



Vincenzo Parente

# Topological States of Matter

Transport properties in Graphene and Topological Insulators



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# Topological States Of Matter Transport Properties In Graphene And Topological Insulators

**Olena Fesenko, Leonid Yatsenko**



## **Topological States Of Matter Transport Properties In Graphene And Topological Insulators:**

*Topological States of Matter* Vincenzo Parente, 2013 Abstract from dissertation My research program is focused on the study of elastic deformation and topological defects in two materials graphene and topological insulators In both systems at low energies the electrons have a nearly linear spectrum i.e. they behave like relativistic fermions This allows the study of the effects of defects and deformations on the dynamics of electrons through the formalism of Dirac equation on curved space time In this setting it is possible to derive correction to observable properties of the systems like the conductivity for example In the case of graphene I have derived the contribution to conductivity in the Born approximation of the metric arising from the so called bumps and made a comparison with the scattering on the gauge potential arising from the elastic deformation A particular defect the edge dislocation is found to be a possible responsible for the behaviour of the conductivity at low energies The topological insulators are a class of band insulators showing gapless edge states capable of conduction This situation is similar to Quantum Hall Effect both physically and formally Indeed as in QHE topological invariants Chern numbers classify the behaviour of the material I am thus focused on the study of these material both formally on the ground of differential geometry and physically studying topological defect in topological insulators Further investigation has been devoted to the analysis of electron phonon interaction at the surface of a 3D TI analysing superconductive instability

**Topology and Condensed Matter Physics** Somendra Mohan Bhattacharjee, Mahan Mj, Abhijit Bandyopadhyay, 2017-12-20 This book introduces aspects of topology and applications to problems in condensed matter physics Basic topics in mathematics have been introduced in a form accessible to physicists and the use of topology in quantum statistical and solid state physics has been developed with an emphasis on pedagogy The aim is to bridge the language barrier between physics and mathematics as well as the different specializations in physics Pitched at the level of a graduate student of physics this book does not assume any additional knowledge of mathematics or physics It is therefore suited for advanced postgraduate students as well A collection of selected problems will help the reader learn the topics on one's own and the broad range of topics covered will make the text a valuable resource for practising researchers in the field The book consists of two parts one corresponds to developing the necessary mathematics and the other discusses applications to physical problems The section on mathematics is a quick but more or less complete review of topology The focus is on explaining fundamental concepts rather than dwelling on details of proofs while retaining the mathematical flavour There is an overview chapter at the beginning and a recapitulation chapter on group theory The physics section starts with an introduction and then goes on to topics in quantum mechanics statistical mechanics of polymers knots and vertex models solid state physics exotic excitations such as Dirac quasiparticles Majorana modes Abelian and non Abelian anyons Quantum spin liquids and quantum information processing are also covered in some detail

[Nanocomposites, Nanostructures, and Their Applications](#) Olena Fesenko, Leonid Yatsenko, 2019-08-02 This book highlights some of the latest

advances in nanotechnology and nanomaterials from leading researchers in Ukraine Europe and beyond It features contributions from participants in the 6th International Science and Practice Conference Nanotechnology and Nanomaterials NANO2018 in Kiev Ukraine on August 27 30 2018 organized by the Institute of Physics of the National Academy of Sciences of Ukraine University of Tartu Estonia University of Turin Italy and Pierre and Marie Curie University France Internationally recognized experts from a wide range of universities and research institutions share their knowledge and key results on material properties behavior and synthesis This book s companion volume also addresses topics such as nanooptics energy storage and biomedical applications      *Collective Excitations in the Antisymmetric Channel of Raman Spectroscopy* Hsiang-Hsi Kung, 2021-12-08 This thesis contains three breakthrough results in condensed matter physics Firstly broken reflection symmetry in the hidden order phase of the heavy fermion material URu<sub>2</sub>Si<sub>2</sub> is observed for the first time This represents a significant advance in the understanding of this enigmatic material which has long intrigued the condensed matter community due to its emergent long range order exhibited at low temperatures the so called hidden order Secondly and thirdly a novel collective mode the chiral spin wave and a novel composite particle the chiral exciton are discovered in the three dimensional topological insulator Bi<sub>2</sub>Se<sub>3</sub> This opens up new avenues of possibility for the use of topological insulators in photonic optoelectronic and spintronic devices These discoveries are facilitated by using low temperature polarized Raman spectroscopy as a tool for identifying optically excited collective modes in strongly correlated electron systems and three dimensional topological insulators      *Encyclopedia of Interfacial Chemistry*, 2018-03-29 Encyclopedia of Interfacial Chemistry Surface Science and Electrochemistry Seven Volume Set summarizes current fundamental knowledge of interfacial chemistry bringing readers the latest developments in the field As the chemical and physical properties and processes at solid and liquid interfaces are the scientific basis of so many technologies which enhance our lives and create new opportunities its important to highlight how these technologies enable the design and optimization of functional materials for heterogeneous and electro catalysts in food production pollution control energy conversion and storage medical applications requiring biocompatibility drug delivery and more This book provides an interdisciplinary view that lies at the intersection of these fields Presents fundamental knowledge of interfacial chemistry surface science and electrochemistry and provides cutting edge research from academics and practitioners across various fields and global regions      Modern Condensed Matter Physics Steven M. Girvin, Kun Yang, 2019-02-28 Modern Condensed Matter Physics brings together the most important advances in the field of recent decades It provides instructors teaching graduate level condensed matter courses with a comprehensive and in depth textbook that will prepare graduate students for research or further study as well as reading more advanced and specialized books and research literature in the field This textbook covers the basics of crystalline solids as well as analogous optical lattices and photonic crystals while discussing cutting edge topics such as disordered systems mesoscopic systems many body systems quantum magnetism Bose Einstein condensates quantum

entanglement and superconducting quantum bits Students are provided with the appropriate mathematical background to understand the topological concepts that have been permeating the field together with numerous physical examples ranging from the fractional quantum Hall effect to topological insulators the toric code and majorana fermions Exercises commentary boxes and appendices afford guidance and feedback for beginners and experts alike

*Nanomaterials and Nanocomposites, Nanostructure Surfaces, and Their Applications* Olena Fesenko, Leonid Yatsenko, 2020-11-25 This book highlights some of the latest advances in nanotechnology and nanomaterials from leading researchers in Ukraine Europe and beyond It features contributions presented at the 7th International Science and Practice Conference Nanotechnology and Nanomaterials NANO2019 which was held on August 27 30 2019 at Lviv Polytechnic National University and was jointly organized by the Institute of Physics of the National Academy of Sciences of Ukraine University of Tartu Estonia University of Turin Italy and Pierre and Marie Curie University France Internationally recognized experts from a wide range of universities and research institutions share their knowledge and key findings on material properties behavior and synthesis This book's companion volume also addresses topics such as nano optics energy storage and biomedical applications

*Field Theories of Condensed Matter Physics* Eduardo Fradkin, 2013-02-28 Presenting the physics of the most challenging problems in condensed matter using the conceptual framework of quantum field theory this book is of great interest to physicists in condensed matter and high energy and string theorists as well as mathematicians Revised and updated this second edition features new chapters on the renormalization group the Luttinger liquid gauge theory topological fluids topological insulators and quantum entanglement The book begins with the basic concepts and tools developing them gradually to bring readers to the issues currently faced at the frontiers of research such as topological phases of matter quantum and classical critical phenomena quantum Hall effects and superconductors Other topics covered include one dimensional strongly correlated systems quantum ordered and disordered phases topological structures in condensed matter and in field theory and fractional statistics

Journal of the Physical Society of Japan, 2016

**Topological Insulators** Jeroen B. Oostinga, Alberto F. Morpurgo, 2013-11-23 The discovery of topological insulators as a new state of matter has generated immense interest in this new class of materials Three dimensional 3D topological insulators are characterized by the presence of an odd number of families of Dirac fermions ideally one at each of their surfaces Angle resolved photoemission experiments have demonstrated the presence of the expected Dirac fermions but it is clear that to explore the electronic properties of these systems transport measurements in many different device geometries are called for just as it has been the case for Dirac fermions in graphene In this chapter we review the status of transport studies through 3D topological insulators as of early summer 2012 after that a first generation of experiments has been performed The results provide many different indications of the presence of surface fermions as well as evidence of their Dirac nature However no textbook manifestation of surface Dirac fermions has been reported so far in these materials Indeed experiments also show that

investigations are severely hampered by the material quality in most cases because of the effect of high conductivity in the bulk of low carrier mobility of technical difficulties hampering device fabrication and other reasons In this chapter we attempt to give a balanced overview of the work done during this first period and of the results obtained stressing the implications and the limits of many of the observations that have been reported in the literature

**Science** John Michels (Journalist),2007

**Nature** Sir Norman Lockyer,2008

**Electrical Transport Properties of Topological Insulators and Graphene** Zhiyong Wang,2014 For single layer MoS<sub>2</sub> at the valence band maxima the band is split by 160 meV due to strong spin orbit coupling Spin up and spin down electrons reside in different bands due to the broken inversion symmetry Valley and spin degrees of freedom of the valence bands are inherently coupled in single layer MoS<sub>2</sub> It is an ideal material to study the valley Hall effect

**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* 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

Electronic Properties of Rhombohedral Graphite Servet Ozdemir,2021-10-25 This thesis presents the first systematic electron transport investigation of rhombohedral graphite RG films and thus lies at the interface of graphene physics vdW

heterostructure devices and topological matter Electron transport investigation into the rhombohedral phase of graphite was limited to a few layers of graphene due to the competing hexagonal phase being more abundant This work reports that in exfoliated natural graphite films rhombohedral domains of up to 50 layers can be found In the low energy limit these domains behave as an N layer generalisation of graphene Moreover being a potential alternative to twisted bilayer graphene systems RG films show a spontaneous metal insulator transition with characteristic symmetry properties that could be described by mean field theory where superconductivity is also predicted in these low energy bands A nodal line semimetal in the bulk limit RG thin films are a 3D generalisation of the simplest topological insulator model the Su Schrieffer Heeger chain Similar to the more usual topological insulators RG films exhibit parallel conduction of bulk states which undergo three dimensional quantum transport that reflects bulk topology

**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

*Strong and Weak Topology Probed by Surface Science* Christian Pauly, 2016-01-22 Christian Pauly demonstrates the strong topological properties of the technologically relevant phase change materials  $\text{Sb}_2\text{Te}_3$  and  $\text{Ge}_2\text{Sb}_2\text{Te}_5$  by using two powerful techniques for mapping the surface electronic structure scanning tunneling spectroscopy STS and angle resolved photoemission spectroscopy ARPES In the case of a phase change material this opens up the possibility of switching between an insulating amorphous and a conducting topological phase on nanosecond time scales Moreover the author presents first experimental results of a weak topological insulator namely on the bismuth based graphene like sheet system  $\text{Bi}_{14}\text{Rh}_3\text{I}_9$  revealing a topologically protected one dimensional edge channel as its fingerprint The edge state is as narrow as 0.8 nm making it extremely attractive to device physics Those strong and weak topological insulators are a new phase of quantum matter giving rise to robust boundary states which are protected from backscattering and localization

**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

**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



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