Decoherence And The Appearance Of A Classical World In Quantum Theory

Traditional quantum theory has a very rigid structure, making it difficult to accommodate new properties emerging from novel systems. This book presents a flexible and unified theory for physical systems, from micro and macro quantum to classical. This is achieved by incorporating superselection rules and maximal symmetric operators into the theory. The resulting theory is applicable to classical, microscopic quantum and non-orthodox mixed quantum systems of which macroscopic quantum systems are examples. A unified formalism also greatly facilitates the discussion of interactions between these systems. A scheme of quantization by parts is introduced, based on the mathematics of selfadjoint and maximal symmetric extensions of symmetric operators, to describe point interactions. The results are applied to treat superconducting quantum circuits in various configurations.This book also discusses various topics of interest such as the asymptotic treatment of quantum state preparation and quantum measurement, local observables and local values, Schrödinger's cat states in superconducting systems, and a path space formulation of quantum mechanics.This self-contained book is complete with a review of relevant geometric and operator theories, for example, vector fields and operators, symmetric operators and their maximal symmetric extensions, direct integrals of Hilbert spaces and operators.

The aim of this book is to give graduate students an overview of quantum gravity but it also covers related topics from astrophysics. Some well-written contributions can serve as an introduction into basic conceptual concepts like time in quantum gravity or the emergence of a classical world from quantum cosmology. This makes the volume attractive to philosophers of science, too. Other topics are black holes, gravitational waves and non-commutative extensions of physical theories.

This volume is the proceedings of a workshop to discuss the recent work on complex systems in physics and biology, its epistemological and cultural implications, and its effect for the development of these two sciences. The workshop is geared towards physicists, biologists, and science historians.

This book features the proceedings of the NATO Advanced Study Institute "Manipulating Quantum Coherence in Solid State Systems", held in Cluj-Napoca, Romania, August 2005, which presented a fundamental introduction to solid-state approaches to achieving quantum computation. This proceedings volume describes the properties of quantum coherence in semiconductor spin-based systems and the behavior of quantum coherence in superconducting systems.

This collection of essays presented to Carl Friedrich von Weizsäcker on the occasion of his 90th birthday addresses a wide readership interested in astronomy, physics, and the history and philosophy of science. The articles treat subjects such as the social responsibility of scientists, thermonuclear processes in stars and stellar neutrinos, turbulence and the emergence of planetary systems. Furthermore, considerable attention is paid to the unity of nature, the nature of time, and to information about, and interpretation of, the structure of quantum theory, all important philosophical problems of our times. The last section describes von Weizsäcker's ur-hypothesis and how it will theoretically permit the construction of particles and interactions from quantized bits of information.

In the quantum world, a particle can behave like a wave and accordingly seems to be in two places at the same time. This of course is contradictory to our daily experiences with classical particles. How then should this be understood? What happens in the transitional area between the classical world and quantum mechanics? The present book answers exciting questions like these in a way that is easy to follow and to understand and is shows that the link between these two worlds will have concrete and applied effects on our daily life in the near future. It will, for example, improve and change the conventional methods of information processing. With the help of quantum cryptography, it will be possible to communicate tap-proof. Using quantum computers we will be able to solve highly complicated problems in a very short time.

This volume brings together leading quantum physicists to expound on the meaning and future directions of quantum mechanics. It offers new insights from different vantage points to tackle essential questions in quantum mechanics and its interpretation. All the authors have written for a broad readership, and the resulting volume will appeal to everyone wishing to keep abreast of new developments in quantum mechanics, as well as its history and philosophy.

This is a rapidly developing field to which the author is a leading contributor New methods in quantum dynamics and computational techniques, with applications to interesting physical problems, are brought together in this book Useful to both students and researchers

A unique description of the phenomena that arise from the interaction between quantum systems and their environment. Because of the novel character of the approach discussed, the book addresses scientists from all fields of physics and related disciplines as well as students of physics.

This concise tutorial provides the bachelor student and the practitioner with a short text on quantum physics that allows them to understand a wealth of quantum phenomena based on a compact, well readable, yet still concise and accurate description of nonrelativistic quantum theory. This “quadrature of the circle” is achieved by concentrating first on the simplest quantum system that still displays all basic features of quantum theory, namely, a system with only two quantized energy levels. For most readers it is very helpful to understand such simple systems before slowly proceeding to more demanding topics like particle entanglement, quantum chaos, or the use of irreducible tensors. This tutorial does not intend to replace the standard textbooks on quantum mechanics, but will help the average student to understand them, often for the first time.

Quantum theory is at the foundation of the physical description of our world. One of the people who contributed significantly to our conceptual understanding of this theory was Heinz-Dieter Zeh (1932-2018). He was the pioneer of the process of decoherence, through which the classical appearance of our world can be understood. This volume presents a collection of essays dedicated to his memory, written by distinguished scientists and scholars. They cover all aspects of the interpretation of quantum theory in general and the quantum-to-classical transition in particular. This volume provides illuminating reading to anyone seeking a deep understanding of quantum theory and its relevance to the foundations of physics.

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

solved exercises, this book, which includes an ambitious bibliography of about 3500 items, will serve as a valuable reference for lecturers and researchers.

This title is a self-contained follow-up to Understanding Our Unseen Reality: Solving Quantum Riddles (2015). Intended for the general reader but including more advanced material and an appendix of technical references for physics students and researchers, it reviews the basics of the transactional interpretation of quantum mechanics in its newer incarnation as a fully relativistic, realist interpretation of quantum theory, while embarking on further explorations of the implications of quantum theory. This interpretation is applied to new experiments and alleged 'paradoxes' that are found to be fully explicable once various misconceptions are identified.There is currently much disagreement about the meaning of quantum theory, as well as confusion about the implications of various experiments such as 'weak measurements,' 'quantum eraser,' and delayed choice. This book provides a clear way forward, presenting new developments and elaborating a promising interpretational approach that has completely nullified earlier objections (such as the Maudlin objection). It also explains why some prominent competing interpretations, such as 'decoherence' in an Everettian ('Many Worlds') approach, do not work as advertised.Adventures in Quantumland: Exploring Our Unseen Reality offers a fully relativistic interpretation of quantum mechanics with no discontinuity between non-relativistic and relativistic domains and shows how quantum theory allows for free will and for reconciliation of science and spiritual traditions.Related Link(s)

This extended tutorial essay views thermodynamics as an incomplete description of quantum systems with many degrees of freedom. The main goal is to show that the approach to equilibrium - with equilibrium characterized by maximum ignorance about the open system of interest - neither requires that many particles nor is it a precise way of partitioning relevant for the salient features of equilibrium and equilibration. Moreover it is indeed quantum effects that are at work in bringing about universal thermodynamic behaviour of modestly sized open systems. Von Neumann`s concept of entropy thus proves to be much more widely useful than something to be feared, and far beyond truly macroscopic systems in equilibrium.

The idea of editing the present volume in the Lecture Notes in Physics series arosewhileorganizingthe“ConferenceonIrreversibleQuantumDynamics”that took place at The Abdus Salam International Center for Theoretical Physics, Trieste, Italy, from July 29 to August 2, 2002. The aim of the Conference was to bring together di?erent groups of - searcherswhoseinterestsandpursuitsinvolveirreversibilityandtimeasymmetry in quantum mechanics. The Conference promoted open and in-depth exchanges of di?erent points of view, concerning both the content and character of qu- tum irreversibility and the methodologies used to study it. The following main themes were addressed: • Theoretical Aspects of Quantum Irreversible Dynamics • Open Quantum Systems and Applications • Foundational Aspects of Irreversible Quantum Dynamics • Asymmetric Time Evolution and Resonances Eachthemewasreviewedbyanexpertinthe?eld,accompaniedbymorespeci?c, research-like shorter talks. The whole topic of quantum irreversibility in all its manifold aspects has always raised a lot of interest, starting with the description of unstable systems in quantum mechanics and the issue of quantum measurement. Further, in - cent years a boost of activity concerning noise, dissipation and open systems has been prompted by the fast developing ?eld of quantum communication and information theory. These considerations motivated the editors to put together a volume that tries to summarize the present day status of the research in the ?eld, with the aim of providing the reader with an accessible and exhaustive introduction to it.

As the end of the nineteenth century neared, it was clear to many in the physics community that if only Newton's equations plus Maxwell's equations could be solved adequately, there would really be nothing very new in physics on a fundamental level. Then came relativity and quantum mechanics. As we now approach the end of the twentieth century, it is clear to many in the physics community that if one could adequately solve somebody's gauge field theory (or somebody else's string model), then nothing fundamentally new would ever again enter into physics. To others in the physics community, it is somewhat doubtful that our present physical understanding of the world, especially of quantum mechanics, has reached such a pinnacle.This conference was organized to discuss the present state of affairs in our knowledge, both experimental and theoretical, of the basic tenets of quantum mechanics. Many fields of physics in which quantum mechanics plays a central role were included: (i) atomic and molecular beams; (ii) photon beams; (iii) atomic interference in atom-surface physics and atom wire physics; (iv) Bose-condensed systems; (v) quantum '1/f' noise; (vi) quantum electrodynamics effects in water, colloidal systems and biological systems; (vii) quantum interference in neutrino physics; (viii) periodic-in-time driven quantum systems; (ix) superconducting quantum circuits; and (x) quantum computer circuit elements.The large variety of different topics, all of current importance, allowed for various viewpoints that are usually not present when conferences devoted to narrower topics are held. The cross-fertilization of ideas was greatly appreciated by the participants, and will be of equal interest to the reader of the proceedings.

This volume presents detailed discussions of a number of unsolved conceptual and technical issues arising, in particular, in the foundations of quantum theory and the philosophy of science. The 14 contributions capture a wide variety of viewpoints and backgrounds. Some chapters deal primarily with the main experimental issues; others focus on theoretical and philosophical questions. In addition, attempts are made to systematically analyze ways in which quantum physics can be connected to the neurosciences and consciousness research.

This is a collection of high-quality research papers in the philosophy of science, deriving from papers presented at the second meeting of the European Philosophy of Science Association in Amsterdam, October 2009.

The Journal of Biblical and Theological Studies (JBTS) is an academic journal focused on the fields of Bible and Theology from an inter-denominational point of view. The journal is comprised of an editorial board of scholars that represent several academic institutions throughout the world. JBTS is concerned with presenting high-level original scholarship in an approachable way. Academic journals are often written by scholars for other scholars. They are technical in nature, assuming a robust knowledge of the field. There are fewer journals that seek to introduce biblical and theological scholarship that is also accessible to students. JBTS seeks to provide high-level scholarship and research to both scholars and students, which results in original scholarship that is readable and accessible. As an inter-denominational journal JBTS is broadly evangelical. We accept contributions in all theological disciplines from any evangelical perspective. In particular, we encourage articles and book reviews within the fields of Old Testament, New Testament, Biblical Theology, Church History, Systematic Theology, Practical Theology, Philosophical Theology, Philosophy, and Ethics.

Emergent quantum mechanics explores the possibility of an ontology for quantum mechanics. The resurgence of interest in "deeper-level" theories for quantum phenomena challenges the standard, textbook interpretation. The book presents expert views that critically evaluate the significance—for 21st century physics—of ontological quantum mechanics, an approach that David Bohm helped pioneer. The possibility of a deterministic quantum theory was first introduced with the original de Broglie-Bohm theory, which has also been developed as Bohmian mechanics. The wide range of perspectives that were contributed to this book on the occasion of David Bohm’s centennial celebration provide ample evidence for the physical consistency of ontological quantum mechanics. The book addresses deeper-level questions such as the following: Is reality intrinsically random or fundamentally interconnected? Is the universe local or nonlocal? Might a radically new conception of reality include a form of quantum causality or quantum ontology? What is the role of the experimenter agent? As the book demonstrates, the advancement of ‘quantum ontology’—as a scientific concept—marks a clear break with classical reality. The search for quantum reality entails unconventional causal structures and non-classical ontology, which can be fully consistent with the known record of quantum observations in the laboratory.

The current volume of the Parmenides Series “On Thinking” addresses our deepest and most personal experience of the world, the

experience of “the present,” from a modern perspective combining physics and philosophy. Many prominent researchers have contributed articles to the volume, in which they present models and express their opinions on and, in some cases, also their skepticism about the subject and how it may be (or may not be) addressed, as well as which aspects they consider most relevant in this context. While Einstein might have once hoped that “the present” would find its place in the theory of general relativity, in a later discussion with Carnap he expressed his disappointment that he was never able to achieve this goal. This collection of articles provides a unique overview of different modern approaches, representing not only a valuable summary for experts, but also a nearly inexhaustible source of profound and novel ideas for those who are simply interested in this question.

MATRIX is Australia’s international and residential mathematical research institute. It facilitates new collaborations and mathematical advances through intensive residential research programs, each 1-4 weeks in duration. This book is a scientific record of the ten programs held at MATRIX in 2019 and the two programs held in January 2020: · Topology of Manifolds: Interactions Between High and Low Dimensions · Australian-German Workshop on Differential Geometry in the Large · Aperiodic Order meets Number Theory · Ergodic Theory, Diophantine Approximation and Related Topics · Influencing Public Health Policy with Data-informed Mathematical Models of Infectious Diseases · International Workshop on Spatial Statistics · Mathematics of Physiological Rhythms · Conservation Laws, Interfaces and Mixing · Structural Graph Theory Downunder · Tropical Geometry and Mirror Symmetry · Early Career Researchers Workshop on Geometric Analysis and PDEs · Harmonic Analysis and Dispersive PDEs: Problems and Progress The articles are grouped into peer-reviewed contributions and other contributions. The peer-reviewed articles present original results or reviews on a topic related to the MATRIX program; the remaining contributions are predominantly lecture notes or short articles based on talks or activities at MATRIX.

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 collection of essays is above all intended to pay tribute to the fact that while QM today is a refined and incredibly successful instrument, many issues concerning the internal consistency and the interpretation of this theory are still not nearly as well understood as they ought to be. In addition, whenever possible these essays take the opportunity to link foundational issues to the many exciting developments that are often linked to major experimental and technological breakthroughs in exploiting the electromagnetic field and in particular, its quantum properties and its interactions with matter, as well as to advances in solid state physics (such as new quantum Hall liquids, topological insulators and graphene). The present volume also focuses on various areas, including new interference experiments with very large molecules passing through double-slits, which test the validity of the Kochen-Specker theorem; new tests of the violation of Bell’s inequalities and the consequences of entanglement; new non-demolition measurements and tests of “wave-function collapse” to name but a few. These experimental developments have raised many challenging questions for theorists, leading to a new surge of interest in the foundations of QM, which have puzzled physicists ever since this theory was pioneered almost ninety years ago. The outcome of a seminar program of the same name on foundational issues in quantum physics (QM), organized by the editors of this book and addressing newcomers to the field and more seasoned specialists alike, this volume provides a pedagogically inspired snapshot view of many of the unresolved issues in the field of foundational QM.

The topic of this book is a comparison between holism in the philosophy and language and social holism on the one hand and holism about space-time and quantum systems on the other hand. The main claim is that holism in the humanities and holism in fundamental physics come under the same substantial, general conception of holism. That is to say: arguments to the effect that the holism of the mental is unscientific or that the mental is separated from the physical owing to holism are not sound. The holism of the mental fits into a world-view that bases itself on scientific realism. The addressees of this book are all those who care about our view of the world and ourselves in the spirit of an argumentative examination of different positions. No familiarity with physics is presupposed.

This volume explores multiscale methods as applied to various areas of physics and to the relative developments in mathematics. In the last few years, multiscale methods have lead to spectacular progress in our understanding of complex physical systems and have stimulated the development of very refined mathematical techniques. At the same time on the experimental side, equally spectacular progress has been made in developing experimental machinery and techniques to test the foundations of quantum mechanics.

The book gives a broad coverage of the basic elements necessary to understand and carry out research in quantum optics. It presents a variety of theoretical tools and important results for two-level and semiconductor media, many of which could only be found in the original literature of in specialized monographs up to now. The text reveals the close connection between many seemingly unrelated topics. The book "e;Quantum Optics"e; has been written to meet the requirement of the degree and post graduate students. The subject matter has been discussed in such a simple way that the students will find no difficult to understand it. Most of the examples given in the book have been selected from various university examination papers and the book cover the syllabus of almost all the universities.

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.

Major advances in the quantum theory of macroscopic systems, in combination with stunning experimental achievements, have brightened the field and brought it to the attention of the general community in natural sciences. Today, working knowledge of dissipative quantum mechanics is an essential tool for many physicists. This book —

originally published in 1990 and republished in 1999 as an enlarged second edition — delves much deeper than ever before into the fundamental concepts, methods, and applications of quantum dissipative systems, including the most recent developments.In this third edition, 26 chapters from the second edition contain additional material and several chapters are completely rewritten. It deals with the phenomena and theory of decoherence, relaxation, and dissipation in quantum mechanics that arise from the interaction with the environment. In so doing, a general path integral description of equilibrium thermodynamics and nonequilibrium dynamics is developed.

What if life isn't just a part of the universe . . . what if it determines the very structure of the universe itself? The theory that blew your mind in Biocentrism and Beyond Biocentrism is back, with brand-new research revealing the startling truth about our existence. What is consciousness? Why are we here? Where did it all come from—the laws of nature, the stars, the universe? Humans have been asking these questions forever, but science hasn't succeeded in providing many answers—until now. In The Grand Biocentric Design, Robert Lanza, one of Time Magazine's "100 Most Influential People," is joined by theoretical physicist Matej Pavšic and astronomer Bob Berman to shed light on the big picture that has long eluded philosophers and scientists alike. This engaging, mind-stretching exposition of how the history of physics has led us to Biocentrism—the idea that life creates reality-takes readers on a step-by-step adventure into the great science breakthroughs of the past centuries, from Newton to the weirdness of quantum theory, culminating in recent revelations that will challenge everything you think you know about our role in the universe. ?This book offers the most complete explanation of the science behind Biocentrism to date, delving into the origins of the memorable principles introduced in previous books in this series, as well as introducing new principles that complete the theory. The authors dive deep into topics including consciousness, time, and the evidence that our observations-or even knowledge in our minds-can affect how physical objects behave. The Grand Biocentric Design is a one-of-a-kind, groundbreaking explanation of how the universe works, and an exploration of the science behind the astounding fact that time, space, and reality itself, all ultimately depend upon us.

The True Jacob is a presentation of quantum mechanics and physics from the perspective of the information interpretation, which states that the quantum is an amount of information about an event. There is much emphasis placed upon philosophical questions related to physics with a bias to the philosophy of reductionism. In addition there are new inspirational directions for quantum mechanics that are discussed including a theory of life from first principles and an experimental direction for instant communication in quantum mechanics. A philosophical world view is also postulated in the context of the information interpretation.

This book presents written versions of selected invited lectures from the spring meeting of the Arbeitskreis Festkörperphysik of the Deutsche Physikalische Gesellschaft which was held from 27 to 31 March 2006 in Dresden, Germany. Many topical talks given at the numerous symposia are included. Most of these were organized collaboratively by several of the divisions of the Arbeitskreis. The book presents, to some extent, the status of the field of solid-state physics in 2006 not only in Germany but also internationally.

This detailed, accessible introduction to the field of quantum decoherence reviews the basics and then explains the essential consequences of the phenomenon for our understanding of the world. The discussion includes, among other things: How the classical world of our experience can emerge from quantum mechanics; the implications of decoherence for various interpretations of quantum mechanics; recent experiments confirming the puzzling consequences of the quantum superposition principle and making decoherence processes directly observable.

The book deals with expounding the nature of Reality as it is understood in contemporary times in Quantum Physics. It also explains the classical Indian theory of ??nya in its diverse facets. Thereafter it undertakes comparison between the two which is an area of great topical interest. It is a cross-disciplinary study by erudite Indian and western scholars between traditional Indian knowledge system and contemporary researches in Physical sciences. It points out how the theory of ‘??nyat? has many seminal ideas and theories in common with contemporary Quantum Physics. The learned authors have tried to dissolve the “mysteries” of Quantum Physics and resolved its “weird paradoxes” with the help of theory of ??nyat?. The issue of non-separability or entanglement has been approached with the help of the Buddhist theory of Prat?tyasamutp?da. The paradoxical situation of “wave-particle duality” has been explained with the help of Upani?adic theory of complementarity of the two opposites. The measurement problem represented by “Schrodinger’s cat” has been dealt with by resorting to two forms of the calculation of probabilities. Some writers have argued for ??nyat?-like non-essentialist position to understand quantum reality. To make sense of quantum theory some papers provide a happy symbiosis of technical understanding and personal meditative experience by drawing multifarious parallels. This book will be of interest to philosophically inclined physicists and philosophers with interest in quantum mechanics.

This comprehensive textbook provides the fundamental concepts and methods of dissipative quantum mechanics and related issues in condensed matter physics starting from first principles. It deals with the phenomena and theory of decoherence, relaxation and dissipation in quantum mechanics that arise from the random exchange of energy with the environment. Major theoretical advances in combination with stunning experimental achievements and the arising perspective for quantum computing have brightened the field and brought it to the attention of the general community in natural sciences. Expertise in dissipative quantum mechanics is by now beneficial in a broad sphere.This book — originally published in 1992 and republished as enlarged and updated second, third and fourth edition in 1999, 2008, and 2012 — dives even deeper into the fundamental concepts, methods and applications of quantum dissipation. The fifth edition provides a self-contained and updated account of the quantum mechanics and quantum statistics of open systems. The subject matter of the book has been thoroughly revised to better comply with the needs of newcomers and the demands of the advanced readership. Most of the chapters are rewritten to enhance clarity and topicality. Four new chapters covering recent developments in the field have been added. There are about 600 references. This book is intended for use by advanced undergraduate and graduate students in physics, and for researchers active in the field. They will find the monograph as a rich and stimulating source.

Recent advances in the quantum theory of macroscopic systems have brightened up the field and brought it into the focus of a

general community in natural sciences. The fundamental concepts, methods and applications including the most recent developments, previously covered for the most part only in the original literature, are presented here in a comprehensive treatment to an audience who is reasonably familiar with quantum-statistical mechanics and has had rudimentary contacts with the path integral formulation.This book deals with the phenomena and theory of decoherence and dissipation in quantum mechanics that arise from the interaction with the environment. A general path integral description of equilibrium thermodynamics and non-equilibrium dynamics is developed. The approach can deal with weak and strong dissipation, and with all kinds of memory effects. Applications to numerous phenomenological and microscopic systems are presented, where emphasis is put on condensed matter and chemical physics. The basic principles and methods of preparation functions, propagating functions, and time correlation functions are described. Special attention is focused on quantum tunneling and quantum coherence phenomena of macroscopic variables. Many illustrative realistic examples are discussed in some detail. The book attempts to provide a broad perspective and to open up this rapidly developing field to interested researchers normally working in different fields.In this enlarged second edition, the nineteen chapters of the first edition have been expanded by about one-third to better meet both the requests of newcomers to the field and of advanced readers, and seven new chapters have been added that review the most recent important developments.

Over the last decade, the biggest advances in physical chemistry have come from thinking smaller. The leading edge in research pushes closer to the atomic frontier with every passing year. Collecting the latest developments in the science and engineering of finely dispersed particles and related systems, Finely Dispersed Particles: Micro-, Nano-, and Atto-Engineering explores heat, mass, momentum and electron transfer phenomena of well-characterized interfaces at the milli-, micro-, nano-, and atto-scales. An interdisciplinary team of leading experts from around the world discuss recent concepts in the physics and chemistry of various well-studied interfaces of rigid and deformable particles in homo- and hetero-aggregate dispersed systems, including emulsions, dispersoids, foams, fluosols, polymer membranes, and biocolloids. The contributors clearly elucidate the hydrodynamic, electrodynamic, and thermodynamic instabilities that occur at interfaces, as well as the rheological properties of interfacial layers responsible for droplets, particles, and droplet-particle-film structures in finely dispersed systems. The book examines structure and dynamics from various angles, such as relativistic and non-relativistic theories, molecular orbital methods, and transient state theories. With a comprehensive survey of our current understanding, Finely Dispersed Particles: Micro-, Nano-, and Atto-Engineering provides a solid platform for further exploration and discovery at increasingly smaller scales.

This edited book presents the problems of time and direction from an interdisciplinary point of view, concentrating in particular on the following relations: • Time and physics • Time, philosophy and psychology • Time, mathematics and information theory It is a unique contribution by philosophers and scientists who are active in mathematics, physics, biology, engineering, information theory and psychology. Questions such as the existence of a Big Bang, the neurobiological basis regarding the coexistence of free will and determinism, intercultural aspects of time, mathematical models of time, psychopathological features of time, and micro reversibility versus macroscopic irreversibility are studied. It also provides a truly interdisciplinary study of the problematic 'arrow of time'.