

Preface

This book is an edited version of the review talks given in the Sixth Aegean School on *Quantum Gravity and Quantum Cosmology*, held in Chora on Naxos Island, Greece, from 12th to 17th of September 2011. The aim is to present an advanced multiauthored textbook meeting the needs of both postgraduate students and young researchers, in the fields of gravity, relativity, cosmology and quantum field theory.

Quantum gravity in a broad sense is a fast-growing subject in physics and its study is expected to give answers on the short-distance behaviour of the gravitational interaction. Probing the high-energy and high-curvature regimes of gravitating systems can shed some light on the ways to achieve an ultraviolet complete quantum theory of gravity, giving us information about fundamental problems of classical gravity such as the initial big-bang singularity, the cosmological constant problem and the physics at and beyond the Planck scale. On the other hand, it can give vital information on the early-time inflationary evolution of our Universe.

The selected contributions to this volume discuss quantum gravity theories in connection with cosmological models and observations, and explore what type of signature modern and mathematically rigorous frameworks can be detected by experiments.

In the first part of the book, the idea of quantum gravity is introduced and approached from different angles. In the article by Kelly Stelle, an overview is given of the way in which the unification program of particle physics has evolved into the proposal of superstring theory as a prime candidate for unifying gravity with the other forces and particles of nature. A key concern with quantum gravity has been the problem of ultraviolet divergences, which is naturally solved in string theory by replacing particles with spatially extended states as the fundamental excitations. Next, Abhay Ashtekar is presenting a broad perspective on loop quantum gravity and cosmology, while the article by Carlo Rovelli summarizes the present state of the covariant formulation of the loop quantum gravity dynamics. A lattice spinor gravity is formulated in the next article by Christof Wetterich, explaining why the key ingredient for lattice regularized quantum gravity is diffeomorphism symmetry. Andrzej Görlich describes the method of causal dynamical triangulations, a non-perturbative and background independent approach to quantum theory of gravity.

The first part of the book ends with the article by E. Bergshoeff, M. Kovacevic, J. Rosseel and Y. Yin who review the recent developments in massive gravity.

The second part of the book deals with quantum cosmology. Martin Bojowald presents loop quantum cosmology as an attempt to understand the dynamics of loop quantum gravity by realizing crucial effects in simpler, usually symmetric settings. The next article by Martin Reuter and Frank Saueressig, after introducing the basic ideas of the asymptotic safety approach to quantum Einstein gravity, discusses the implications of asymptotic safety for the cosmology of the early Universe. The last article is by Paul McFadden, about the recent developments in holographic cosmology which enables four-dimensional inflationary universes to be described in terms of three-dimensional dual quantum field theories.

In the third part of the book, the observational status of dark matter (the article by Joe Silk) and the observational status of dark energy (overviewed by Shinji Tsujikawa) are presented. The contribution by Robert Brandenberger describes two alternatives to the current cosmological scenario, the matter bounce and the string gas cosmology scenarios. The last article, by M. Romania, N. Tsamis and R. Woodard, presents a class of non-local, gravitational models obtained in quantum gravity in an accelerating cosmological background.

The Sixth Aegean School and the present book became possible with the kind support of many people and organizations. The School was organized and sponsored by the Albert Einstein Institute in Potsdam, the Physics Department of the University of Crete, the Physics Department of the University of Tennessee and the Physics Department of National Technical University of Athens, and it was cosponsored by the Municipality of Naxos and the General Secretariat of Aegean and Island Policy. We specially thank the Municipality of Naxos for making available to us all the excellent facilities of the Cultural Center in the former Ursuline School and all the staff of the center for helping us to run smoothly the school. We also thank Katerina Chiou-Lahanas for her valuable help in organizing the school in Naxos. The administrative support of the Sixth Aegean School was taken up with great care by Fani Siatra and Katerina Papantonopoulou. We acknowledge the help of Vassilis Zamarias who designed and maintained the website of the School. We also thank Petros Skamagoulis for helping us in editing this book.

Last, but not least, we are grateful to the staff of Springer-Verlag, responsible for the Lecture Notes in Physics, whose abilities and help contributed greatly to the appearance of this book.

Gianluca Calcagni
Lefteris Papantonopoulos
George Siopsis
Nikos Tsamis

Quantum Gravity and Quantum Cosmology

Calcagni, G.; Papantonopoulos, L.; Siopsis, G.; Tsamis, N. (Eds.)

2013, XII, 399 p. 75 illus., Softcover

ISBN: 978-3-642-33035-3