number of vector multiplets as well as tensor multiplets to supergravity [6]. The scalar fields of these theories parametrize certain symmetric spaces in $D=3,4,5$ [1] that were later referred to as very special quaternionic Kähler, very special Kähler and very special real, respectively. Very special geometries have been studied extensively [7–10]. See [11] for a review of these geometries, their relation to $6D$ theories and a more complete list of references on the subject.[1] The magical theories in $D=6$ are parent theories from which all the magical supergravities in $D=3,4,5$ can be obtained by dimensional reduction. The scalar coset spaces in all magical supergravities are collected in Table 1. Stringy origins and constructions of some of the magical supergravity theories in various dimensions, with or without additional hypermultiplet couplings, are known [16–21].

Gaugings of magical supergravities have been investigated in $D=5$ [22–24] as well as in 4 and 3 dimensions [25–29]. However, the gaugings associated with the isometries of the scalar cosets in $D=6$ listed above have not been studied so far. In this paper, we aim to close this gap. The gauging phenomenon is especially interesting in this case since it involves tensor as well as vector multiplets such that the corresponding tensor and vector fields transform in the vector and spinor representations of the isometry group $SO(n_T,1)$, respectively. Furthermore, the vector multiplets do not contain any scalar fields. Including the coupling of hypermultiplet couplings introduces additional subtleties with regard to the nature of full gauge group that are allowed by supersymmetry.

We determine the general gauging of magical supergravities in six dimensions and show that in the absence of hypermultiplet couplings the gauge group is uniquely determined by the maximal set of (n_T-1) commuting translations within the isometry group $SO(n_T,1)$. In addition, a linear combination of these generators may act on the fermion fields as a $U(1)_R$ generator of the R-symmetry group $Sp(1)_R$. In the general case, the gauge algebra allows for central charges that may have nontrivial action on the hypermultiplet scalars. We show that the emergence of central charges can be explained by the fact that the gauge group is a diagonal subgroup of (n_T-1) translational isometries and (n_T-1) Abelian gauge symmetries of the vector fields.

The plan of the paper is as follows. In the next section, we give a review of the magical supergravity theories in six dimensions. In Section 3 we determine the possible gauge groups and

[1] In this paper we are only interested in the magical supergravity theories. The conditions for oxidation of a generic real geometry to six dimensions were studied in [12,13]. The general conditions for oxidation of theories with 8 supercharges and symmetric target spaces, which include the magical theories, were studied in [14,15].