On The Dirac Equation In Curved Space Time

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Paul Dirac
Complex Solutions to the Einstein, Maxwell, Schr�dinger, and Dirac Equations
Some Aspects of the Dirac Equation in Non-cartesian Coordinate Systems
From Spinors To Quantum Mechanics
Introduction to Relativistic Quantum Chemistry
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The Massless Dirac Equation from the Continuum Mechanics and Microlocal Analysis Perspectives

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Advanced Quantum Mechanics World Scientific
This book explains and develops the Dirac equation in the context of general relativistic quantum mechanics in a range of spacetime dimensions. It clarifies the subject by carefully pointing out the various conventions used and explaining how they are related to each other. The prerequisites are familiarity with general relativity and an exposure to the Dirac equation at the level of special relativistic quantum mechanics, but a review of this latter topic is given in the first chapter as a reference and framework for the physical interpretations that follow. Worked examples and exercises with solutions are provided. Appendices include reviews of topics used in the body of the text. This book should benefit researchers and graduate students in general relativity and in condensed matter.
Spectral Theory and the External Field Model for the Dirac Equation University-Press.org
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.
The Dirac Equation
From Spinors to Quantum Mechanics discusses group theory and its use in quantum mechanics. Chapters 1 to 4 offer an introduction to group theory, and it provides the reader with an exact and clear intuition of what a spinor is, showing that spinors are just a mathematically complete notation for group elements. Chapter 5 contains the first rigorous derivation of the Dirac equation from a simple set of assumptions. The remaining chapters will interest the advanced reader who is interested in the meaning of quantum mechanics. They propose a novel approach to the foundations of quantum mechanics, based on the idea that the meaning of the formalism is already provided by the mathematics.In the traditional approach to quantum mechanics as initiated by Heisenberg, one has to start from a number of experimental results and then derive a set of rules and

calculations that reproduce the observed experimental results. In such an inductive approach the underlying assumptions are not given at the outset. The reader has to figure them out, and this has proven to be difficult. The book shows that a different, bottom-up approach to quantum mechanics is possible, which merits further investigation as it demonstrates that with the methods used, the reader can obtain the correct results in a context where one would hitherto not expect this to be possible.

Solution of the Dirac Equation in Non-Asymptotically Flat Geometries Courier Dover Publications

This book comprises the lectures of a two-semester course on quantum field theory, presented in a quite informal and personal manner. The course starts with relativistic one-particle systems, and develops the basics of quantum field theory with an analysis on the representations of the Poincaré group. Canonical quantization is carried out for scalar, fermion, Abelian and non-Abelian gauge theories. Covariant quantization of gauge theories is also carried out with a detailed description of the BRST symmetry. The Higgs phenomenon and the standard model of electroweak interactions are also developed systematically. Regularization and (BPHZ) renormalization of field theories as well as gauge theories are discussed in detail, leading to a derivation of the renormalization group equation. In addition, two chapters — one on the Dirac quantization of constrained systems and another on discrete symmetries — are included for completeness, although these are not covered in the two-semester course.This second edition includes two new chapters, one on Nielsen identities and the other on basics of global supersymmetry. It also includes two appendices, one on fermions in arbitrary dimensions and the other on gauge invariant potentials and the Fock-Schwinger gauge.

The Dirac Equation in Curved Spacetime

American Mathematical Soc.

This new edition presents a unified description of these insulators from one to three dimensions based on the modified Dirac equation. It derives a series of solutions of the bound states near the boundary, and describes the current status of these solutions. Readers are introduced to topological invariants and their applications to a variety of systems from one-dimensional polyacetylene, to two-dimensional quantum spin Hall effect and p-wave superconductors, three-dimensional topological insulators and superconductors or superfluids, and topological Weyl semimetals, helping them to better understand this fascinating field. To reflect research advances in topological insulators, several parts of the book have been updated for the second edition, including: Spin-Triplet Superconductors, Superconductivity in Doped Topological Insulators, Detection of Majorana Fermions and so on. In particular, the book features a new chapter on Weyl semimetals, a topic that has attracted considerable attention and has already become a new hotpot of research in the community.

Nonlinear Dirac Equation: Spectral Stability of Solitary Waves Walter de

Gruyter GmbH & Co KG
Visual Quantum Mechanics is a systematic effort to investigate and to teach quantum mechanics with the aid of computer-generated animations. Although it is self-contained, this book is part of a two-volume set on Visual Quantum Mechanics. The first book appeared in 2000, and earned the European Academic Software Award in 2001 for oustanding innovation in its field. While topics in book one mainly concerned quantum mechanics in one- and two-dimensions, book two sets out to present three-dimensional systems, the hydrogen atom, particles with spin, and relativistic particles. Together the two volumes constitute a complete course in quantum mechanics that places an emphasis on ideas and concepts, with a fair to moderate amount of mathematical rigor.
Parallel Implementation of the Dirac Equation in Three Cartesian Dimensions World Scientific
Please note that the content of this book primarily consists of articles available from Wikipedia or other free sources online. Pages: 38. Chapters: Dirac adjoint, Dirac equation, Dirac equation in the algebra of physical space, Dirac spinor, Fermionic field, Feynman checkerboard, Feynman slash notation, Fierz identity, Gamma matrices, Higher-dimensional gamma matrices, Killing spinor, Majorana equation, Orientation entanglement, Plate trick, Pure spinor, Rarita-Schwinger equation, Spinors in three dimensions, Spinor field, Spin connection, Spin group, Spin representation, Spin spherical harmonics, Tangloids, Triality, Van der Waerden notation, Weyl-Brauer matrices.
A Guide for Calculations Springer Science & Business Media
This collection brings together the five books of the series "concepts of physics". The books cover the following topics: complex numbers, special relativity, the mathematics for quantum mechanics, the Dirac equation, relativity, decays and electromagnetic fields. These are basic concepts of physics, indispensable for its complete understanding.
The Dirac equation Springer Science & Business Media
This book is dedicated to the Dirac equation. The main arguments are: Dirac equation, gamma matrices in Dirac representation, properties of gamma matrices, covariance of the Dirac equation, Dirac Lagrangian and derivation of the Dirac equation from the equations of the Euler-Lagrange motion, Dirac equation in Hamiltonian form and free solutions in the rest and in any reference frame.
The Dirac Equation and its Solutions Springer
The Dirac equation, a relativistic quantum mechanical wave equation invented by Paul Dirac in 1928, originally designed to overcome the negative probability problem arising in the Klein-Gordon's scalar wave equation. The Dirac equation is fully consistent with the principles of quantum mechanics and largely in accordance with the theory of General Relativity. Paul Dirac's original equation can be modified to an advanced form in order to have the behaviors of the fermions in any curved spacetime. In this regard, the pioneering work of the Dirac equation in the asymptotically flat spacetime around a Kerr black hole was done by

Nobel laureate Subrahmanyan Chandrasekhar in 976. After Chandrasekhar, progress was made to analyzing the Dirac equation in a non-asymptotically flat geometry, which is now a major focus of attention in Einstein's gravity theory enriched with various fields like Maxwell, Yang-Mills, Born-Infeld etc. Izzet Sakalli, one of the researchers of the Dirac equation, develops and explains some methods about how one separates and solves the Dirac equation in non-asymptotically flat geometry.

A Whirlwind Tour of Special Relativity World Scientific

The Maxwell, Einstein, Schr□dinger and Dirac equations are considered the most important equations in all of physics. This volume aims to provide new eight- and twelve-dimensional complex solutions to these equations for the first time in order to reveal their richness and continued importance for advancing fundamental Physics. If M-Theory is to keep its promise of defining the ultimate structure of matter and spacetime, it is only through the topological configurations of additional dimensionality (or degrees of freedom) that this will be possible. Stretching the exploration of complex space through all of the main equations of Physics should help tighten the noose on ?the? fundamental theory. This kind of exploration of higher dimensional spacetime has for the most part been neglected by M-theorists and physicists in general and is taken to its penultimate form here.

Elementary Theory Springer Science & Business Media

This monograph gives a comprehensive treatment of spectral (linear) stability of weakly relativistic solitary waves in the nonlinear Dirac equation. It turns out that the instability is not an intrinsic property of the Dirac equation that is only resolved in the framework of the second quantization with the Dirac sea hypothesis. Whereas general results about the Dirac-Maxwell and similar equations are not yet available, we can consider the Dirac equation with scalar self-interaction, the model first introduced in 1938. In this book we show that in particular cases solitary waves in this model may be spectrally stable (no linear instability). This result is the first step towards proving asymptotic stability of solitary waves. The book presents the necessary overview of the functional analysis, spectral theory, and the existence and linear stability of solitary waves of the nonlinear Schrödinger equation. It also presents the necessary tools such as the limiting absorption principle and the Carleman estimates in the form applicable to the Dirac operator, and proves the general form of the Dirac-Pauli theorem. All of these results are used to prove the spectral stability of weakly relativistic solitary wave solutions of the nonlinear Dirac equation.

The Dirac Equation
World Scientific

This book covers advanced topics in quantum mechanics, including nonrelativistic multi-particle systems, relativistic wave equations, and relativistic fields. Numerous examples for application help readers gain a thorough understanding of the subject. The presentation 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. The authors earlier book, Quantum Mechanics, was praised for its unsurpassed clarity.

The Dirac Equation in Projective Relativity Cambridge University Press

The solution of the Dirac equation for an electron in a Coulomb field is systematically treated here by utilizing new insights provided by supersymmetry. It is shown that each of the concepts has its analogue in the non-relativistic case. Indeed, the non-relativistic case is developed first, in order to introduce the new concepts in a familiar context. The symmetry of the non-relativistic model is already present in the classical limit, so the classical Kepler problem is first discussed in order to bring out the role played by the Laplace vector, one of the central concepts of the whole book. Analysis of the concept of eccentricity of the orbits turns out to be essential to understanding the relation of the classical and quantum mechanical models. The opportunity is taken to relive the great moments of physics: From Kepler's discovery of the laws of motion of the planets the development is traced through the Dirac equation up to modern advances, which bring the concepts of supersymmetry to bear on the derivation of the solutions.

Dirac's equation in a Weyl space Springer Science & Business Media

This book provides a hands-on experience with atomic structure calculations. Material covered includes angular momentum methods, the central field Schrödinger and Dirac equations, Hartree-Fock and Dirac-Hartree-Fock equations, multiplet structure, hyperfine structure, the isotope shift, dipole and multipole transitions, basic many-body perturbation theory, configuration interaction, and correlation corrections to matrix elements. The book also contains numerical methods for solving the Schrödinger and Dirac eigenvalue problems and the (Dirac)-Hartree-Fock equations.

Exact Solutions of the Dirac Equation in Spatially Nonflat Robertson-Walker Space Times Forschungszentrum Jülich

Ever since its invention in 1929 the Dirac equation has played a fundamental role in various areas of modern physics and mathematics. Its applications are so widespread that a description of all aspects cannot be done with sufficient depth within a single volume. In this book the emphasis is on the role of the Dirac equation in the relativistic quantum mechanics of spin-1/2 particles. We cover the range from the description of a single free particle to the external field problem in quantum electrodynamics. Relativistic quantum mechanics is the historical origin of the Dirac equation and has become a fixed part of the education of theoretical physicists. There are some famous textbooks covering this area. Since the appearance of these standard texts many books (both physical and mathematical) on the non relativistic Schrodinger equation have been published, but only very few on the Dirac equation. I wrote this book because I felt that a modern, comprehensive presentation of Dirac's electron theory satisfying some basic requirements of mathematical rigor was still missing.

Advanced Visual Quantum Mechanics LAP Lambert Academic Publishing
The Dirac EquationSpringer Science & Business Media
Clifford Algebras and Their Applications in Mathematical Physics Springer Science & Business Media
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 Quantum Mechanics Oxford University Press
This fifteenth volume of the Poincare Seminar Series, Dirac Matter, describes the surprising resurgence, as a low-energy effective theory of conducting electrons in many condensed matter systems, including graphene and topological insulators, of the famous equation originally invented by P.A.M. Dirac for relativistic quantum mechanics. In five highly pedagogical articles, as befits their origin in lectures to a broad scientific audience, this book explains why Dirac matters. Highlights include the detailed "Graphene and Relativistic Quantum Physics", written by the experimental pioneer, Philip Kim, and devoted to graphene, a form of carbon crystallized in a two-dimensional hexagonal lattice, from its discovery in 2004-2005 by the future Nobel prize winners Kostya Novoselov and Andre Geim to the so-called relativistic quantum Hall effect; the review entitled "Dirac Fermions in Condensed Matter and Beyond", written by two prominent theoreticians, Mark Goerbig and Gilles Montambaux, who consider many other materials than graphene, collectively known as "Dirac matter", and offer a thorough description of the merging transition of Dirac cones that occurs in the energy spectrum, in various experiments involving stretching of the microscopic hexagonal lattice; the third contribution, entitled "Quantum Transport in Graphene: Impurity Scattering as a Probe of the Dirac Spectrum", given by Hélène Bouchiat, a leading experimentalist in mesoscopic physics, with Sophie Guéron and Chuan Li, shows how measuring electrical transport, in particular magneto-transport in real graphene devices - contaminated by impurities and hence exhibiting a diffusive regime - allows one to deeply probe the Dirac nature of electrons. The last two contributions focus on topological insulators; in the authoritative "Experimental Signatures of Topological Insulators", Laurent Lévy reviews recent experimental progress in the physics of mercury-telluride samples under strain, which demonstrates that the surface of a three-dimensional topological insulator hosts a two-dimensional massless Dirac metal; the illuminating final contribution by David Carpentier, entitled "Topology of Bands in Solids: From Insulators to Dirac Matter", provides a

geometric description of Bloch wave functions in terms of Berry phases and parallel transport, and of their topological classification in terms of invariants such as Chern numbers, and ends with a perspective on three-dimensional semi-metals as described by the Weyl equation. This book will be of broad general interest to physicists, mathematicians, and historians of science.

Quantum Mechanics in the Geometry of Space-Time Springer Science & Business Media

The thesis is concerned with the study of the massless Dirac equation. In the first part we study the massless Dirac equation in dimension 1+3 in the stationary setting, i.e. when the spinor field oscillates harmonically in time. We suggest a new geometric interpretation for this equation. We think of our 3-dimensional space as an elastic continuum and assume that material points can experience no displacements, only rotations. This framework is a special case of the Cosserat theory of elasticity. Rotations of material points are described mathematically by attaching to each geometric point an orthonormal basis which gives a field of orthonormal bases called the coframe. As the dynamical variables we choose the coframe and a density. We choose a particular potential energy which is conformally invariant and then incorporate time into our action by subtracting kinetic energy. We prove that in the stationary setting our model is equivalent to a pair of massless Dirac equations. In the second part we consider an elliptic self-adjoint first order pseudodifferential operator acting on columns of m complex-valued half-densities over a compact n-dimensional manifold. The eigenvalues of the principal symbol are assumed to be simple but no assumptions are made on their sign, so the operator is not necessarily semi-bounded. We study the spectral function and derive a two-term asymptotic formula. We then restrict our study to the case when m=2, n=3, the operator is differential and has trace-free principal symbol, and address the question: is our operator a massless Dirac operator? We prove that it is a massless Dirac operator if and only if, at every point, a) the subprincipal symbol is proportional to the identity matrix and b) the second asymptotic coefficient of the spectral function is zero.