Preface

The decision to write this book arose in discussions among members of the Working Group 1 (WG1) of the European Cooperation in Science and Technology (COST) action MP0905 "Black Holes in a Violent Universe," which started in 2010 and ended in May 2014.

The four years of the action have been absolutely fantastic for the research themes represented by WG1. The discovery of the Higgs boson which completes the standard model of particle physics was crowned by the 2013 Nobel prize. This discovery has important implications for the unification of the standard model with general relativity which is important for Planck size black holes. Understanding at what energy scale these forces merge into a unified theory, will tell us what is the lightest possible mass for a black hole. In other words, the Large Hadron Collider (LHC) at CERN data allows us to set bounds on the Planck scale. We now know that the Planck scale is above 5 TeV. Thus, Planckian black holes are heavier than 5 TeV. The fact that no dark matter has been discovered at the LHC in the form of a new particle strengthens the assumption that primordial black holes could play that role.

The data from the Planck satellite reinforce the need for inflation. Planckian black holes can make an important contribution at the earliest moment of our universe, namely during inflation if the scale at which inflation took place is close enough to the Planck scale. There have been several interesting proposals relating the Higgs boson of the standard model of particle physics with inflation. Indeed, the LHC data imply that the Higgs boson could be the inflation if the Higgs boson is non-minimally coupled to space-time curvature.

In relation to the black hole information paradox, there has been much excitement about firewalls or what happens when an observer falls through the horizon of a black hole. However, firewalls rely on a theorem by Banks, Susskind and Peskin [Nucl. Phys. B244 (1984) 125] for which there are known counter examples as shown in 1995 by Wald and Unruh [Phys. Rev. D52 (1995) 2176–2182]. It will be interesting to see how the situation evolves in the next few years.

These then are the reasons for writing this book, which reflects on the progress made in recent years in a field which is still developing rapidly. As well as some of the members of our working group, several other international experts have kindly agreed to contribute to the book. The result is a collection of 10 chapters dealing with different aspects of quantum effects in black holes. By quantum effects we mean both quantum mechanical effects such as Hawking radiation and quantum gravitational effects such as Planck size quantum black hole.

Chapter 1 is meant to provide a broad introduction to the field of quantum effects in black holes before focusing on Planckian quantum black holes. Chapter 2 covers the thermodynamics of black holes while Chap. 3 deals with the famous information paradox. Chapter 4 discusses another type of object, so-called monsters, which have more entropy than black holes of equal mass. Primordial black holes are discussed in Chaps. 5 and 6 reviews self-gravitating Bose-Einstein condensates which open up the exciting possibility that black holes are Bose-Einstein condensates. The formation of black holes in supersymmetric theories is investigated in Chap. 7. Chapter 8 covers Hawking radiation in higher dimensional black holes. Chapter 9 presents the latest bounds on the mass of small black holes which could have been produced at the LHC. Last but not least, Chap. 10 covers non-minimal length effects in black holes. All chapters have been through a strict reviewing process.

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Brighton, August 2014 Xavier Calmet

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