

For relativistic case, we start with relativistic energy momentum relationship

$$E^2 = \mathbf{p}^2 + m^2,$$
$$E^2 - \mathbf{p}^2 = p^\mu p_\mu = m^2. \quad \text{-----}(3)$$

Using operator substitution and operating over scalar wave function ϕ

$$p^\mu p_\mu \phi = m^2 \phi,$$

$$\text{or,} \quad (i\hbar\partial^\mu)(i\hbar\partial_\mu)\phi = m^2\phi,$$

$$\text{or,} \quad -\hbar^2\Box\phi = m^2\phi. \quad \Box = \partial^2 = \partial^\mu\partial_\mu = \frac{\partial^2}{\partial t^2} - \nabla^2,$$

Relativistic Quantum Mechanics Wave Equa

Douglas M. Gingrich



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Relativistic Quantum Mechanics. Wave Equations Walter Greiner, 2013-03-09 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 Mechanics: Wave Equations, 3E Walter Greiner, 2007-01-01 *Practical Quantum Electrodynamics* Douglas M.

Gingrich, 2006-05-10 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 ca

Spin - 1/2 Wave Equations in Relativistic Quantum Mechanics Donald Stephen Staudte, 1993 Relativistic Quantum Mechanics. Wave Equations Walter Greiner, 2000-06-15 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 **Advanced Molecular Quantum Mechanics** R. Moss, 2012-12-06 This book is primarily intended for graduate chemists and chemical physicists Indeed it is based on a graduate course that I give in the Chemistry Department of Southampton University Nowadays undergraduate chemistry courses usually include an introduction to quantum mechanics with particular reference to molecular properties and there are a number of excellent textbooks aimed specifically at undergraduate chemists In valence theory and molecular spectroscopy physical concepts are often encountered that are normally taken on trust For example electron spin and the anomalous magnetic moment of the electron are usually accepted as postulates although they are well understood by physicists In addition the advent of new techniques has led to experimental situations that can only be accounted for adequately by relatively sophisticated physical theory Relativistic corrections to molecular orbital energies are needed to explain X ray photo electron spectra while the use of lasers can give rise to multiphoton transitions which are not easy to understand using the classical theory of radiation Of course the relevant equations may be extracted from the literature but if the underlying physics is not understood this is a practice that is at best dissatisfying and at worst dangerous One instance where great care must be taken is in the use of spectroscopically determined parameters to test the accuracy of electronic wave functions *Wave Equations in Higher Dimensions* Shi-Hai Dong, 2011-07-09 Higher dimensional theories have

attracted much attention because they make it possible to reduce much of physics in a concise elegant fashion that unifies the two great theories of the 20th century Quantum Theory and Relativity This book provides an elementary description of quantum wave equations in higher dimensions at an advanced level so as to put all current mathematical and physical concepts and techniques at the reader's disposal A comprehensive description of quantum wave equations in higher dimensions and their broad range of applications in quantum mechanics is provided which complements the traditional coverage found in the existing quantum mechanics textbooks and gives scientists a fresh outlook on quantum systems in all branches of physics In Parts I and II the basic properties of the SO_n group are reviewed and basic theories and techniques related to wave equations in higher dimensions are introduced Parts III and IV cover important quantum systems in the framework of non relativistic and relativistic quantum mechanics in terms of the theories presented in Part II In particular the Levinson theorem and the generalized hypervirial theorem in higher dimensions the Schrödinger equation with position dependent mass and the Kaluza Klein theory in higher dimensions are investigated In this context the dependence of the energy levels on the dimension is shown Finally Part V contains conclusions outlooks and an extensive bibliography

The Dirac Equation and its Solutions Vladislav G. Bagrov, Dmitry Gitman, 2014-08-20 The Dirac equation is of fundamental importance for relativistic quantum mechanics and quantum electrodynamics In relativistic quantum mechanics the Dirac equation is referred to as one particle wave equation of motion for electron in an external electromagnetic field In quantum electrodynamics exact solutions of this equation are needed to treat the interaction between the electron and the external field exactly In this monograph all propagators of a particle i.e. the various Green's functions are constructed in a certain way by using exact solutions of the Dirac equation

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 PPGP 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 PPGP 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 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

Theoretical Physics: Relativistic quantum mechanics: wave equations Walter Greiner, 1989 **Relativistic Wave Mechanics** E. Corinaldesi, 2015-06-16 Geared toward advanced undergraduate and graduate students of physics this text provides readers with a background in relativistic wave mechanics and prepares them for the study of field theory The treatment originated as a series of lectures from a course on advanced quantum mechanics that has been further amplified

by student contributions An introductory section related to particles and wave functions precedes the three part treatment An examination of particles of spin zero follows addressing wave equation Lagrangian formalism physical quantities as mean values translation and rotation operators spin zero particles in electromagnetic field pi mesic atoms and discontinuous transformations The second section explores particles of spin one half in terms of spin operators the Weyl and Dirac equations constants of motion plane wave solutions and invariance properties of the Dirac equation the Dirac equation for a charged particle in an electromagnetic field non relativistic limit of the Dirac equation and Dirac particle in a central electrostatic field The final section on collision and radiation processes covers time independent scattering of a spinless particle non relativistic steady state scattering of a particle of spin one half time independent scattering of Dirac particles non relativistic time dependent scattering theory emission and absorption of electromagnetic radiation and time dependent relativistic scattering theory

Advanced Quantum Mechanics Franz Schwabl, 2013-06-29 Advanced Quantum Mechanics the second volume on quantum mechanics by Franz Schwabl discusses nonrelativistic multi particle systems relativistic wave equations and relativistic fields As expected in Schwabl s works the text features a compelling mathematical presentation in which all intermediate steps are derived and where numerous examples for application and exercises help the student to gain a thorough working knowledge of the subject The treatment of relativistic wave equations and their symmetries and the fundamentals of quantum field theory lay the foundations for advanced studies in solid state physics nuclear and elementary particle physics This text 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

Relativistic Quantum Mechanics and Quantum Field Theory V. Devanathan, 2011 Deals with the single particle relativistic wave equations and the elements of quantum field theory In this book 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 discussed

Relativistic Quantum Mechanics Hartmut Pilkuhn, 2005-12-12 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 This second edition of the successful textbook adds various new sections on relativistic quantum chemistry and on the relativistic treatment of the proton in hydrogen Others chapters have been expanded e g on hyperfinite interactions or carefully revisited

Relativistic Quantum Mechanics and Quantum Fields Ta-you Wu, W.-Y. Pauchy

Hwang,1991 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

Quantum Mechanics II Rubin H. Landau,1990-02-08 The first section presents detailed and thorough coverage of integral quantum mechanics and scattering In the second section an operational treatment of relativistic quantum mechanics is provided Quantum fields are introduced in the third part using perturbation theory to emphasize the connections with familiar quantum mechanics and the field theory is illustrated with examples of actual physical processes

Relativistic Quantum Mechanics Ian Johnston Rhind Aitchison,1972

Multi-time Wave Functions Matthias Lienert,Sören Petrat,Roderich Tumulka,2020-10-30 The natural generalization of the quantum mechanical N particle wave function to relativistic space time is a function of N space time points and thus of N time variables This book based on a collection of lectures given at a spring school in T bingen in 2019 provides an accessible and concise introduction to the recent development of the theory of multi time wave functions their use in quantum field theory their relation to detection probabilities and the mathematical question of consistency of their time evolution equations The book is intended for advanced students and researchers with an interest in relativity and quantum physics

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