\( \mathcal{N} = 2 \) world-sheet approach to D-branes on generalized Kähler geometries: II. Dualities

Alexander Sevrin\textsuperscript{1,∗}, Wieland Staessens\textsuperscript{1,**}, and Alexander Wijns\textsuperscript{2,3,***}

\textsuperscript{1} Theoretische Natuurkunde, Vrije Universiteit Brussel and The International Solvay Institutes, Pleinlaan 2, B-1050 Brussels, Belgium
\textsuperscript{2} Department of Mathematics, Science Institute, University of Iceland, Dunhaga 2, 107 Reykjavik, Iceland.
\textsuperscript{3} NORDITA, Roslagstullsbacken 23, 106 91 Stockholm, Sweden.

Received 2008, revised 2008, accepted 2008
Published online 2008

Key words Superspace, Sigma models, D-branes, Duality.

PACS 11.30.Pb, 11.25.Uv

Following the general formalism reviewed in [10] we present several examples of possible D3-brane configurations on four-dimensional generalized Kähler geometries. We will discuss T-duality transformations in \( \mathcal{N} = 2 \) boundary superspace and apply the duality transformations to the constructed D3-branes. The duality transformations lead to a systematic method to construct coisotropic branes, even on target spaces that are not hyper-Kähler.

Copyright line will be provided by the publisher

1 Motivational introduction

Already in the early days of supersymmetry it was realized that there exists an intimate relation between extended supersymmetry and complex geometry, when applied to (non-linear) \( \sigma \)-models [1, 2, 3, 4, 5, 6]. From a more modern perspective - inspired by flux compactifications - the two-dimensional \( \mathcal{N} = (2,2) \) \( \sigma \)-model is part of the stringy toolbox to study type II superstrings on internal manifolds without R-R fluxes. The geometrical data to describe this type of manifold is given by a metric, a closed 3-form and two complex structures. The complex structures are covariantly constant and the metric is hermitian with respect to both complex structures. This type of geometry was originally called bihermitian geometry [3], but since the birth of generalized complex geometry [7] it is usually referred to as generalized Kähler geometry. The conditions on the metric, the 3-form and the complex structures can be solved in terms of a single real potential, the so-called generalized Kähler potential, from which we can determine the metric and 3-form.

In order to make the \( \mathcal{N} = (2,2) \) manifest, to simplify the analysis and to expose the geometrical structure of the target space it is useful to formulate the \( \mathcal{N} = (2,2) \) non-linear \( \sigma \)-model in terms of an \( \mathcal{N} = (2,2) \) superspace. The most general Lagrangian density one can write down in \( \mathcal{N} = (2,2) \) superspace consists of (the superspace integration) of a real scalar potential, as can be seen from dimensional analysis. This scalar potential is a function of three types of \( \mathcal{N} = (2,2) \) scalar superfield (chiral, twisted chiral and semi-chiral) and is naturally interpreted as the generalized Kähler potential, as we will explain in the first part of section 2.

It is well known that the spectrum of type II superstrings also contains open string states describing the excitations of D-branes to which the open string is attached. Therefore, it is a cromulent question

∗ E-mail: Alexandre.Sevrin@vub.ac.be
∗∗ E-mail: Wieland.Staessens@vub.ac.be, FWO aspirant
*** E-mail: awijns@nordita.org

Copyright line will be provided by the publisher
whether we can use these two-dimensional $\mathcal{N} = (2,2)$ $\sigma$-models to describe the propagation of an open string in (generalized) Kähler backgrounds with (supersymmetric) D-branes. We can invoke the effects of a (supersymmetric) D-brane quite easily by noticing that the boundary conditions of the open string will break half of the supersymmetry to an $\mathcal{N} = 2$ boundary supersymmetry. To have a manifestly supersymmetric description of the boundary conditions for an open string we need to introduce an $\mathcal{N} = 2$ boundary superspace. The picture for exclusively chiral or exclusively twisted chiral superfields was developed in [8], which lead to type B and respectively type A branes on Kähler target spaces. The picture for chiral and twisted chiral superfields was successfully unraveled in [9] and is reviewed in [10]. A brief review of the picture will be given in section[2] followed by some examples of D-branes wrapped on (generalized) Kähler geometries.

In the third section we start by discussing the main philosophy of T-dualization in the $\mathcal{N} = (2,2)$ superspace formalism, which basically corresponds to a Legendre transformation interchanging chiral and twisted chiral superfields. The natural follow-up question is whether we can perform duality transformations in the presence of boundaries. We will point out that it is possible, though there are some subtleties to take into account. Knowing these subtleties allowed us to come up with a systematic procedure to construct coisotropic D-branes via T-dualization of a chiral superfield [9]. We will conclude section[3] with some explicit examples.

2 The boundary superspace approach and D-branes

Let us start by giving a quick review of the $\mathcal{N} = (2,2)$ non-linear $\sigma$-model in an $\mathcal{N} = (2,2)$ superspace. The world-sheet bosonic coordinates are given by $(\sigma, \tau)$, while we also introduce four Grassmann coordinates $(\theta^+, \theta^-, \bar{\theta}^+, \bar{\theta}^-)$ and associated super-covariant derivatives $\{D_+, D_-, \bar{D}_+, \bar{D}_-\}$. The most general action in $\mathcal{N} = (2,2)$ superspace reads on dimensional grounds,

$$S = 4 \int d^2 \sigma \, d^2 \theta \, d^2 \bar{\theta} \, V(X, \bar{X}),$$  \hspace{1cm} (1)

where the lagrange density $V(X, \bar{X})$ is a real function of complex $\mathcal{N} = (2,2)$ scalar superfields. A closer look at the number of degrees of freedom of the $\mathcal{N} = (2,2)$ superfields indicates that there are too many degrees of freedom in comparison with an $\mathcal{N} = (2,1)$ superspace. In order to eliminate some of the degrees of freedom we should impose constraints on the $\mathcal{N} = (2,2)$ scalar superfields. We can distinguish three different types of constraint, leading to three different types of superfield: chiral, twisted chiral and semi-chiral superfields. However, in the remainder of the note we shall mostly focus on the first two types:

- chiral superfields $z^\alpha, \bar{z}^{\alpha}$ with $\alpha, \bar{\alpha} \in \{1, \cdots, n_c\}$

  $$\bar{D}_+ z^\alpha = 0, \quad \bar{D}_- z^\alpha = 0,$$  \hspace{1cm} (2)

- twisted chiral superfields $w^\mu, w^{\bar{\mu}}$ with $\mu, \bar{\mu} \in \{1, \cdots, n_t\}$

  $$\bar{D}_+ w^\mu = 0 = \bar{D}_- w^\mu, \quad D_+ w^{\bar{\mu}} = 0 = D_- w^{\bar{\mu}},$$  \hspace{1cm} (3)

- semi-chiral superfields $l^\alpha, l^{\bar{\alpha}}, r^\mu, r^{\bar{\mu}}$ with $\alpha, \bar{\alpha}, \mu, \bar{\mu} \in \{1, \cdots, n_s\}$

  $$\bar{D}_+ l^\alpha = 0, \quad \bar{D}_- l^{\bar{\alpha}} = 0, \quad D_+ r^\mu = 0, \quad D_- r^{\bar{\mu}} = 0$$  \hspace{1cm} (4)

Introducing these constraints makes it also possible to investigate the dynamics of the $\mathcal{N} = (2,2)$ $\sigma$-models, which is clearly not present in action eq. (1). The proper way to see the dynamics is by reducing the action eq. (1) to $\mathcal{N} = (1,1)$ superspace by integrating out $\bar{D}_+$ and $D_-$. Comparing the resulting action with the most general $\mathcal{N} = (1,1)$ superspace action[3], we can read off the expressions for the metric $g_{ab}$ and

---

1 Note that we use a different basis w.r.t. [10]. For conventions we refer to [5, 9].

2 The most general $\mathcal{N} = (1,1)$ superspace action can e.g. be found in [10].
the 2-form potential $b_{ab}$ in terms of $V$. In case of chiral and twisted chiral fields, we get the following expressions,

$$
g_{\alpha\beta} = +V_{\alpha\beta}, \quad g_{\mu\nu} = -V_{\mu\nu}, \quad b_{\alpha\nu} = -V_{\alpha\nu}, \quad b_{\mu\beta} = +V_{\mu\beta}, \quad (5)$$

and all other components vanish. From these relations it is obvious that $V$ plays the role of the (generalized) Kähler potential.

Let us now give some examples of four-dimensional target spaces that can be parameterized by chiral and/or twisted chiral superfields. The easier target spaces are the torus $T^4$ and $D\times T^2$, where $D$ represents the disk with a singular boundary. Both target spaces can be parameterized by two chiral superfields, two twisted chiral superfields, or one chiral and one twisted chiral superfield. A third example is the Wess-Zumino-Witten (WZW) model on $SU(2)\times U(1)$, which is the only $\mathcal{N} = (2,2)$ WZW model that can be parameterized without the use of semi-chiral superfields \[11\], in which case it is parameterized by one chiral and one twisted chiral superfield. The target space is characterized by a metric and a torsion. This concludes our discussion of a closed string propagating on (generalized) Kähler backgrounds.

Next, we will discuss the propagation of an open string in the presence of a D-brane to which the open string is attached. Invoking the presence of a D-brane comes down to introducing a boundary that breaks the re-parametrization invariance along the open string and half of the supersymmetries on the world-sheet. In practice it is sufficient to recombine the supercovariant derivatives ($\partial_{\mu}$, $\partial_{\bar{\mu}}$) into the following linear combinations,

$$ D \equiv D_+ + D_-, \quad \bar{D} \equiv \bar{D}_+ + \bar{D}_-, \quad D' \equiv D_+ - D_-, \quad \bar{D}' \equiv \bar{D}_+ - \bar{D}_-, \quad (6)$$

where $D$ and $\bar{D}$ represent the directions which remain invariant. In the next step we rewrite the superfield constraints eqs. (2) and (3) in terms of these new supercovariant derivatives to arrive at $\mathcal{N} = 2$ boundary superfields:

- chiral boundary superfields $z^\alpha, \bar{z}^{\bar{\alpha}}$

$$ \bar{D}z^\alpha = 0 = \bar{D}'z^\alpha, \quad Dz^{\bar{\alpha}} = 0 = D'z^{\bar{\alpha}}, \quad (7)$$

- twisted chiral boundary superfields $w^\mu, \bar{w}_{\bar{\mu}}$

$$ D'w^\mu = \bar{D}w^\mu, \quad D'w_{\bar{\mu}} = -\bar{D}w_{\bar{\mu}}, \quad (8)$$

These manipulations form the basic procedure to arrive at the $\mathcal{N} = 2$ boundary superspace formalism. Finally we write down the most general $\mathcal{N} = 2$ boundary superspace action with chiral and twisted chiral superfields as,

$$ S = -\frac{1}{4} \int d^2\sigma d\theta d\bar{\theta} \bar{D}'D' V(z^\alpha, \bar{z}^{\bar{\alpha}}, w^\mu, \bar{w}_{\bar{\mu}}) + i \int d\tau d\theta d\bar{\theta} W(z^\alpha, \bar{z}^{\bar{\alpha}}, w^\mu, \bar{w}_{\bar{\mu}}), \quad (9)$$

where $V$ is the (real) bulk potential and $W$ the (real) boundary potential, and where we have to integrate out $D'$ and $\bar{D}'$. We can describe the local embedding of a D-brane by examining the boundary conditions of the open string attached to the D-brane. We therefore vary the action eq. (9) with respect to the chiral and twisted chiral superfields, after integrating out the derivatives $D'$ and $\bar{D}'$. This variation will yield a bulk term and a boundary term. The bulk term will describe the propagation of the bulk of the open string and contains information about the target space geometry on which the string is propagating. The boundary term describes the propagation of the endpoints of the open string and thus contains information about the local D-brane geometry. For a complete analysis we refer to \[8\]\[9\]. In this note we shall limit ourselves to four-dimensional target spaces, parameterized by chiral and/or twisted chiral superfields, to see how the analysis works in practice.

---

3 An expression of the form $V_{\alpha\bar{\nu}}$ is a shorthand notation for $\partial_{\alpha}\partial_{\bar{\nu}} V$, etc.
4 $SU(2)\times U(1)$ can also be seen as the Hopf surface $S^3 \times S^1$. 

Copyright line will be provided by the publisher
In order for the boundary variation to vanish it is necessary to impose appropriate boundary conditions. These boundary conditions are determined by the bulk potential \( V \), the boundary potential \( W \) and the constraints on the boundary superfields. For the chiral superfield the boundary variation allows us to impose a Dirichlet or a Neumann boundary condition, but the boundary superfield constraints imply the same type of boundary condition for the superfield and its complex conjugated. Thus, we can impose two Dirichlet boundary conditions or two Neumann boundary conditions for one chiral boundary superfield. This means that we can have three different types of branes (so-called B-branes) for a four-dimensional target space parameterized by purely chiral superfields: D0-, D2- and D4-branes. The boundary constraints for a twisted chiral superfield imply that every Dirichlet condition should be accompanied by an associated Neumann boundary condition. However, in the case of two (or more) twisted chiral superfields, one can impose four independent Neumann boundary conditions. Thus, on a four-dimensional target space parameterized by purely twisted chiral superfields we can wrap two different types of brane (so-called A-branes): lagrangian D2ℓ-branes and (space-filling) coisotropic D4c-branes.

In the case of a four-dimensional target space parameterized by a chiral and a twisted chiral superfield, we will always have one Dirichlet and one Neumann boundary condition for the twisted chiral field and two Dirichlet or two Neumann boundary conditions for the chiral field. Hence, we encounter two different types of brane: D1-branes and D3-branes. Now, we are able to give an overview table with the different possible D-branes wrapping a subspace of a (generalized) Kähler geometry and preserving half of the \( N = (2,2) \) world-sheet supersymmetry,

| field content | geometry       | branes       |
|--------------|----------------|--------------|
| 2 chiral     | Kähler         | D0, D2, D4   |
| 1 chiral + 1 twisted chiral | (Generalized) Kähler | D1, D3       |
| 2 twisted chiral | Kähler         | D2ℓ, D4c     |

Table 1 Possible D-brane configurations for a four-dimensional target space

In [9] we constructed a D3-brane on \( T^4 \) and \( S^3 \times S^1 \). The Dirichlet boundary condition of the D3-brane on \( T^4 \) is given by,

\[
\alpha w + \bar{\alpha} \bar{w} = \beta z + \bar{\beta} \bar{z},
\]

where \( \alpha, \beta \in \mathbb{Z} + i \mathbb{Z} \) and \( \alpha \neq 0 \). In the example of \( S^3 \times S^1 \) we choose the following Dirichlet boundary condition\[5\]

\[
-i \ln \frac{w}{\bar{w}} = m_1 x + m_2 y,
\]

where \( m_1, m_2 \in \mathbb{Z} \). For simplicity we defined \( x \equiv \ln(z \bar{z} + w \bar{w}) \) and \( y \equiv -i \ln \frac{z}{\bar{z}} \). Both types of D3-brane are non-trivial embeddings satisfying all consistency requirements and made possible due to the presence of a \( U(1) \) gauge field on the D3-brane world-volume.

### 3 Duality transformations in extended superspace

T-duality is another important feature of type II superstring models and it is therefore interesting to see how T-duality can be made manifest in the \( \mathcal{N} = (2,2) \) non-linear \( \sigma \)-models. Like in the previous section we prefer to work in \( \mathcal{N} = (2,2) \) superspace, where a T-duality corresponds to a Legendre-transformation interchanging different types of \( \mathcal{N} = (2,2) \) superfield \[3, 13\].

We will first summarize the basic procedure to dualize a chiral or a twisted chiral superfield in the absence of boundaries. In order to dualize on the level of the action we have to assume that the model in

---

\[5\] One can make this embedding less mysterious by introducing the Hopf coordinates \( z = \cos \psi \, e^{\rho + i \phi_1}, w = \sin \psi \, e^{\rho + i \phi_2} \), with \( \phi_1, \phi_2, \rho \in \mathbb{R} \mod 2\pi \) and \( \psi \in [0, \pi/2] \).
eq. (1) exhibits an isometry of the form $X + \bar{X}$. This isometry then needs to be gauged on the world-sheet, which demands the introduction of a real $\mathcal{N} = (2,2)$ gauge superfield $Y$ to preserve the (local) isometry. Since the gauge field $Y$ should not introduce extra degrees of freedom, we should impose that $Y$ is purely gauge. This can be done through a complex $\mathcal{N} = (2,2)$ superfield (serving as a Lagrange-multiplier) imposing that the field strengths derived from the gauge field $Y$ vanish. The gauged Kähler potential together with the Lagrange multiplier terms form the complete first order potential. If we integrate out the Lagrange multipliers from this first order action, we retrieve the original model. To arrive at the dual model we need to integrate out the gauge field and the dual superfield $\tilde{X}$ will be expressed in terms of superspace derivatives of the Lagrange-multiplier. Performing this philosophy we can dualize a chiral field to a twisted chiral field and vice versa. Let us conclude the discussion of T-dualization in the absence of boundaries by giving some concrete four-dimensional examples. The torus $T^4$ parameterized by a chiral and a twisted chiral superfield can be dualized to a dual torus $T^4$ parameterized by two chiral superfields or two twisted chiral superfields. The WZW model on the Hopf-surface $S^3 \times S^1$ parameterized by a chiral and a twisted chiral superfield can be dualized to $D \times T^2$ parameterized by two chiral superfields or two twisted chiral superfields.

The next step is to translate this general philosophy to $\mathcal{N} = 2$ boundary superspace and to investigate which kind of D-brane configuration we get after T-dualization. An initial analysis of duality transformations in the presence of boundaries can be found in [8]. There it was already realized that one should pay extra attention to the boundary term in order to get consistent dual boundary conditions. First of all we might want to rewrite the boundary potential such that the symmetry of the form $X + \bar{X}$ remains present at the boundary, albeit not necessarily explicitly. To arrive at the correct and consistent boundary conditions, we might also need to add extra terms to the boundary action. This enabled us for instance to dualize a space-filling B-brane on a Kähler target space to a lagrangian A-brane on the dual Kähler target space, and a lagrangian D1-brane on $T^2$ to a space-filling D2-brane on the dual $T^2$. Moreover, starting from a coisotropic D4-brane on a four-dimensional hyper-Kähler target space we were able to construct a D3-brane on a generalized Kähler target space via dualization. In [9] we improved the dualization method in the presence of boundaries by deriving two identities eqs. (6.14) and (6.15) that made it possible to introduce the correct boundary terms. With these two identities all dualizations interchanging chiral and twisted chiral superfields can be performed.

We will not dwell too long on the general philosophy of T-dualization in superspace and try to clarify it by reviewing some practical examples. We shall focus again on the D3-branes constructed on $T^4$ and $S^3 \times S^1$, as discussed in section [8]. It will become clear through these examples that the parameters describing the D3-brane embedding determine the characteristics of the dual brane. Let us start by dualizing the chiral superfield. Looking at the Dirichlet boundary conditions eqs. (10) and (11) we see that the Dirichlet boundary condition preserves the symmetry of the form $z + \bar{z}$ if $\beta = \bar{\beta}$, and $m_2 = 0$ respectively and that one of the D3-brane directions is wrapped along the $z + \bar{z}$ direction. When dualizing along this direction we expect a (lagrangian) D2-brane in the dual theory. For the D3-brane on $S^3 \times S^1$ we find as the dual model a lagrangian D2-brane wrapped along one direction in $D$ and one direction in $T^2$, where the (quantized) wrapping angle is given by $m_1$. On the other hand, if $\beta \neq \bar{\beta}$, and $m_2 \neq 0$ respectively, then the Dirichlet boundary conditions eqs. (10) and (11) violate the symmetry of the form $z + \bar{z}$. The D3-brane is wrapped differently and when dualizing along the direction $z + \bar{z}$ we expect a D4-brane in the dual theory. In the case of the (dual) $T^4$ the constructed space-filling coisotropic D4-brane is a generalization of the coisotropic D4-brane described in [8]. The coisotropic D4-brane on $D \times T^2$ is a quite interesting result, since it is a first example of a coisotropic D4-brane on a non-hyper-Kähler target space. From a target space perspective the dual target space should allow for a (second) complex structure $K$, which does not commute with the complex structures $J_{(1\bar{z})}$ characterizing the target space geometry. On the world-volume of the coisotropic D4-brane lives a $U(1)$ fieldstrength that can be given in terms of the complex structures and the metric (see e.g. eq. (4.61) in [2]).

In our case, the models also exhibit the isometry $w + \bar{w}$ in the bulk for the twisted chiral superfield. We were able to dualize the D3-branes along this isometry direction, leaving us with dual models completely
parameterized by two chiral superfields. In the case of the D3-brane on $T^4$ we can distinguish once more two different cases, i.e. $\alpha = \bar{\alpha}$ and $\alpha \neq \bar{\alpha}$. In the first case the D3-brane is wrapped along the direction we dualize (i.e. $\nu + \bar{\nu}$) and so we expect a D2-brane in the dual model. The D2-brane is now wrapping a holomorphic 2-cycle with a non-trivial $U(1)$ bundle on its world-volume. The dualization on the level of the action is rather subtle for this case and for details we refer to [9]. In the latter case the D-brane is no longer wrapped along the dualization direction and we find a D4-brane wrapping a holomorphic 4-cycle with a non-trivial $U(1)$ bundle on its world-volume. The constructed D3-brane on $S^3 \times S^1$ can only be dualized to a D4-brane wrapping a holomorphic 4-cycle on $D \times T^2$ with a non-trivial $U(1)$-bundle on its world-volume.

Besides the dualization of only one type of superfield, we would also like to briefly consider here the dualization of a chiral and twisted chiral pair to a semi-chiral supermultiplet [13]. The underlying gauge structure and T-duality transformations were discussed in [14, 15]. In [9] we started the analysis of dualizing a chiral and twisted chiral pair to a semi-chiral supermultiplet in the presence of boundaries. Starting from the torus $T^4$ parameterized by a chiral/twisted chiral pair and the D3-brane given in eq. (10), we were able to dualize the D3-brane to a lagrangian-like D2-brane and a coisotropic-like D4-brane, depending on the embedding parameters of the D3-brane. This dualization allowed us to have a quick look at the possible boundary conditions for semi-chiral superfields and initiated the study of semi-chiral boundary superfields, which will be continued in [12]. In this upcoming paper, we will also consider the dualization of $D \times T^2$ parameterized by a chiral/twisted chiral pair to $S^3 \times S^1$ parameterized by a semi-chiral multiplet. Through this dualization it is possible to construct a lagrangian-like D2-brane and a coisotropic-like D4-brane on $S^3 \times S^1$, starting from a D3-brane on $D \times T^2$.

\section{Closing remarks and outlook}

In this note we briefly discussed a manifestly $\mathcal{N} = 2$ supersymmetric world-sheet description of D-branes wrapping subspaces of bihermitian geometries with commuting complex structures. For this type of geometries, the target space is parameterized by a set of chiral and/or twisted chiral superfields. We gave some four-dimensional examples parameterized by a chiral and a twisted chiral superfield to clarify the general formalism developed in [9] and discussed in [10]. Building on the results of [8] we explored the subtleties in dualizing one of the superfields when boundaries are present. This exploration led to a systematic method to construct coisotropic D-branes via dualization of the chiral superfield, which allowed us to construct a coisotropic D4-brane on a non-hyper-Kähler target space. In [9] we also dualized the chiral/twisted chiral pair to one semi-chiral multiplet, which gave a brief taste of the $\mathcal{N} = 2$ boundary superspace description of D-branes on generalized Kähler manifolds parameterized by semi-chiral superfields. This will be discussed in depth in [12] and reviewed in [10].

In a later stage, it would be interesting to check the stability of the constructed D-branes by studying the quantum conformal invariance of the two-dimensional models using a $\mathcal{N} = 2$ boundary superspace approach, as was done in [16]. Studying the quantum conformal invariance of these models will also allow us to investigate the number of target space supersymmetries preserved by the constructed D-branes.

\textbf{Acknowledgements} We thank Ulf Lindström, Martin Roček and Maxim Zabine for useful discussions and suggestions. W.S. and A.W. would like to thank the organizers of the fourth EU RTN workshop in Varna for the opportunity to present their work. All authors are supported in part by the European Commission FP6 RTN programme MRTN-CT-2004-005104. AS and WS are supported in part by the Belgian Federal Science Policy Office through the Interuniversity Attraction Pole P6/11, and in part by the “FWO-Vlaanderen” through project G.0428.06. AW is supported in part by grant 070034022 from the Icelandic Research Fund.
References

[1] B. Zumino, Phys. Lett. B 87 (1979) 203.
[2] L. Alvarez-Gaume and D. Z. Freedman, Commun. Math. Phys. 80 (1981) 443.
[3] S. J. Gates, C. M. Hull and M. Roček, Nucl. Phys. B 248 (1984) 157.
[4] T. Buscher, U. Lindström and M. Roček, Phys. Lett. B 202 (1988) 94.
[5] A. Sevrin and J. Troost, Nucl. Phys. B 492 (1997) 623, [arXiv:hep-th/9610102].
[6] U. Lindstrom, M. Rocek, R. von Unge and M. Zabzine, Commun. Math. Phys. 269 (2007) 833, [arXiv:hep-th/0512164].
[7] M. Gualtieri, [arXiv:math/0401221], arXiv:math/0703298
[8] A. Sevrin, W. Staessens and A. Wijns, JHEP 0711 (2007) 061, arXiv:0709.3733 [hep-th].
[9] A. Sevrin, W. Staessens and A. Wijns, JHEP 0810 (2008) 108, arXiv:0809.3659 [hep-th].
[10] A. Sevrin, W. Staessens and A. Wijns, arXiv:0810.5355 [hep-th]
[11] M. Roček, K. Schoutens and A. Sevrin, Phys. Lett. B 265 (1991) 303.
[12] A. Sevrin, W. Staessens and A. Wijns, work in progress.
[13] M. T. Grisaru, M. Massar, A. Sevrin, J. Troost, [arXiv:hep-th/9801080].
[14] U. Lindström, M. Roček, I. Ryb, R. von Unge, and M. Zabzine, arXiv:0705.3201 [hep-th].
[15] S. J. Gates Jr., W. Merrell, [arXiv:0705.3207] [hep-th].
[16] S. Nevens, A. Sevrin, W. Troost, A. Wijns, JHEP 0608 (2006) 086, arXiv:hep-th/0606255