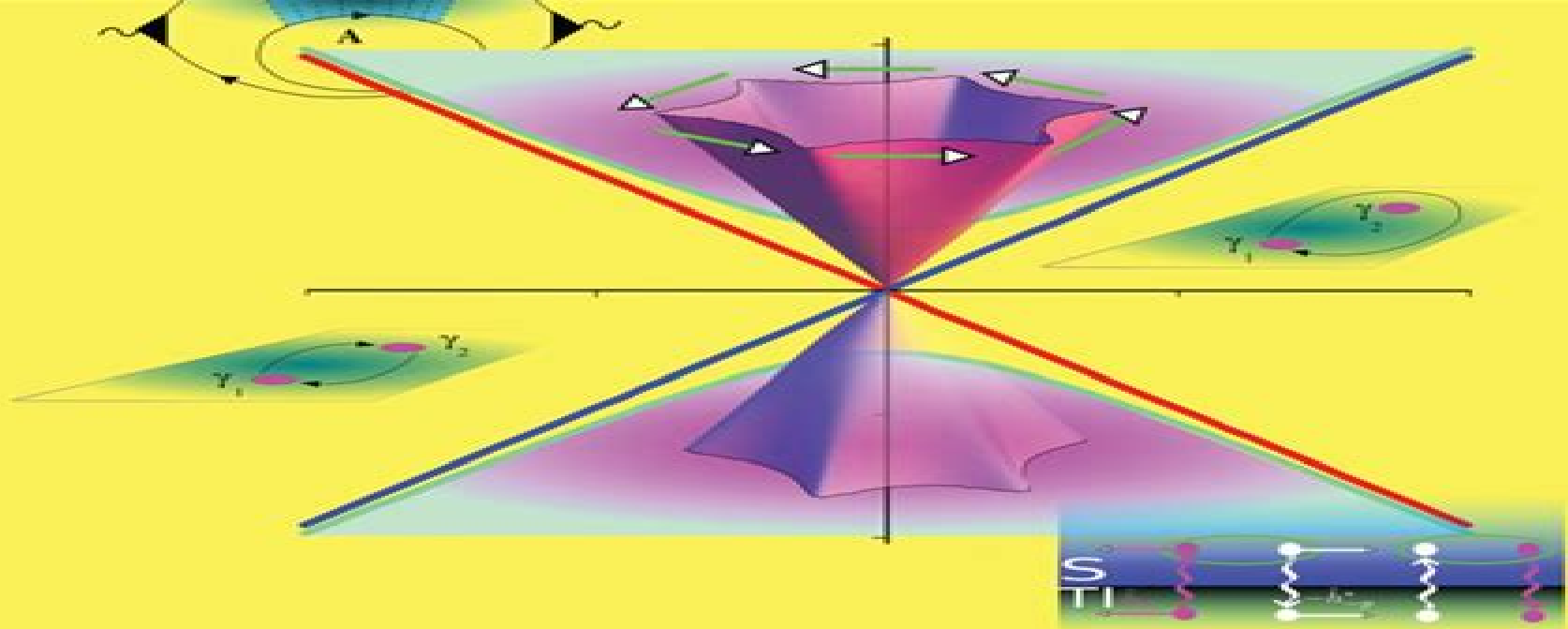




Topological Insulators

The Physics of Spin Helicity
in Quantum Transport

Grigory Tkachov



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Topological Insulators The Physics Of Spin Helicity In Quantum Transport

Colin Howard



Topological Insulators The Physics Of Spin Helicity In Quantum Transport:

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 carries the spin Hall effect of light

Topological Quantum Materials Grigory Tkachov, 2022-08-18 In topological quantum materials quantum effects emerge at macroscopic scales and are robust to continuous changes in a material's state This striking synergy between quantum and topological properties is of great interest for both fundamental research and emerging technologies especially in the fields of electronics and quantum information This edition of the book presents a wealth of topological quantum materials bringing together burgeoning research from different areas topological insulators transition metal dichalcogenides Weyl semimetals and unconventional and topological superconductors The realization of the application potential of topological quantum materials requires understanding their properties at a fundamental level This brings us back to the discovery of topological phases of matter which earned the Nobel Prize in Physics in 2016 This book explores the connection between pioneering work on topological phases of matter and a flurry of activity that followed The topics covered include the quantum anomalous and spin Hall effects emergent axion electrodynamics and topological magnetoelectric effects Weyl nodes and surface Fermi arcs weak antilocalization induced triplet superconductivity Majorana fermion modes and the fractional Josephson effect

Introduction to the Physics of Nanoelectronics Seng Ghee Tan, Mansoor B. A. Jalil, 2012-03-28 This book provides an introduction to the physics of nanoelectronics with a focus on the theoretical aspects of nanoscale devices The book begins with an overview of the mathematics and quantum mechanics pertaining to nanoscale electronics to facilitate the understanding of subsequent chapters It goes on to encompass quantum electronics spintronics Hall effects carbon and graphene electronics and topological physics in nanoscale devices Theoretical methodology is developed using quantum mechanical and non equilibrium Green's function NEGF techniques to calculate electronic currents and elucidate their transport properties at the atomic scale The spin Hall effect is explained and its application to the emerging field of spintronics where an electron's spin as well as its charge is utilised is discussed Topological dynamics and gauge potential are introduced with the relevant mathematics and their application in nanoelectronic systems is explained Graphene one of the most promising carbon based nanostructures for nanoelectronics is also explored Begins with an overview of the mathematics and quantum mechanics pertaining to nanoscale electronics Encompasses quantum electronics spintronics Hall effects carbon and graphene electronics and topological physics in nanoscale devices Comprehensively introduces topological dynamics and gauge potential with the relevant mathematics and extensively discusses their application in nanoelectronic systems

Spintronics Handbook, Second Edition: Spin Transport and Magnetism Evgeny Y. Tsymbal, Igor Žutić, 2019-06-26 Spintronics Handbook Second Edition offers an update on the

single most comprehensive survey of the two intertwined fields of spintronics and magnetism covering the diverse array of materials and structures including silicon organic semiconductors carbon nanotubes graphene and engineered nanostructures It focuses on seminal pioneering work together with the latest in cutting edge advances notably extended discussion of two dimensional materials beyond graphene topological insulators skyrmions and molecular spintronics The main sections cover physical phenomena spin dependent tunneling control of spin and magnetism in semiconductors and spin based applications Features Presents the most comprehensive reference text for the overlapping fields of spintronics spin transport and magnetism Covers the full spectrum of materials and structures from silicon and organic semiconductors to carbon nanotubes graphene and engineered nanostructures Extends coverage of two dimensional materials beyond graphene including molybdenum disulfide and study of their spin relaxation mechanisms Includes new dedicated chapters on cutting edge topics such as spin orbit torques topological insulators half metals complex oxide materials and skyrmions Discusses important emerging areas of spintronics with superconductors spin wave spintronics benchmarking of spintronics devices and theory and experimental approaches to molecular spintronics Evgeny Tsymbal's research is focused on computational materials science aiming at the understanding of fundamental properties of advanced ferromagnetic and ferroelectric nanostructures and materials relevant to nanoelectronics and spintronics He is a George Holmes University Distinguished Professor at the Department of Physics and Astronomy of the University of Nebraska Lincoln UNL Director of the UNL's Materials Research Science and Engineering Center MRSEC and Director of the multi institutional Center for NanoFerroic Devices CNFD Igor uti received his Ph D in theoretical physics at the University of Minnesota His work spans a range of topics from high temperature superconductors and ferromagnetism that can get stronger as the temperature is increased to prediction of various spin based devices He is a recipient of 2006 National Science Foundation CAREER Award 2005 National Research Council American Society for Engineering Education Postdoctoral Research Award and the National Research Council Fellowship 2003 2005 His research is supported by the National Science Foundation the Office of Naval Research the Department of Energy and the Airforce Office of Scientific Research

Comprehensive Semiconductor Science and Technology, 2011-01-28 Semiconductors are at the heart of modern living Almost everything we do be it work travel communication or entertainment all depend on some feature of semiconductor technology Comprehensive Semiconductor Science and Technology Six Volume Set captures the breadth of this important field and presents it in a single source to the large audience who study make and exploit semiconductors Previous attempts at this achievement have been abbreviated and have omitted important topics Written and Edited by a truly international team of experts this work delivers an objective yet cohesive global review of the semiconductor world The work is divided into three sections The first section is concerned with the fundamental physics of semiconductors showing how the electronic features and the lattice dynamics change drastically when systems vary from bulk to a low dimensional structure and further to a nanometer size

Throughout this section there is an emphasis on the full understanding of the underlying physics The second section deals largely with the transformation of the conceptual framework of solid state physics into devices and systems which require the growth of extremely high purity nearly defect free bulk and epitaxial materials The last section is devoted to exploitation of the knowledge described in the previous sections to highlight the spectrum of devices we see all around us Provides a comprehensive global picture of the semiconductor world Each of the work s three sections presents a complete description of one aspect of the whole Written and Edited by a truly international team of experts

Recent Topics on Topology - From Classical to Modern Applications Paul Bracken,2024-11-27 Topology plays a fundamental role in many branches of mathematics and science In recent years there has been a resurgence of interest in physics particularly in condensed matter physics This book provides an accessible yet rigorous overview of current research in topology making it an invaluable resource for mathematicians physicists and researchers in related fields

Topological Phases of Matter Roderich Moessner,Joel E. Moore,2021-04-29 Topological Phases of Matter are an exceptionally dynamic field of research several of the most exciting recent experimental discoveries and conceptual advances in modern physics have originated in this field These have generated new topological notions of order interactions and excitations This text provides an accessible unified and comprehensive introduction to the phenomena surrounding topological matter with detailed expositions of the underlying theoretical tools and conceptual framework alongside accounts of the central experimental breakthroughs Among the systems covered are topological insulators magnets semimetals and superconductors The emergence of new particles with remarkable properties such as fractional charge and statistics is discussed alongside possible applications such as fault tolerant topological quantum computing Suitable as a textbook for graduate or advanced undergraduate students or as a reference for more experienced researchers the book assumes little prior background providing self contained introductions to topics as varied as phase transitions superconductivity and localisation

Spintronic 2D Materials Wenqing Liu,Yongbing Xu,2019-12-04 Spintronic 2D Materials Fundamentals and Applications provides an overview of the fundamental theory of 2D electronic systems that includes a selection of the most intensively investigated 2D materials The book tells the story of 2D spintronics in a systematic and comprehensive way providing the growing community of spintronics researchers with a key reference Part One addresses the fundamental theoretical aspects of 2D materials and spin transport while Parts Two through Four explore 2D material systems including graphene topological insulators and transition metal dichalcogenides Each section discusses properties key issues and recent developments In addition the material growth method from lab to mass production device fabrication and characterization techniques are included throughout the book

Measuring, Interpreting and Translating Electron Quasiparticle - Phonon Interactions on the Surfaces of the Topological Insulators Bismuth Selenide and Bismuth Telluride Colin Howard,2016-10-14 The thesis presents experimental and theoretical results about the surface dynamics and the surface Dirac fermion DF spectral function of the strong topological

insulators Bi₂Te₃ and Bi₂Se₃ The experimental results reveal the presence of a strong Kohn anomaly in the measured surface phonon dispersion of a low lying optical mode and the absence of surface Rayleigh acoustic phonons Fitting the experimental data to theoretical models employing phonon Matsubara functions allowed the extraction of the matrix elements of the coupling Hamiltonian and the modifications to the surface phonon propagator that are encoded in the phonon self energy This allowed for the first time calculation of phonon mode specific DF coupling q from experimental data with average coupling significantly higher than typical values for metals underscoring the strong coupling between optical surface phonons and surface DFs in topological insulators Finally to connect to experimental results obtained from photoemission spectroscopies an electronic DF Matsubara function was constructed using the determined electron phonon matrix elements and the optical phonon dispersion This allowed calculation of the DF spectral function and density of states allowing for comparison with photoemission and scanning tunneling spectroscopies The results set the necessary energy resolution and extraction methodology for calculating from the DF perspective

Smart Materials for Energy Storage and Biomedical Applications Amodini Mishra, Vinay Pathak, 2025-08-18 This book brings together a curated selection of research in the broad field of smart materials emphasizing their properties functionality and transformative potential Covering diverse applications from energy systems to biomedical advancements it offers a snapshot of current innovations across multiple disciplines The chapters begin with an introduction to smart material properties and their applications progressing to in depth discussions on topics like magnetocaloric effects in pyrochlore oxides topological insulators and magnetoelectric perovskites Key studies examine magnetic nanoparticles for cancer biology soft materials for sustainable technologies and Pb free perovskite ceramics with giant dielectric constants Advanced research on nano structured materials material oxides in thin film technologies and photonic crystals further enrich this collection A special focus is given to topological spin textures such as skyrmions and their applications in spintronic devices From theoretical models to experimental insights this book encompasses a wide range of topics that appeal to both established scientists and emerging researchers

Skyrmions and Hall Transport Bom Soo Kim, 2023-05-05 In the past decade the field of physics has witnessed renewed advances in physical systems without mirror parity symmetry Firstly the experimental discovery of chiral magnetic skyrmions has stirred a great deal of anticipation because their nanoscale size topological protection and energy efficiency make them an attractive candidate for cutting edge spintronic applications Secondly the discovery of Hall viscosity a new universal transport coefficient through advancements in hydrodynamics has triggered extensive theoretical work in quantum Hall systems This book unites these two findings in an extensive account of skyrmion dynamics using novel analytical tools Of particular interest is a generalized field theory Ward identity a first principle method using symmetries and the associated conservation equations which facilitates our understanding of Hall viscosity as a universal part of skyrmion motion In articulating the role of this mysterious Hall viscosity in skyrmion physics this book guides readers through frontline interdisciplinary research

that encompasses high energy physics condensed matter and materials science It also provides the necessary background and physical clarity for advanced undergraduates to meaningfully explore its contents through mathematical expressions conveyed in both vector and index notations

Quantum Transport in 2 and 3 Dimensional Topological Insulators Di Xiao, 2019 Topological insulators are materials that are insulating in the bulk but that conduct via topologically protected states on the boundary The concept of topology in condensed matter physics was first introduced to explain the integer quantum Hall IQH effect The perfect quantization of these topologically protected edge states insensitive to sample geometry and disorder stimulated an extensive search for many exciting new topological materials One of the milestones along the journey was the theoretical prediction and experimental discovery of Z₂ topological insulators The first class of Z₂ topological insulators discovered was the 2 dimensional topological insulator 2D TI also known as the quantum spin Hall QSH insulator The 2D TI can be viewed as a variation of the IQH system but with time reversal symmetry TRS The topological invariant for a 2D TI is the Z₂ number defined by its nontrivial band structure instead of the Chern number in the IQH case Generalizing this idea to 3 dimensions led to the discovery of the 3D TI with four Z₂ invariants Both the 2D and 3D TIs are of interest as model platforms for testing theoretical problems of fundamental interest For instance they allow us to realize artificial condensed matter analogs of fundamental particles such as Majorana fermions and axions that have yet to be observed in nature They are also of interest for potential technological applications principally spintronics and quantum computing This dissertation focuses on the synthesis characterization and transport properties of both 2D and 3D TIs We first discuss the 2D TI candidate material system type II InAs GaSb quantum wells which exhibits a rich topological phase diagram that can be tuned by several parameters such as sample geometry or electrostatic gating By changing the thicknesses of relevant layers we are able to enter a new insulating regime where unexpected high density quantum oscillations are observed We elucidate this phenomenon through theoretical calculation and through control experiments The seemingly controversial coexistence of high density states and the insulating regime can be explained by the effect of the attractive Coulomb interaction which was not considered in earlier theories The second topic we address is quantum transport in 3D TI systems Breaking the TRS of the 3D TI surface states leads to many exotic phenomena including the quantum anomalous Hall QAH effect and the axion insulator state By constructing a sandwich heterostructure that has different magnetic coercive fields in the top and bottom magnetic layers while keeping the center layer free from magnetic impurities both the QAH and the axion insulator state can be observed in low temperature transport measurements when the magnetization alignment of the top and bottom layers is parallel and antiparallel respectively We also discuss the scaling behavior of the topological quantum phase transition between these two states

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

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

Quantum Transport and Interaction in Topological Materials Kaijie Yang, 2024 Theoretical quantum matter describes a class of materials characterized by certain nontrivial topological invariant in their bulk electronic band structures and the electronic modes localized at the boundary of a finite sample In this dissertation I implement theoretical studies on the transport and interaction effect in topological states of matter My research includes the spin transport in a variety of topological insulator and semimetal materials Chapter 2 the theoretical proposal of topologically nontrivial moiré minibands in a class of topological insulator based moiré heterostructures and the interaction effects Chapter 3 and a new class of topological semimetals originating from the low energy effective models rather than protected by crystalline symmetries Chapter 4 Chapter 2 focuses on the spin transport in topological insulators and topological semimetals First we propose that

a topologically stable spin texture spin antivortex in momentum space can appear in 2D monolayer Pb on top of SiC Different from spin vortex due to the band degeneracy in the Rashba model the existence of spin antivortex is guaranteed by the Poincaré Hopf theorem and thus topologically stable The existence of spin antivortex can be featured by rapid variations in current induced spin polarization and spin Hall conductivity when the Fermi energy is tuned across the spin antivortex

Second We investigate the archetypal Dirac semimetal Cd₃As₂ interfaced with In_{1-x}Mn_xAs a ferromagnetic semiconductor with perpendicular magnetic anisotropy Our calculation reveals a nonzero off diagonal spin susceptibility in the Cd₃As₂ thin film due to the Rashba spin orbit coupling from broken inversion symmetry which can mediate local moments in the neighboring In_{1-x}Mn_xAs layer by the presence of a Dzyaloshinskii Moriya interaction and implies a real space chiral spin texture with topological Hall effects in transport measurement This shows the heterostructure as a promising electrostatically tunable platform with the interplay between the helical Dirac fermions and chiral real space spin textures in a ferromagnet Third we study the electrical switch of edge state chirality in the quantum anomalous Hall insulator by a current pulse We obtain spin polarization induced by the longitudinal and Hall currents of the surface states in the quantum anomalous Hall insulator and simulate the magnetization flipping dynamics with the spin orbit torques from the spin polarization which proves in principle the easy and instantaneous manipulation of the quantum anomalous Hall state by the interplay between magnetism and topological phases

Chapter 3 discusses about the search of topological phases in moiré materials with strong Coulomb interaction First we predict the topological insulator under a hexagonal moiré superlattice potential can have Z_2 nontrivial minibands interaction driven quantum anomalous Hall state and monolayer Sb₂ on top of Sb₂Te₃ films as a candidate heterostructure Second we introduce a new mechanism which originates from the band folding induced by moiré superlattice for topological mini bands in moiré materials and use the Rashba model under a moiré superlattice for illustration A general theory based on symmetry representations has also been developed for a generalization of this mechanism to other space groups In Chapter 4 we generalize the symmetry principle to the quasi symmetry in low energy effective Hamiltonian obtain a range of nodal structures in 230 space groups beyond the representation theory of crystal symmetries and identify a class of potential topological semimetals in the topological material database A notable example is that the existence of nodal points or nodal lines between two states with opposite mirror symmetry eigenvalue in certain space group is guaranteed by the $\mathbf{k} \cdot \mathbf{p}$ Hamiltonian linear or quadratic in momentum for all Hamiltonian parameters and robust against high order perturbations in momentum even though the mirror symmetry can only lead to accidental degeneracy which shows the quasi symmetry as a new principle in search of topological materials

Topological Insulators and Topological Superconductors B. Andrei Bernevig, Taylor L. Hughes, 2013-04-07 This graduate level textbook 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 graduate students and researchers preparing to work in this area and it will be an essential reference both within and outside the classroom The book begins with simple concepts such as Berry phases Dirac fermions Hall conductance and its link to topology and the Hofstadter problem of lattice electrons in a magnetic field It moves on to explain topological phases of matter such as Chern insulators two and three dimensional topological insulators and Majorana p wave wires Additionally the book covers zero modes on vortices in topological superconductors time reversal topological superconductors and topological responses field theory and topological indices The book also analyzes recent topics in condensed matter theory and concludes by surveying active subfields of research such as insulators with point group symmetries and the stability of topological semimetals Problems at the end of each chapter offer opportunities to test knowledge and engage with frontier research issues Topological Insulators and Topological Superconductors will provide graduate students and researchers with the physical understanding and mathematical tools needed to embark on research in this rapidly evolving field *Topological Insulator and Related Topics*, 2021-09-24 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

QUANTUM TRANSPORT IN TOPOLOGICAL MATERIALS. Run Xiao, 2022 This dissertation focuses on the synthesis characterization fabrication and electrical transport measurements of topological materials including magnetically doped topological insulators and Dirac semimetal Cd₃As₂ Bismuth chalcogenide topological insulators have time reversal symmetry protected surface states due to the strong spin orbit coupling Breaking the time reversal symmetry by magnetic dopants can lead to fascinating exotic phenomena such as the quantum anomalous Hall effect On the other hand Dirac semimetals host three dimensional Dirac fermions and can be identified as a parent phase of other topological phases such as Weyl semimetals In this dissertation quantum transport measurements are performed on thin films of topological materials to investigate and understand the unusual electronic states that host these topological phases These studies can motivate and facilitate the development of potential applications of topological materials especially in spintronics and quantum computing The first topological material studied in this dissertation is a magnetically doped topological insulator system Cr doped Bi Sb

2Te_3 Bi Sb 2Te_3 Cr doped Bi Sb 2Te_3 sandwich heterostructure By tuning the chemical and asymmetric potentials using dual gates both the quantum anomalous Hall effect due to the topology in the momentum space and the topological Hall effect due to the topology in real space can be observed in this heterostructure system We also mapped out a phase diagram of the topological Hall and quantum anomalous Hall effects as a function of the chemical and asymmetry potentials paving a way to understand and manipulate the chiral magnetic spin textures in real space The second topological material is Dirac semimetal Cd_3As_2 We investigated the integer quantum Hall effect in Cd_3As_2 thin films under strong to moderate quantum confinement thicknesses of 10 nm 12 nm and 15 nm In all the films we observed the integer quantum Hall effect in the spin polarized lowest Landau level filling factor $\nu = 1$ and at spin degenerate higher index Landau levels with even filling factors $\nu = 2, 4, 6$ We also observed the lifting of the Landau level spin degeneracy at $\nu = 3$ with strong quantum confinement A tight binding calculation suggests that the enhanced g factor due to the quantum confinement and corrections from nearby subbands can be the reason for the emergence of $\nu = 3$ quantum Hall plateau Last we explored the introduction of the transition metal Mn into Cd_3As_2 thin films to break the time reversal symmetry Scanning transmission electron microscopy of these films shows a formation of an Mn rich layer on top of a pure Cd_3As_2 layer using both uniform and delta doping methods The low solubility of Mn in Cd_3As_2 can be the reason for the phase separation The Mn rich region shows out of plane magnetic anisotropy in superconducting quantum interference device magnetometry measurements Moreover the presence of the Mn surfactant lowers the carrier density in the Cd_3As_2 layer and an incipient quantum Hall effect can be observed in low temperature transport measurements

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

Topological Insulators Vadim Nemytov, 2013 In this thesis we investigate quantum transport properties of topological insulator TI Bi_2Se_3 from atomistic point of view TI is a material having an energy gap in its bulk but supporting gapless helical states on its boundary The helical states have Dirac like linear energy dispersion continuously crossing the bulk band gap with a spin texture in which the electron spin is locked perpendicular to the electron momentum The peculiar electronic structure of TI material Bi_2Se_3 is due to a strong spin orbit interaction and is protected by the time reversal

symmetry The thesis consists of two main parts The first reviews the theory of TI and the second presents our atomistic calculations of electron transport in the Bi_2Se_3 material In the theoretical review of the physics of TI I follow the literature and attempt to present it in a reasonably accessible manner The theory of TI is explained in terms of well known physical phenomena including classical and quantum Hall effects spin orbit coupling spin current and spin Hall effect The concept of Berry's phase is then introduced to link with the formal conventional classification of TI by the topological $\mathbb{Z}_2$ invariants The entire discussion is within the well known Bloch band theory In the second part of this thesis numerical studies of transport properties of Bi_2Se_3 are presented After a brief discussion of the relevant quantum transport theory and the tight binding atomistic model we present our calculated quantum transport results of Bi_2Se_3 films having a trench in the middle Such a large defect if on normal conductors would cause significant back scattering of the carriers Here by topological protection of the helical states back scattering is forbidden due to the spin momentum locking Nevertheless large trenches in the film may cause the helical states on the surface to mix inside the trench thereby affecting the transmission

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Topological Insulators The Physics Of Spin Helicity In Quantum Transport Introduction

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