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Quantum Cosmology Gravity, Gauge Theories and Quantum Cosmology Foundations of Quantum Cosmology Canonical Quantum Gravity Classical and Quantum Cosmology Quantum Cosmology: Fundamentals Quantum Gravity, Quantum Cosmology and Lorentzian Geometries Quantum Cosmology And Baby Universes: Proceedings Of 7th Jerusalem Winter School Quantum Cosmology - The Supersymmetric Perspective - Vol. 1 Quantum Gravity and Quantum Cosmology Three Roads to Quantum Gravity Gravity and the Quantum The Structural Foundations of Quantum Gravity Quantum Gravity, Quantum Cosmology and Lorentzian Geometries Timeless Quantum Mechanics and the Early Universe Primordial Cosmology Approaches to Quantum Gravity Quantum Cosmology - The Supersymmetric Perspective - Vol. 2 Quantum Gravity Fundamental Aspects of Asymptotic Safety in Quantum Gravity String Gravity and Physics at the Planck Energy Scale Quantum Cosmology Introduction to Quantum Effects in Gravity The Philosophy of Cosmology Primordial Cosmology Cosmology and String Theory Experimental Search for Quantum Gravity Conversations on Quantum Gravity

100 Years of Fundamental Theoretical Physics in the Palm of Your Hand The Problem of Time Quantum Cosmology and Baby Universes The Arrows of Time The Problem of Time Physics Meets Philosophy at the Planck Scale Quantum Coherence The Future of Theoretical Physics and Cosmology Inflation and Quantum Cosmology Quantum Gravity Fundamental Aspects of Asymptotic Safety in Quantum Gravity Asymptotic Safety and Black Holes

Introduction to Quantum Effects in Gravity Apr 01 2021 This book, first published in 2007, is an introductory textbook on quantum field theory in gravitational backgrounds intended for undergraduate and beginning graduate students in the fields of theoretical astrophysics, cosmology, particle physics, and string theory. The book covers the basic (but essential) material of quantization of fields in an expanding universe and quantum fluctuations in inflationary spacetime. It also contains a detailed explanation of the Casimir, Unruh, and Hawking effects, and introduces the method of effective action used for calculating the back-reaction of quantum systems on a classical external gravitational field. The broad scope of the material covered will provide the reader with a thorough perspective of the subject. Every major result is derived from first principles and thoroughly explained. The book is self-contained and assumes only a basic knowledge of general relativity. Exercises

with detailed solutions are provided throughout the book.

The Structural Foundations of Quantum Gravity Feb 11 2022 What is spacetime? General relativity and quantum field theory answer this question in different ways. This collection of essays looks at the problem of uniting these two fundamental theories of our world, focusing on the nature of space and time within this quantum framework.

Primordial Cosmology Nov 08 2021 Primordial Cosmology deals with one of the most puzzling and fascinating topics debated in modern physics - the nature of the Big Bang singularity. The authors provide a self-consistent and complete treatment of the very early Universe dynamics, passing through a concise discussion of the Standard Cosmological Model, a precise characterization of the role played by the theory of inflation, up to a detailed analysis of the anisotropic and inhomogeneous cosmological models. The most peculiar feature of this book is its uniqueness in treating advanced topics of quantum cosmology with a well-traced link to more canonical and pedagogical notions of fundamental cosmology. This book traces clearly the backward temporal evolution of the Universe, starting with the Robertsonndash;Walker geometry and ending with the recent results of loop quantum cosmology in view of the Big Bounce. The reader is accompanied in this journey by an initial technical presentation which, thanks to the

fundamental tools given earlier in the book, never seems heavy or obscure.

Fundamental Aspects of Asymptotic Safety in Quantum Gravity Nov 15 2019 After an extensive introduction to the asymptotic safety approach to quantum gravity, this thesis explains recent key advances reported in four influential papers. Firstly, two exact solutions to the reconstruction problem (how to recover a bare action from the effective average action) are provided. Secondly, the fundamental requirement of background independence in quantum gravity is successfully implemented. Working within the derivative expansion of conformally reduced gravity, the notion of compatibility is developed, uncovering the underlying reasons for background dependence generically forbidding fixed points in such models. Thirdly, in order to understand the true nature of fixed-point solutions, one needs to study their asymptotic behaviour. The author carefully explains how to find the asymptotic form of fixed point solutions within the f(R) approximation. Finally, the key findings are summarised and useful extensions of the work are identified. The thesis finishes by considering the need to incorporate matter into the formalism in a compatible way and touches upon potential opportunities to test asymptotic safety in the future.

The Problem of Time May 22 2020 This book is a treatise on time and on background independence in physics. It first considers how time is conceived of in

each accepted paradigm of physics: Newtonian, special relativity, quantum mechanics (QM) and general relativity (GR). Substantial differences are moreover uncovered between what is meant by time in QM and in GR. These differences jointly source the Problem of Time: Nine interlinked facets which arise upon attempting concurrent treatment of the QM and GR paradigms, as is required in particular for a background independent theory of quantum gravity. A sizeable proportion of current quantum gravity programs - e.g. geometrodynamical and loop quantum gravity approaches to quantum GR, quantum cosmology, supergravity and M-theory - are background independent in this sense. This book's foundational topic is thus furthermore of practical relevance in the ongoing development of quantum gravity programs. This book shows moreover that eight of the nine facets of the Problem of Time already occur upon entertaining background independence in classical (rather than quantum) physics. By this development, and interpreting shape theory as modelling background independence, this book further establishes background independence as a field of study. Background independent mechanics, as well as minisuperspace (spatially homogeneous) models of GR and perturbations thereabout are used to illustrate these points. As hitherto formulated, the different facets of the Problem of Time greatly interfere with each others' attempted resolutions. This book explains

how, none the less, a local resolution of the Problem of Time can be arrived at after various reconceptualizations of the facets and reformulations of their mathematical implementation. Self-contained appendices on mathematical methods for basic and foundational quantum gravity are included. Finally, this book outlines how supergravity is refreshingly different from GR as a realization of background independence, and what background independence entails at the topological level and beyond.

Asymptotic Safety and Black Holes Oct 15 2019 One of the open challenges in fundamental physics is to combine Einstein's theory of general relativity with the principles of quantum mechancis. In this thesis, the question is raised whether metric quantum gravity could be fundamental in the spirit of Steven Weinberg's seminal asymptotic safety conjecture, and if so, what are the consequences for the physics of small, possibly Planck-size black holes? To address the first question, new techniques are provided which allow, for the first time, a self-consistent study of high-order polynomial actions including up to 34 powers in the Ricci scalar. These novel insights are then exploited to explain quantum gravity effects in black holes, including their horizon and causal structure, conformal scaling, evaporation, and the thermodynamics of quantum space-time. Results indicate upper limits on black hole temperature, and the existence of small black holes based on asymptotic safety for gravity and

thermodynamical arguments.
Quantum Coherence Mar 20 2020 The foundations of quantum mechanics has acquired tremendous importance in recent years for three reasons: First, a large number of experiments have tested concepts which previously were purely theoretical. Second, ideas from the foundations of quantum mechanics are being applied now to many fields such as condensed matter physics, quantum statistics, quantum cosmology and quantum gravity. Third, difficulties in constructing a quantum cosmology and theory of gravity have made many theorists examine the foundations of quantum theory to see if quantum mechanics itself needs to be modified. Very distinguished physicists from around the world gave talks on their recent research on a variety of theoretical and experimental aspects on these subjects at this conference. Contents: The Berry Phase as an Appropriate Correspondence Limit of the Aharonov-Anandan Phase in a Simple Model (J Christian & A Shimony)On the Nature of the Transition in Quantum Field Theory from Flat to Curved Space-Time (P J Camp & J L Safko)The Aharonov-Bohm Effect without Gauge Fields – A Paradox (I Klebanov & L Susskind)Geometrical and Topological (AN)Holonomies in Optical Experiments (R Y Chiao)Some Global Problems in Gauge Theories (F Wilczek)Experimental Verification of the Aharonov-Casher Effect for Neutrons with a Crystal

Interferometer (G I Opat et al.)Fundamental Aspects of Quantum Theory Related to the Problem of Quantizing Black Holes (G ' t Hooft)A Suggested New Translation Gauge Invariance for Space-time (D Bohm)Spin and the Aharonov-Bohm Effect (C R Hagen)The Aharonov-Bohm Effect in Small Resistive Devices (R A Webb)Wave Geometry: A Plurality of Singularities (M V Berry)Analogue of the Aharonov-Bohm Effect for Black Holes and Strings (S B Giddings)Closing in on a Renormalizable and Unitary Point-Local Quantum Field Theory of Gravity (Y Ne ' eman & C-Y Lee)Gravitational Chern-Simons Term, Anyons and AB (S Deser)Experimental Confirmation of the Aharonov-Bohm Effect by Electron Holography (A Tonomura)A Geometric View of Quantum Mechanics (J Anandan)Towards a Two Vector Formulation of Quantum Mechanics (Y Aharonov & D Rohrlich)Musings on Quantum Statistics (A Zee)Topology, Quantum Theory and Dynamics (E C G Sudarshan)and other papers Readership: Experimental and theoretical physicists. keywords:

Gravity and the Quantum Mar 12 2022 This book provides a compilation of in-depth articles and reviews on key topics within gravitation, cosmology and related issues. It is a celebratory volume dedicated to Prof. Thanu Padmanabhan ("Paddy"), the renowned relativist and cosmologist from IUCAA, India, on the occasion of his 60th birthday. The authors, many of them leaders of their fields, are all colleagues, collaborators and former

students of Paddy, who have worked with him over a research career spanning more than four decades. Paddy is a scientist of diverse interests, who attaches great importance to teaching. With this in mind, the aim of this compilation is to provide an accessible pedagogic introduction to, and overview of, various important topics in cosmology, gravitation and astrophysics. As such it will be an invaluable resource for scientists, graduate students and also advanced undergraduates seeking to broaden their horizons.

Quantum Gravity Dec 17 2019 The relation between quantum theory and the theory of gravitation remains one of the most outstanding unresolved issues of modern physics. According to general expectation, general relativity as well as quantum (field) theory in a fixed background spacetime cannot be fundamentally correct. Hence there should exist a broader theory comprising both in appropriate limits, i.e., quantum gravity. This book gives readers a comprehensive introduction accessible to interested non-experts to the main issues surrounding the search for quantum gravity. These issues relate to fundamental questions concerning the various formalisms of quantization; specific questions concerning concrete processes, like gravitational collapse or black-hole evaporation; and the all important question concerning the possibility of experimental tests of quantum-gravity effects.

Foundations of Quantum Cosmology Dec 21 2022 This book lays the foundations of quantum cosmology,

developing classical cosmology and quantum physics based on general principles without requiring detailed background knowledge in these fields. Throughout the book, the discussion focuses on the physical meaning of space-time--classical or quantum--and on the important requirement of general covariance. Various classical models are derived from this condition and applied to basic questions in cosmology and the physics of black holes. The book's introduction of relevant ingredients from quantum physics makes it possible to derive fundamental features of quantum cosmology, to present the main approaches to quantum gravity, including string theory and causal dynamical triangulations, and to outline some of their cosmological implications. It is an essential guide for researchers in quantum gravity and astrophysicists interested in fundamental aspects of cosmology.

Quantum Cosmology - The Supersymmetric Perspective - Vol. 2 Sep 06 2021 We read in order to know we are not alone, I once heard, and perhaps it could also be suggested that we write in order not to be alone, to endorse, to promote continuity. The idea for this book took about 10 years to materialize, and it is the author’s hope that its content will constitute the beginning of further explorations beyond current horizons. More speci cally, this book appeals to the reader to engage upon and persevere with a journey, moving through the less well explored territories in the evolution of the very early universe, and pushing

towards new landscapes. P- haps, during or after consulting this book, this attitude and this willingness will be embraced by someone, somewhere, and this person will go on to enrich our quantum cosmological description of the early universe, by means of a clearer supersymm- ric perspective. It is to these creative and inquisitive 'young minds' that the book is addressed. The reader will not therefore nd in this book all the answers to all the problems regarding a supersymmetric and quantum description of the early universe, and this remark is substantiated in the book by a list of unresolved and challenging problems, itself incomplete.

Quantum Cosmology and Baby Universes Jul 24 2020

Three Roads to Quantum Gravity Apr 13 2022 A leading theoretical physicist describes the search for a 'theory of everything'. The Holy Grail of modern physics is the search for a 'quantum gravity' view of the universe that unites Einstein's general relativity with quantum theory. Until recently, these two foundational pillars of modern science have seemed incompatible: relativity deals exclusively with the universe at the large scale (planets, solar systems and galaxies), whereas quantum theory is restricted to the domain of the very small (molecules, atoms, electrons). Here, Lee Smolin provides the first accessible overview of current attempts to reconcile these two theories. Written with wit and style, Three Roads to Quantum Gravity touches on some of the deepest questions

about the nature of the universe - are space and time continuous or infinitely divisible? Is there a limit to how small things can be? - while speculating on what developments we can expect at the frontiers of physics in the twenty-first century.

Approaches to Quantum Gravity Oct 07 2021 Containing contributions from leading researchers in this field, this book provides a complete overview of this field from the frontiers of theoretical physics research for graduate students and researchers. It introduces the most current approaches to this problem, and reviews their main achievements.

Gravity, Gauge Theories and Quantum Cosmology Jan 22 2023 For several decades since its inception, Einstein's general theory of relativity stood somewhat aloof from the rest of physics. Paradoxically, the attributes which normally boost a physical theory - namely, its perfection as a theoreti cal framework and the extraordinary intellectual achievement underlying i- prevented the general theory from being assimilated in the mainstream of physics. It was as if theoreticians hesitated to tamper with something that is manifestly so beautiful. Happily, two developments in the 1970s have narrowed the gap. In 1974 Stephen Hawking arrived at the remarkable result that black holes radiate after all. And in the second half of the decade, particle physicists discovered that the only scenario for applying their grand unified theories was offered by the very early phase in the history of the Big Bang

universe. In both cases, it was necessary to discuss the ideas of quantum field theory in the background of curved spacetime that is basic to general relativity. This is, however, only half the total story. If gravity is to be brought into the general fold of theoretical physics we have to know how to quantize it. To date this has proved a formidable task although most physicists would agree that, as in the case of grand unified theories, quantum gravity will have applications to cosmology, in the very early stages of the Big Bang universe. In fact, the present picture of the Big Bang universe necessarily forces us to think of quantum cosmology.

Conversations on Quantum Gravity Oct 27 2020 Leading theorists share their important insights into the ongoing quest of theoretical physics to find a quantum theory of gravity.

The Future of Theoretical Physics and Cosmology Feb 17 2020 Based on lectures given in honour of Stephen Hawking's sixtieth birthday, this book comprises contributions from some of the world's leading theoretical physicists. It begins with a section containing chapters by successful scientific popularisers, bringing to life both Hawking's work and other exciting developments in physics. The book then goes on to provide a critical evaluation of advanced subjects in modern cosmology and theoretical physics. Topics covered include the origin of the universe, warped spacetime, cosmological singularities,

quantum gravity, black holes, string theory, quantum cosmology and inflation. As well as providing a fascinating overview of the wide variety of subject areas to which Stephen Hawking has contributed, this book represents an important assessment of prospects for the future of fundamental physics and cosmology.

Timeless Quantum Mechanics and the Early Universe Dec 09 2021 The book is based on the author's PhD thesis, which deals with the concept of time in quantum gravity and its relevance for the physics of the early Universe. It presents a consistent and complete new relational formulation of quantum gravity (more specifically, of quantum mechanics models with diffeomorphism invariance), which is applied to potentially observable cosmological effects. The work provides answers to the following questions: How can the dynamics of quantum states of matter and geometry be defined in a diffeomorphism-invariant way? What is the relevant space of physical states and which operators act on it? How are the quantum states related to probabilities in the absence of a preferred time? The answers can provide a further part of the route to constructing a fundamental theory of quantum gravity. The book is well-suited to graduate students as well as professional researchers in the fields of general relativity and gravitation, cosmology, and quantum foundations.

The Problem of Time Aug 25 2020 This book is a treatise on time and on background independence in

physics. It first considers how time is conceived of in each accepted paradigm of physics: Newtonian, special relativity, quantum mechanics (QM) and general relativity (GR). Substantial differences are moreover uncovered between what is meant by time in QM and in GR. These differences jointly source the Problem of Time: Nine interlinked facets which arise upon attempting concurrent treatment of the QM and GR paradigms, as is required in particular for a background independent theory of quantum gravity. A sizeable proportion of current quantum gravity programs - e.g. geometrodynamical and loop quantum gravity approaches to quantum GR, quantum cosmology, supergravity and M-theory - are background independent in this sense. This book's foundational topic is thus furthermore of practical relevance in the ongoing development of quantum gravity programs. This book shows moreover that eight of the nine facets of the Problem of Time already occur upon entertaining background independence in classical (rather than quantum) physics. By this development, and interpreting shape theory as modelling background independence, this book further establishes background independence as a field of study. Background independent mechanics, as well as minisuperspace (spatially homogeneous) models of GR and perturbations thereabout are used to illustrate these points. As hitherto formulated, the different facets of the Problem of Time greatly interfere with

each others' attempted resolutions. This book explains how, none the less, a local resolution of the Problem of Time can be arrived at after various reconceptualizations of the facets and reformulations of their mathematical implementation. Self-contained appendices on mathematical methods for basic and foundational quantum gravity are included. Finally, this book outlines how supergravity is refreshingly different from GR as a realization of background independence, and what background independence entails at the topological level and beyond.

The Arrows of Time Jun 22 2020 The concept of time has fascinated humanity throughout recorded history, and it remains one of the biggest mysteries in science and philosophy. Time is clearly one of the fundamental building blocks of the universe and thus a deeper understanding of nature at a fundamental level also demands a comprehension of time. Furthermore, the origins of the universe are closely intertwined with the puzzle of time: Did time emerge at the Big Bang? Why does the arrow of time 'conspire' with the order of the initial state of the universe? This book addresses many of the most important questions about time: What is time, and is it fundamental or emergent? Why is there such an arrow of time, closely related to the initial state of the universe, and why do the cosmic, thermodynamic and other arrows agree? These issues are discussed here by leading experts, and each offers a new perspective on the debate. Their contributions

delve into the most difficult research topic in physics, also describing the latest cutting edge research on the subject. The book also offers readers a comparison between the different outlooks of philosophy, physics and cosmology on the puzzle of time. This volume is intended to be useful for research purposes, but most chapters are also accessible to a more general audience of scientifically educated readers looking for deeper insights.

Physics Meets Philosophy at the Planck Scale Apr 20 2020 Was the first book to examine the exciting area of overlap between philosophy and quantum mechanics with chapters by leading experts from around the world.

Quantum Cosmology: Fundamentals Sep 18 2022

Fundamental Aspects of Asymptotic Safety in Quantum Gravity Jul 04 2021 After an extensive introduction to the asymptotic safety approach to quantum gravity, this thesis explains recent key advances reported in four influential papers. Firstly, two exact solutions to the reconstruction problem (how to recover a bare action from the effective average action) are provided. Secondly, the fundamental requirement of background independence in quantum gravity is successfully implemented. Working within the derivative expansion of conformally reduced gravity, the notion of compatibility is developed, uncovering the underlying reasons for background dependence generically forbidding fixed points in such

models. Thirdly, in order to understand the true nature of fixed-point solutions, one needs to study their asymptotic behaviour. The author carefully explains how to find the asymptotic form of fixed point solutions within the f(R) approximation. Finally, the key findings are summarised and useful extensions of the work are identified. The thesis finishes by considering the need to incorporate matter into the formalism in a compatible way and touches upon potential opportunities to test asymptotic safety in the future.

Quantum Gravity, Quantum Cosmology and Lorentzian Geometries Aug 17 2022 This book is aimed at theoretical and mathematical physicists and mathematicians interested in modern gravitational physics. I have thus tried to use language familiar to readers working on classical and quantum gravity, paying attention both to difficult calculations and to existence theorems, and discussing in detail the current literature. The first aim of the book is to describe recent work on the problern of boundary conditions in one-loop quantum cosmology. The motivation of this research was to under stand whether supersymmetric theories are one-loop finite in the presence of boundaries, with application to the boundary-value problems occurring in quantum cosmology. Indeed, higher-loop calculations in the absence of boundaries are already available in the litera ture, showing that supergravity is not finite. I believe, however, that one-loop calculations in the

presence of boundaries are more fundamental, in that they provide a more direct check of the inconsistency of Supersymmetrie quantum cosmology from the perturbative point of view. It therefore appears that higher-order calculations are not strictly needed, if the one-loop test already yields negative results. Even though the question is not yet settled, this research has led to many interesting, new applications of areas of theoretical and mathematical physics such as twistor theory in flat space, self-adjointness theory, the generalized Iliemann zeta-function, and the theory of boundary counterterms in super gravity.

Quantum Gravity, Quantum Cosmology and Lorentzian Geometries Jan 10 2022 This book is aimed at theoretical and mathematical physicists and mathematicians interested in modern gravitational physics. I have thus tried to use language familiar to readers working on classical and quantum gravity, paying attention both to difficult calculations and to existence theorems, and discussing in detail the current literature. The first aim of the book is to describe recent work on the problem of boundary conditions in one-loop quantum cosmology. The motivation of this research was to under stand whether supersymmetric theories are one-loop finite in the presence of boundaries, with application to the boundary-value problemsoccurring in quantum cosmology. Indeed, higher-loop calculations in the absence of boundaries are already available in the

litera ture, showing that supergravity is not finite. I believe, however, that one-loop calculations in the presence of boundaries are more fundamental, in that they provide a more direct check of the inconsistency of supersymmetric quantum cosmology from the perturbative point of view. It therefore appears that higher-order calculations are not strictly needed, if the one-loop test already yields negative results. Even though the question is not yet settled, this research has led to many interesting, new applications of areas of theoretical and mathematical physics such as twistor theory in flat space, self-adjointness theory, the generalized Riemann zeta-function, and the theory of boundary counterterms in super gravity. I have also compared in detail my work with results by other authors, explaining, whenever possible, the origin of different results, the limits of my work and the unsolved problems.

Inflation and Quantum Cosmology Jan 18 2020 Inflation and Quantum Cosmology discusses the inflationary universe scenario, including the problems of the standard big bang theory and the interplay between elementary-particle theory and cosmology. Inflationary universe models generate many different final perturbation spectra. For example, a model of an inflationary universe, through a casual mechanism, can predict energy density fluctuations leading to the formation of galaxies. The inflationary universe scenario makes possible simultaneous solutions to ten

problems related to cosmology and elementary particle physics. One problem concerns the origin of density perturbations that show a picture of the large-scale structure of the universe. Some unexplored possibilities are related to isothermal perturbations generated during inflation or to adiabatic perturbations with a non-flat spectrum. An inflationary universe cosmology also includes stochastic inflation that describes the universe on very large scales—from fragmented mini-universes to another inflationary cosmos. The book also discusses the problem relating to the initial conditions from which an inflationary universe starts. This book is suitable for astronomers, astrophysicists, and professors of cosmology and cosmogenesis.

Cosmology and String Theory Dec 29 2020 Cosmology describes the evolution of the Universe and is based on a description of its beginning from quantum fluctuations. String theory is the only known consistent theory of quantum gravity that can deal with the highest energy scales near the Planck energy, relevant for cosmology's beginning. As a result, only string theory can give a fully consistent picture of cosmological origins. This book describes the best current avenues for obtaining cosmology from string theory. It is aimed at graduate students, and also researchers, with some familiarity with cosmology and string theory, however no detailed knowledge is required.

Quantum Gravity Aug 05 2021 The search for a quantum theory of the gravitational field is one of the great open problems in theoretical physics. This book presents a self-contained discussion of the concepts, methods and applications that can be expected in such a theory. The two main approaches to its construction — the direct quantisation of Einstein's general theory of relativity and string theory — are covered. Whereas the first attempts to construct a viable theory for the gravitational field alone, string theory assumes that a quantum theory of gravity will be achieved only through a unification of all the interactions. However, both employ the general method of quantization of constrained systems, which is described together with illustrative examples relevant for quantum gravity. There is a detailed presentation of the main approaches employed in quantum general relativity: path-integral quantization, the background-field method and canonical quantum gravity in the metric, connection and loop formulations. The discussion of string theory centres around its quantum-gravitational aspects and the comparison with quantum general relativity. Physical applications discussed at length include the quantization of black holes, quantum cosmology, the indications of a discrete structure of spacetime, and the origin of irreversibility. This third edition contains new chapters or sections on quantum gravity phenomenology, Horava-Lifshitz quantum gravity, analogue gravity, the holographic principle, and affine

quantum gravity. It will present updates on loop quantum cosmology, the LTB model, asymptotic safety, and various discrete approaches. The third edition also contains pedagogical extensions throughout the text. This book will be of interest to researchers and students working in relativity and gravitation, cosmology, quantum field theory and related topics. It will also be of interest to mathematicians and philosophers of science.

Classical and Quantum Cosmology Oct 19 2022 This comprehensive textbook is devoted to classical and quantum cosmology, with particular emphasis on modern approaches to quantum gravity and string theory and on their observational imprint. It covers major challenges in theoretical physics such as the big bang and the cosmological constant problem. An extensive review of standard cosmology, the cosmic microwave background, inflation and dark energy sets the scene for the phenomenological application of all the main quantum-gravity and string-theory models of cosmology. Born of the author's teaching experience and commitment to bridging the gap between cosmologists and theoreticians working beyond the established laws of particle physics and general relativity, this is a unique text where quantum-gravity approaches and string theory are treated on an equal footing. As well as introducing cosmology to undergraduate and graduate students with its pedagogical presentation and the help of 45 solved

exercises, this book, which includes an ambitious bibliography of about 3500 items, will serve as a valuable reference for lecturers and researchers.
Canonical Quantum Gravity Nov 20 2022 This book aims to present a pedagogical and self-consistent treatment of the canonical approach to Quantum Gravity, starting from its original formulation to the most recent developments in the field. We start with an innovative and enlightening introduction to the formalism and concepts on which General Relativity has been built, giving all the information necessary in the later analysis. A brief sketch of the Standard Cosmological Model describing the Universe evolution is also given alongside the analysis of the inflationary mechanism. After deepening the fundamental properties of constrained dynamic systems, the Lagrangian approach to the Einsteinian Theory is presented in some detail, underlining the parallelism with non-Abelian gauge theories. Then, the basic concepts of the canonical approach to Quantum Mechanics are provided, focusing on all those formulations which are relevant for the Canonical Quantum Gravity problem. The Hamiltonian formulation of General Relativity and its constrained structure is then analyzed by comparing different formulations. The resulting quantum dynamics, described by the Wheeler–DeWitt equation, is fully discussed in order to outline its merits and limits. Afterwards, the reformulation of Canonical Quantum Gravity in terms of

the Ashtekar–Barbero–Immirzi variables is faced by a detailed discussion of the resulting Loop Quantum Gravity Theory. Finally, we provide a consistent picture of canonical Quantum Cosmology by facing the main features of the Wheeler–DeWitt equation for the homogeneous Bianchi models and then by a detailed treatment of Loop Quantum Cosmology, including very recent developments. Contents:Introduction to General RelativityElements of CosmologyConstrained Hamiltonian SystemsLagrangian FormulationsQuantization MethodsQuantum GeometrodynamicsGravity as a Gauge TheoryLoop Quantum GravityQuantum Cosmology Readership: Researchers in theoretical physics, quantum physics, general relativity and astrophysics. Keywords:Canonical Quantum Gravity;Quantum Gravity;Loop Quantum Gravity Theory;General RelativityKey Features:An independent and sound analysis touching many crucial points in the attempt toward a consistent Canonical Quantum Gravity theoryA pedagogical and exhaustive review of fundamental concepts of Quantum Mechanics and General RelativityA solid introduction to Hamiltonian constrained systems with a detailed analysis of the notion of canonical transformation in this class of systems with some concrete examples giving useful insightA self-consistent derivation of the Loop Quantum Gravity Approach, outlining the main progresses and the shortcomings of this theory

Quantum Gravity and Quantum Cosmology *May 14 2022 Quantum gravity has developed into a fast-growing subject in physics and it is expected that probing the high-energy and high-curvature regimes of gravitating systems will shed some light on how to eventually achieve an ultraviolet complete quantum theory of gravity. Such a theory would provide the much needed information about fundamental problems of classical gravity, such as the initial big-bang singularity, the cosmological constant problem, Planck scale physics and the early-time inflationary evolution of our Universe. While in the first part of this book concepts of quantum gravity are introduced and approached from different angles, the second part discusses these theories in connection with cosmological models and observations, thereby exploring which types of signatures of modern and mathematically rigorous frameworks can be detected by experiments. The third and final part briefly reviews the observational status of dark matter and dark energy, and introduces alternative cosmological models. Edited and authored by leading researchers in the field and cast into the form of a multi-author textbook at postgraduate level, this volume will be of benefit to all postgraduate students and newcomers from neighboring disciplines wishing to find a comprehensive guide for their future research.*

Quantum Cosmology - The Supersymmetric Perspective - Vol. 1 Jun 15 2022 We read in order to

know we are not alone, I once heard, and perhaps it could also be suggested that we write in order not to be alone, to endorse, to promote continuity. The idea for this book took about ten years to materialize, and it is the author's hope that its content will constitute the beginning of further explorations beyond current horizons. More speci cally, this book appeals to the reader to engage upon and persevere with a journey, moving through the less well explored territories in the evolution of the very early universe, and pushing towards new landscapes. P- haps, during or after consulting this book, this attitude and this willingness will be embraced by someone, somewhere, and this person will go on to enrich our quantum cosmological description of the early universe, by means of a clearer supersymm- ric perspective. It is to these creative and inquisitive 'young minds' that the book is addressed. The reader will not therefore nd in this book all the answers to all the problems regarding a supersymmetric and quantum description of the early universe, and this remark is substantiated in the book by a list of unresolved and challenging problems, itself incomplete.

String Gravity and Physics at the Planck Energy Scale

Jun 03 2021 The contemporary trends in the quantum unification of all interactions including gravity motivate this Course. The main goal and impact of modern string theory is to provide a consistent quantum theory of gravity. This, Course is intended to provide an

updated understanding of the last developments and current problems of string theory in connection with gravity and the physics at the Planck energy scale. It is also the aim of this Course to discuss fundamental problems of quantum gravity in the present-day context irrespective of strings or any other models. Emphasis is given to the mutual impact of string theory, gravity and cosmology, within a deep a well defined programme, which provides, in addition, a careful interdisciplinarity. Since the most relevant new physics provided by strings concerns the quantization of gravity, we must, at least, understand string quantization in curved space-times to start. Curved space-times, besides their evident relevance m classical gravitation, are also important at energies of the order of the Planck scale. At the Planck energy, gravitational interactions are at least as important as the rest and can not be neglected anymore. Special care is taken here to provide the grounds of the different lines of research in competition (not just only one approach); this provides an excellent opportunity to learn about the real state of the discipline, and to learn it in a critical way.

Quantum Cosmology And Baby Universes: Proceedings Of 7th Jerusalem Winter School *Jul 16 2022 The subject of Quantum Cosmology is concerned with providing a quantum mechanical description of the universe as a whole and, within that description, to constructing a theory of the universe's initial condition*

whose predictions can be compared with observation. The recent progress in this area has profound implications for physics at all scales. The lectures at this School describe these theories and their implications. They cover basic quantum mechanics of cosmology, proposals for theories of initial conditions, and their application to the prediction of the large scale features of our universe. A special emphasis of the School is the implication of topological fluctuations of spacetime (wormholes, baby universes) for the observed coupling constants of the low energy interactions of elementary particles and as a potential explanation for the vanishing of the cosmological constant.

Experimental Search for Quantum Gravity Nov 27 2020 This book summarizes recent developments in the research area of quantum gravity phenomenology. A series of short and nontechnical essays lays out the prospects of various experimental possibilities and their current status. Finding observational evidence for the quantization of space-time was long thought impossible. In the last decade however, new experimental design and technological advances have changed the research landscape and opened new perspectives on quantum gravity. Formerly dominated by purely theoretical constructions, quantum gravity now has a lively phenomenology to offer. From high precision measurements using macroscopic quantum oscillators to new analysis methods of the cosmic

microwave background, no stone is being left unturned in the experimental search for quantum gravity. This book sheds new light on the connection of astroparticle physics with the quantum gravity problem. Gravitational waves and their detection are covered. It illustrates findings from the interconnection between general relativity, black holes and Planck stars. Finally, the return on investment in quantum-gravitation research is illuminated. The book is intended for graduate students and researchers entering the field.

Primordial Cosmology Jan 30 2021

The Philosophy of Cosmology Feb 28 2021 This book addresses foundational questions raised by observational and theoretical progress in modern cosmology. As the foundational volume of an emerging academic discipline, experts from relevant fields lay out the fundamental problems of contemporary cosmology and explore the routes toward finding possible solutions, for a broad academic audience.

Quantum Cosmology Feb 23 2023 Consequences of quantum gravity on grander scales are expected to be enormous: only such a theory can show how black holes really behave and where our universe came from. Applications of loop quantum gravity to cosmology have especially by now shed much light on cosmic evolution of a universe in a fundamental, microscopic description. Modern techniques are explained in this book which demonstrate how the universe could have

come from a non-singular phase before the big bang, how equations for the evolution of structure can be derived, but also what fundamental limitations remain to our knowledge of the universe before the big bang. The following topics will be covered in this book: Hamiltonian cosmology: a general basic treatment of isotropy, perturbations and their role for observations; useful in general cosmology. Effective equations: an efficient way to evaluate equations of quantum gravity, which is also useful in other areas of physics where quantum theory is involved. Loop quantization: a new formalism for the atomic picture of space-time; usually presented at a sophisticated mathematical level, but evaluated here from an intuitive physical side. The book will start with physical motivations, rather than mathematical developments which is more common in other expositions of this field. All the required mathematical methods will be presented, but will not distract the reader from seeing the underlying physics. Simple but representative models will be presented first to show the basic features, which are then used to work upwards to a general description of quantum gravity and its applications in cosmology. This will make the book accessible to a more general physics readership.

100 Years of Fundamental Theoretical Physics in the Palm of Your Hand Sep 25 2020 This book aims to integrate, in a pedagogical and technical manner, with detailed derivations, all essential principles of

fundamental theoretical physics as developed over the past 100 years. It covers: Quantum physics and Stability Problems in the Quantum World, Minkowski Spacetime Physics Particle Classifications and Underlying Symmetries, Symmetry Violations, Quantum Field Theory of Particle Interactions, Higgs Field Physics, Supersymmetry: A Theory with Mathematical Beauty Superstrings, Gravity and Supergravity, General Relativity Predictions, including Frame Dragging, Intricacies of Black Hole Physics, Perturbative and Non-perturbative Quantum Gravity Intricacies of Modern Cosmology, including Inflation and Power Spectrum If you are in the process of learning, or are lecturing on, any of the subjects above, then this is your book - irrespective of your specialty. With over-specialization and no time to master all the fields given above, students, and perhaps many physicists, may find it difficult to keep up with all the exciting developments going on, and are even less familiar with their underlying technicalities: e.g. they might have heard that the Universe is 13.8 billion years old, but have no idea on how this number is actually computed. This unique book will be of great value to graduate students, instructors and researchers interested in the intricacies and derivations of the many aspects of modern fundamental theoretical physics. And, although a graduate level book, some chapters may also be suitable for advanced undergraduates in their final year.

Quantum Cosmology *May 02 2021 Within the second half of the last century, quantum cosmology concretely became one of the main research lines within gravitational theory and cosmology. Substantial progress has been made. Furthermore, quantum cosmology can become a domain that will gradually develop further over the next handful of decades, perhaps assisted by technological developments. Indications for new physics (i.e., beyond the standard model of particle physics or general relativity) could emerge and then the observable universe would surely be seen from quite a new perspective. This motivates bringing quantum cosmology to more research groups and individuals. This Special Issue (SI) aims to provide a wide set of reviews, ranging from foundational issues to (very) recent advancing discussions. Concretely, we want to inspire new work proposing observational tests, providing an aggregated set of contributions, covering several lines, some of which are thoroughly explored, some allowing progress, and others much unexplored. The aim of this SI is motivate new researchers to employ and further develop quantum cosmology over the forthcoming decades. Textbooks and reviews exist on the present subject, and this SI will complementarily assist in offering open access to a set of wide-ranging reviews. Hopefully, this will assist new interested researchers, in having a single open access online volume, with reviews that can help. In particular, this will help in selecting what to explore,*

what to read in more detail, where to proceed, and what to investigate further within quantum cosmology.

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- *How To Write A Novel Using The Snowflake Method Advanced Fiction Writing Volume 1*
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