Foundations Of Quantum Gravity

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.

This book presents a comprehensive course of quantum mechanics for undergraduate and graduate students. After a brief outline of the innovative ideas that lead up to the quantum theory, the book reviews properties of the Schrödinger equation, the quantization phenomena and the physical meaning of wave functions. The book discusses, in a direct and intelligible style, topics of the standard quantum formalism like the dynamical operators and their expected values, the Heisenberg and matrix representation, the approximate methods, the Dirac notation, harmonic oscillator, angular momentum and hydrogen atom, the spin-field and spin-orbit interactions, identical particles and Bose-Einstein condensation etc. Special emphasis is devoted to study the tunneling phenomena, transmission coefficients, phase coherence, energy levels splitting and related phenomena, of interest for quantum devices and heterostructures. The discussion of these problems and the WKB approximation is done using the transfer matrix method, introduced at a tutorial level. This book is a textbook for upper undergraduate physics and electronic engineering students.

This book has two sections. The section Selected Topics in Applications of Quantum Mechanics provides seven chapters about different applications of quantum mechanics in science and technology. The section Selected Topics in Foundations of Quantum Mechanics provides seven chapters about the foundations of quantum mechanics. This book is written by a community of expert scientists from different research institutes and universities from all over the world. Without a doubt, quantum mechanics is the greatest discovery of the 20th century. Therefore, its history and foundations are of great interest to scientists and students. This book covers some of the applications of quantum mechanics in nuclear physics, medical science, information technology, atomic physics and material science, as well as selected topics of quantum mechanics through different bases and ideas about quantum mechanics. The basic idea of the publication of this book is to make scientists and researchers, as well as graduate students, familiar with the foundations of quantum mechanics.

Quantum Field Theory (QFT) has proved to be the most useful strategy for the description of elementary particle interactions and as such is regarded as a fundamental part of modern theoretical physics. In most presentations, the emphasis is on the effectiveness of the theory in producing experimentally testable predictions, which at present essentially means Perturbative QFT. However, after more than fifty years of QFT, we still are in the embarrassing situation of not knowing a single non-trivial (even non-realistic) model of QFT in 3+1 dimensions, allowing a non-perturbative control. As a reaction to these consistency problems one may take the position that they are related to our ignorance of the physics of small distances and that QFT is only an effective theory, so that radically new ideas are needed for a consistent quantum theory of relativistic interactions (in 3+1 dimensions). The book starts by discussing the conflict between locality or hyperbolicity and positivity of the energy for relativistic wave equations, which marks the origin of quantum field theory, and the mathematical problems of the perturbative expansion (canonical quantization, interaction picture, non-Fock representation, asymptotic convergence of the series etc.). The general physical principles of positivity of the energy, Poincare' covariance and locality provide a substitute for canonical quantization, qualify the non-perturbative foundation and lead to very relevant results, like the Spin-statistics theorem, TCP symmetry, a substitute for canonical quantization, non-canonical behaviour, the euclidean formulation at the basis of the functional integral approach, the non-perturbative definition of the S-matrix (LSZ, Haag-Ruelle-Buchholz theory). A characteristic feature of gauge field theories is Gauss' law constraint. It is responsible for the conflict between locality of the charged fields and positivity, it yields the superselection of the (unbroken) gauge charges, provides a non-perturbative explanation of the Higgs mechanism in the local gauges, implies the infraparticle structure of the charged particles in QED and the breaking of the Lorentz group in the charged sectors. A non-perturbative proof of the Higgs mechanism is discussed in the Coulomb gauge: the vector bosons corresponding to the broken generators are massive and their two point function dominates the Goldstone spectrum, thus excluding the occurrence of massless Goldstone bosons. The solution of the U(1) problem in QCD, the theta vacuum structure and the inevitable breaking of the chiral symmetry in each theta sector are

derived solely from the topology of the gauge group, without relying on the semiclassical instanton approximation.

The aim of this book is to develop a modified quantum theory of gravity , to solve the problems involving the combination of very high energy and very small dimensions of space, such as the behavior of Black holes and the origin of the universe.

This is the first book to lay the physical foundations of quantum cosmology, complete with an introduction to space-time physics, quantum theory, and the main approaches to quantum gravity. It is an essential guide for researchers in quantum gravity and astrophysicists interested in fundamental aspects of cosmology.

This textbook covers a broad spectrum of developments in QFT, emphasizing those aspects that are now well consolidated and for which satisfactory theoretical descriptions have been provided. The book is unique in that it offers a new approach to the subject and explores many topics merely touched upon, if covered at all, in standard reference works. A detailed and largely non-technical introductory chapter traces the development of QFT from its inception in 1926. The elegant functional differential approach put forward by Schwinger, referred to as the quantum dynamical (action) principle, and its underlying theory are used systematically in order to generate the so-called vacuum-to-vacuum transition amplitude of both abelian and non-abelian gauge theories, in addition to Feynman's well-known functional integral approach, referred to as the path-integral approach. Given the wealth of information also to be found in the abelian case, equal importance is put on both abelian and non-abelian gauge theories. Particular emphasis is placed on the concept of a quantum field and its particle content to provide an appropriate description of physical processes at high energies, where relativity becomes indispensable. Moreover, quantum mechanics implies that a wave function renormalization arises in the QFT field independent of any perturbation theory - a point not sufficiently emphasized in the literature. The book provides an overview of all the fields encountered in present high-energy physics, together with the details of the underlying derivations. Further, it presents "deep inelastic" experiments as a fundamental application of quantum chromodynamics. Though the author makes a point of deriving points in detail, the book still requires good background knowledge of quantum mechanics, including the Dirac Theory, as well as elements of the Klein-Gordon equation. The present volume sets the language, the notation and provides additional background for reading Quantum Field Theory II - Introduction to Quantum Gravity, Supersymmetry and String Theory, by the same author. Students in this field might benefit from first reading the book Quantum Theory: A Wide Spectrum (Springer, 2006), by the same author.

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.

Advances made by physicists in understanding matter, space, and time and by astronomers in understanding the universe as a whole have closely intertwined the question being asked about the universe at its two extremesâ € "the very large and the very small. This report identifies 11 key questions that have a good chance to be answered in the next decade. It urges that a new research strategy be created that brings to bear the techniques of both astronomy and sub-atomic physics in a cross-disciplinary way to address these questions. The report presents seven recommendations to facilitate the necessary research and development coordination. These recommendations identify key priorities for future scientific projects critical for realizing these scientific opportunities.

This text shows that insights in quantum physics can be obtained by exploring the mathematical structure of quantum mechanics. It presents the theory of Hermitean operators and Hilbert spaces, providing the framework for transformation theory, and using th

It has often been claimed that without drastic conceptual innovations a genuine explanation of quantum interference effects and quantum randomness is impossible. This book concerns Bohmian mechanics, a simple particle theory that is a counterexample to such claims. The gentle introduction and other contributions collected here show how the phenomena of non-relativistic quantum mechanics, from Heisenberg's uncertainty principle to non-commuting observables, emerge from the Bohmian motion of particles, the natural particle motion associated with Schrödinger's equation. This book will be of value to all students and researchers in physics with an interest in the meaning of quantum theory as well as to philosophers of science.

Encapsulates the latest debates on this topic, giving researchers and graduate students an up-to-date view of the field.

Quantum information has dramatically changed information science and technology, looking at the quantum nature of the information carrier as a resource for building new information protocols, designing radically new communication and computation algorithms, and ultra-sensitive measurements in metrology, with a wealth of applications. From a fundamental perspective, this new discipline has led us to regard quantum theory itself as a special theory of information, and has opened routes for exploring solutions to the tension with general relativity, based, for example, on the holographic principle, on non-causal variations of the theory, or else on the powerful algorithm of the quantum cellular automaton, which has revealed new routes for exploring quantum fields theory, both as a new microscopic mechanism on the fundamental side, and as a tool for efficient physical quantum simulations for practical purposes. In this golden age of foundations, an astonishing number of new ideas, frameworks, and results, spawned by the quantum information theory experience, have revolutionized the way we think about the subject, with a new research community emerging worldwide, including scientists from computer science and mathematics.

This book is the most complete collection of John S Bell's research papers, review articles and lecture notes on the foundations of quantum mechanics. Some of this material has hitherto been difficult to access. The book also appears in a paperback edition, aimed at students and young researchers.This volume will be very useful to researchers in the foundations and applications of quantum mechanics.

Multi-author volume on the history and philosophy of physics.

"Exploring how the subtleties of quantum coherence can be consistently incorporated into Einstein's theory of gravitation, this book is ideal for researchers interested in the foundations of relativity and quantum physics. The book examines those properties of coherent gravitating systems that are most closely connected to experimental observations. Examples of consistent co-gravitating quantum systems whose overall effects upon the geometry are independent of the coherence state of each constituent are provided, and the properties of the trapping regions of non-singular black objects, black holes, and a dynamic de Sitter cosmology are discussed analytically, numerically, and diagrammatically. The extensive use of diagrams to summarise the results of the mathematics enables readers to bypass the need for a detailed understanding of the steps involved. Assuming some knowledge of quantum physics and relativity, the book provides textboxes featuring supplementary information for readers particularly interested in the philosophy and foundations of the physics"--

Einstein's Unfinished Revolution
Mathematical Foundations of Quantum Mechanics
The Search for What Lies Beyond the Quantum
Bridging Foundations of Physics and Mathematics
Topics in the Foundations of General Relativity and Newtonian Gravitation Theory
An Elementary Introduction to Quantum Gravity and Spinfoam Theory
Quantum Gravity
The Structural Foundations of Quantum Gravity
Reflections on Quantum Gravity
Quantum Worlds and the Emergence of Spacetime
The Foundations of Quantum Gravity

This book provides an introduction to the conceptual foundations of quantum mechanics, from classical mechanics and a discussion of the quantum phenomena that undermine our classical intuitions about how the physical world works, to the quantum measurement problem and alternatives to the standard von Neumann-Dirac formulation.

Introducing a geometric view of fundamental physics, ideal for advanced undergraduate and graduate students in quantum mechanics and mathematical physics.

Quantum mechanics is an extraordinarily successful scientific theory. But it is also completely mad. Although the theory quite obviously works, it leaves us chasing ghosts and phantoms; particles that are waves and waves that are particles; cats that are at once both alive and dead; lots of seemingly spooky goings-on; and a desperate desire to lie down quietly in a darkened room. The Quantum Cookbook explains why this is. It provides a unique bridge between popular exposition and formal textbook presentation, written for curious readers with some background in physics and sufficient mathematical capability. It aims not to teach readers how to do quantum mechanics but rather helps them to understand how to think about quantum mechanics. Each derivation is presented as a 'recipe' with listed ingredients, including standard results from the mathematician's toolkit, set out in a series of easy-to-follow steps. The recipes have been written sympathetically, for readers who - like the author - will often struggle to follow the logic of a derivation which misses out steps that are 'obvious', or which use techniques that readers are assumed to know.

This book takes a pedagogical approach to explaining quantum gravity, supersymmetry and string theory in a coherent way. It is aimed at graduate students and researchers in quantum field theory and high-energy physics. The first part of the book introduces quantum gravity, without requiring previous knowledge of general relativity (GR). The necessary geometrical aspects are derived afresh leading to explicit general Lagrangians for gravity, including that of general relativity. The quantum aspect of gravitation, as described by the graviton, is introduced and perturbative quantum GR is discussed. The Schwinger-DeWitt formalism is developed to compute the one-loop contribution to the theory and renormalizability aspects of the perturbative theory are also discussed. This follows by introducing only the very basics of a non-perturbative, background-independent, formulation of quantum gravity, referred to as "loop quantum gravity", which gives rise to a quantization of space. In the second part the author introduces supersymmetry and its consequences. The generation of superfields is represented in detail. Supersymmetric generalizations of Maxwell's Theory as well as of Yang-Mills field theory, and of the standard model are worked out. Spontaneous symmetry breaking, improvement of the divergence problem in supersymmetric field theory, and its role in the hierarchy problem are covered. The unification of the fundamental constants in a supersymmetric version of *the standard model are then studied. Geometrical aspects necessary to study supergravity are developed culminating in the derivation of its full action. The third part introduces string theory and the analysis of the spectra of the mass (squared) operator associated with the oscillating strings. The properties of the underlying fields, associated with massless particles, encountered in string theory are studied in some detail. Elements of compactification, duality and D-branes are given, as well of the generation of vertices and interactions of strings. In the final sections, the author shows how to recover GR and the Yang-Mills field Theory from string theory.*

This 2004 textbook provides a pedagogical introduction to the formalism, foundations and applications of quantum mechanics. Part I covers the basic material which is necessary to understand the transition from classical to wave mechanics. Topics include classical dynamics, with emphasis on canonical transformations and the Hamilton-Jacobi equation, the Cauchy problem for the wave equation, Helmholtz equation and eikonal approximation, introduction to spin, perturbation theory and scattering theory. The Weyl quantization is presented in Part II, along with the postulates of quantum mechanics. Part III is devoted to topics such as statistical mechanics and black-body radiation, Lagrangian and phase-space formulations of quantum mechanics, and the Dirac equation. This book is intended for use as a textbook for beginning graduate and advanced undergraduate courses. It is self-contained and includes problems to aid the reader's understanding.

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.

Exploring how the subtleties of quantum coherence can be consistently incorporated into Einstein's theory of gravitation, this book is ideal for researchers interested in the foundations of relativity and quantum physics. The book examines those properties of coherent gravitating systems that are most closely connected to experimental observations. Examples of consistent co-gravitating quantum systems whose overall effects upon the geometry are independent of the coherence state of each constituent are provided, and the properties of the trapping regions of non-singular black objects, black holes and a dynamic de Sitter cosmology are discussed analytically, numerically and diagrammatically. The extensive use of diagrams to summarise the results of the mathematics enables readers to bypass the need for a detailed understanding of the steps involved. Assuming some knowledge of quantum physics and relativity, the book provides text boxes featuring supplementary information for readers particularly interested in the philosophy and foundations of the physics.

INSTANT NEW YORK TIMES BESTSELLER A Science News favorite science book of 2019 As you read these words, copies of you are being created. Sean Carroll, theoretical physicist and one of this world's most celebrated writers on science, rewrites the history of 20th century physics. Already hailed as a masterpiece, Something Deeply Hidden shows for the first time that facing up to the essential puzzle of quantum mechanics utterly transforms how we think about space and time. His reconciling of quantum mechanics with Einstein's theory of relativity changes, well, everything. Most physicists haven't even recognized the uncomfortable truth: physics has been in crisis since 1927. Quantum mechanics has always had obvious gaps—which have come to be simply ignored. Science popularizers keep telling us how weird it is, how impossible it is to understand. Academics discourage students from working on the "dead end" of quantum foundations. Putting his professional reputation on the line with this audacious yet entirely reasonable book, Carroll says that the crisis can now come to an end. We just have to accept that there is more than one of us in the universe. There are many, many Sean Carrolls. Many of every one of us. Copies of you are generated thousands of times per second. The Many Worlds Theory of quantum behavior says that every time there is a quantum event, a world splits off with everything in it the same, except in that other world the quantum event didn't happen. Step-by-step in Carroll's uniquely lucid way, he tackles the major objections to this otherworldly revelation until his case is inescapably established. Rarely does a book so fully reorganize how we think about our place in the universe. We are on the threshold of a new understanding—of where we are in the cosmos, and what we are made of.

Quantum Information and Foundations
John S. Bell on the Foundations of Quantum Mechanics
The Cellular Automaton Interpretation of Quantum Mechanics
Quantum Field Theory I
Foundations of Quantum Gravity the Nucleus Black Hole Parallel
Fundamentals of Quantum Physics
Foundations of Quantum Gravity
Advanced Concepts in Quantum Mechanics
Foundations of Space and Time
Selected Topics in Applications of Quantum Mechanics
Experimental Search for Quantum Gravity

This book provides an accessible introduction to loop quantum gravity and some of its applications, at a level suitable for undergraduate students and others with only a minimal knowledge of college level physics. In particular it is not assumed that the reader is familiar with general relativity and only minimally familiar with quantum mechanics and Hamiltonian mechanics. Most chapters end with problems that elaborate on the text, and aid learning. Applications such as loop quantum cosmology, black hole entropy and spin foams are briefly covered. The text is ideally suited for an undergraduate course in the senior year of a physics major. It can also be used to introduce undergraduates to general relativity and quantum field theory as part of a 'special topics' type of course.

This graduate-level text introduces fundamentals of classical mechanics; surveys basics of quantum mechanics; and concludes with a look at group theory and quantum mechanics of the atom. 1963 edition.

This book presents the deterministic view of quantum mechanics developed by Nobel Laureate Gerard 't Hooft. Dissatisfied with the uncomfortable gaps in the way conventional quantum mechanics meshes with the classical world, 't Hooft has revived the old hidden variable ideas, but now in a much more systematic way than usual. In this, quantum mechanics is viewed as a tool rather than a theory. The author gives examples of models that are classical in essence, but can be analysed by the use of quantum techniques, and argues that even the Standard Model, together with gravitational interactions, might be viewed as a quantum mechanical approach to analysing a system that could be classical at its core. He shows how this approach, even though it is based on hidden variables, can be plausibly reconciled with Bell's theorem, and how the usual objections voiced against the idea of 'superdeterminism' can be overcome, at least in principle. This framework elegantly explains - and automatically cures - the problems of the wave function collapse and the measurement problem. Even the existence of an “arrow of time" can perhaps be explained in a more elegant way than usual. As well as reviewing the author’s earlier work in the field, the book also contains many new observations and calculations. It provides stimulating reading for all physicists working on the foundations of quantum theory.

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.

A daring new vision of the quantum universe, and the scandals controversies, and questions that may illuminate our future--from Canada's leading mind on contemporary physics. Quantum physics is the golden child of modern science. It is the basis of our understanding of atoms, radiation, and so much else, from elementary particles and basic forces to the behaviour of materials. But for a century it has also been the problem child of science, plagued by intense disagreements between its intellectual giants, from Albert Einstein to Stephen Hawking, over the strange paradoxes and implications that seem like the stuff of fantasy. Whether it's Schrödinger's cat--a creature that is simultaneously dead and alive--or a belief that the world does not exist independently of our observations of it, quantum theory is what challenges our fundamental assumptions about our reality. In Einstein's Unfinished Revolution, globally renowned theoretical physicist Lee Smolin provocatively argues that the problems which have bedeviled quantum physics since its inception are unsolved for the simple reason that the theory is incomplete. There is more, waiting to be discovered. Our task--if we are to have simple answers to our simple questions about the universe we live in--must be to go beyond it to a description of the world on an atomic scale that makes sense. In this vibrant and accessible book, Smolin takes us on a journey through the basics of quantum physics, introducing the stories of the experiments and figures that have transformed the field, before wrestling with the puzzles and conundrums that they present. Along the way, he illuminates the existing theories about the quantum world that might solve these problems, guiding us toward his own vision that embraces common sense realism. If we are to have any hope of completing the revolution that Einstein began nearly a century ago, we must go beyond quantum mechanics as we know it to find a theory that will give us a complete description of nature. In Einstein's Unfinished Revolution, Lee Smolin brings us a step closer to resolving one of the greatest scientific controversies of our age.

Explores how quantum coherence can be consistently incorporated into Einstein's theory of gravitation, for researchers in the foundations of physics.

This book studies the foundations of quantum theory through its relationship to classical physics. This idea goes back to the Copenhagen Interpretation (in the original version due to Bohr and Heisenberg), which the author relates to the mathematical formalism of operator algebras originally created by von Neumann. The book therefore includes comprehensive appendices on functional analysis and C*-algebras, as well as a briefer one on logic, category theory, and topos theory. Matters of foundational as well as mathematical interest that are covered in detail include symmetry (and its "spontaneous" breaking), the measurement problem, the Kochen-Specker, Free Will, and Bell Theorems, the Kadison-Singer conjecture, quantization, indistinguishable particles, the quantum theory of large systems, and quantum logic, the latter in connection with the topos approach to quantum theory. This book is Open Access under a CC BY licence.

In Topics in the Foundations of General Relativity and Newtonian Gravitation Theory, David B. Malament presents the basic logical-mathematical structure of general relativity and considers a number of special topics concerning the foundations of general relativity and its relation to Newtonian gravitation theory. These special topics include the geometrized formulation of Newtonian theory (also known as Newton-Cartan theory), the concept of rotation in general relativity, and Gödel spacetime. One of the highlights of the book is a no-go theorem that can be understood to show that there is no criterion of orbital rotation in general relativity that fully answers to our classical intuitions. Topics is intended for both students and researchers in mathematical physics and philosophy of science.

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.

The aim of this book is twofold: to provide a comprehensive account of the foundations of the theory and to outline a theoretical and philosophical interpretation suggested from the results of the last twenty years.There is a need to provide an account of the foundations of the theory because recent experience has largely confirmed the theory and offered a wealth of new discoveries and possibilities. On the other side, the following results have generated a new basis for discussing the problem of the interpretation: the new developments in measurement theory; the experimental generation of ?Schr”dinger cats?; recent developments which allow, for the first time, the simultaneous measurement of complementary observables; quantum information processing, teleportation and computation.To accomplish this task, the book combines historical, systematic and thematic approaches.

A collection of essays discussing the philosophy and foundations of quantum gravity. Written by leading philosophers and physicists in the field, chapters cover the important conceptual questions in the search for a quantum theory of gravity, and the current state of understanding among philosophers and physicists.

A comprehensible introduction to the most fascinating research in theoretical physics: advanced quantum gravity. Ideal for researchers and graduate students.

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.

This book focuses on a critical discussion of the status and prospects of current approaches in quantum mechanics and quantum field theory, in particular concerning gravity. It contains a carefully selected cross-section of lectures and discussions at the seventh conference “Progress and Visions in Quantum Theory in View of Gravity” which took place in fall 2018 at the Max Planck Institute for Mathematics in the Sciences in Leipzig. In contrast to usual proceeding volumes, instead of reporting on the most recent technical results, contributors were asked to discuss visions and new ideas in foundational physics, in particular concerning foundations of quantum field theory. A special focus has been put on the question of which physical principles of quantum (field) theory can be considered fundamental in view of gravity. The book is mainly addressed to mathematicians and physicists who are interested in fundamental questions of mathematical physics. It allows the reader to obtain a broad and up-to-date overview of a fascinating active research area.

Quantum gravity is perhaps the most important open problem in fundamental physics. It is the problem of merging quantum mechanics and general relativity, the two great conceptual revolutions in the physics of the twentieth century. The loop and spinfoam approach, presented in this 2004 book, is one of the leading research programs in the field. The first part of the book discusses the reformulation of the basis of classical and quantum Hamiltonian physics required by general relativity. The second part covers the basic technical research directions. Appendices include a detailed history of the subject of quantum gravity, hard-to-find mathematical material, and a discussion of some philosophical issues raised by the subject. This fascinating text is ideal for graduate students entering the field, as well as researchers already working in quantum gravity. It will also appeal to philosophers and other scholars interested in the nature of space and time.