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The spectra of supersymmetric states in string theory

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Part II

String Compactification

In the previous part of the thesis we have introduced various basic aspects of superstring theory. In this part we will discuss the properties of these theories compactified on the manifolds with special holonomy, in particular the Calabi-Yau three-folds and the K3 manifolds.

There are various motivations to study superstring or M-theory on some small, compact “internal” manifolds. First of all, the world we see are not ten- or eleven-dimensional. One way to connect string theory to the “reality” we see around us is therefore to take some of the ten or eleven dimensions to be extremely small. The other possibility, the so-called brane world scenario, is to assume that we live on a lower dimensional sub-manifold of the total ten- or eleven-dimensional spacetime. At the time of writing, both of them seem to be worth investigating.

More particularly, there are various reasons to study compactifications with unbroken spacetime supersymmetry. First is the analytic control over the system supersymmetry grants us. It’s fair to say that, studying generic non-supersymmetric compactifications quantitatively is at the time of writing still out of control.

Last but not least, we also want to study these compactifications for purely theoretical purposes. As we have seen in the example of type IIB S-duality and as will see later in this chapter, more string dualities become manifest upon compactification on these special supersymmetry-preserving manifolds. Compactification can therefore be seen as an element of the net connecting all different string theories. Furthermore, as we will often see in the discussions about Calabi-Yau three-folds, strings are amazing probes for geometry compared to point particles and compactifying string theory on a particular kind of manifolds often offers great insights into the nature of these manifolds.

For the purpose of the present thesis, discussing compactification is indispensable since many of the properties of the lower-dimensional theories we will study in details later could be best understood as the properties of the internal manifolds.

This part is organized as follows. We will assume that the reader has some familiarity with the defining properties of Calabi-Yau and K3 manifolds. A self-contained small review of them can be found in Appendix A. In chapter 2 we will discuss the Calabi-Yau compactification and chapter 3 the K3 compactification. In both chapters we will describe the compactification first from a world-sheet and then from a spacetime point of view. These discussions will be quite general, and we will leave the more specific topics, namely the (multi-) black hole solutions of the low-energy supergravity theories and the microscopic counting of the BPS states, for later chapters.

