Relativistic Quantum Mechanics Theoretical And Mathematical Physics

Special relativity and quantum mechanics, formulated early in the twentieth century, are the two most important scientific languages and are likely to remain so for many years to come. In the 1920's, when quantum mechanics was developed, the most pressing theoretical problem was how to make it consistent with special relativity. In the 1980's, this is still the most pressing problem. The only difference is that the situation is more urgent now than before, because of the significant quantity of experimental data which need to be explained in terms of both quantum mechanics and special relativity. In unifying the concepts and algorithms of quantum mechanics and special relativity, it is important to realize that the underlying scientific language for both disciplines is that of group theory. The role of group theory in quantum mechanics is well known. The same is true for special relativity. Therefore, the most effective approach to the problem of unifying these two important theories is to develop a group theory which can accommodate both special relativity and quantum mechanics. As is well known, Eugene P. Wigner is one of the pioneers in developing group theoretical approaches to relativistic quantum mechanics. His 1939 paper on the inhomogeneous Lorentz group laid the foundation for this important research line. It is generally agreed that this paper was somewhat ahead of its time in 1939, and that contemporary physicists must continue to make real efforts to appreciate fully the content of this classic work.

In this book, quantum mechanics is developed from the outset on a relativistic basis, using the superposition principle, Lorentz invariance and gauge invariance. Nonrelativistic quantum mechanics appears as a special case, and classical relativistic mechanics as another one. These special cases are important for giving plausible names to operators, for example "orbital angular momentum", "spin" or "magnetic moment". A subject which is treated for the first time in this book is the theory of binaries in terms of differential equations which have the mathematical structure of the corresponding one-body equations (Klein--Gordon for two spin- less particles, Dirac for two spinor particles).

This textbook is mainly for physics students at the advanced undergraduate and beginning graduate levels, especially those with a theoretical inclination. Its chief purpose is to give a systematic introduction to the main ingredients of the fundamentals of quantum theory, with special emphasis on those aspects of group theory (spacetime and permutational symmetries and group representations) and differential geometry (geometrical phases, topological quantum numbers, and Chern–Simons Theory) that are relevant in modern developments of the subject. It will provide students with an overview of key elements of the theory, as well as a solid preparation in calculational techniques.

An accessible, comprehensive reference to modern quantum mechanics and field theory. In surveying available books on advanced quantum mechanics and field theory, Franz Gross determined that while established books were outdated, newer titles tended to focus on recent developments and disregard the basics. Relativistic Quantum Mechanics and Field Theory fills this striking gap in the field. With a strong emphasis on applications to practical problems as well as calculations, Dr. Gross provides complete, up-to-date coverage of both elementary and advanced topics essential for a well-rounded understanding of the field. Developing the material at a level accessible even to newcomers to quantum mechanics, the book begins with topics that every physicist should know-quantization of the electromagnetic field, relativistic one body wave equations, and the theoretical explanation of atomic decay. Subsequent chapters prepare readers for advanced work, covering such major topics as gauge theories, path integral techniques, spontaneous symmetry breaking, and an introduction to QCD, chiral symmetry, and the Standard Model. A special chapter is devoted to relativistic bound state wave equations-an important topic that is often overlooked in other books. Clear and concise throughout, Relativistic Quantum Mechanics and Field Theory boasts examples from atomic and nuclear physics as well as particle physics, and includes appendices with background material. It is an essential reference for anyone working in quantum mechanics today.

Non-Relativistic Quantum Theory
Relativistic Quantum Mechanics of Leptons and Fields
An Introduction to Relativistic Quantum Field Theory
Point Form Relativistic Quantum Mechanics
Textbook of Relativistic Quantum Physics

Complete, systematic, and self-contained, this text introduces modern quantum field theory. "Combines thorough knowledge with a high degree of didactic ability and a delightful style." — Mathematical Reviews. 1961 edition.

This book is intended for physicists and chemists who need to understand the theory of atomic and molecular structure and processes, and who wish to apply the theory to practical problems. As far as practicable, the book provides a self-contained account of the theory of relativistic atomic and molecular structure, based on the accepted formalism of bound-state Quantum Electrodynamics. The author was elected a Fellow of the Royal Society of London in 1992.

This graduate text introduces relativistic quantum theory, emphasising its important applications in condensed matter physics. Relativistic quantum theory is the unification into a consistent theory of Einstein's theory of relativity and the quantum mechanics of Bohr, Schrödinger, and Heisenberg, etc. Beginning with basic theory, the book then describes essential topics. Many worked examples and exercises are included along with an extensive reference list. This clear account of a crucial topic in science will be valuable to graduates and researchers working in condensed matter physics and quantum physics.

Since the discovery of the corpuscular nature of radiation by Planck more than fifty years ago the quantum theory of radiation has gone through many stages of development which seemed to alternate between spectacular success and hopeless frustration. The most recent phase started in 1947 with the discovery of the electromagnetic level shifts and the realization that the exist ing theory, when properly interpreted, was perfectly adequate to explain these effects to an apparently unlimited degree of accuracy. This phase has now reached a certain conclusion: for the first time in the checkered history of this field of research it has become possible to give a unified and consistent presen tation of radiation theory in full conformity with the principles of relativity and quantum mechanics. To this task the present book is devoted. The plan for a book of this type was conceived during *the year 1951 while the first-named author (J. M. J.) held a Fulbright research scholarship at Cambridge University. During this year of freedom from teaching and other duties he had the opportunity of conferring with physicists in many different countries on the recent developments in radiation theory. The comments seemed to be almost unanimous that a book on quantum electrodynamics at the present time would be of inestimable value to physicists in many parts of the world. However, it was not until the spring of 1952 that work on the book began in earnest.*

Theory of Atomic Bound States

Relativistic Particle Physics

Relativistic Quantum Mechanics and Introduction to Field Theory

Lectures on Quantum Mechanics and Relativistic Field Theory

Relativistic Quantum Theory of Atoms and Molecules

Special relativity and quantum mechanics are likely to remain the two most important languages in physics for many years to come. The underlying language for both disciplines is group theory. Eugene P. Wigner's 1939 paper on the Unitary Representations of the Inhomogeneous Lorentz Group laid the foundation for unifying the concepts and algorithms of quantum mechanics and special relativity. In view of the strong current interest in the space-time symmetries of elementary particles, it is safe to say that Wigner's 1939 paper was fifty years ahead of its time. This edited volume consists of Wigner's 1939 paper and the major papers on the Lorentz group published since 1939. . This volume is intended for graduate and advanced undergraduate students in physics and mathematics, as well as mature physicists wishing to understand the more fundamental aspects of physics than are available from the fashion-oriented theoretical models which come and go. The original papers contained in this volume are useful as supplementary reading material for students in courses on group theory, relativistic quantum mechanics and quantum field theory, relativistic electrodynamics, general relativity, and elementary particle physics. This reprint collection is an extension of the textbook by the present editors entitled "Theory and Applications of the Poincare Group." Since this book is largely based on the articles contained herein, the present volume should be viewed as a reading for the previous work. continuation of and supplementary We would like to thank Professors J. Bjorken, R. Feynman, R. Hofstadter, J.

Written by two researchers in the field, this book is a reference to explain the principles and fundamentals in a self–contained, complete and consistent way. Much attention is paid to the didactical value, with the chapters interconnected and based on each other. From the contents: * Fundamentals * Relativistic Theory of a Free Electron: Dirac´s Equation * Dirac Theory of a Single Electron in a Central Potential * Many–Electron Theory I: Quantum Electrodynamics * Many–Electron Theory II: Dirac–Hartree–Fock Theory * Elimination of the Small Component * Unitary Transformation Schemes * Relativistic Density Functional Theory * Physical Observables and Molecular Properties * Interpretive Approach to Relativistic Quantum Chemistry From beginning to end, the authors deduce all the concepts and rules, such that readers are able to understand the fundamentals and principles behind the theory. Essential reading for theoretical chemists and physicists.

Quantum physics and special relativity theory were two of the greatest breakthroughs in physics during the twentieth century and contributed to paradigm shifts in physics. This book combines these two discoveries to provide a complete description of the fundamentals of relativistic quantum physics, guiding the reader effortlessly from relativistic quantum mechanics to basic quantum field theory. The book gives a thorough and detailed treatment of the subject, beginning with the classification of particles, the Klein–Gordon equation and the Dirac equation. It then moves on to the canonical quantization procedure of the Klein–Gordon, Dirac and electromagnetic fields. Classical Yang–Mills theory, the LSZ formalism, perturbation theory, elementary processes in QED are introduced, and regularization, renormalization and radiative corrections are explored. With exercises scattered through the text and problems at the end of most chapters, the book is ideal for advanced undergraduate and graduate students in theoretical physics.

More than a generation of Gennan-speaking students around the world have worked their way to an understanding and appreciation of the power and beauty of modern theoretical physics - with mathematics, the most fundamental of sciences - using Walter Greiner's textbooks as their guide. The idea of developing a coherent, complete presentation of an entire field of science in a series of closely related textbooks is not a new one. Many older physicists remember with real pleasure their sense of adventure and discovery as they worked their ways through the classic series by Sommerfeld, by Planck and by Landau and Lifshitz. From the students' viewpoint, there are a great many obvious advantages to be gained through use of consistent notation, logical ordering of topics and coherence of presentation; beyond this, the complete coverage of the science provides a unique opportunity for the author to convey his personal enthusiasm and love for his subject. The present five volume set, Theoretical Physics, is in fact only that part of the complete set of textbooks developed by Greiner and his students that presents the quantum theory. I have long urged him to make the remaining volumes on classical mechanics and dynamics, on electromagnetism, on nuclear and particle physics, and on special topics available to an English-speaking audience as well, and we can hope for these companion volumes covering all of theoretical physics some time in the future.

Theory and Computation

Relativity, Symmetry, and the Structure of Quantum Theory, Volume 2
The Relativistic Quantum Field Theory of Charged Particles with Spin One-half

Perspectives on Quantum Reality

Why study relativistic particle physics? Because of deeper understanding, curiosity and applications. Consider first deeper understanding. Physics forms the basis of many other sciences, and relativistic particle physics forms the basis of physics. Starting from nonrelativistic point mechanics, there are three major steps: first to classical (unquantized) relativistic electrodynamics, then to non relativistic quantum mechanics and finally to relativistic quantum physics. This book describes the third step. Relativistic particle problems which are mainly classical (such as synchrotron radiation) are largely omitted (see for example Jackson 1975). I have divided the subject into several smaller steps. The step from the Schrödinger equation to the Klein-Gordon and Dirac equations (chapter 1) is easy, apart from logical inconsistencies in limiting cases. Chapter 2 deals mainly with two-particle problems. From two-particle unitarity (sect. 2-5) and a symmetric treatment of projectile and target in the Born approxima tion to scattering (sect. 2-7), one is able to deduce recoil corrections to the relativistic one-particle equations (mainly the reduced mass, sect. 2-9). The final formulas provide a rather firm basis for atomic physics. Quantum electrodynamics (QED) is presented in chapter 3. Clearly, many things must be omitted if one allots one chapter to the subject of whole 1976, Källen 1958, Akhiezer and Berestetskii books (Jauch and Rohrlieh 1965, Bjorken and Drell 1965, Landau and Lifshitz 1971, 1975, and others).
RELATIVISTIC QUANTUM PHYSICS includes in its fold both Relativistic Quantum Mechanics and Quantum Field Theory. It is shown how Feynman's positron theory and Feynman diagrams have greatly simplified the calculations for various processes in Quantum Electrodynamics. Elements of Quantum Field Theory and its essential features are also presented. Neutrinos and neutrino oscillations, Gauge theories and Guage bosons, Higgs field and Higgs bosons, spontaneous symmetry breaking and Higgs mechanism, and how the particles acquire mass by Higgs mechanism are some of the topics that are dealt with exhaustively in this book.
Unlike most introductory and advanced books on quantum mechanics, this book covers a large number of applications of quantum mechanics including their relativistic generalization and even quantum chemistry. It thereby closes a gap between books of quantum mechanics and quantum field theory. Starting with quantum mechanics, the book then treats the equations of relativistic quantum mechanics with emphasis on Dirac's equation, followed by a discussion of spin to finally arrive at quantum field theory. The relativistic equations are used as a starting point to explain all the small corrections to quantum mechanics leading to measurable effects. The chapters on scattering and bound states convey a deep understanding of the field. Hyperfine shifts and dispersive effects like the Lambshift are treated in a comprehensible manner. The beautiful symmetries on which the particle classifications are based are discussed in subsequent sections. The appendices illustrate technical difficulties encountered in calculations. In the third edition of this successful text, published posthumously, many sections have been revised and widely extended. In particular the discussion of Hyperfine shifts, radiation, dispersive effects, quarks have been thoroughly revisited and split up into three chapters. Sections on Kramer's equation and on electroweak interactions have been added. The book will be of interest to researchers and graduate students in quantum mechanics and quantum field theory.
The second edition of Relativistic Quantum Chemistry: The Fundamental Theory of Molecular Science expands on some of the latest developments in this fascinating field. The text retains its clear and consistent style, allowing for a readily accessible overview of the complex topic. It is also self-contained, building on the fundamental equations and providing the mathematical background necessary. While some parts of the text have been restructured for the sake of clarity a significant amount of new content has also been added. This includes, for example, an in-depth discussion of the Brown-Ravenhall disease, of spin in current-density functional theory, and of exact two-component methods and its local variants. A strength of the first edition of this textbook was its list of almost 1000 references to the original research literature, which has made it a valuable reference also for experts in the field.
Relativistic Quantum Mechanics and Field Theory
Relativistic Quantum Fields
LSC Relativistic Quantum Mechanics
Relativistic Quantum Mechanics and Quantum Fields
Theory and Applications of the Poincaré Group

This book describes a relativistic quantum theory developed by the author starting from the E.C.G. Stueckelberg approach proposed in the early 40s. In this framework a universal invariant evolution parameter (corresponding to the time originally postulated by Newton) is introduced to describe dynamical evolution. This theory is able to provide solutions for some of the fundamental problems encountered in early attempts to construct a relativistic quantum theory. A relativistically covariant construction is given for which particle spins and angular momenta can be combined through the usual rotation group Clebsch-Gordan coefficients.

Solutions are defined for both the classical and quantum two body bound state and scattering problems. The recently developed quantum Lax-Phillips theory of semi group evolution of resonant states is described. The experiment of Lindner and coworkers on interference in time is discussed showing how the property of coherence in time provides a simple understanding of the results. The full gauge invariance of the Stueckelberg-Schroedinger equation results in a 5D generalization of the usual gauge theories. A description of this structure and some of its consequences for both Abelian and non-Abelian fields are discussed. A review of the basic foundations of relativistic classical and quantum statistical mechanics is also given. The Bekenstein-Sanders construction for imbedding Milgrom's theory of modified spacetime structure into general relativity as an alternative to dark matter is also studied.

This advanced textbook supplies graduate students with a primer in quantum theory. A variety of processes are discussed with concepts such as potentials, classical current distributions, prescribed external fields dealt with in the framework of relativistic quantum mechanics. Then, in an introduction to field theory, the author emphasizes the deduction of the said potentials or currents. A modern presentation of the subject together with many exercises, unique in its unusual underlying concept of combining relativistic quantum mechanics with basic quantum field theory.

The material contained in this work concerns relativistic quantum mechanics, and as such pertains to classical fields. On the one hand it is meant to serve as a text on the subject, a desire stemming from the author's fruitless searches for an adequate, up-to-date reference when lecturing on these topics. At times the supplementary material was found to exceed by far that in the assigned text. On the other hand, there is some flavor of a monograph to what follows, most particularly in the later chapters, for a major goal is to demonstrate just how far we can advance our understanding of the behavior of stable particles and their interactions without introducing quantized fields. Those wishing to describe the world in this way may view the result as a point of departure, despite the fact that their wish remains unfulfilled. Confirmed quantum-field theorists, however, will doubtless view it as a summary of just why they feel compelled to quantize the fields. Approximately half the book is devoted to the single-particle Dirac equation and its solutions. A great deal of detail is provided in this respect, and the discus sion is reasonably comprehensive. The Dirac equation is extraordinarily important in its own right, particularly as a basis for quantum electrodynamics (QED), and is thus worthy of extensive study.

This book provides an accessible treatment of non-relativistic and relativistic quantum mechanics. It is an ideal textbook for undergraduate and graduate physics students, as well as researchers in theoretical physics, quantum mechanics, condensed matter, mathematical physics, quantum chemistry and electronic students. This student-friendly and self-contained textbook covers the typical topics in a core undergraduate program as well as more advanced topics in a graduate course with an elegant mathematical rigor, contemporary style, and rejuvenated approach. It balances theory and worked examples, which reinforce the readers' understanding of the fundamental concepts. The analytical methods employed in this book describe physical situations written with mathematical rigor and in-depth clarity, emphasizing the essential understanding of the subject matter without need for prior knowledge of classical mechanics, electromagnetic theory, atomic structure and differential equations. Key Features: Remains accessible but incorporates a rigorous mathematical treatment with clarity and emphasizing a contemporary style and a rejuvenated approach Presents a student-friendly and self-contained structure Balances theory and worked examples

Relativistic Quantum Mechanics. Wave Equations

Relativistic Quantum Chemistry

Relativistic Quantum Physics

Parametrized Relativistic Quantum Theory

The Theory of Photons and Electrons

In this text the authors develop a propagator theory of Dirac particles, photons, and Klein-Gordon mesons and per- form a series of calculations designed to illustrate various useful techniques and concepts in electromagnetic, weak, and strong interactions. these include defining and implementing the renormalization program and evaluating effects of radia- tive corrections, such as the Lamb shift, in low-order calculations. The necessary background for the book is pro- vided by a course in nonrelativistic quantum mechanics at the general level of Schiff's text, QUANTUM MECHANICS.

Written by two of the world's leading experts on particle physics and the standard model - including an award-winning former Director General of CERN - this textbook provides a completely up-to-date account of relativistic quantum mechanics and quantum field theory. It describes the formal and phenomenological aspects of the standard model of particle physics, and is suitable for advanced undergraduate and graduate students studying both theoretical and experimental physics.

Quantum Mechanics, Third Edition: Non-relativistic Theory is devoted to non-relativistic quantum mechanics. The theory of the addition of angular momenta, collision theory, and the theory of symmetry are examined, together with spin, nuclear structure, motion in a magnetic field, and diatomic and polyatomic molecules. This book is comprised of 18 chapters and begins with an introduction to the basic concepts of quantum mechanics, with emphasis on the uncertainty principle, the principle of superposition, and operators, as well as the continuous spectrum and the wave function. The following chapters explore energy and momentum; Schrödinger's equation; angular momentum; and motion in a centrally symmetric field and in a magnetic field. Perturbation theory, spin, and the properties of quasi-classical systems are also considered. The remaining chapters deal with the identity of particles, atoms, and diatomic and polyatomic molecules. The final two chapters describe elastic and inelastic collisions. This monograph will be a valuable source of information for physicists.

Foundations of the relativistic quantum mechanics and field theory of arbitrary spin are presented. New relativistic wave equations without redundant components for the particle-antiparticle doublets of arbitrary spin are considered. The comparison with known arbitrary spin equations of Bhabha, Bargman-Wigner and with Pauli-Fierz, Rarita-Schwinger equations (for the spin s=3/2) demonstrates the advantages of the presented approach. The special procedure of synthesis of higher spin relativistic wave equations is suggested. New equations are considered on three levels of (i) relativistic canonical quantum mechanics, (ii) canonical Foldy-Wouthuysen type field theory, and (iii) manifestly covariant field theory. The derivation of field equations based on the start from the relativistic canonical quantum mechanics is given. The corresponding transition operator, which is the extended Foldy-Wouthuysen transformation, is suggested and described. This model of relativistic quantum mechanics is described here on the level of von Neumann's consideration of non-relativistic case. The Lagrange approach for the spinor field in the Foldy-Wouthuysen representation is analyzed. The proof of the Fermi-Bose duality property of a few main equations of field theory, which before were known to have only single Fermi (or single Bose) property, is given. Hidden Bose properties (symmetry, solutions, and conservation laws) of the Dirac equation are proved. Both cases of non-zero and zero mass are considered. New useful mathematical objects, which are the pure matrix representations of the 64-dimensional Clifford and 28-dimensional SO(8) algebras over the field of real numbers, are put into consideration. The application of such algebras to the Dirac and Dirac-like equations properties analysis is demonstrated. Fermi and Bose SO(4) symmetries of the relativistic hydrogen atom are found. New symmetries and solutions of the Maxwell equations are considered. The Maxwell equations in the form, having maximal symmetry, are suggested and described. The application of such field-strength equations to the atomic microworld phenomena is demonstrated. On the basis of such Maxwell system the relativistic hydrogen atom spectrum and quantum properties of this atom are described. The Sommerfeld-Dirac fine structure formula, Plank constant and the Bohr postulates are derived in the frameworks of classical electrodynamics. The limits and boarders of classical physics applications in inneratomic microworld are discussed. In order to determine the place of our approach among other investigations the 26 variants of the Dirac equation derivation are considered.

With an Introduction into Modern Relativistic Quantum Mechanics

Non-Relativistic, Relativistic, and Field-Theoretic

Wave Equations

An Introduction to Relativistic Quantum Fields

With Applications in Condensed Matter and Atomic Physics

But to admit things not visible to the gross creatures that we are is, in my opinion, to show a decent humility, and not just a lamentable addiction to metaphysics. J. S. Bell, Are There Quantum Jumps? ON CANADIAN THANKSGIVING WEEKEND in the autumn of 1994, a lively conference was held at The University of Western Ontario under the title "Conceptual Problems of Relativistic Quantum Mechanics". Most of the eighteen papers in this volume are directly connected with that conference. Articles by both theoretical physicists and philosophers of science are included, and many authors will be recognized immediately for their already substantive work in the foundations of physics. A quarter century ago Howard Stein suggested that relativistic quantum field theory should be 'the contemporary locus of metaphysical research', but there were few takers. Only fairly recently has that changed, with the result that the bulk of the papers here pursue issues that go beyond nonrelativistic quantum mechanics (or at least have serious implications for its relativistic generalization). Nevertheless, problems interpreting the nonrelativistic theory remain a persistent thorn in the side of any such endeavor, and so some of the papers develop innovative approaches to those issues as well.

*RELATIVISTIC QUANTUM MECHANICS AND QUANTUM FIELD THEORY deals with the single particle relativistic wave equations and the elements of quantum field theory. The Klein-Gordon equation is discussed briefly and elaborately the Dirac equation, its free particle solutions and Feynman's positron theory with a view to emphasize how the intuitive approach of Feynman has enormously simplified the calculations in Quantum Electrodynamics -- the interaction of radiation with matter -- by the introduction of Feynman diagrams. It is shown that Feynman's approach is equivalent to the other more general approach of quantum field theory and the equivalence of the two approaches has been demonstrated through the S-matrix formalism which leads to the Feynman diagrams by the application of Wick's theorem. How the quantum field theory is stretched beyond quantum electrodynamics to include electro weak interactions and strong interactions and how it leads to the formulation of the standard model of elementary particles are briefly discussed. KEY FEATURE: * Review Questions * Problems with Solutions at the end of each chapter*

The fundamental goal of physics is an understanding of the forces of nature in their simplest and most general terms. Yet there is much more involved than just a basic set of equations which eventually has to be solved when applied to specific problems. We have learned in recent years that the structure of the ground state of field theories (with which we are generally concerned) plays an equally funda mental role as the equations of motion themselves. Heisenberg was probably the first to recognize that the ground state, the vacuum, could acquire certain prop erties (quantum numbers) when he devised a theory of ferromagnetism. Since then, many more such examples are known in solid state physics, e. g. supercon ductivity, superfluidity, in fact all problems concerned with phase transitions of many-body systems, which are often summarized under the name synergetics. Inspired by the experimental observation that also fundamental symmetries, such as parity or chiral symmetry, may be violated in nature, it has become wide ly accepted that the same field theory may be based on different vacua. Practical ly all these different field phases have the status of more or less hypothetical models, not (yet) directly accessible to experiments. There is one magnificent ex ception and this is the change of the ground state (vacuum) of the electron-posi tron field in superstrong electric fields.

The first version of quantum theory, developed in the mid 1920's, is what is called nonrelativistic quantum theory; it is based on a form of relativity which, in a previous volume, was called Newton relativity. But quickly after this first development, it was realized that, in order to account for high energy phenomena such as particle creation, it was necessary to develop a quantum theory based on Einstein relativity. This in turn led to the development of relativistic quantum field theory, which is an intrinsically many-body theory. But this is not the only possibility for a relativistic quantum theory. In this book we take the point of view of a particle theory, based on the irreducible representations of the Poincare group, the group that expresses the symmetry of Einstein relativity. There are several ways of formulating such a theory; we develop what is called relativistic point form quantum mechanics, which, unlike quantum field theory, deals with a fixed number of particles in a relativistically invariant way. A central issue in any relativistic quantum theory is how to introduce interactions without spoiling relativistic invariance. We show that interactions can be incorporated in a mass operator, in such a way that relativistic invariance is maintained. Surprisingly for a relativistic theory, such a construction allows for instantaneous interactions; in addition, dynamical particle exchange and particle production can be included in a multichannel formulation of the mass operator. For systems of more than two particles, however, straightforward application of such a construction leads to the undesirable property that clusters of widely separated particles continue to interact with one another, even if the interactions between the individual particles are of short range. A significant part of this volume deals with the solution of this problem. Since relativistic quantum mechanics is not as well-known as relativistic quantum field theory, a chapter is devoted to applications of point form quantum mechanics to nuclear physics; in particular we show how constituent quark models can be used to derive electromagnetic and other properties of hadrons.

Relativistic Quantum Mechanics and Field Theory of Arbitrary Spin

Relativistic Quantum Mechanics and Introduction to Quantum Field Theory

Relativistic Quantum Mechanics
Quantum Mechanics
Special Relativity and Quantum Theory

This invaluable textbook is divided into two parts. The first part includes a detailed discussion on the discrete transformations for the Dirac equation, as well as on the central force problem for the Dirac equation. In the second part, the external field problem is examined; pair production and vacuum polarization leading to charge renormalization are treated in detail. Relativistic Quantum Mechanic's and Introduction to Quantum Field Theory has arisen from a graduate course which the author taught for several years at the University of Alberta to students interested in particle physics and field theory.

A sequel to the well received book, Quantum Mechanics by T Y Wu, this book carries on where the earlier volume ends. This present volume follows the generally pedagogic style of Quantum Mechanics. The scope ranges from relativistic quantum mechanics to an introduction to quantum field theory with quantum electrodynamics as the basic example and ends with an exposition of important issues related to the standard model. The book presents the subject in basic and easy-to-grasp notions which will enhance the purpose of this book as a useful textbook in the area of relativistic quantum mechanics and quantum electrodynamics. Request Inspection Copy

"This graduate-level text contains statistical and quantitative techniques for performing calculations in quantum field theory. Topics include renormalization, functional differentiation and integration, and the Schwinger-Dyson equations; dimensional regularization; the gauge and infrared properties of quantum electrodynamics; and asymptotic behavior and renormalization group methods. Reference features include an appendix, bibliography, and index. 1978 edition"--

This revised and up to date classic reference lays the foundation for subsequent studies in advanced quantum mechanics and field theory, offering problems and solutions to guide readers through Greiner's lecture texts. Includes 87 worked examples and exercises. 443 p.

Dynamics, Symmetry, and Geometry

A Collection of Papers on the Poincaré Group

RELATIVISTIC QUANTUM MECHANICS AND RELATED TOPICS

New Developments in Relativistic Quantum Field Theory and Its Applications

Quantum Electrodynamics of Strong Fields

Over the past five de-::ades researchers have sought to develop a new framework that would resolve the anomalies attributable to a patchwork formulation of relativistic quantum mechanics. This book chronicles the development of a new paradigm for describing relativistic quantum phenomena. What makes the new paradigm unique is its inclusion of a physically measurable, invariant evolution parameter. The resulting theory has been sufficiently well developed in the refereed literature that it is now possible to present a synthesis of its ideas and techniques. My synthesis is intended to encourage and enhance future research, and is presented in six parts. The environment within which the conventional paradigm exists is described in the Introduction. Part I eases the mainstream reader into the ideas of the new paradigm by providing the reader with a discussion that should look very familiar, but contains subtle nuances. Indeed, I try to provide the mainstream reader with familiar "landmarks" throughout the text. This is possible because the new paradigm contains the conventional paradigm as a subset. The foundation of the new paradigm is presented in Part II, fol!owed by numerous applications in the remaining three parts. The reader should notice that the new paradigm handles not only the broad class of problems typically dealt with in conventional relativistic quantum theory, but also contains fertile research areas for both experimentalists and theorists. To avoid developing a theoretical framework without physical validity, numerous comparisons between theory and experiment are provided, and several predictions are made.

** Which problems do arise within relativistic enhancements of the Schrödinger theory, especially if one adheres to the usual one-particle interpretation? * To what extent can these problems be overcome? * What is the physical necessity of quantum field theories? In many textbooks, only insufficient answers to these fundamental questions are provided by treating the relativistic quantum mechanical one-particle concept very superficially and instead introducing field quantization as soon as possible. By contrast, this book emphasizes particularly this point of view (relativistic quantum mechanics in the ''narrow sense''): it extensively discusses the relativistic one-particle view and reveals its problems and limitations, therefore illustrating the necessity of quantized fields in a physically comprehensible way. The first two chapters contain a detailed presentation and comparison of the Klein-Gordon and Dirac theory, always with a view to the non-relativistic theory. In the third chapter, we consider relativistic scattering processes and develop the Feynman rules from propagator techniques. This is where the indispensability of quantum field theory reasoning becomes apparent and basic quantum field theory concepts are introduced. This textbook addresses undergraduate and graduate Physics students who are interested in a clearly arranged and structured presentation of relativistic quantum mechanics in the "narrow sense" and its connection to quantum field theories. Each section contains a short summary and exercises with solutions. A mathematical appendix rounds out this excellent textbook on relativistic quantum mechanics.*

This book develops and simplifies the concept of quantum mechanics based on the postulates of quantum mechanics. The text discusses the technique of disentangling the exponential of a sum of operators, closed under the operation of commutation, as the product of exponentials to simplify calculations of harmonic oscillator and angular momentum. Based on its singularity structure, the Schrödinger equation for various continuous potentials is solved in terms of the hypergeometric or the confluent hypergeometric functions. The forms of the potentials for which the one-dimensional Schrödinger equation is exactly solvable are derived in detail. The problem of identifying the states of two-level systems which have no classical

analogy is addressed by going beyond Bell-like inequalities and separability. The measures of quantumness of mutual information in two two-level systems is also covered in detail.
2012 Reprint of 1955 Edition. Exact facsimile of the original edition, not reproduced with Optical Recognition Software. Dirac is widely regarded as one of the world's greatest physicists. He was one of the founders of quantum mechanics and quantum electrodynamics. His early contributions include the modern operator calculus for quantum mechanics, which he called transformation theory, and an early version of the path integral. His relativistic wave equation for the electron was the first successful attack on the problem of relativistic quantum mechanics. Dirac founded quantum field theory with his reinterpretation of the Dirac equation as a many-body equation, which predicted the existence of antimatter and matter-antimatter annihilation. He was the first to formulate quantum electrodynamics, although he could not calculate arbitrary quantities because the short distance limit requires renormalization. Dirac discovered the magnetic monopole solutions, the first topological configuration in physics, and used them to give the modern explanation of charge quantization. He developed constrained quantization in the 1960s, identifying the general quantum rules for arbitrary classical systems. These lectures were given delivered and published during his tenure at Princeton's Institute for Advanced Study in the 1930's.
From Advanced Quantum Mechanics to Introductory Quantum Field Theory
Non-Relativistic and Relativistic Theory
Relativistic Quantum Mechanics and Quantum Field Theory
Non-Relativistic Theory
The Fundamental Theory of Molecular Science

Relativistic Quantum Mechanics. Wave Equations concentrates mainly on the wave equations for spin-0 and spin-1/2 particles. Chapter 1 deals with the Klein-Gordon equation and its properties and applications. The chapters that follow introduce the Dirac equation, investigate its covariance properties and present various approaches to obtaining solutions. Numerous applications are discussed in detail, including the two-center Dirac equation, hole theory, CPT symmetry, Klein's paradox, and relativistic symmetry principles. Chapter 15 presents the relativistic wave equations for higher spin (Proca, Rarita-Schwinger, and Bargmann-Wigner). The extensive presentation of the mathematical tools and the 62 worked examples and problems make this a unique text for an advanced quantum mechanics course. This third edition has been slightly revised to bring the text up-to-date.
Relativistic Quantum MechanicsSpringer Science & Business Media
Non-Relativistic Quantum Mechanics