UTRECHT UNIVERSITY

Department of Physics

Theoretical Physics master thesis

D-brane gauge theories with spontaneous supersymmetry braking through freely acting orbifolds

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April 30, 2024

Abstract

In the context of String Theory, freely acting orbifolds have proven to be an effective method of spontaneously breaking supersymmetry (cite). The effects on the spectrum of the closed string in type IIB String Theory have been studied in detail in (cite), and this thesis aims to explore the effects of the SUSY breaking in the open string spectrum. Here we first show how the open string spectrum is affected in general by the orbifold action, and we calculate the full orbifold projection on a specific example of D1/D5 brane system. This system is closely linked to black hole solutions of the low energy supergravity, and in the last section we give predictions as to how the orbifold projection acts on the low energy worldvolume CFT and thus the black hole theormodynamics in the system with broken supersymmetry.

Contents

1. Introduction

Physics aims to describe the dynamics between all the fundamental constutuents of nature. In the one hand, we can use Quantum Field Theory to describe Particle Physics, and in the other we can use General Relativity to describe astronomical interactions. These two theories are fundamentally different in the sense that the first is a quantum theory, while the second one is not, and the most naive attempts to convert it to quantum language fail fundamentally.

String theory is a paradigm change to the way Particle Physics is built, in the sense that now the fundamental objects are no longer point-like, but extended one dimensional *strings*. Among an impressive list of results that were derived not long after String Theory was invented, the most notable one might be that this fully quantum theory is a theory of gravity, thus being a promising candidate for a unifying theory of physics.

1.1 Outline

This thesis will be organized as follows. In Chapter 2 we will briefly describe general aspects of String Theory relevant for delevoping the later calculations. In Chapter 3 we will describe the massless spectrum of type IIB String Theory from a group theoretical point of view. In Chapter 4 we will use the group theoretical description to understand how the orbifold modifies the spectrum and thus breaks supersymmetry.

Lastly, in Chapters 5 and 6 we will give a dynamical description to the spectrum found in previous chapters, with the goal of calculating thermodynamic quantities of the black hole that describes the D1/D5 system in the orbifold background.

1.2 Conventions

2. Preliminaries

In this chapter we will present some basic concepts necessary to later build

2.1 Type IIB string theory

2.1.1 D-branes

2.2 Orbifolds

3. Open string spectrum

In this chapter we will describe the spectrum of D-brane systems in the context of type IIB String Theory. We start by discussing single brane spectrums, and then move on to general brane configurations, to conclude with the main example of this thesis, the D1/D5 brane system.

3.1 Dp-Dp spectrum

Consider a single Dp-brane, and the string that attaches its ends to it.

3.2 Dp-D(p+4) spectrum

3.3 D1/D5 spectrum

4. Orbifolds

4.1 Orbifold compactification

4.2 Orbifold group action on the spectrum

Representations of the rotation group -> action by the orbifold group (discrete SO(4) rotations). So non-trivial charges.

5. D-brane gauge theories

5.1 Gauge theory on a single brane and dimensional reduction

5.2 Gauge theory of the D1/D5 system

5.3 Coulomb and Higgs branch

6. Infrared limit and Black Hole thermodynamics

6.1 IR SCFT = black hole theormodynamics

6.2 Predictions of IR limit in orbifold context

7. Conclusions

Appendices

A. Spinors in various dimensions

A.1 Weyl Spinors in $D = 2, 4, 6, 8, 10$

A.2 Majorana condition

A.3 Table of irreducible spinors in even dimensions