Fundamentals of the pure spinor formalism

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This thesis is the tangible result of my years as a PhD student at the Institute for Theoretical Physics of the University of Amsterdam. During this period I have, in cooperation with my co-authors, published three papers on the pure spinor formalism, which have already been mentioned in this preliminary part. While the content of these papers forms an important part of this work, the latter also contains an introduction into all the ingredients that are necessary to fully appreciate the results of the papers. In writing this introduction I only have assumed that the reader is familiar with quantum field theory and general relativity, so in particular knowledge of string theory is not absolutely necessary, although readers who have read some textbook material on perturbative string theory will find this thesis easier to read.

Arguably the best one line description of the first chapter is: “the shortest path from quantum field theory and general relativity to the pure spinor formalism”. In this chapter perturbative string theory is introduced along with its motivations. I have done this in a way that puts emphasis on the parts that are relevant for the pure spinor formalism, which is the most recent string theory formalism. This formalism is introduced in chapter two, where I will demonstrate that the pure spinor formalism distinguishes itself from the two other string theory formalisms (RNS and Green-Schwarz) by the fact that important symmetries of the theory (Lorentz invariance and supersymmetry) are manifest. This has a simplifying effect on amplitude computations and indeed the pure spinor formalism has proved to be more powerful than the other two formalisms. The next chapter contains details of the arguments used in chapter two and sets the stage for the derivations in the next two chapters.

The last couple of chapters before the conclusion is based on my three papers, which all deal with fundamental issues of the pure spinor formalism. The first provided a first principles derivation for the amplitude prescription of the pure spinor formalism. The other two papers contain the proof of an important property that any quantum theory must have, which involves unphysical states. These are states that one includes in the theory at an intermediary stage in order to preserve important symmetries, but should not be part of the physical spectrum of the theory. Thus
in the end the theory should be such that if one scatters a number of physical states, unphysical states will not be produced, in other words unphysical states must decouple. The proof of this decoupling in the case of the pure spinor formalism is the subject of the fifth chapter. More precisely this chapter contains the proof for one of the two versions of the pure spinor formalism, the so-called minimal formalism. Decoupling of unphysical states in the other version is trivial to prove and will therefore not be discussed at length.

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