

The Relativistic Many Body Problem

[#Relativistic Many-Body Problem](#) [#Quantum Field Theory](#) [#Particle Physics](#) [#Computational Physics](#) [#High Energy Physics](#)

The Relativistic Many Body Problem explores the intricate dynamics of multiple interacting particles within the framework of special or general relativity, posing significant challenges in theoretical physics. This fundamental issue arises in diverse areas such as quantum field theory, nuclear physics, and condensed matter systems, where understanding collective behavior at high energies or velocities is crucial for advancing our knowledge of the universe.

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Relativistic Many-Body Theory

This book gives a comprehensive account of relativistic many-body perturbation theory, based upon field theory. After some introductory chapters about time-independent and time dependent many-body perturbation theory (MBPT), the standard techniques of S-matrix and Green's functions are reviewed. Next, the newly introduced covariant-evolution-operator method is described, which can be used, like the S-matrix method, for calculations in quantum electrodynamics (QED). Unlike the S-matrix method, this has a structure that is similar to that of MBPT and therefore can serve as basis for a unified theory. Such an approach is developed in the final chapters, and its equivalence to the Bethe-Salpeter equation is demonstrated. Possible applications are discussed and numerical illustrations given.

Relativistic Many-Body Theory and Statistical Mechanics

In 1941, E.C.G. Stueckelberg wrote a paper, based on ideas of V. Fock, that established the foundations of a theory that could covariantly describe the classical and quantum relativistic mechanics of a single particle. Horwitz and Piron extended the applicability of this theory in 1973 (to be called the SHP theory) to the many-body problem. It is the purpose of this book to explain this development and provide examples of its applications. We first review the basic ideas of the SHP theory, both classical and quantum, and develop the appropriate form of electromagnetism on this dynamics. After studying the two body problem classically and quantum mechanically, we formulate the N-body problem. We then develop the general quantum scattering theory for the N-body problem and prove a quantum mechanical relativistically covariant form of the Gell-Mann-Low theorem. The quantum theory of relativistic spin is then developed, including spin-statistics, providing the necessary apparatus for Clebsch-Gordan additivity, and we then discuss the phenomenon of entanglement at unequal times. In the second part, we develop relativistic statistical mechanics, including a mechanism for stability of the off-shell mass, and a high temperature phase transition to the mass shell. Finally, some applications

are given, such as the explanation of the Lindneret alexperiment, the proposed experiment of Palacios et al which should demonstrate relativistic entanglement (at unequal times), the space-time lattice, low energy nuclear reactions and applications to black hole physics.

Relativistic Many-body Bound Systems

The principles and the mathematical details of a fully relativistic nuclear theory are given. Since the concept of nuclear forces is a strictly non-relativistic construct, it must be abandoned and the forces must be replaced explicitly by their physical origin, i.e., by the interaction between nucleons and mesons. Thus, in this monograph the description of a nucleus has been formulated as a problem of relativistic quantum field theory which is solved by nuclear physics methods. To wit: The physics is described by specifying a Lagrangian which is a functional of the constituent fields (= of the parton fields). The solutions for the physical systems then are obtained in a time-independent treatment as expansions in the parton fields: both particles and nuclei are composite systems, made up of parton configurations, which define a representation of the Hamiltonian (associated with the specified Lagrangian).

Density Functional Theory

Density Functional Theory is a rapidly developing branch of many-particle physics that has found applications in atomic, molecular, solid-state and nuclear physics. This book describes the conceptual framework of density functional theory and discusses in detail the derivation of explicit functionals from first principles as well as their application to Coulomb systems. Both non-relativistic and relativistic systems are treated. The connection of density functional theory with other many-body methods is highlighted. The presentation is self-contained; the book is, thus, well suited for a graduate course on density functional theory.

Classical Relativistic Many-Body Dynamics

in this work, we must therefore assume several abstract concepts that hardly need defending at this point in the history of mechanics. Most notably, these include the concept of the point particle and the concept of the inertial observer. The study of the relativistic particle system is undertaken here by means of a particular classical theory, which also exists on the quantum level, and which is especially suited to the many-body system in flat spacetime. In its fundamental postulates, the theory may be considered to be primarily the work of E.C.G. Stüickelberg in the 1940's, and of L.P. Horwitz and C. Piron in the 1970's, who may be said to have provided the generalization of Stüickelberg's theory to the many-body system. The references for these works may be found in Chapter 1. The theory itself may be legitimately called off-shell Hamiltonian dynamics, parameterized relativistic mechanics, or even classical event dynamics. The most important feature of the theory is probably the use of an invariant world time parameter, usually denoted T , which provides an evolution time for the system in such a way as to allow manifest covariance within a Hamiltonian formalism. In general, this parameter is neither a Lorentz-frame time, nor the proper time of the particles in the system.

Relativistic Many-Body Theory

The present volume contains the texts of the invited talks delivered at the Seventh International Conference on Recent Progress in Many-Body Theories held at the University of Minnesota during the period August 26-31, 1991. The proceedings of the Fourth Conference (Oulu, Finland, 1987) and Fifth Conference (Arad, Israel, 1989) have been published by Plenum as the first two volumes of this series. Papers from the First Conference (Trieste, 1978) comprise Nuclear Physics volume A328, Nos. 1, 2. The Second Conference (Oaxtepec, Mexico, 1989) was published by Springer-Verlag as volume 142 of "Lecture Notes in Physics," entitled "Recent Progress in Many Body Theories." Volume 198 of the same series contains the papers from the Third Conference (Altenberg, Germany, 1983). These volumes are intended to cover a broad spectrum of current research topics in physics that benefit from the application of many-body theories for their elucidation. At the same time there is a focus on the development and refinement of many-body methods. One of the major aims of the conference series has been to foster the exchange of ideas among physicists working in such diverse areas as nucleon-nucleon interactions, nuclear physics, astronomy, atomic and molecular physics, quantum chemistry, quantum fluids, and condensed matter physics. The present volume contains contributions from all of these areas.

Recent Progress in Many-Body Theories

Quantum mechanics provides the fundamental theoretical apparatus for describing the structure and properties of atoms and molecules in terms of the behaviour of their fundamental components, electrons and nucleons. For heavy atoms and molecules containing them, the electrons can move at speeds which represent a substantial fraction of the speed of light, and thus relativity must be taken into account. Relativistic quantum mechanics therefore provides the basic formalism for calculating the properties of heavy-atom systems. The purpose of this book is to provide a detailed description of the application of relativistic quantum mechanics to the many-body problem in the theoretical chemistry and physics of heavy and superheavy elements. Recent years have witnessed a continued and growing interest in relativistic quantum chemical methods and the associated computational algorithms which facilitate their application. This interest is fuelled by the need to develop robust, yet efficient theoretical approaches, together with efficient algorithms, which can be applied to atoms in the lower part of the Periodic Table and, more particularly, molecules and molecular entities containing such atoms. Such relativistic theories and computational algorithms are an essential ingredient for the description of heavy element chemistry, becoming even more important in the case of superheavy elements. They are destined to become an indispensable tool in the quantum chemist's armoury. Indeed, since relativity influences the structure of every atom in the Periodic Table, relativistic molecular structure methods may replace in many applications the non-relativistic techniques widely used in contemporary research.

Relativistic Nuclear Many-body Physics

The 1985 Summer School on Nuclear Dynamics, organized by the Nuclear Physics Division of the Netherlands' Physical Society, was the sixth in a series that started in 1963. This year's topic has been nuclear dynamics rather than nuclear structure as in the foregoing years. This change reflects a shift in focus to nuclear processes at higher energy, or, more generally, to nuclear processes under less traditional circumstances. For many years nuclear physics has been restricted to the domain of the ground state and excited states of low energy. The boundaries between nuclear physics and high-energy physics are rapidly disappearing, however, and the future will presumably show that the two fields of research will contribute to one another. With the advent of a new generation of heavy-ion and electron accelerators research activities on various new aspects of nuclear dynamics over a wide range of energies have become possible. This research focuses in particular on nonnucleonic degrees of freedom and on nuclear matter under extreme conditions, which require the explicit introduction of quarks into the description of nuclear reactions. Mean-field formulations are no longer adequate for the description of nucleus-nucleus collisions at high nucleon energies as the nucleon-nucleon collisions begin to dominate. Novel dynamical theories are being developed, such as those based upon the Boltzmann equation or hydrodynamic models. The vitality of nuclear physics was clearly demonstrated by the enthusiastic lecturers at this summer school. They presented a series of clear and thorough courses on the subjects above.

Theoretical Chemistry and Physics of Heavy and Superheavy Elements

This book aims to provide a detailed introduction to the state-of-the-art covariant density functional theory, which follows the Lorentz invariance from the very beginning and is able to describe nuclear many-body quantum systems microscopically and self-consistently. Covariant density functional theory was introduced in nuclear physics in the 1970s and has since been developed and used to describe the diversity of nuclear properties and phenomena with great success. In order to provide an advanced and updated textbook of covariant density functional theory for graduate students and nuclear physics researchers, this book summarizes the enormous amount of material that has accumulated in the field of covariant density functional theory over the last few decades as well as the latest developments in this area. Moreover, the book contains enough details for readers to follow the formalism and theoretical results, and provides exhaustive references to explore the research literature. Contents: Concept of Covariant Density Functional Theory (P Ring) Relativistic Mean-Field Theory (J Meng, P Ring and P W Zhao) Relativistic Mean Field Description of Exotic Nuclei (J Meng, P Ring, P W Zhao and S G Zhou) Relativistic Hartree-Fock-Bogoliubov Theory: Ground States and Excitations (W H Long, J Meng and N Van Giai) Superheavy Nuclei and Fission Barriers (B N Lu, J Zhao, E G Zhao and S G Zhou) Relativistic Symmetries in Nuclear Single-Particle Spectra (J Y Guo, H Z Liang, J Meng and S-G Zhou) Structure of Hypernuclei in Relativistic Approaches (K Hagino and J M Yao) Rotating Nuclei: From Ground State to the Extremes of Spin and Deformation (A V Afanasjev) Novel Rotational Excitations (J Meng, S Q Zhang and P W Zhao) Small Amplitude Motion (N Paar and Y Niu) Nuclear

Shell Structure and Response with Quasiparticle-Vibration Coupling (E Litvinova and P Ring) Beyond the Relativistic Mean-Field Approximation — Collective Correlations (Z P Li, T Nikšić, D Vretenar and J M Yao) Heavy Element in Astrophysical Nucleosynthesis (B H Sun and Z M Niu) Relativistic Density Functional Theory for Finite Nuclei and Neutron Stars (J Piekarewicz) Relativistic Versus Non-Relativistic Mean Field (P-G Reinhard) Readership: Graduate students in nuclear physics, nuclear physicists; theoretical physicists interested in the study of quantum many body problems. Key Features: This book focuses on the covariant version of density functional theory, summarizes the latest developments as well as the enormous amount of material that has accumulated over the last few decades, and provides a comprehensive overview of its development and applications for nuclear structure. This book contains enough details for a beginner in nuclear physics to follow the formalism and theoretical results, and provides exhaustive references to explore the research literature. The authors include all the experts in this field including many world-leading scientists from China, Europe, Japan, and United States. Keywords: Covariant Density Functional Theory; Relativistic Mean-Field; Pairing Correlations; Exotic Nucleus; Hartree(–Fock)–Bogoliubov Theory; Relativistic Symmetries; Superheavy Nuclei; Fission; Hypernuclei; Well-Deformed and Superdeformed Rotational Excitation; Electric and Magnetic Rotation; Collective Excitations; Small Amplitude Motion; Quasiparticle-Vibration Coupling; Beyond Mean-Field Approximation; Astrophysical Nucleosynthesis; Neutron Star

New Vistas in Nuclear Dynamics

This book differs from its predecessor, Lieb & Mattis Mathematical Physics in One Dimension, in a number of important ways. Classic discoveries which once had to be omitted owing to lack of space — such as the seminal paper by Fermi, Pasta and Ulam on lack of ergodicity of the linear chain, or Bethe's original paper on the Bethe ansatz — can now be incorporated. Many applications which did not even exist in 1966 (some of which were originally spawned by the publication of Lieb & Mattis) are newly included. Among these, this new book contains critical surveys of a number of important developments: the exact solution of the Hubbard model, the concept of spinons, the Haldane gap in magnetic spin-one chains, bosonization and fermionization, solitons and the approach to thermodynamic equilibrium, quantum statistical mechanics, localization of normal modes and eigenstates in disordered chains, and a number of other contemporary concerns.

Relativistic Density Functional for Nuclear Structure

The book reviews several theoretical, mostly exactly solvable, models for selected systems in condensed states of matter, including the solid, liquid, and disordered states, and for systems of few or many bodies, both with boson, fermion, or anyon statistics. Some attention is devoted to models for quantum liquids, including superconductors and superfluids. Open problems in relativistic fields and quantum gravity are also briefly reviewed. The book ranges almost comprehensively, but concisely, across several fields of theoretical physics of matter at various degrees of correlation and at different energy scales, with relevance to molecular, solid-state, and liquid-state physics, as well as to phase transitions, particularly for quantum liquids. Mostly exactly solvable models are presented, with attention also to their numerical approximation and, of course, to their relevance for experiments. Contents: Low-Order Density Matrices Solvable Models for Small Clusters of Fermions Small Clusters of Bosons Anyon Statistics with Models Superconductivity and Superfluidity Exact Results for an Isolated Impurity in a Solid Pair Potential and Many-Body Force Models for Liquids Anderson Localization in Disordered Systems Statistical Field Theory: Especially Models of Critical Exponents Relativistic Fields Towards Quantum Gravity Appendices Readership: Graduate students and researchers in condensed matter theory.

The Many-body Problem

Single-volume account of methods used in dealing with the many-body problem and the resulting physics. Single-particle approximations, second quantization, many-body perturbation theory, Fermi fluids, superconductivity, many-boson systems, more. Each chapter contains well-chosen problems. Only prerequisite is basic understanding of elementary quantum mechanics. 1967 edition.

Relativistic Quantum Mechanics of Electrons

These proceedings discuss the quantal system with many particles mainly from the theoretical point of view. The topics discussed include the relativistic nuclear many-body problem, perspective in hadron

structure, mean-field and semiclassical methods, thermal theories, symmetries and group theoretical methods, and density functional theories.

Group Theory and the Many-body Problem

This book explains the development of the SHP theory, reviews its basic concepts, and gives examples of its applications..

Exactly Solvable Models in Many-Body Theory

An expert and illuminating review of the leading models of nuclear structure: effective field theories based on quantum chromodynamics; ab initio models based on Monte Carlo methods employing effective nucleon-nucleon interactions; diagonalization and the Monte Carlo shell model; non-relativistic and relativistic mean-field theory and its extensions; and symmetry-dictated approaches. Theoretical advances in major areas of nuclear structure are discussed: nuclei far from stability and radioactive ion beams; gamma ray spectroscopy; nuclear astrophysics and electroweak interactions in nuclei; electron scattering; nuclear superconductivity; superheavy elements. The interdisciplinary aspects of the many-body problem are also discussed. Recent experimental data are examined in light of state-of-the-art calculations. Recent advances in several broad areas of theoretical structure are covered, making the book ideal as a supplementary textbook.

Applications of a Relativistic Quantum Field Theory to the Nuclear Many-body Problem

Auth: Georgian Academy of Sciences, Highly mathematical.

The Many-Body Problem in Quantum Mechanics

Standard textbooks on the many-body problem do not include a wealth of valuable experimental data, in particular recent results from direct knockout reactions, which are directly related to the single-particle propagator in many-body theory. In this indispensable book, the comparison with experimental data is incorporated from the start, making the abstract concept of propagators vivid and comprehensible. The discussion of numerical calculations using propagators or Green's functions, also absent from current textbooks, is presented in this book. Much of the material has been tested in the classroom and the introductory chapters allow a seamless connection with a one-year graduate course in quantum mechanics. While the majority of books on many-body theory deal with the subject from the viewpoint of condensed matter physics, this book also emphasizes finite systems and should be of considerable interest to researchers in nuclear, atomic, and molecular physics. A unified treatment of many different many-body systems is presented using the approach of self-consistent Green's functions. Several topics, not available in other books, in particular the description of atomic Bose–Einstein condensates, have been included. The coverage proceeds in a systematic way from elementary concepts, such as second quantization and mean-field properties, to a more advanced but self-contained presentation of the physics of atoms, molecules, nuclei, nuclear and neutron matter, electron gas, quantum liquids, atomic Bose–Einstein and fermion condensates, and pairing correlations in finite and infinite systems.

Many-body Physics - Proceedings Of The International Conference

This book focuses treatable This class on exactly many' body problems. does not include most We are therefore reminded "of physical problems. the of the man home late at after an alcoholic who, story returning night the for his under he was a knew, evening, scanning ground key lamppost; be that he had it somewhere but under the to sure, dropped else, only Yet was there to conduct a searchW' . light lamppost enough proper we feel the interest for such models is nowadays sufficiently widespread because of their their mathematical relevance and their multi beauty, furious that need be made for no our apologies applicative potential choice. In whoever undertakes to read this book will know from any case, its title what she is in for! Yet this title a of it some may require explanations: gloss (including its extended inside front follows. version, see cover) and nonrelativistic "Classical" we mean nonquantal (although By consider the which indeed some are Ruijsenaars Schneider models, treated in this relativistic versions as known, nonre book, of, previously lativistic is focussed see our on models; below): presentation mainly of whose time evolution is determined many body point particles systems Newtonian of motion to by equations (acceleration proportional force).

Relativistic Many-body Theory and Statistical Mechanics

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.

Methods in Relativistic Nuclear Physics

Proceedings of the Seventh International Conference on Recent Progress in Many-Body Theories at the U. of Minnesota, August 1991. Papers are divided into seven sections representing diverse areas of physics: nuclear theory, condensed matter, quantum fluids and solids, atomic many-body, models and me

The Nuclear Many-Body Problem 2001

Density Functional Theory is a rapidly developing branch of many-particle physics that has found applications in atomic, molecular, solid-state and nuclear physics. This book describes the conceptual framework of density functional theory and discusses in detail the derivation of explicit functionals from first principles as well as their application to Coulomb systems. Both non-relativistic and relativistic systems are treated. The connection of density functional theory with other many-body methods is highlighted. The presentation is self-contained; the book is, thus, well suited for a graduate course on density functional theory.

Relativistic Nuclear Physics in the Light Front Formalism

Taking a heuristic approach to relativistic quantum mechanics, Practical Quantum Electrodynamics provides a complete introduction to the theory, methodologies, and calculations used for explaining the physical interaction of charged particles. This book combines the principles of relativity and quantum theory necessary for performing the calculations of the electromagnetic scattering of electrons and positrons and the emission and absorption of photons. Beginning with an introduction of the wave equations for spin-0 and spin-1/2 particles, the author compares and contrasts the relativistic and spin effects for both types of particles. He emphasizes how the relativistic treatment of quantum mechanics and the spin-1/2 degree of freedom are necessary to describe electromagnetic interactions involving electron scattering and points out the shortfalls of the wave-equation approach to relativistic quantum mechanics. Developing the Feynman rules for quantum electrodynamics by example, the book offers an intuitive, hands-on approach for performing fundamental calculations. It also illustrates how to perform calculations that can be related to experiments such as diagrams, lifetimes, and cross sections. Practical Quantum Electrodynamics builds a strong foundation for further studies and research in theoretical and particle physics, particularly relativistic quantum field theory or nonrelativistic many-body theory.

Relativistic Many-body Theory and Statistical Mechanics

This work explores the application of harmonic oscillator states in problems of atomic, molecular, nuclear and elementary particle physics. The early chapters offer a comprehensive discussion of

problems involving from one to four particles and the n -particle problem in the Hartree-Fock approximation, with extensive use of the transformation brackets for harmonic oscillator coefficients and related concepts. The application of harmonic oscillator states to scattering problems is also discussed, as is the group theory underlying the harmonic oscillator and its application to the Coulomb problem, collective motions in nuclei, and relativistic many body problems with oscillator interactions. Written by two internationally-recognized experts in the field, this book will serve as an essential resource for the serious graduate student as well as the professional physicist or mathematician.

Many-Body Theory Exposed!

Aage Bohr (1922-2009) was the central artificer of the unification of the independent (shell) -- and of the collective (liquid drop) -- models of the atomic nucleus. This unification constitutes the basis of what can be called the second discovery of the atomic nucleus, for which Aage Bohr and his close collaborator Ben Mottelson co-shared the 1975 Nobel Prize in Physics. The selected papers of Aage Bohr published in the present volume provide a clear account of Aage Bohr's ideas concerning the finite quantal many-body system. These ideas changed the nuclear paradigm and connected the field of nuclear physics with that of quantum condensed matter physics as well as with Quantum Electrodynamics (QED). It has also inspired a whole generation of theorists and experimentalists, helping to create the "Copenhagen School of Nuclear Physics" which turned the Niels Bohr Institute into the Mecca for research in this subject during the 1960s and 1970s. The legacy of Aage Bohr's scientific achievements and that of the school he founded are felt to this day in connection with the cutting-edge research carried out at the forefront of nuclear structure and nuclear reaction studies. Remembering the words of the sage that "We are dwarfs mounted on the shoulders of giants, so that we can see more and further than they"

Classical Many-Body Problems Amenable to Exact Treatments

This introduction to the field of many-body atomic physics is suitable for researchers and graduate students. Drawing from three major subject areas, atomic structure, atomic photoionization, and electron-atom collisions, this book begins with an introduction to many-body diagrams, and continues with several chapters devoted to each subject area written by leading theorists in that field. Topics in atomic structure include the relativistic theory for highly charged atomic ions and calculations of parity nonconservation. Topics in atomic photoionization include single and double photoionization processes, and photoelectron angular distributions. Topics in electron-atom collisions include the theory of electron impact ionization, perturbation series methods, target dependence of the triply differential cross section, Thomas processes, R-matrix theory, close coupling, and distorted-wave theory. This coherent and carefully edited volume has been prepared by leading atomic physicists as a tribute to Hugh Kelly, one of the pioneers of many-body theory.

Relativity, Symmetry, and the Structure of Quantum Theory, Volume 2

The book contains pedagogical articles on the dominant non-stochastic methods of microscopic many-body theories: Density functional theory, coupled cluster theory, and correlated basis functions methods in their widest sense. Further articles introduce students to applications of these methods in front -- line research such as Bose-Einstein condensates, the nuclear many-body problem, and the dynamics of quantum liquids. These keynote articles are supplemented by experimental reviews on intimately connected topics of current relevance. The book addresses the striking lack of pedagogical reference literature in the field that allows researchers to acquire the requisite physical insight and technical skills. The volume should, therefore, not only researchers to acquire the requisite physical insight and technical skills. The volume should, therefore, not only serve as a collection of information relevant to those who attended the school, but it provides be useful reference material to a broad range of theoretical physicists in condensed matter and nuclear theory.

The N-Body Problem in General Relativity

In the new edition only minor modifications have been made. Some printing errors have been corrected and a few clarifications have been made. In recent years the activity in relativistic many-body theory has increased considerably, but this field falls outside the scope of this book. A brief summary of the recent developments, however, has been included in the section on "relativistic effects" in Chap. 14. In addition, only a very limited number of references have been added, without any systematic updating of the material. Goteborg, December 1985 I. Lindgren · J. Morrison Preface to the First Edition This book

has developed through a series of lectures on atomic theory given these last eight years at Chalmers University of Technology and several other research centers. These courses were intended to make the basic elements of atomic theory available to experimentalists working with the hyperfine structure and the optical properties of atoms and to provide some insight into recent developments in the theory.

Recent Progress in Many-body Theories

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 fundamental role as the equations of motion themselves. Heisenberg was probably the first to recognize that the ground state, the vacuum, could acquire certain properties (quantum numbers) when he devised a theory of ferromagnetism. Since then, many more such examples are known in solid state physics, e. g. superconductivity, 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 widely accepted that the same field theory may be based on different vacua. Practically all these different field phases have the status of more or less hypothetical models, not (yet) directly accessible to experiments. There is one magnificent exception and this is the change of the ground state (vacuum) of the electron-positron field in superstrong electric fields.

Proceedings of the International Conference on Many-Body Physics, Coimbra, Portugal, 20-25 September, 1993

Relativistic Many-body Bound Systems