

# Relativistic Quantum Mechanics with an Introduction to Tensors

$$(p^\mu \cdot p_\mu) \psi = m^2 c^2 \psi$$
$$i\hbar \frac{\partial \psi}{\partial t} = (c \vec{\alpha} \cdot \vec{p} + m \beta c^2) \psi$$



Dr. Mohammad Masroor Ahmed

# Relativistic Quantum Mechanics

**Pauchy W-y Hwang**



## **Relativistic Quantum Mechanics:**

**An Introduction to Relativistic Quantum Field Theory** Silvan S. Schweber, 2013-10-10 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

**Relativistic Quantum Mechanics and Introduction to Quantum Field Theory** Anton Z. Capri, 2002 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 Mechanics 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

Relativistic Quantum Mechanics Armin Wachter, 2010-09-29 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

**Relativistic Quantum Mechanics** Ian Johnston Rhind Aitchison, 1972

*Relativistic Quantum Physics* Tommy Ohlsson, 2011-09-22 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

**Relativistic Quantum Mechanics And Quantum Fields** Ta-you Wu, Pauchy W-y Hwang, 1991-03-06 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

**Relativistic Quantum Mechanics** Luciano Maiani, Omar Benhar, 2015-11-18 Written by two of the most prominent leaders in particle physics Relativistic Quantum Mechanics An Introduction to Relativistic Quantum Fields provides a classroom tested introduction to the formal and conceptual foundations of quantum field theory Designed for advanced undergraduate and graduate level physics students the text only requires p

**Relativistic Quantum Mechanics** James D. Bjorken, Sidney David Drell, 1964 In this text the authors develop a propagator theory of Dirac particles photons and Klein Gordon mesons and perform 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 radiative corrections such as the Lamb shift in low order calculations The necessary background for the book is provided by a course in nonrelativistic quantum mechanics at the general level of Schiff's text QUANTUM MECHANICS

*Relativistic Quantum Mechanics* Paul Strange, 1998-09-17 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

**Relativistic Quantum Mechanics** R. Parthasarathy, 2010 Relativistic Quantum Mechanics begins with the Klein Gordon equation describing its features and motivating the need for a correct relativistic equation for the electron It then introduces the Dirac equation by linearizing the second order relativistic equation which reveals the spin spin magnetic moment and the spin orbit coupling of the electron After demonstrating the relativistic covariance of the Dirac equation the discrete transformations of the Dirac spinor are explained The Dirac equation for a free electron and an electron in hydrogen atom are solved these solutions are used to interpret the negative energy states in the hole theory of Dirac As applications of the Dirac equation the scattering of electrons by a Coulomb

potential is given in detail and extended to electron proton scattering As a further application the Dirac equation with zero mass is considered to describe the neutrino The chapter on neutrinos contains a brief description of neutrino oscillations The book ends with giving an elementary treatment of spin manifolds with illustrative examples **Relativistic Quantum**

**Mechanics** Walter Greiner,2013-06-29 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 **Relativistic Quantum**

**Mechanics and Introduction to Field Theory** Francisco J. Yndurain,2012-12-06 A fully relativistic treatment of the quantum mechanics of particles requires the introduction of quantum field theory that is to say the quantum mechanics of systems with an infinite number of degrees of freedom This is because the relativistic equivalence of mass and energy plus the quantum possibility of fluctuations imply the existence of real or virtual creation and annihilation of particles in unlimited numbers In spite of this there exist processes and energy ranges where a treatment in terms of ordinary quantum mechanical tools is appropriate and the approximation of neglecting the full field theoretic description is justified Thus one may use concepts such as potentials and wave equations classical fields and classical currents etc The present text is devoted precisely to the systematic discussion of these topics to which we have added a general description of one and two particle relativistic states in particular for scattering processes A field theoretic approach may not be entirely avoided and in fact an introduction to quantum field theory is presented in this text However field theory is not the object per se of this book apart from a few examples field theory is mainly employed to establish the connection with equivalent potentials to study the classical limit of the emission of radiation or to discuss the propagation of a fermion in classical electromagnetic fields

**Textbook of Relativistic Quantum Physics** V Devanathan,2018-06-08 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 Gauge 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 *Relativistic Quantum Mechanics* Hartmut Pilkuhn,2013-06-29 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 as well as classical relativistic mechanics appear as special cases They are the sources of familiar names such as orbital angular momentum spin orbit coupling and magnetic moment for operators of the relativistic quantum formalism The theory of binaries in terms of differential equations is treated for the first time in this book These have the mathematical structure of the corresponding one body equations Klein Gordon for two spinless particles Dirac for two spinor particles with a relativistically reduced mass They allow the calculation of radiative corrections via the vector potential operator

**Relativistic and Non-Relativistic Quantum Mechanics** Luis Grave de Peralta, Maricela Fernández Lozada, Hira Farooq, Gage Eichman, Abhishek Singh, Gabrielle Prime, 2023-08-28 Currently relativistic quantum mechanics is considered an advanced topic only accessible to students who have already received considerable training in non relativistic quantum mechanics However the authors believe that they have found an excellent pedagogic approach for simultaneously introducing both topics This book is considered an Introductory Quantum Mechanics textbook that presents relativistic quantum mechanics to interested learners with no previous knowledge of it The authors avoid utilization of the well known Lorentz invariant equations Additionally they only refer to the Klein Gordon and Dirac equations to justify the use of the Poveda Poirier Grave de Peralta PGP equations upon which this book is solely based while sporadically referring to well known results obtained using the Klein Gordon and Dirac equations to avoid unnecessary complications in an introductory book There also exist two complementary Schrödinger like and Pauli like PGP equations the solutions of which are identical to the respective solutions of the Klein Gordon and Dirac equations associated with negative kinetic energies These equations relation to the existence of antiparticles is discussed The intended readership is undergraduate physics chemistry and engineering students with no previous knowledge of quantum mechanics as well as graduate students and professionals interested in the subject

**Relativistic Quantum Mechanics and Field Theory** Franz Gross, 2008-07-11 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

**Relativistic Quantum Mechanics And Quantum Fields: Second Edition For The 21st Century** Pauchy W-y Hwang, 2018-04-26 This present edition of the book 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

**Advanced Quantum Mechanics** Franz Schwabl, 2008-08-01 Advanced Quantum Mechanics the second volume on quantum mechanics by Franz Schwabl discusses nonrelativistic multi particle systems relativistic wave equations and relativistic quantum fields Characteristic of the author's work are the comprehensive mathematical discussions in which all intermediate steps are derived and where numerous examples of application and exercises help the reader gain a thorough working knowledge of the subject The topics treated in the book lay the foundation for advanced studies in solid state physics nuclear and elementary particle physics This text both extends and complements Schwabl's introductory Quantum Mechanics which covers nonrelativistic quantum mechanics and offers a short treatment of the quantization of the radiation field The fourth edition has been thoroughly revised with new material having been added Furthermore the layout of the figures has been unified which should facilitate comprehension

**Relativistic Quantum Mechanics of Leptons and Fields** W.T. Grandy, 1991 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 discussion 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

*Relativistic Quantum Mechanics* Luciano Maiani, Omar Benhar, 2024 Written by two of the most prominent leaders in particle physics Relativistic Quantum Mechanics An Introduction to Relativistic Quantum Fields provides a classroom tested introduction to the formal and conceptual foundations of quantum field theory Designed for advanced undergraduate and graduate level physics students the text only

requires previous courses in classical mechanics relativity and quantum mechanics The introductory chapters of the book summarise the theory of special relativity and its application to the classical description of the motion of a free particle and a field The authors then explain the quantum formulation of field theory through the simple example of a scalar field described by the Klein Gordon equation as well as its extension to the case of spin particles described by the Dirac equation They also present the elements necessary for constructing the foundational theories of the standard model of electroweak interactions namely quantum electrodynamics and the Fermi theory of neutron beta decay Many applications to quantum electrodynamics and weak interaction processes are thoroughly analysed The book also explores the timely topic of neutrino oscillations Logically progressing from the fundamentals to recent discoveries this textbook provides students with the essential foundation to study more advanced theoretical physics and elementary particle physics It will help them understand the theory of electroweak interactions and gauge theories



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