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Shun-Qing Shen

Topological Insulators

Dirac Equation in Condensed Matters

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Topological Insulators Dirac Equation In Condensed Matters Springer Series In Solid State Sciences

Ari M. Turner, Ashvin Vishwanath



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Topological Insulators Shun-Qing Shen, 2013-01-11 Topological insulators are insulating in the bulk but process metallic states present around its boundary owing to the topological origin of the band structure The metallic edge or surface states are immune to weak disorder or impurities and robust against the deformation of the system geometry This book the first of its kind on topological insulators presents a unified description of topological insulators from one to three dimensions based on the modified Dirac equation A series of solutions of the bound states near the boundary are derived and the existing conditions of these solutions are described Topological invariants and their applications to a variety of systems from one dimensional polyacetalene to two dimensional quantum spin Hall effect and p wave superconductors and three dimensional topological insulators and superconductors or superfluids are introduced helping readers to better understand this fascinating new field This book is intended for researchers and graduate students working in the field of topological insulators and related areas Shun Qing Shen is a Professor at the Department of Physics the University of Hong Kong China

Topological Insulators Shun-Qing Shen, 2017-08-18 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

Introduction to Topological Quantum Matter & Quantum Computation Tudor D. Stanescu, 2016-12-19 What is topological about topological quantum states How many types of topological quantum phases are there What is a zero energy Majorana mode how can it be realized in a solid state system and how can it be used as a platform for topological quantum computation What is quantum computation and what makes it different from classical computation Addressing these and other related questions Introduction to Topological Quantum Matter Quantum Computation provides an introduction to and a synthesis of a fascinating and rapidly expanding research field emerging at the crossroads of condensed matter physics mathematics and computer science Providing the big picture this book is ideal for graduate students and researchers entering this field as it allows for the fruitful transfer of paradigms and ideas amongst different areas and includes many specific examples to help the reader understand abstract and sometimes challenging concepts It explores the topological quantum world beyond the well known topological insulators and superconductors and emphasizes the deep

connections with quantum computation It addresses key principles behind the classification of topological quantum phases and relevant mathematical concepts and discusses models of interacting and noninteracting topological systems such as the toric code and the p wave superconductor The book also covers the basic properties of anyons and aspects concerning the realization of topological states in solid state structures and cold atom systems Quantum computation is also presented using a broad perspective which includes fundamental aspects of quantum mechanics such as Bell's theorem basic concepts in the theory of computation such as computational models and computational complexity examples of quantum algorithms and elements of classical and quantum information theory

Spin Orbitronics And Topological Properties Of Nanostructures - Lecture Notes Of The Twelfth International School On Theoretical Physics Vitalii K Dugaev,Igor Tralle,Andrzej Wal,Jozef Barnas,2017-11-24 This volume presents lecture notes of the 12th International School of Theoretical Physics held in 2016 in Rzesz w Poland The lectures serve as an introduction for young physicists starting their career in condensed matter

theoretical physics The book provides a comprehensive overview of modern ideas and advances in theories and experiments of new materials quantum nanostructures as well as new mathematical methods This lecture note is an essential source of reference for physicists and materials scientists It is also a suitable reading for graduate students

Contemporary Quantum Mechanics in Practice Lilia M. Woods,Pablo Rodríguez López,2024-06-13 This book introduces problems in quantum mechanics from topics of contemporary research interest to complement traditional textbooks

Topological Insulators Shunqing Shen,2017 **Topological Insulators**,2013-11-23 Topological Insulators volume six in the Contemporary Concepts of Condensed Matter Series describes the recent revolution in condensed matter physics that occurred in our understanding of crystalline solids The book chronicles the work done worldwide that led to these discoveries and provides the reader with a comprehensive overview of the field Starting in 2004 theorists began to explore the effect of topology on the physics of band insulators a field previously considered well understood However the inclusion of topology brings key new elements into this old field Whereas it was thought that all band insulators are essentially equivalent the new theory predicts two distinct classes of band insulators in two spatial dimensions and 16 classes in three dimensions These topological insulators exhibit a host of unusual physical properties including topologically protected gapless surface states and exotic electromagnetic response previously thought impossible in such systems Within a short time this new state of quantum matter topological insulators has been discovered experimentally both in 2D thin film structures and in 3D crystals and alloys It appears that topological insulators are quite common in nature and there are dozens of confirmed substances that exhibit this behavior Theoretical and experimental studies of these materials are ongoing with the goal of attaining the fundamental understanding and exploiting them in future practical applications Usable as a textbook for graduate students and as a reference resource for professionals Includes the most recent discoveries and visions for future technological applications All authors are prominent in the field

Advanced Topological Insulators Huixia Luo,2019-03-12 This book

is the first pedagogical synthesis of the field of topological insulators and superconductors one of the most exciting areas of research in condensed matter physics Presenting the latest developments while providing all the calculations necessary for a self contained and complete description of the discipline it is ideal for researchers and graduate students preparing to work in this area and it will be an essential reference both within and outside the classroom The book begins with the fundamental description on the topological phases of matter such as one two and three dimensional topological insulators and methods and tools for topological material s investigations topological insulators for advanced optoelectronic devices topological superconductors saturable absorber and in plasmonic devices Advanced Topological Insulators provides researchers and graduate students with the physical understanding and mathematical tools needed to embark on research in this rapidly evolving field

Dirac Matter Bertrand Duplantier, Vincent Rivasseau, Jean-Nöel Fuchs, 2017-02-01 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 H l ne Bouchiat a leading experimentalist in mesoscopic physics with Sophie Gu ron 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 L vy 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

Reshaping of

Dirac Cones in Topological Insulators and Graphene Álvaro Díaz Fernández, 2020-12-09 Dirac cones are ubiquitous to non trivial quantum matter and are expected to boost and reshape the field of modern electronics Particularly relevant examples where these cones arise are topological insulators and graphene From a fundamental perspective this thesis proposes schemes towards modifying basic properties of these cones in the aforementioned materials The thesis begins with a brief historical introduction which is followed by an extensive chapter that endows the reader with the basic tools of symmetry and topology needed to understand the remaining text The subsequent four chapters are devoted to the reshaping of Dirac cones by external fields and delta doping At all times the ideas discussed in the second chapter are always a guiding principle to understand the phenomena discussed in those four chapters As a result the thesis is cohesive and represents a major advance in our understanding of the physics of Dirac materials

Topological Insulators Naoto Nagaosa, 2013-11-23 The discovery of the rich topological structures of electronic states in solids has opened up many interesting possibilities The twist of the wavefunctions in momentum space which is characterized by topological invariants leads to the robust edge or surface states The electron fractionalization associated with these topological states brings about the novel physics such as absence of localization topological magneto electric effect and Majorana fermions Here we describe the principles and some concrete examples of the theoretical design of the topological materials and their functions based on these recent developments

Topological Insulator and Related Topics Lu Li, Kai Sun, 2021-09-28 Topological Insulator and Related Topics Volume 108 in the Semiconductors and Semimetal series highlights new advances in the field with this new volume presenting interesting chapters on topics such as Majorana modes at the ends of one dimensional topological superconductors Optical electronic properties of Weyl semimetals High magnetic fields to unveil the electronic structure magnetic field induced transitions and unconventional transport properties of topological semimetals New aspects of strongly correlated superconductivity in the nearly flat band regime Anomalous transport properties in topological semimetals Pseudo gauge field and piezo electromagnetic response in topological materials Topological Gapped States Protected by Spatial Symmetries and more Provides the authority and expertise of leading contributors from an international board of authors Presents the latest release in the Semiconductors and Semimetals series Updated release includes the latest information on Topological Insulator and Related Topics

Topological Insulators Gregory Tkachov, 2015-10-14 This book is the result of dynamic developments that have occurred in condensed matter physics after the recent discovery of a new class of electronic materials topological insulators A topological insulator is a material that behaves as a band insulator in its interior while acting as a metallic conductor at its surface The surface current car

Topological Insulators Joel E. Moore, 2013-11-23 The theory of the topological insulator phase that emerges via spin orbit coupling in three dimensional materials is introduced stressing its relationship to earlier topological phases in two dimensions An unusual surface state with an odd number of Dirac points appears as a consequence of bulk topological invariants of the band structure A different theoretical approach is

then presented based on the Berry phase of Bloch electrons in order to illustrate a deep connection to the orbital contribution to the magnetoelectric polarizability in all materials The unique features of transport in the topological insulator surface state are reviewed with an emphasis on possible experiments The final section discusses briefly connections to interacting phases including topological superconductors and some recent efforts to construct fractional topological insulators in three dimensions

A Short Course on Topological Insulators János K. Asbóth, László Oroszlány, András Pályi Pályi, 2016-02-22 This course based primer provides newcomers to the field with a concise introduction to some of the core topics in the emerging field of topological insulators The aim is to provide a basic understanding of edge states bulk topological invariants and of the bulk boundary correspondence with as simple mathematical tools as possible The present approach uses noninteracting lattice models of topological insulators building gradually on these to arrive from the simplest one dimensional case the Su Schrieffer Heeger model for polyacetylene to two dimensional time reversal invariant topological insulators the Bernevig Hughes Zhang model for HgTe In each case the discussion of simple toy models is followed by the formulation of the general arguments regarding topological insulators The only prerequisite for the reader is a working knowledge in quantum mechanics the relevant solid state physics background is provided as part of this self contained text which is complemented by end of chapter problems

Topological Insulators Chaoxing Liu, Shoucheng Zhang, 2013-11-23 In the chapter we review two proto type models of topological insulators namely the Bernevig Hughes Zhang model for HgTe quantum wells and the four band model for family of materials Based on these two simple models we discuss helical edge surface states of topological insulators as well as their exotic physical properties including total angular momentum spin and orbital textures topological stability and topological response of the surface states Moreover we summarize the basic principle to search for topological insulators from these two models and discuss the related topological materials

Optical and electrical properties of topological insulator Bi₂Se₃ Jiajun Zhu, 2017-07-12 Topological insulator is one of the hottest research topics in solid state physics This is the first book to describe the vibrational spectroscopies and electrical transport of topological insulator Bi₂Se₃ one of the most exciting areas of research in condensed matter physics In particular attempts have been made to summarize and develop the various theories and new experimental techniques developed over years from the studies of Raman scattering infrared spectroscopy and electrical transport of topological insulator Bi₂Se₃ It is intended for material and physics researchers and graduate students doing research in the field of optical and electrical properties of topological insulators providing them the physical understanding and mathematical tools needed to engage research in this quickly growing field Some key topics in the emerging field of topological insulators are introduced

Topological Insulators Ari M. Turner, Ashvin Vishwanath, 2013-11-23

Effective Continuous Model on Topological Insulators Wenyu Shan, 2017-01-26 This dissertation Effective Continuous Model on Topological Insulators by Wenyu Shan was obtained from The University of Hong Kong Pokfulam Hong

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Abstract Topological insulators are electronic materials that have a conventional energy gap as an insulator or semiconductor in the bulk but possess gapless conducting states around their boundary They are novel topological states of quantum matters and exhibit a series of exotic physics such as quantum spin Hall effect single valley Dirac fermions Majorana fermions topological magnetoelectric effect etc The conducting edge and surface states have topological origin of the electron band structure and are protected by time reversal symmetry such that they are robust or immune against local perturbation In this dissertation an effective continuous model for surface states is established from the three dimensional modified Dirac model and a theory of ultrathin film for topological insulators is developed The established electronic model helps us explore spin physics of massive Dirac fermions The theory has been successfully applied to explain an energy gap opening of the surface states in Bi₂Se₃ thin film in the measurement of angle resolved photoemission spectroscopy ARPES In gap bound states are also considered due to vacancy and impurity in topological insulators It is found that a vacancy can always induce in gap bound states in both two and threedimensional topological insulators and a half quantum magnetic flux inside the vacancy can result in helical Dirac zero modes Finally the effect of random impurities on the surface transport in topological insulators is investigated particularly the weak anti localization of surface electrons in the quantum diffusion regime It is found that the spin orbit scattering may suppress the weak localization behaviors of massive Dirac fermions which suggests an experiment to detect the weak localization in the topological insulator thin film DOI 10.5353/th_b4961767 Subjects Condensed matter

Topological Insulators Xiao-Liang Qi, 2013-11-23 In this chapter we provide an overview of the topological field theory approach to topological insulators We start by reviewing the topological field theory description of integer quantum Hall states which also illustrates the general features of topological field theory approach Then we reviewed the topological field theory approach of three dimensional topological insulators and its physical consequences In the last part of this section we discuss the generalizations of topological field theory approach to generic dimensions and other topological states of matter

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