Unknitting the black hole: black holes as effective geometries
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Part II

D1-D5 System and Coarse Graining
The study of simple systems and toy models plays an important role in discovering new concepts in physics as well as checking them. Following this line of thoughts, we are going to study the D1-D5 system under the microscope of the fuzzball program. The importance of this system is twofold. On one hand, we already know a great deal of its field theory dual (see for example [24] and references there in). This gives us a solid reference point to which we can turn to for comparison, inspiration, and guidance. On the other hand, the large symmetry that this system enjoys allows us to be explicit in our discussion. This can help us understand better how to apply the fuzzball ideas developed so far, and also shed some light on the possible limitations of their applicability.

We will start by reviewing the D1-D5 system and its naive ten dimensional geometry. Then, we will describe its space of solutions (called also “solution space”), which is comprised of what is known as the “Lunin-Mathur” geometries (LM in short). This space of solutions will be our working material in the remaining of this part of the thesis. After that, a quick review of the solution space quantization and the resulting Hilbert space will follow.

The last chapter of this part of the thesis will deal mainly with coarse graining. Due to the simple structure of the D1-D5 Hilbert space, we can average over geometries. The resulting effective geometries look exactly like the associated black objects except around the “origin”, where the geometry becomes smooth instead of being singular. During the process we uncover a version of the no-hair theorem. It turns out that the effective description looses almost all information about the thermodynamical ensemble it describes, except for three quantum numbers that we understand very well. We will see that it is possible to put extra hair whenever the dual quantum system behaves like a Bose-Einstein condensate. As an example, we will treat a simple case associated to the “small” black ring. We close this chapter by showing that it is not possible to construct conical defect metrics with an arbitrary opening angle. Some technical manipulations will be left to appendix C.