Abstract

This thesis focuses on the study of rigid supersymmetry and supergravity theories with the aim of exploiting them in the analysis of 2+1 dimensional condensed matter systems, like graphene.
In the introductory part, we illustrate the so-called rheonomic approach, a useful tool for the construction of supergravity theories and we discuss the AdS/CFT conjecture in the case of its best studied example. Furthermore, we briefly introduce the wide topic of Analogue Gravity, mainly focusing on the 2+1 dimensional condensed matter systems, like graphene, and we describe the main features of the "unconventional supersymmetry", a model capable to connect condensed matter and high energy physics. These topics are the fundamental ingredients exploited for our analysis in the core of the thesis.
In the first part, we perform a holographic analysis, in the context of the AdS/CFT conjecture, of the four dimensional pure $\mathcal{N} = 2$ anti-de Sitter supergravity. It is carried out by including all the contributions coming from fermionic fields and studying the behaviour of the bulk fields and parameters at the boundary of asymptotically locally AdS spacetimes. Moreover, we construct the corresponding currents of the conformal field theory and show, by following the prescription of the AdS/CFT correspondence, that they are in fact conserved at the quantum level.
In the second part of the thesis, inspired by a duality discovered by Kapustin and Saulina, we construct the superspace Lagrangian for an $\mathcal{N} = 4$ rigid supersymmetric theory of hypermultiplets, whose superspace isometry is encoded in the $\mathrm{D}^2(2,1;\boldsymbol{\alpha})$ exceptional supergroup. After projecting the Lagrangian to spacetime, in order to enlight some features of the model, we perform two different twists on the spinorial fields of the hypermultiplets. The first one relates our work to that of Kapustin and Saulina, generalising it to the case in presence of a cosmological constant. The second allows to obtain a Lagrangian whose structure admits the "unconventional supersymmetry".
Eventually, we conclude both parts with comments on the obtained results and a discussion of the possible future developments for the works carried out during the PhD.