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XG5ORC - ALISSON ROBERSON

The Routledge Companion to Philosophy of Physics is a comprehensive and authoritative guide to the state of the art in the philosophy of physics. It comprisess 54 self-contained chapters written by leading philosophers of physics at both senior and junior levels, making it the most thorough and detailed volume of its type on the market – nearly every major perspective in the field is represented. The Companion’s 54 chapters are organized into 12 parts. The first seven parts cover all of the major physical theories investigated by philosophers of physics today, and the last five explore key themes that unite the study of these theories. I. Newtonian Mechanics II. Special Relativity III. General Relativity IV. Non-Relativistic Quantum Theory V. Quantum Field Theory VI. Quantum Gravity VII. Statistical Mechanics and Thermodynamics VIII. Explanation IX. Intertheoretic Relations X. Symmetries XI. Metaphysics XII. Cosmology The difficulty level of the chapters has been carefully pitched so as to offer both accessible summaries for those new to philosophy of physics and standard reference points for active researchers on the front lines. An introductory chapter by the editors maps out the field, and each part also begins with a short summary that places the individual chapters in context. The volume will be indispensable to any serious student or scholar of philosophy of physics.
Entanglement was initially thought by some to be an oddity restricted to the realm of thought experiments. However, Bell’s inequality delimiting local - havior and the experimental demonstration of its violation more than 25 years ago made it entirely clear that non-local properties of pure quantum states are more than an intellectual curiosity. Entanglement and non-locality are now understood to ?gure prominently in the microphysical world, a realm into which technology is rapidly hurtling. Information theory is also increasingly recognized by physicists and philosophers as intimately related to the foun- tions of mechanics. The clearest indicator of this relationship is that between quantum information and entanglement. To some degree, a deep relationship between information and mechanics in the quantum context was already there to be seen upon the introduction by Max Born and Wolfgang Pauli of the idea that the essence of pure quantum states lies in their provision of probabilities regarding the behavior of quantum systems, via what has come to be known as the Born rule. The signi?cance of the relationship between mechanics and information became even clearer with Leo Szilard’s analysis of James Clerk Maxwell’s infamous demon thought experiment. Here, in addition to examining both entanglement and quantum infor- tion and their relationship, I endeavor to critically assess the in?uence of the study of these subjects on the interpretation of quantum theory.

The second edition deals with all essential aspects of non-relativistic quantum physics up to the quantisation of fields. In contrast to common textbooks of quantum mechanics, modern experiments are described both for the purpose of foundation of the theory and in relation to recent applications. Links are made to important research fields and applications such as elementary particle physics, solid state physics and nuclear magnetic resonance in medicine, biology and material science. Special emphasis is paid to quantum physics in nanoelectronics such as resonant tunnelling, Coulomb blockade and the realisation of quantum bits. This second edition also considers quantum transport through quantum point contacts and its application as charge detectors in nanoelectronic circuits. Also the realization and the study of electronic properties of an artificial quantum dot molecule are presented. Because of its recent interest a brief discussion of Bose-Einstein condensation has been included, as well as the recently detected Higgs particle. Another essential new addition to the present book concerns a detailed discussion of the particle picture in quantum field theory. Counterintuitive aspects of single particle quantum physics such as particle-wave duality and the Einstein-Podolski-Rosen (EPR) paradox appear more acceptable to our understanding if discussed on the background of quantum field theory. The non-locality of quantum fields explains non-local behaviour of particles in classical Schrödinger quantum mechanics. Finally, new problems have been added. The book is suitable as an introduction into quantum physics, not only for physicists but also for chemists, biologists, engineers, computer scientists and even for philosophers as far as they are interested in natural philosophy and epistemology.
This book deals with some of the current issues in the philosophy, methodology and foundations of physics. Some such problems are: - Do mathematical formalisms interpret themselves or is it necessary to adjoin them interpretation assumptions, and if so how are these as sumptions to be framed? - What are physical theories about: physical systems or laboratory operations or both or neither? - How are the basic concepts of a theory to be introduced: by ref erence to measurements or by explicit definition or axiomatically? - What is the use ofaxiomatics in physics? - How are the various physical theories inter-related: like Chinese boxes or in more complex ways? - What is the role of analogy in the construction and in the inter pretation of physical theories? In particular, are classical analogues like those of particle and wave indispensable in quantum theories? - What is the role of the apparatus in quantum phenomena and what is the place of measurement theory in quantum mechanics? - How does a theory face experiment: single-handed or with the help of further theories? These and several other questions of the kind are met with by the research physicist, the physics teach-

er and the physics student in their everyday work. If dodged they will recur. And a wrong answer to them may obscure the understanding of what has been achieved and may even hamper further advancement. Philosophy, methodology and foundations, like rose bushes, are enjoyable when cultivated but become ugly and thorny when neglected.

From the very beginning it was realised that quantum physics involves radically new interpretative and epistemological consequences. While hitherto there has been no satisfactory philosophical analysis of these consequences, recent years have witnessed the accomplishment of many experiments to test the foundations of quantum physics, opening up vistas to a completely novel technology: quantum technology. The contributions in the present volume review the interpretative situation, analyze recent fundamental experiments, and discuss the implications of possible future technological applications. Readership: Analytic philosophers (logical empiricists), scientists (especially physicists), historians of logic, mathematics and physics, philosophers of science, and advanced students and researchers in these fields. Can be used for seminars on theoretical and experimental physics and philosophy of science, and as supplementary reading at advanced undergraduate and graduate levels.
This self-contained essay collection is published to commemorate half a century of Bell’s theorem. Like its much acclaimed predecessor “Quantum [Un]Speakables: From Bell to Quantum Information” (published 2002), it comprises essays by many of the worlds leading quantum physicists and philosophers. These revisit the foundations of quantum theory as well as elucidating the remarkable progress in quantum technologies achieved in the last couple of decades. Fundamental concepts such as entanglement, nonlocality and contextuality are described in an accessible manner and, alongside lively descriptions of the various theoretical and experimental approaches, the book also delivers interesting philosophical insights. The collection as a whole will serve as a broad introduction for students and newcomers as well as delighting the scientifically literate general reader.
This book is a historical analysis of the quantum mechanical revolution and the emergence of a new discipline from the perspective, not of a professor, but of a recent or actual Ph.D. student just embarking on an uncertain academic career in economically hard times. Quantum mechanics exploded on to the intellectual scene between 1925 and 1927, with more than 200 publications across the world, the majority of them authored by young scientists under the age of 30, graduate students or postdoctoral fellows. The resulting theory was a collective product that no single authority could claim, but it had a major geographical nod – the Copenhagen Institute of Theoretical Physics – where most of the informal, pre-published exchange of ideas occurred and where every participant of the new community aspired to visit. A rare combination of circumstances and resources – political, diplomatic, financial, and intellectual – allowed Niels Bohr to establish this “Mecca” of quantum theory outside of traditional and more powerful centres of science. Transitory international postdoctoral fellows, rather than established professors, developed a culture of research that became the source of major innovations in the field. Temporary assistantships, postdoctoral positions, and their equivalents were the chief mode of existence for young academics during the period of economic crisis and post-WWI international tensions. Insecure career trajectories and unpredictable moves through nonstable temporary positions contributed to their general outlook and interpretations of the emerging theory of quantum mechanics. This book is part of a four-volume collection addressing the beginnings of quantum physics research at the major European centres of Göttingen, Copenhagen, Berlin, and Munich; these works emerged from an expansive study on the quantum revolution as a major transformation of physical knowledge undertaken by the Max Planck Institute for the History of Science and the Fritz Haber Institute (2006–2012). For more on this project, see the dedicated Feature Story, The Networks of Early Quantum Theory, at the Max Planck Institute for the History of Science, https://www.mpiwg-berlin.mpg.de/feature-story/networks-early-quantum-theory
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.

A sophisticated and original introduction to the philosophy of quantum mechanics from one of the world’s leading philosophers of physics In this book, Tim Maudlin, one of the world’s leading philosophers of physics, offers a sophisticated, original introduction to the philosophy of quantum mechanics. The briefest, clearest, and most refined account of his influential approach to the subject, the book will be invaluable to all students of philosophy and physics. Quantum mechanics holds a unique place in the history of physics. It has produced the most accurate predictions of any scientific theory, but, more astonishing, there has never been any agreement about what the theory implies about physical reality. Maudlin argues that the very term “quantum theory” is a misnomer. A proper physical theory should clearly describe what is there and what it does—yet standard textbooks present quantum mechanics as a predictive recipe in search of a physical theory. In contrast, Maudlin explores three proper theories that recover the quantum predictions: the indeterministic wavefunction collapse theory of Ghirardi, Rimini, and Weber; the deterministic particle theory of deBroglie and Bohm; and the conceptually challenging Many Worlds theory of Everett. Each offers a radically different proposal for the nature of physical reality, but Maudlin shows that none of them are what they

are generally taken to be.
Leading scholars explore the connections between quantum physics and process philosophy.
From Aristotle's Physics to quantum teleportation, learn about the scientific pursuit of instantaneous connections in this insightful examination of our world. For millennia, scientists have puzzled over a simple question: Does the universe have a speed limit? If not, some effects could happen at the same instant as the actions that caused them -- and some effects, ludicrously, might even happen before their causes. By one hundred years ago, it seemed clear that the speed of light was the fastest possible speed. Causality was safe. And then quantum mechanics happened, introducing spooky connections that seemed to circumvent the law of cause and effect. Inspired by the new physics, psychologist Carl Jung and physicist Wolfgang Pauli explored a concept called synchronicity, a weird phenomenon they thought could link events without causes. Synchronicity tells that sprawling tale of insight and creativity, and asks where these ideas -- some plain crazy, and others crazy powerful -- are taking the human story next.
"In question & answer format, discusses the history, science, applications, and relevant current issues of quantum physics in an accessible way for the non-scientist"--

This book presents quantum theory as a theory based on new relationships among matter, thought, and experimental technology, as against those previously found in physics, relationships that also redefine those between mathematics and physics in quantum theory. The argument of the book is based on its title concept, reality without realism (RWR), and in the corresponding view, the RWR view, of quantum theory. The book considers, from this perspective, the thinking of Bohr, Heisenberg, Schrödinger, and Dirac, with the aim of bringing together the philosophy and history of quantum theory. With quantum theory, the book argues, the architecture of thought in theoretical physics was radically changed by the irreducible role of experimental technology in the constitution of physical phenomena, accordingly, no longer defined independently by matter alone, as they were in classical physics or relativity. Or so it appeared. For, quantum theory, the book further argues, made us realize that experimental technology, beginning with that of our bodies, irreducibly shapes all physical phenomena, and thus makes us rethink the relationships among matter, thought, and technology in all of physics.
This book traces the evolution of the ideas that eventually resulted in the elementary quantum theory in 1925/26. Further, it discusses the essential differences between the fundamental equations of Quantum Theory derived by Born and Jordan, logically comprising Quantum Mechanics and Quantum Optics, and the traditional view of the development of Quantum Mechanics. Drawing on original publications and letters written by the main protagonists of that time, it shows that Einstein’s contributions from 1905 to 1924 laid the essential foundations for the development of Quantum Theory. Einstein introduced quantization of the radiation field; Born added quantized mechanical behavior. In addition, Born recognized that Quantum Mechanics necessarily required Quantum Optics; his radical concept of truly discontinuous and statistical quantum transitions (“quantum leaps”) was directly based on Einstein’s physical concepts.
This book is the final outcome of two projects. My first project was to publish a set of texts written by Schrodinger at the beginning of the 1950's for his seminars and lectures at the Dublin Institute for Advanced Studies. These almost completely forgotten texts contained important insights into the interpretation of quantum mechanics, and they provided several ideas which were missing or elusively expressed in SchrOdinger's published papers and books of the same period. However, they were likely to be misinterpreted out of their context. The problem was that current scholarship could not help very much the reader of these writings to figure out their significance. The few available studies about SchrOdinger's interpretation of quantum mechanics are generally excellent, but almost entirely restricted to the initial period 1925-1927. Very little work has been done on Schrodinger's late views on the theory he contributed to create and develop. The generally accepted view is that he never really recovered from his interpretative failure of 1926-1927, and that his late reflections (during the 1950's) are little more than an expression of his rising nostalgia for the lost ideal of picturing the world, not to say for some favourite traditional picture. But the content and style of Schrodinger's texts of the 1950's do not agree at all with this melancholic appraisal; they rather set the stage for a thorough renewal of accepted representations. In order to elucidate this paradox, I adopted several strategies.
This book presents a thoroughly empiricist account of physics. By providing an overview of the development of empiricism from Ockham to van Fraassen the book lays the foundation for its own version of empiricism. Empiricism for the author consists of three ideas: nominalism, i.e. dismissing second order quantification as unnecessary, epistemological naturalism, and viewing classification of things in natural kinds as a human habit not in need for any justification. The book offers views on the realism-antirealism debate as well as on the individuation of theories as a thoroughly neglected aspect of underdetermination. The book next discusses a broad range of topics, including the predicates body, spatial distance and time interval, the ontology of electromagnetism, propensities, the measurement problem and other philosophical issues in quantum theory. Discussions about the direction of time and about string theory make up the final part of the book.

Combining physics and philosophy, this is a uniquely interdisciplinary examination of quantum information science. Suitable as both a discussion of the conceptual and philosophical problems of this field and a comprehensive stand-alone introduction, this book will benefit both experienced and new researchers in quantum information and the philosophy of physics.
This volume has 41 chapters written to honor the 100th birthday of Mario Bunge. It celebrates the work of this influential Argentine/Canadian physicist and philosopher. Contributions show the value of Bunge’s science-informed philosophy and his systematic approach to philosophical problems. The chapters explore the exceptionally wide spectrum of Bunge’s contributions to: metaphysics, methodology and philosophy of science, philosophy of mathematics, philosophy of physics, philosophy of psychology, philosophy of social science, philosophy of biology, philosophy of technology, moral philosophy, social and political philosophy, medical philosophy, and education. The contributors include scholars from 16 countries. Bunge combines ontological realism with epistemological fallibilism. He believes that science provides the best and most warranted knowledge of the natural and social world, and that such knowledge is the only sound basis for moral decision making and social and political reform. Bunge argues for the unity of knowledge. In his eyes, science and philosophy constitute a fruitful and necessary partnership. Readers will discover the wisdom of this approach and will gain insight into the utility of cross-disciplinary scholarship. This anthology will appeal to researchers, students, and teachers in philosophy of science, social science, and liberal education pro-

grammes. 1. Introduction Section I. An Academic Vocation (3 chapters) Section II. Philosophy (12 chapters) Section III. Physics and Philosophy of Physics (4 chapters) Section IV. Cognitive Science and Philosophy of Mind (2 chapters) Section V. Sociology and Social Theory (4 chapters) Section VI. Ethics and Political Philosophy (3 chapters) Section VII. Biology and Philosophy of Biology (3 chapters) Section VIII. Mathematics (3 chapters) Section IX. Education (2 chapters) Section X. Varia (3 chapters) Section XI. Bibliography

Bestselling author and acclaimed physicist Lawrence Krauss offers a paradigm-shifting view of how everything that exists came to be in the first place. “Where did the universe come from? What was there before it? What will the future bring? And finally, why is there something rather than nothing?” One of the few prominent scientists today to have crossed the chasm between science and popular culture, Krauss describes the staggeringly beautiful experimental observations and mind-bending new theories that demonstrate not only can something arise from nothing, something will always arise from nothing. With a new preface about the significance of the discovery of the Higgs particle, A Universe from Nothing uses Krauss’s characteristic wry humor and wonderfully clear explanations to take us back to the beginning of the beginning, presenting the most recent evidence for how our universe evolved—and the implications for how it’s going to end. Provocative, challenging, and delightfully readable, this is a game-changing look at the most basic underpinning of existence and a powerful antidote to outmoded philosophical, religious, and scientific thinking.

With contributions by leading quantum physicists, philosophers and historians, this comprehensive A-to-Z of quantum physics provides a lucid understanding of key concepts of quantum theory and experiment. It covers technical and interpretational aspects alike, and includes both traditional and new concepts, making it an indispensable resource for concise, up-to-date information about the many facets of quantum physics.

This concise book introduces nonphysicists to the core philosophical issues surrounding the nature and structure of space and time, and is also an ideal resource for physicists interested in the conceptual foundations of space-time theory. Tim Maudlin's broad historical overview examines Aristotelian and Newtonian accounts of space and time, and traces how Galileo's conceptions of relativity and space-time led to Einstein's special and general theories of relativity. Maudlin explains special relativity with enough detail to solve concrete physical problems while presenting general relativity in more qualitative terms. Additional topics include the Twins Paradox, the physical aspects of the Lorentz-FitzGerald contraction, the constancy of the speed of light, time travel, the direction of time, and more. Introduces nonphysicists to the philosophical foundations of space-time theory Provides a broad historical overview, from Aristotle to Einstein Explains special relativity geometrically, emphasizing the intrinsic structure of space-time Covers the Twins Paradox, Galilean relativity, time travel, and more Requires only basic algebra and no formal knowledge of physics

At the end of the nineteenth century, some physicists believed that the basic principles underlying their subject were already known, and that physics in the future would only consist of filling in the details. They could hardly have been more wrong. The past century has seen the rise of quantum mechanics, relativity, cosmology, particle physics, and solid-state physics, among other fields. These subjects have fundamentally changed our understanding of space, time, and matter. They have also transformed daily life, inspiring a technological revolution that has included the development of radio, television, lasers, nuclear power, and computers. In Quantum Generations, Helge Kragh, one of the world's leading historians of physics, presents a sweeping account of these extraordinary achievements of the past one hundred years. The first comprehensive one-volume history of twentieth-century physics, the book takes us from the discovery of X rays in the mid-1890s to superstring theory in the 1990s. Unlike most previous histories of physics, written either from a scientific perspective or from a social and institutional perspective, Quantum Generations combines both approaches. Kragh writes about pure science with the expertise of a trained physicist, while keeping the content accessible to nonspecialists and paying careful attention to practical uses of science, ranging from compact disks to bombs. As a historian, Kragh skillfully outlines the social and economic contexts that have shaped the field in the twentieth century. He writes, for example, about the impact of the two world wars, the fate of physics under Hitler, Mussolini, and Stalin, the role of military research, the emerging leadership of the United States, and the backlash against science that began in the 1960s. He also shows how the revolutionary discoveries of scientists ranging from Einstein, Planck, and Bohr to Stephen Hawking have been built on the great traditions of earlier centuries. Combining a mastery of detail with a sure sense of the broad contours of historical change, Kragh has written a fitting tribute to the scientists who have played such a decisive role in the making of the modern world.

"On Physics and Philosophy is an accessible, mathematics-free reflection on the philosophical meaning of the quantum revolution, by one of the world's leading authorities on the subject. D'Espagnat presents an objective account of the main guiding principles of contemporary physics - in particular, quantum mechanics - followed by a look at just what consequences these should imply for philosophical thinking."--

Quantum mechanics is an extraordinarily successful scientific theory. 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; and lots of seemingly spooky goings-on. But if we're prepared to be a little more specific about what we mean when we talk about 'reality' and a little more circumspect in the way we think a scientific theory might represent such a reality, then all the mystery goes away. This shows that the choice we face is actually a philosophical one. Here, Jim Baggott provides a quick but comprehensive introduction to quantum mechanics for the general reader, and explains what makes this theory so very different from the rest. He also explores the processes involved in developing scientific theories and explains how these lead to different philosophical positions, essential if we are to understand the nature of the great debate between Niels Bohr and Albert Einstein. Moving forwards, Baggott then provides a comprehensive guide to attempts to determine what the theory actually means, from the Copenhagen interpretation to many worlds and the multiverse. Richard Feynman once declared that 'nobody understands quantum mechanics'. This book will tell you why.

Probably the most successful scientific theory ever created, quantum theory has profoundly changed our view of the world and extended the limits of our knowledge, impacting both the theoretical interpretation of a tremendous range of phenomena and the practical development of a host of technological breakthroughs. Yet for all its success, quantum t

Causality is central to understanding the mechanisms of nature: some event "A" is the cause of

another event “B”. Surprisingly, causality does not follow this simple rule in quantum physics: due to to quantum superposition we might be led to believe that "A causes B” and that "B causes A”. This idea is not only important to the foundations of physics but also leads to practical advantages: a quantum circuit with such indefinite causality performs computationally better than one with definite causality. This thesis provides one of the first comprehensive introductions to quantum causality, and presents a number of advances. It provides an extension and generalization of a framework that enables us to study causality within quantum mechanics, thereby setting the stage for the rest of the work. This comprises: mathematical tools to define causality in terms of probabilities; computational tools to prove indefinite causality in an experiment; means to experimentally test particular causal structures; and finally an algorithm that detects the exact causal structure in an quantum experiment.

The classical mechanistic idea of nature that prevailed during the eighteenth and nineteenth centuries was essentially mindless: the physically described aspects of nature were asserted to be completely determined by prior physically described aspects alone, with conscious experiences entering only passively. In the last century these classical concepts were found inadequate. In the new quantum mechanics theory, conscious experiences enter into the dynamics in specified ways not fixed by physically described aspects alone.

The explosive debate that transformed our views about time and scientific truth On April 6, 1922, in Paris, Albert Einstein and Henri Bergson publicly debated the nature of time. Einstein considered Bergson's theory of time to be a soft, psychological notion, irreconcilable with the quantitative realities of physics. Bergson, who gained fame as a philosopher by arguing that time should not be understood exclusively through the lens of science, criticized Einstein's theory of time for being a metaphysics grafted on to science, one that ignored the intuitive aspects of time. The Physicist and the Philosopher tells the remarkable story of how this explosive debate transformed our understanding of time and drove a rift between science and the humanities that persists today. Jimena Canales introduces readers to the revolutionary ideas of Einstein and Bergson, describes how they dramatically collided in Paris, and traces how this clash of worldviews reverberated across the twentieth century. She shows how it provoked responses from figures such as Bertrand Russell and Martin Heidegger, and carried repercussions for American pragmatism, logical positivism, phenomenology, and quantum mechanics. Canales explains how the new technologies of the period—such as wristwatches, radio, and film—helped to shape people’s conceptions of time and further polarized the public debate. She also discusses how Bergson and Einstein, toward the end of their lives, each reflected on his rival’s legacy—Bergson during the Nazi occupation of Paris and Einstein in the context of the first hydrogen bomb explosion. The Physicist and the Philosopher is a magisterial and revealing account that shows how scientific truth was placed on trial in a divided century marked by a new sense of time.

The volume presents reports of the latest developments in various areas of quantum information, quantum communication, and quantum computation, including quantum information theory, theoretical and experimental aspects of quantum computing, quantum communication systems, cryptography, new quantum effects and their experimental realizations, generation detection and applications of non-classical light, quantum noise, stochastic processes and filtering, quantum measurement theory, and quantum control. It is a very useful reference book to the students, researchers and engineers in the rapidly developing areas.

Very Short Introductions: Brilliant, Sharp, Inspiring Philosophy of physics is concerned with the deepest theories of modern physics - notably quantum theory, our theories of space, time and symmetry, and thermal physics - and their strange, even bizarre conceptual implications. A deeper understanding of these theories helps both physics, through pointing the way to new theories and new applications, and philosophy, through seeing how our worldview has to change in the light of what we learn from physics. This Very Short Introduction explores the core topics in philosophy of physics through three key themes. The first - the nature of space, time, and motion - begins by considering the philosophical puzzles that led Isaac Newton to propose the existence of absolute space, and then discusses how those puzzles change - but do not disappear - in the context of the revolutions in our understanding of space and time that came first from special, and then from general, relativity. The second - the emergence of irreversible behavior in statistical mechanics - considers how the microscopic laws of physics, which know of no distinction between past and future, can be compatible with the melting of ice, the cooling of coffee, the passing of youth, and all the other ways in which the large-scale world distinguishes past from future. The last section discusses quantum theory - the foundation of most of modern physics, yet mysterious to this day. It explains just why quantum theory is so difficult to make sense of, how we might nonetheless attempt to do it, and why the question has been highly relevant to the development of physics, and continues to be so. ABOUT THE SERIES: The Very Short Introductions series from Oxford University Press contains hundreds of titles in almost every subject area. These pocket-sized books are the perfect way to get ahead in a new subject quickly. Our expert authors combine facts, analysis, perspective, new ideas, and enthusiasm to make interesting and challenging topics highly readable.

Authored by an acclaimed teacher of quantum physics and philosophy, this textbook pays special attention to the aspects that many courses sweep under the carpet. Traditional courses in quantum mechanics teach students how to use the quantum formalism to make calculations. But even the best students - indeed, especially the best students - emerge rather confused about what, exactly, the theory says is going on, physically, in microscopic systems. This supplementary textbook is designed to help such students understand that they are not alone in their confusions (luminaries such as Albert Einstein, Erwin Schroedinger, and John Stewart Bell having shared them), to sharpen their understanding of the most important difficulties associated with interpreting quantum theory in a realistic manner, and to introduce them to the most promising attempts to formulate the theory in a way that is physically clear and coherent. The text is accessible to students with at least one semester of prior exposure to quantum (or "modern") physics and includes over a hundred engaging end-of-chapter "Projects" that make the book suitable for either a traditional classroom or for self-study.

A look at quantum physics covers wave motion, the problem with measurement, Bell's theorem, and the implications concerning the nature of reality

Here, the author provides a review and oversight of many views on the interpretation of quantum physics and the wide philosophical debate that still embroils this subject over 100 years since its initial development.

Philosophy and the Interpretation of Quantum PhysicsIOP Publishing Limited
Takes students and researchers on a tour through some of the deepest ideas of maths, computer science and physics.
Preliminaries. From laboratory to theory ; from classical experiments to quantum theory -- Bohr's vision in practice : the old quantum theory. Spectral lines, quantum states, and a master model of the atom ; The correspondence principle as an intermediary hypothesis ; Reception ; The scientific moderator -- Toward Quantum mechanics. Quantum corpuscles, quantum waves, and the experiments ; The uncertainty principle as an intermediary hypothesis ; Metaphysical principles and heuristic rules ; New formalisms and Bohr's atom -- Complementarity established and applied -- Aftermath. Bohr and the "Copenhagen orthodoxy" ; Bohr's response to the Einstein-Podolsky-Rosen argument ; The mature Bohr and the rise of slick theory and theoreticians.

This book offers a thorough technical elaboration and philosophical defense of an objectivist informational interpretation of quantum mechanics according to which its novel content is located in its kinematical framework, that is, in how the theory describes systems independently of the specifics of their dynamics. It will be of interest to researchers and students in the philosophy of physics and in theoretical physics with an interest in the foundations of quantum mechanics. Additionally, parts of the book may be used as the basis for courses introducing non-physics majors to quantum mechanics, or for self-study by those outside of the university with an interest in quantum mechanics. With a Foreword by Jeffrey Bub. -- “Understanding Quantum Raffles is a wonderful book for both the specialists and those with curious minds. The elegance and the simplicity with which the 'three Mikes' explain some of the deepest aspects of quantum mechanics on the basis of probabilities and correlations are dazzling and delightful. The same elegance and simplicity also make the book ideal for any engaged reader who ever wondered what is so special about quantum mechanics. In our age of new quantum technologies, this is something anyone should read.” (Guido Bacciagaluppi, author of Quantum Theory at the Crossroads) “This book makes a sustained argument for an informational interpretation of quantum theory, blending an elegant mathematical characterisation of quantum correlations with incisive historical and philosophical analysis. A must-read for those interested in quantum foundations, and also a fertile source of teaching inspiration for quantum theory.” (Leah Henderson, author of Philosophy of quantum information and entanglement) “This is one of the most fascinating and accessible presentations of the informational approach to quantum mechanics. What has so far been mostly restricted to the theoretical physics community is here masterfully explained for a broader audience even without a physics background. Scholars, students, and laypeople alike will appreciate the clear, vivid, and yet deep discussion of what raffle tickets and correlation elliptopes can tell us about the physics and philosophy of the quantum world.” (Markus Müller, Institute for Quantum Optics and Quantum Information, Austria).
This book tells the story of the second quantum revolution which will shape the 21st century as much as the first quantum revolution shaped the 20th century. It provides unique orientation in today's discussion and the latest progress on the interpretation of quantum physics and its further technological potential. As you read this book the first prototypes of this revolution are being built in laboratories worldwide. Super-technologies such as nanotechnology, quantum computers, quantum information processing, and others will soon shape our daily lives, even if physicists themselves continue to disagree on how to interpret the central theory of modern physics. The book will thus also touch on the profound philosophical questions at the heart of quantum mechanics.
Quantum mechanics – the grandiose theory that describes nature down to the submicroscopic level – was first formulated in Göttingen in 1925. How did this come about and why is it that Göttingen became the pre-eminent location for a revolution in physics? This book is the first to investigate the wide range of factors that were pivotal for quantum physics to be established in Göttingen. These include the process of generational change of physics professors, the hopes of mathematicians seeking new fields of research, and a new understanding of the interplay of experiment, theory and philosophy.
Philosophy and the Interpretation of Quantum PhysicsIOP Publishing LimitedHere, the author provides a review and oversight of many views on the interpretation of quantum physics and the wide philosophical debate that still embroils this subject over 100 years since its initial development.Philosophy of PhysicsQuantum TheoryPrinceton University PressA sophisticated and original introduction to the philosophy of quantum mechanics from one of the world’s leading philosophers of physics In this book, Tim Maudlin, one of the world’s leading philosophers of physics, offers a sophisticated, original introduction to the philosophy of quantum mechanics. The briefest, clearest, and most refined account of his influential approach to the subject, the book will be invaluable to all students of philosophy and physics. Quantum mechanics holds a unique place in the history of physics. It has produced the most accurate predictions of any scientific theory, but, more astonishing, there has never been any agreement about what the theory implies about physical reality. Maudlin argues that the very term “quantum theory” is a misnomer. A proper physical theory should clearly describe what is there and what it does—yet standard textbooks present quantum mechanics as a predictive recipe in search of a physical theory. In contrast, Maudlin explores three proper theories that recover the quantum predictions: the indeterministic wavefunction collapse theory of Ghirardi, Rimini, and Weber; the deterministic particle theory of deBroglie and Bohm; and the conceptually challenging Many Worlds theory of Everett. Each offers a radically different proposal for the nature of physical reality, but Maudlin shows that none of them are what they are generally taken to be.Reality Without RealismMatter, Thought, and Technology in Quantum PhysicsSpringerThis book presents quantum theory as a theory based on new relationships among matter, thought, and experimental technology, as against those previously found in physics, relationships that also redefine those between mathematics and physics in quantum theory. The argument of the book is based on its title concept, reality without realism (RWR), and in the corresponding view, the RWR view, of quantum theory. The book considers, from this perspective, the thinking of Bohr, Heisenberg, Schrödinger, and Dirac, with the aim of bringing together the philosophy and history of quantum theory. With quantum theory, the book argues, the architecture of thought in theoretical physics was radically changed by the irreducible role of experimental technology in the constitution of physical phenomena, accordingly, no longer defined independently by matter alone, as they were in classical physics or relativity. Or so it appeared. For, quantum theory, the book further argues, made us realize that experimental technology, beginning with that of our bodies, irreducibly shapes all physical phenomena, and thus makes us rethink the relationships among matter, thought, and technology in all of physics.Epistemological and Experimental Perspectives on Quantum PhysicsSpringer Science & Busi-

ness MediaFrom the very beginning it was realised that quantum physics involves radically new interpretative and epistemological consequences. While hitherto there has been no satisfactory philosophical analysis of these consequences, recent years have witnessed the accomplishment of many experiments to test the foundations of quantum physics, opening up vistas to a completely novel technology: quantum technology. The contributions in the present volume review the interpretative situation, analyze recent fundamental experiments, and discuss the implications of possible future technological applications. Readership: Analytic philosophers (logical empiricists), scientists (especially physicists), historians of logic, mathematics and physics, philosophers of science, and advanced students and researchers in these fields. Can be used for seminars on theoretical and experimental physics and philosophy of science, and as supplementary reading at advanced undergraduate and graduate levels.The Second Quantum RevolutionFrom Entanglement to Quantum Computing and Other Super-TechnologiesSpringerThis book tells the story of the second quantum revolution which will shape the 21st century as much as the first quantum revolution shaped the 20th century. It provides unique orientation in today's discussion and the latest progress on the interpretation of quantum physics and its further technological potential. As you read this book the first prototypes of this revolution are being built in laboratories worldwide. Super-technologies such as nanotechnology, quantum computers, quantum information processing, and others will soon shape our daily lives, even if physicists themselves continue to disagree on how to interpret the central theory of modern physics. The book will thus also touch on the profound philosophical questions at the heart of quantum mechanics.Understanding Quantum RafflesQuantum Mechanics on an Informational Approach : Structure and InterpretationSpringer NatureThis book offers a thorough technical elaboration and philosophical defense of an objectivist informational interpretation of quantum mechanics according to which its novel content is located in its kinematical framework, that is, in how the theory describes systems independently of the specifics of their dynamics. It will be of interest to researchers and students in the philosophy of physics and in theoretical physics with an interest in the foundations of quantum mechanics. Additionally, parts of the book may be used as the basis for courses introducing non-physics majors to quantum mechanics, or for self-study by those outside of the university with an interest in quantum mechanics. With a Foreword by Jeffrey Bub. -- “Understanding Quantum Raffles is a wonderful book for both the specialists and those with curious minds. The elegance and the simplicity with which the 'three Mikes' explain some of the deepest aspects of quantum mechanics on the basis of probabilities and correlations are dazzling and delightful. The same elegance and simplicity also make the book ideal for any engaged reader who ever wondered what is so special about quantum mechanics. In our age of new quantum technologies, this is something anyone should read.” (Guido Bacciagaluppi, author of Quantum Theory at the Crossroads) “This book makes a sustained argument for an informational interpretation of quantum theory, blending an elegant mathematical characterisation of quantum correlations with incisive historical and philosophical analysis. A must-read for those interested in quantum foundations, and also a fertile source of teaching inspiration for quantum theory.” (Leah Henderson, author of Philosophy of quantum information and entanglement) “This is one of the most fascinating and accessible presentations of the informational approach to quantum mechanics. What has so far been mostly restricted to the theoretical physics community is here masterfully explained for a broader audience even without a physics background. Scholars, students, and laypeople alike will appreciate the clear, vivid, and yet deep discussion of what raffle tickets and correlation elliptopes can tell us about the physics and philosophy of the quantum world.” (Markus Müller, Institute for Quantum Optics and Quantum Information, Austria).A Universe from NothingWhy There Is Something Rather than NothingSimon and SchusterBestselling author and acclaimed physicist Lawrence Krauss offers a paradigm-shifting view of how everything that exists came to be in the first place. “Where did the universe come from? What was there before it? What will the future bring? And finally, why is there something rather than nothing?” One of the few prominent scientists today to have crossed the chasm between science and popular culture, Krauss describes the staggeringly beautiful experimental observations and mind-bending new theories that demonstrate not only can something arise from nothing, something will always arise from nothing. With a new preface about the significance of the discovery of the Higgs particle, A Universe from Nothing uses Krauss’s characteristic wry humor and wonderfully clear explanations to take us back to the beginning of the beginning, presenting the most recent evidence for how our universe evolved—and the implications for how it’s going to end. Provocative, challenging, and delightfully readable, this is a game-changing look at the most basic underpinning of existence and a powerful antidote to outmoded philosophical, religious, and scientific thinking.Quantum RealityTheory and PhilosophyCRC PressProbably the most successful scientific theory ever created, quantum theory has profoundly changed our view of the world and extended the limits of our knowledge, impacting both the theoretical interpretation of a tremendous range of phenomena and the practical development of a host of technological breakthroughs. Yet for all its success, quantum tThe Routledge Companion to Philosophy of PhysicsRoutledgeThe Routledge Companion to Philosophy of Physics is a comprehensive and authoritative guide to the state of the art in the philosophy of physics. It comprisess 54 self--contained chapters written by leading philosophers of physics at both senior and junior levels, making it the most thorough and detailed volume of its type on the market – nearly every major perspective in the field is represented. The Companion’s 54 chapters are organized into 12 parts. The first seven parts cover all of the major physical theories investigated by philosophers of physics today, and the last five explore key themes that unite the study of these theories. I. Newtonian Mechanics II. Special Relativity III. General Relativity IV. Non-Relativistic Quantum Theory V. Quantum Field Theory VI. Quantum Gravity VII. Statistical Mechanics and Thermodynamics VIII. Explanation IX. Intertheoretic Relations X. Symmetries XI. Metaphysics XII. Cosmology The difficulty level of the chapters has been carefully pitched so as to offer both accessible summaries for those new to philosophy of physics and standard reference points for active researchers on the front lines. An introductory chapter by the editors maps out the field, and each part also begins with a short summary that places the individual chapters in context. The volume will be indispensable to any serious student or scholar of philosophy of physics.On Physics and PhilosophyPrinceton University Press"On Physics and Philosophy is an accessible, mathematics-free reflection on the philosophical meaning of the quantum revolution, by one of the world's leading authorities on the subject. D'Espagnat presents an objective account of the main guiding principles of contemporary physics - in particular, quantum mechanics - followed by a look at just what consequences these should imply for philosophical thinking."--Mindful UniverseQuantum Mechanics and the Participating ObserverSpringer Science & Business MediaThe classical mechanistic idea of nature that prevailed during the eighteenth and nine-

teenth centuries was essentially mindless: the physically described aspects of nature were asserted to be completely determined by prior physically described aspects alone, with conscious experiences entering only passively. In the last century these classical concepts were found inadequate. In the new quantum mechanics theory, conscious experiences enter into the dynamics in specified ways not fixed by physically described aspects alone.Quantum RealityThe Quest for the Real Meaning of Quantum Mechanics - a Game of TheoriesOxford University Press, USAQuantum mechanics is an extraordinarily successful scientific theory. 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; and lots of seemingly spooky goings-on. But if we're prepared to be a little more specific about what we mean when we talk about 'reality' and a little more circumspect in the way we think a scientific theory might represent such a reality, then all the mystery goes away. This shows that the choice we face is actually a philosophical one. Here, Jim Baggott provides a quick but comprehensive introduction to quantum mechanics for the general reader, and explains what makes this theory so very different from the rest. He also explores the processes involved in developing scientific theories and explains how these lead to different philosophical positions, essential if we are to understand the nature of the great debate between Niels Bohr and Albert Einstein. Moving forwards, Baggott then provides a comprehensive guide to attempts to determine what the theory actually means, from the Copenhagen interpretation to many worlds and the multiverse. Richard Feynman once declared that 'nobody understands quantum mechanics'. This book will tell you why.Compendium of Quantum PhysicsConcepts, Experiments, History and PhilosophySpringer Science & Business MediaWith contributions by leading quantum physicists, philosophers and historians, this comprehensive A-to-Z of quantum physics provides a lucid understanding of key concepts of quantum theory and experiment. It covers technical and interpretational aspects alike, and includes both traditional and new concepts, making it an indispensable resource for concise, up-to-date information about the many facets of quantum physics.Reality Without RealismMatter, Thought, and Technology in Quantum PhysicsSpringer NatureQuantum [Un]Speakables IIHalf a Century of Bell's TheoremSpringerThis self-contained essay collection is published to commemorate half a century of Bell’s theorem. Like its much acclaimed predecessor “Quantum [Un]Speakables: From Bell to Quantum Information” (published 2002), it comprises essays by many of the worlds leading quantum physicists and philosophers. These revisit the foundations of quantum theory as well as elucidating the remarkable progress in quantum technologies achieved in the last couple of decades. Fundamental concepts such as entanglement, nonlocality and contextuality are described in an accessible manner and, alongside lively descriptions of the various theoretical and experimental approaches, the book also delivers interesting philosophical insights. The collection as a whole will serve as a broad introduction for students and newcomers as well as delighting the scientifically literate general reader.The Copenhagen NetworkThe Birth of Quantum Mechanics from a Postdoctoral PerspectiveSpringer NatureThis book is a historical analysis of the quantum mechanical revolution and the emergence of a new discipline from the perspective, not of a professor, but of a recent or actual Ph.D. student just embarking on an uncertain academic career in economically hard times. Quantum mechanics exploded on to the intellectual scene between 1925 and 1927, with more than 200 publications across the world, the majority of them authored by young scientists under the age of 30, graduate students or postdoctoral fellows. The resulting theory was a collective product that no single authority could claim, but it had a major geographical nod – the Copenhagen Institute of Theoretical Physics – where most of the informal, pre-published exchange of ideas occurred and where every participant of the new community aspired to visit. A rare combination of circumstances and resources – political, diplomatic, financial, and intellectual – allowed Niels Bohr to establish this “Mecca” of quantum theory outside of traditional and more powerful centres of science. Transitory international postdoctoral fellows, rather than established professors, developed a culture of research that became the source of major innovations in the field. Temporary assistantships, postdoctoral positions, and their equivalents were the chief mode of existence for young academics during the period of economic crisis and post-WWI international tensions. Insecure career trajectories and unpredictable moves through non-stable temporary positions contributed to their general outlook and interpretations of the emerging theory of quantum mechanics. This book is part of a four-volume collection addressing the beginnings of quantum physics research at the major European centres of Göttingen, Copenhagen, Berlin, and Munich; these works emerged from an expansive study on the quantum revolution as a major transformation of physical knowledge undertaken by the Max Planck Institute for the History of Science and the Fritz Haber Institute (2006–2012). For more on this project, see the dedicated Feature Story, The Networks of Early Quantum Theory, at the Max Planck Institute for the History of Science, https://www.mpiwg-berlin.mpg.de/feature-story/networks-early-quantum-theoryEntanglement, Information, and the Interpretation of Quantum MechanicsSpringer Science & Business MediaEntanglement was initially thought by some to be an oddity restricted to the realm of thought experiments. However, Bell’s inequality delimiting local - havior and the experimental demonstration of its violation more than 25 years ago made it entirely clear that non-local properties of pure quantum states are more than an intellectual curiosity. Entanglement and non-locality are now understood to ?gure prominently in the microphysical world, a realm into which technology is rapidly hurtling. Information theory is also increasingly recognized by physicists and philosophers as intimately related to the foun- tions of mechanics. The clearest indicator of this relationship is that between quantum information and entanglement. To some degree, a deep relationship between information and mechanics in the quantum context was already there to be seen upon the introduction by Max Born and Wolfgang Pauli of the idea that the essence of pure quantum states lies in their provision of probabilities regarding the behavior of quantum systems, via what has come to be known as the Born rule. The signi?cance of the relationship between mechanics and information became even clearer with Leo Szilard’s analysis of James Clerk Maxwell’s infamous demon thought experiment. Here, in addition to examining both entanglement and quantum infor- tion and their relationship, I endeavor to critically assess the in?uence of the study of these subjects on the interpretation of quantum theory.Quantum Computing Since DemocritusCambridge University PressTakes students and researchers on a tour through some of the deepest ideas of maths, computer science and physics.Quantum GenerationsA History of Physics in the Twentieth CenturyPrinceton University PressAt the end of the nineteenth century, some physicists believed that the basic principles underlying their subject were already known, and that physics in the future would only consist of filling in the details. They could hardly have been more wrong. The past century has seen the rise of quantum mechanics, relativity, cosmol-

ogy, particle physics, and solid-state physics, among other fields. These subjects have fundamentally changed our understanding of space, time, and matter. They have also transformed daily life, inspiring a technological revolution that has included the development of radio, television, lasers, nuclear power, and computers. In Quantum Generations, Helge Kragh, one of the world's leading historians of physics, presents a sweeping account of these extraordinary achievements of the past one hundred years. The first comprehensive one-volume history of twentieth-century physics, the book takes us from the discovery of X rays in the mid-1890s to superstring theory in the 1990s. Unlike most previous histories of physics, written either from a scientific perspective or from a social and institutional perspective, Quantum Generations combines both approaches. Kragh writes about pure science with the expertise of a trained physicist, while keeping the content accessible to nonspecialists and paying careful attention to practical uses of science, ranging from compact disks to bombs. As a historian, Kragh skillfully outlines the social and economic contexts that have shaped the field in the twentieth century. He writes, for example, about the impact of the two world wars, the fate of physics under Hitler, Mussolini, and Stalin, the role of military research, the emerging leadership of the United States, and the backlash against science that began in the 1960s. He also shows how the revolutionary discoveries of scientists ranging from Einstein, Planck, and Bohr to Stephen Hawking have been built on the great traditions of earlier centuries. Combining a mastery of detail with a sure sense of the broad contours of historical change, Kragh has written a fitting tribute to the scientists who have played such a decisive role in the making of the modern world.Philosophy of PhysicsSpace and TimePrinceton University PressThis concise book introduces nonphysicists to the core philosophical issues surrounding the nature and structure of space and time, and is also an ideal resource for physicists interested in the conceptual foundations of space-time theory. Tim Maudlin's broad historical overview examines Aristotelian and Newtonian accounts of space and time, and traces how Galileo's conceptions of relativity and space-time led to Einstein's special and general theories of relativity. Maudlin explains special relativity with enough detail to solve concrete physical problems while presenting general relativity in more qualitative terms. Additional topics include the Twins Paradox, the physical aspects of the Lorentz-FitzGerald contraction, the constancy of the speed of light, time travel, the direction of time, and more. Introduces nonphysicists to the philosophical foundations of space-time theory Provides a broad historical overview, from Aristotle to Einstein Explains special relativity geometrically, emphasizing the intrinsic structure of space-time Covers the Twins Paradox, Galilean relativity, time travel, and more Requires only basic algebra and no formal knowledge of physicsRethinking Causality in Quantum MechanicsSpringerCausality is central to understanding the mechanisms of nature: some event "A" is the cause of another event “B”. Surprisingly, causality does not follow this simple rule in quantum physics: due to to quantum superposition we might be led to believe that "A causes B” and that "B causes A”. This idea is not only important to the foundations of physics but also leads to practical advantages: a quantum circuit with such indefinite causality performs computationally better than one with definite causality. This thesis provides one of the first comprehensive introductions to quantum causality, and presents a number of advances. It provides an extension and generalization of a framework that enables us to study causality within quantum mechanics, thereby setting the stage for the rest of the work. This comprises: mathematical tools to define causality in terms of probabilities; computational tools to prove indefinite causality in an experiment; means to experimentally test particular causal structures; and finally an algorithm that detects the exact causal structure in an quantum experiment.Einstein's Unfinished RevolutionThe Search for What Lies Beyond the QuantumKnopf CanadaA 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.The Physicist and the PhilosopherEinstein, Bergson, and the Debate That Changed Our Understanding of TimePrinceton University PressThe explosive debate that transformed our views about time and scientific truth On April 6, 1922, in Paris, Albert Einstein and Henri Bergson publicly debated the nature of time. Einstein considered Bergson's theory of time to be a soft, psychological notion, irreconcilable with the quantitative realities of physics. Bergson, who gained fame as a philosopher by arguing that time should not be understood exclusively through the lens of science, criticized Einstein's theory of time for being a metaphysics grafted on to science, one that ignored the intuitive aspects of time. The Physicist and the Philosopher tells the remarkable story of how this explosive debate transformed our understanding of time and drove a rift between science and the humanities that persists today. Jimena Canales introduces readers to the revolutionary ideas of Einstein and Bergson, describes how they dramatically collided in Paris, and traces how this clash of worldviews reverberated across the twentieth century. She shows how it provoked responses from figures such as Bertrand Russell and Martin Heidegger, and carried repercussions for American pragmatism, logical positivism, phenomenology, and quantum mechanics. Canales explains how the new technologies of the period—such as wristwatches, radio, and film—helped to shape people’s conceptions of time and further polarized the public debate. She also discusses how Bergson and Einstein, toward the end of their lives, each reflected on his rival’s

legacy—Bergson during the Nazi occupation of Paris and Einstein in the context of the first hydrogen bomb explosion. The Physicist and the Philosopher is a magisterial and revealing account that shows how scientific truth was placed on trial in a divided century marked by a new sense of time.Physics and WhiteheadQuantum, Process, and ExperienceSUNY PressLeading scholars explore the connections between quantum physics and process philosophy.Establishing Quantum Physics in Göttingen-David Hilbert, Max Born, and Peter Debye in Context, 1900-1926SpringerQuantum mechanics – the grandiose theory that describes nature down to the submicroscopic level – was first formulated in Göttingen in 1925. How did this come about and why is it that Göttingen became the pre-eminent location for a revolution in physics? This book is the first to investigate the wide range of factors that were pivotal for quantum physics to be established in Göttingen. These include the process of generational change of physics professors, the hopes of mathematicians seeking new fields of research, and a new understanding of the interplay of experiment, theory and philosophy.What is Quantum Information?Cambridge University PressCombining physics and philosophy, this is a uniquely interdisciplinary examination of quantum information science. Suitable as both a discussion of the conceptual and philosophical problems of this field and a comprehensive stand-alone introduction, this book will benefit both experienced and new researchers in quantum information and the philosophy of physics.Philosophy of PhysicsSpringer Science & Business MediaThis book deals with some of the current issues in the philosophy, methodology and foundations of physics. Some such problems are: - Do mathematical formalisms interpret themselves or is it necessary to adjoin them interpretation assumptions, and if so how are these as sumptions to be framed? - What are physical theories about: physical systems or laboratory operations or both or neither? - How are the basic concepts of a theory to be introduced: by ref erence to measurements or by explicit definition or axiomatically? - What is the use ofaxiomatics in physics? - How are the various physical theories inter-related: like Chinese boxes or in more complex ways? - What is the role of analogy in the construction and in the inter pretation of physical theories? In particular, are classical analogues like those of particle and wave indispensable in quantum theories? - What is the role of the apparatus in quantum phenomena and what is the place of measurement theory in quantum mechanics? - How does a theory face experiment: single-handed or with the help of further theories? These and several other questions of the kind are met with by the research physicist, the physics teacher and the physics student in their everyday work. If dodged they will recur. And a wrong answer to them may obscure the understanding of what has been achieved and may even hamper further advancement. Philosophy, methodology and foundations, like rose bushes, are enjoyable when cultivated but become ugly and thorny when neglected.The Development of Elementary Quantum TheorySpringerThis book traces the evolution of the ideas that eventually resulted in the elementary quantum theory in 1925/26. Further, it discusses the essential differences between the fundamental equations of Quantum Theory derived by Born and Jordan, logically comprising Quantum Mechanics and Quantum Optics, and the traditional view of the development of Quantum Mechanics. Drawing on original publications and letters written by the main protagonists of that time, it shows that Einstein’s contributions from 1905 to 1924 laid the essential foundations for the development of Quantum Theory. Einstein introduced quantization of the radiation field; Born added quantized mechanical behavior. In addition, Born recognized that Quantum Mechanics necessarily required Quantum Optics; his radical concept of truly discontinuous and statistical quantum transitions (“quantum leaps”) was directly based on Einstein’s physical concepts.Quantum Physics in the NanoworldSchrödinger's Cat and the DwarfsSpringerThe second edition deals with all essential aspects of non-relativistic quantum physics up to the quantisation of fields. In contrast to common textbooks of quantum mechanics, modern experiments are described both for the purpose of foundation of the theory and in relation to recent applications. Links are made to important research fields and applications such as elementary particle physics, solid state physics and nuclear magnetic resonance in medicine, biology and material science. Special emphasis is paid to quantum physics in nanoelectronics such as resonant tunnelling, Coulomb blockade and the realisation of quantum bits. This second edition also considers quantum transport through quantum point contacts and its application as charge detectors in nanoelectronic circuits. Also the realization and the study of electronic properties of an artificial quantum dot molecule are presented. Because of its recent interest a brief discussion of Bose-Einstein condensation has been included, as well as the recently detected Higgs particle. Another essential new addition to the present book concerns a detailed discussion of the particle picture in quantum field theory. Counterintuitive aspects of single particle quantum physics such as particle-wave duality and the Einstein-Podolski-Rosen (EPR) paradox appear more acceptable to our understanding if discussed on the background of quantum field theory. The non-locality of quantum fields explains non-local behaviour of particles in classical Schrödinger quantum mechanics. Finally, new problems have been added. The book is suitable as an introduction into quantum physics, not only for physicists but also for chemists, biologists, engineers, computer scientists and even for philosophers as far as they are interested in natural philosophy and epistemology.From Data to QuantaNiels Bohr’s Vision of PhysicsUniversity of Chicago PressPreliminaries. From laboratory to theory ; from classical experiments to quantum theory -- Bohr's vision in practice : the old quantum theory. Spectral lines, quantum states, and a master model of the atom ; The correspondence principle as an intermediary hypothesis ; Reception ; The scientific moderator -- Toward Quantum mechanics. Quantum corpuscles, quantum waves, and the experiments ; The uncertainty principle as an intermediary hypothesis ; Metaphysical principles and heuristic rules ; New formalisms and Bohr's atom -- Complementarity established and applied -- Aftermath. Bohr and the "Copenhagen orthodoxy" ; Bohr's response to the Einstein-Podolsky-Rosen argument ; The mature Bohr and the rise of slick theory and theoreticians.Philosophy of Physics: A Very Short IntroductionOxford University PressVery Short Introductions: Brilliant, Sharp, Inspiring Philosophy of physics is concerned with the deepest theories of modern physics - notably quantum theory, our theories of space, time and symmetry, and thermal physics - and their strange, even bizarre conceptual implications. A deeper understanding of these theories helps both physics, through pointing the way to new theories and new applications, and philosophy, through seeing how our worldview has to change in the light of what we learn from physics. This Very Short Introduction explores the core topics in philosophy of physics through three key themes. The first - the nature of space, time, and motion - begins by considering the philosophical puzzles that led Isaac Newton to propose the existence of absolute space, and then discusses how those puzzles change - but do not disappear - in the context of the revolutions in our understanding of space and time that came first from special, and then from general, relativity. The second - the emergence of irreversible behavior in statistical mechanics - considers how the microscopic laws of physics, which know of no distinction between past and fu-

ture, can be compatible with the melting of ice, the cooling of coffee, the passing of youth, and all the other ways in which the large-scale world distinguishes past from future. The last section discusses quantum theory - the foundation of most of modern physics, yet mysterious to this day. It explains just why quantum theory is so difficult to make sense of, how we might nonetheless attempt to do it, and why the question has been highly relevant to the development of physics, and continues to be so. ABOUT THE SERIES: The Very Short Introductions series from Oxford University Press contains hundreds of titles in almost every subject area. These pocket-sized books are the perfect way to get ahead in a new subject quickly. Our expert authors combine facts, analysis, perspective, new ideas, and enthusiasm to make interesting and challenging topics highly readable.Foundations of Quantum MechanicsAn Exploration of the Physical Meaning of Quantum TheorySpringerAuthored by an acclaimed teacher of quantum physics and philosophy, this textbook pays special attention to the aspects that many courses sweep under the carpet. Traditional courses in quantum mechanics teach students how to use the quantum formalism to make calculations. But even the best students - indeed, especially the best students - emerge rather confused about what, exactly, the theory says is going on, physically, in microscopic systems. This supplementary textbook is designed to help such students understand that they are not alone in their confusions (luminaries such as Albert Einstein, Erwin Schroedinger, and John Stewart Bell having shared them), to sharpen their understanding of the most important difficulties associated with interpreting quantum theory in a realistic manner, and to introduce them to the most promising attempts to formulate the theory in a way that is physically clear and coherent. The text is accessible to students with at least one semester of prior exposure to quantum (or "modern") physics and includes over a hundred engaging end-of-chapter "Projects" that make the book suitable for either a traditional classroom or for self-study.Quantum RealityBeyond the New PhysicsAnchor BooksA look at quantum physics covers wave motion, the problem with measurement, Bell's theorem, and the implications concerning the nature of reality-Mario Bunge: A Centenary FestschriftSpringerThis volume has 41 chapters written to honor the 100th birthday of Mario Bunge. It celebrates the work of this influential Argentine/Canadian physicist and philosopher. Contributions show the value of Bunge’s science-informed philosophy and his systematic approach to philosophical problems. The chapters explore the exceptionally wide spectrum of Bunge’s contributions to: metaphysics, methodology and philosophy of science, philosophy of mathematics, philosophy of physics, philosophy of psychology, philosophy of social science, philosophy of biology, philosophy of technology, moral philosophy, social and political philosophy, medical philosophy, and education. The contributors include scholars from 16 countries. Bunge combines ontological realism with epistemological fallibilism. He believes that science provides the best and most warranted knowledge of the natural and social world, and that such knowledge is the only sound basis for moral decision making and social and political reform. Bunge argues for the unity of knowledge. In his eyes, science and philosophy constitute a fruitful and necessary partnership. Readers will discover the wisdom of this approach and will gain insight into the utility of cross-disciplinary scholarship. This anthology will appeal to researchers, students, and teachers in philosophy of science, social science, and liberal education programmes. 1. Introduction Section I. An Academic Vocation (3 chapters) Section II. Philosophy (12 chapters) Section III. Physics and Philosophy of Physics (4 chapters) Section IV. Cognitive Science and Philosophy of Mind (2 chapters) Section V. Sociology and Social Theory (4 chapters) Section VI. Ethics and Political Philosophy (3 chapters) Section VII. Biology and Philosophy of Biology (3 chapters) Section VIII. Mathematics (3 chapters) Section IX. Education (2 chapters) Section X. Varia (3 chapters) Section XI. BibliographySchrödinger’s Philosophy of Quantum MechanicsSpringer Science & Business MediaThis book is the final outcome of two projects. My first project was to publish a set of texts written by Schrodinger at the beginning of the 1950's for his seminars and lectures at the Dublin Institute for Advanced Studies. These almost completely forgotten texts contained important insights into the interpretation of quantum mechanics, and they provided several ideas which were missing or elusively expressed in SchrOdinger's published papers and books of the same period. However, they were likely to be misinterpreted out of their context. The problem was that current scholarship could not help very much the reader of these writings to figure out their significance. The few available studies about SchrOdinger's interpretation of quantum mechanics are generally excellent, but almost entirely restricted to the initial period 1925-1927. Very little work has been done on Schrodinger's late views on the theory he contributed to create and develop. The generally accepted view is that he never really recovered from his interpretative failure of 1926-1927, and that his late reflections (during the 1950's) are little more than an expression of his rising nostalgia for the lost ideal of picturing the world, not to say for some favourite traditional picture. But the content and style of Schrodinger's texts of the 1950's do not agree at all with this melancholic appraisal; they rather set the stage for a thorough renewal of accepted representations. In order to elucidate this paradox, I adopted several strategies.Sources for History of Quantum PhysicsAn Inventory and ReportEmpiricism and Philosophy of PhysicsSpringer NatureThis book presents a thoroughly empiricist account of physics. By providing an overview of the development of empiricism from Ockham to van Fraassen the book lays the foundation for its own version of empiricism. Empiricism for the author consists of three ideas: nominalism, i.e. dismissing second order quantification as unnecessary, epistemological naturalism, and viewing classification of things in natural kinds as a human habit not in need for any justification. The book offers views on the realism-antirealism debate as well as on the individuation of theories as a thoroughly neglected aspect of underdetermination. The book next discusses a broad range of topics, including the predicates body, spatial distance and time interval, the ontology of electromagnetism, propensities, the measurement problem and other philosophical issues in quantum theory. Discussions about the direction of time and about string theory make up the final part of the book.Proceedings of the Sixth International Conference on Quantum Communication, Measurement and ComputingRinton PressIncThe volume presents reports of the latest developments in various areas of quantum information, quantum communication, and quantum computation, including quantum information theory, theoretical and experimental aspects of quantum computing, quantum communication systems, cryptography, new quantum effects and their experimental realizations, generation detection and applications of non-classical light, quantum noise, stochastic processes and filtering, quantum measurement theory, and quantum control. It is a very useful reference book to the students, researchers and engineers in the rapidly developing areas.Quantum PhysicsWhat Everyone Needs to KnowOxford University Press"In question & answer format, discusses the history, science, applications, and relevant current issues of quantum physics in an accessible way for the non-scientist"--SynchronicityThe Epic Quest to Understand the Quantum Nature of Cause and EffectBasic BooksFrom Aristotle's Physics to quantum

teleportation, learn about the scientific pursuit of instantaneous connections in this insightful examination of our world. For millennia, scientists have puzzled over a simple question: Does the universe have a speed limit? If not, some effects could happen at the same instant as the actions that caused them -- and some effects, ludicrously, might even happen before their causes. By one hundred years ago, it seemed clear that the speed of light was the fastest possible speed. Causality was safe. And then quantum mechanics happened, introducing spooky connections that seemed to circumvent the law of cause and effect. Inspired by the new physics, psychologist Carl Jung and physicist Wolfgang Pauli explored a concept called synchronicity, a weird phenomenon they thought could link events without causes. Synchronicity tells that sprawling tale of insight and creativity, and asks where these ideas -- some plain crazy, and others crazy powerful -- are taking the human story next.