ICAM-China Summer School:

The Frontier in Condensed Matter Physics

Beijing

July 18 - July 26, 2015

Organized by

Department of Physics (DOP), Tsinghua University
Collaborative Innovation Center of Quantum Matters (CICQM)
State Key Laboratory of Low-Dimensional Quantum Physics (SKL-LDQP)

Organizing Committee

Principle Organizers

- Qi-Kun Xue, Tsinghua University
- Xi Chen, Tsinghua University
- Xincheng Xie, Peking University
- Hong Ding, Institute of Physics, Chinese Academy of Sciences

Coordinator

- Jun Ren, Tsinghua University

Introduction

The 3rd ICAM-China international summer school is organized by the Physics Department of Tsinghua University and the Collaborative Innovation Center of Quantum Matter (CICQM) in Beijing during July 18 - 26, 2015. This summer school is focused on "The Frontier in Condensed Matter Physics", which includes experimental observation and theoretical methods of the quantum anomalous Hall effect (QAHE), new phenomena in topological insulators, new developments of iron-based superconductors, cutting-edge researches on low-dimensional superconductors, novel two-dimensional materials and so on. This summer school is held in Beijing Shunxin Green Resort, the west of Beijing, which is closed to the beautiful Chaobai River. The students' body will includes a balanced mix of international students.

The main purpose of this summer school is to introduce the frontier in condensed matter physics, and bridge the gap between the knowledge for graduate students learnt from textbooks and the cutting edge researches in modern condensed matter physics. It will be hold annually by Tsinghua University, Peking University and Institute of Physics of Chinese Academy of Science alternately, which compose the Collaborative Innovation Center of Quantum Matter. The summer school will be specially designed for senior undergraduate and junior graduate students in condensed matter physics. We are going to include the following contents in this summer school:

- Topological insulator and quantum anomalous Hall effect (QAHE): introduce the topological orders and the topological classifications of the states in condensed matter, and focus on QAHE in theory and realization in experiments;
- Iron-based superconductors: introduce the structure, classification, development and urgent problems of iron-based superconductors;
- Low-dimensional superconductors: introduce interface superconductivity, low-dimensional conventional superconductors/high temperature superconductors;
- Two-dimensional materials: mainly discuss physical properties of graphene, MoS_2, $MnSe_2$, etc.

Sponsor

CICQM	DOP, Tsinghua	SKL-LDQP	ICAM	NSF

Brief History

- The 1st ICAM-China Summer School, 2013 (Wei-Hai)
- The 2nd ICAM-China Summer School, 2014 (Wei-Hai)

Summer School Program

Morning Session: 9:00am - 11:20am (including 20 mins break)
Afternoon Session: 2:00pm - 4:20pm (including 20 mins break)
Venue: Beijing Shunxin Green Resort

Saturday July 18, 2015

10:30 - 11:30 **Shun-Qing Shen**
The Dirac Equation in Topological Insulators & Superconductors

14:00 - 16:20 **Qian Niu**
Berry Phase Effects on Charge and Spin Transport

Sunday July 19, 2015

09:00 - 11:20 **Shun-Qing Shen**
Quantum Hall Effect and Quantum Anomalous Hall Effect in Topological Insulator Thin Film

14:00 - 16:20 **Chaoxing Liu**
Topological Nonsymmorphic Crystalline Insulators and Superconductors

Monday July 20, 2015

09:00 - 11:20 **Xiao-Liang Qi**
Topological Order and Quantum Entanglement

14:00 - 16:20 **Lili Wang**
Searching High Tc at Interface

Tuesday July 21, 2015

09:00 - 11:20 **Xincheng Xie**
Dephasing and Disorder Effects in Topological Systems

14:00 - 16:20 **Yongqing Li**
Transport Properties of Topological Insulators and a Candidate Material for Magnetic Weyl Semimetals

Wednesday July 22, 2015

09:00 - 11:20 **Ruirui Du**

Helical Luttinger-Liquid in InAs/GaSb Quantum Spin Hall Edges

14:00 - 16:20 **Sheng Meng**

Excited State Electron-ion Dynamics at Interface

Thursday July 23, 2015

09:00 - 11:20 **Xiao Hu**

Topological Insulating States in Honeycomb Lattice

14:00 - 16:20 **Jian Wang**

Superconductivity at 2D Limit and Potential to Topological Superconductivity

Friday July 24, 2015

09:00 - 11:20 **Xie Chen**

Symmetry Protected Topological Phases

14:00 - 16:20 **Wei Han**

Spintronics in Two Dimensional Quantum Materials

Saturday July 25, 2015

09:00 - 11:20 **Zheng-Yu Weng**

High-Tc Superconductivity and Strong Correlations

14:00 - 16:20 **Yulin Chen**

Visualizing Electronic Structures of Topological Quantum Materials

Sunday July 26, 2015

09:00 - 11:20 **Round-Table Discussion**

How to Make Students more involved in Summer School?

ABSTRACTS

Quantum Hall Effect and Quantum Anomalous Hall Effect in Topological Insulator Thin Film

Shun-Qing Shen（沈顺清）
Department of Physics, The University of Hong Kong

Abstract

Three-dimensional topological insulators (TIs) are characteristic of the conducting surface electrons whose momentum and spin have a lock-in relation to form the so-called "Dirac cone". The extremely strong spin-orbit coupling of the surface electrons makes TI exhibit exotic electromagnetic effects. The magnetic impurities in TI break the time reversal symmetry, and lead to an energy gap opening at the Dirac point of the surface states. In an ultrathin film of TI, a finite thickness of thin film makes the wavefunctions of top and bottom surface electrons overlapping such that the an energy gap also opens at the Dirac points of the surface states. Recently both quantum anomalous Hall effect in a magnetic thin film of TI, and quantum Hall effect in the presence of an external magnetic field were observed experimentally. In this talk I shall present an effective model for TI thin film from a bulk TI model, and introduce a quantum transport theory for thin films of magnetic topological insulator.

References:
[1]. Massive Dirac fermions and spin physics in an ultrathin film of topological insulator, H. Z. Lu, W. Y. Shan, W. Yao, Q. Niu, and S. Q. Shen, Physical Review B 81, 115407 (2010).
[2]. Effective continuous model for surface states and thin films of three-dimensional topological insulator, W. Y. Shan, H. Z. Lu, and S. Q. Shen, New Journal of Physics 12, 043048 (2010).
[3]. Surface edge state and half-quantized Hall conductance in topological insulators, R. L. Chu, J. R. Shi and S. Q. Shen, Physical Review B 84, 085312 (2011).
[4]. Quantum transport in magnetic topological insulator thin film, H. Z. Lu, A. Zhao, and S. Q. Shen, Phys. Rev. Lett. (October 2013)/arXiv: 1306.6748 (2013).
[5]. S. B. Zhang, H. Z. Lu, and S. Q. Shen Edge states and quantum Hall effect in topological insulator thin film, arXiv:

Biography

Professor Shun-Qing Shen, an expert in the field of condensed matter physics, is distinguished for his research works on topological insulator, spintronics of semiconductors, quantum magnetism and orbital physics in transition metal oxides, and novel quantum states of condensed matters.

Professor Shun-Qing Shen has been a professor of physics at The University of Hong Kong since July 2007. Professor Shen received his BS, MS, and PhD in theoretical physics from Fudan University in Shanghai. He was a postdoctorial fellow (1992 – 1995) in China Center of Advanced Science and Technology (CCAST), Beijing, Alexander von Humboldt fellow (1995 – 1997) in Max Planck Institute for Physics of Complex Systems, Dresden, Germany, and JSPS research fellow (1997) in Tokyo Institute of Technology, Japan. In December 1997 he joined Department of Physics, The University of Hong Kong. He was awarded Croucher Senior Research Fellowship (The Croucher Award, Hong Kong) in 2010.

Berry Phase Effects on Charge and Spin Transport

Qian Niu（牛谦）

Department of Physics, University of Texas at Austin

Abstract

In this talk I will review our semi classical theory for Bloch electrons and discuss various Berry phase and other geometric effects. In particular, I will present our recent advance of this theory to second order accuracy in electromagnetic fields, and show applications on orbital magnetism and Landau levels.

Biography

Prof. Qian Niu Obtained his B.Sc. in Physics from Peking University in 1981, and Ph. D. from University of Washington in 1985. He has been a research associate in University of Illinois during 1985-1987. He joined University of Texas since 1990 and was named Trull Centennial Professor in 2001. He was elected as a Fellow of American Physical Society in 1999, and Chair Professor in ICQM at Peking University in 2010 - current.

Prof. Niu's work has been concentrated on the fundamental theory of condensed matter, and made contribution to its major overhaul by systematic applications of topological and geometric phase ideas. These applications have made lasting impact on the field of quantum Hall effect, paved the ground for adiabatic pumping and theory of polarization, revived the field of anomalous Hall effect, broke new ground for the theory of orbital magnetization, and played a key role in the development of spin Hall effect, among other things to be pointed out below. In today's very diverse and ever specializing subject of condensed matter physics, these new ideas provide a valuable tiding thread and unifying view, and have essentially transformed its basic theory at the textbook level. As a result, we now have a much richer notion of insulators, a much deeper understanding of electron dynamics in metals and semiconductors, and more effective means of calculation of transport as well as thermodynamic properties of materials.

He has 226 publications in refereed journals (13476 citations, h=60), including 73 in Physical Review Letters, 3 in Science, 4 in Nature and its subsidiaries, one each in Review of Modern Physics, Physics Today, and Physics World. Five of these papers are reprinted in books. He has delivered more than 300 invited talks at professional meeting and research institutions.

Talk I: Topological Non-Symmorphic Crystalline Superconductors

Chaoxing Liu（刘朝星）

Department of Physics, The Pennsylvania State University

Abstract

Topological superconductors possess a nodeless superconducting gap in the bulk and gapless zero energy modes, known as “Majorana zero modes”, at the boundary of a finite system. In this work, we introduce a new class of topological superconductors, which are protected by nonsymmorphic crystalline symmetry and thus dubbed “topological nonsymmorphic crystalline superconductors”. We construct an explicit Bogoliubov-de Gennes type of model for this superconducting phase in the D class and show how Majorana zero modes in this model are protected by glide symmetry. Furthermore, we give a classification of topological nonsymmorphic crystalline superconductors with time reversal symmetry in other classes, including the DIII and BDI classes, in two dimensions. Our theory provides a guidance to search for new topological superconducting materials with nonsymmorphic crystal structures.

Talk II: Quantum Anomalous Hall Effect in Magnetic Materials

Abstract

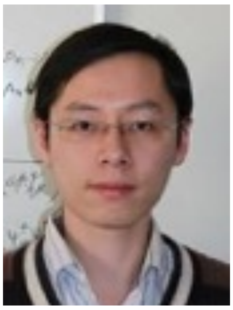
Both the quantum Hall effect and the quantum anomalous Hall effect possess the quantized Hall conductance and zero longitudinal resistance. Different from the conventional quantum Hall effect that requires strong magnetic fields, the quantum anomalous Hall effect is induced by strong exchange coupling between electron spin and magnetic moments in magnetic materials, so it can be realized at a zero magnetic field, enabling the potential application of electronic devices with low energy consumption. A recent experiment on Cr or V doped BiSbTe thin films has observed the quantized Hall conductance at a zero magnetic field and confirmed this novel phenomenon.

In this talk, I would like to discuss our recent work on the quantum anomalous Hall effect in magnetic materials. I will first introduce two key ingredients, inverted band structures and magnetic insulators, for the quantum anomalous Hall effect in realistic magnetic materials. Then, based on these two ingredients, I will discuss different classes of materials for the quantum anomalous Hall effect, focusing on magnetically doped InAs/GaSb quantum wells. I will also consider about spin polarization of chiral edge modes of the quantum anomlaous Hall insulators and discuss the potential applications of the quantum anomalous Hall effect in spintronics.

Reference:

1. Quantum Anomalous Hall Effect in Hg1-yMnyTe Quantum Wells, Chao-Xing Liu, Xiao-Liang Qi, Xi Dai, Zhong Fang, Shou-Cheng Zhang, Phys. Rev. Lett. 101, 146802 (2008).
2. In-plane Magnetization Induced Quantum Anomalous Hall Effect, Xin Liu, Hsiu-Chuan Hsu, Chao-Xing Liu, Phys. Rev. Lett. 111, 086802 (2013).
3. Quantum Anomalous Hall Effect in Magnetically Doped InAs/GaSb Quantum Wells, Qingze Wang, Xin Liu, Hai-Jun Zhang, Nitin Samarth, Shou-Cheng Zhang, Chao-Xing Liu, Phys. Rev. Lett. 113, 147201 (2014).

Biography



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BS 2003: Fundamental Science, Tsinghua University, China
PhD 2009: Physics, Tsinghua University, China
Postdoc 2009-2011: Physics, Wurzburg University, Germany

2012-present: Assistant Professor, Physics, Penn State University

Five products most closely related to the project

1. Liu, X., Hsu, H. C., and Liu, C. X., *In-plane Magnetization Induced Quantum Anomalous Hall Effect*, arXiv: cond-mat /1301.4772, (accepted by Physical Review Letter).
2. Liu, C. X., Ye, P., and Qi, X. L., *Chiral gauge field and axial anomaly in a Weyl semi-metal*, Phys. Rev. B, **87**, (2013) 235306. (DOI: 10.1103/PhysRevB.87.235306
3. Liu, C. X., Qi, X. L., Dai, X., Fang, Z., and Zhang, S. C., *Quantum Anomalous Hall Effect in Hg1−yMnyTe Quantum Wells,* Phys. Rev. Lett., **101**, (2008) 146802. (DOI: 10.1103/PhysRevLett.101.146802)
4. Liu, C., Hughes, T. L., Qi, X. L., Wang, K., and Zhang, S. C., *Quantum Spin Hall Effect in Inverted Type II Semiconductors,* Phys. Rev. Lett., **100**, (2008) 236601. (DOI: 10.1103/PhysRevLett.100.236601)
5. Liu, Q., Liu, C. X., Xu, C., Qi, X. L., and Zhang, S. C., *Magnetic Impurities on the Surface of a Topological Insulator,* Phys. Rev. Lett., **102**, (2009) 156603. DOI: 0.1103/PhysRevLett.102.156603)

Five other significant products

1. Zhang, H., Liu, C. X., Qi, X. L., Dai, X., Fang, Z., and Zhang, S. C., *Topological Insulators in Bi2Se3, Bi2Te3 and Sb2Te3 with a Single Dirac Cone on the Surface*, Nature Physics, **5**, (2009) 438-442. (DOI: 10.1038/NPHYS1270)
2. Zhang, J., Chang, C. Z., Tang, P., Zhang, Z., Feng, X., Li, K., Wang, L. Chen, X., Liu, C., Duan, W., He, K., Xue, Q., K., Ma, X., and Wang, Y., *Topology-driven Magnetic Quantum Phase Transition in Topological Insulators,* Science, **339**, (2013) 1582-1586. (DOI: 10.1126/science.1230905)
3. Buttner, B., Liu, C. X., Tkachov, G., Novik, E. G., Brne, C., Buhmann, H., Hankiewicz, E. M., Recher, P., Trauzettel, B., Zhang, S. C., and Molenkamp, L. W., *Single Valley Dirac Fermions in Zero-gap HgTe Quantum Wells,* Nature Phys., **7**, (2011) 418-422. (DOI: 10.1038/NPHYS1914)
4. Brune, C., Liu, C. X., Novik, E. G., Hankiewicz, E. M., Buhmann, H., Chen, Y. L., Qi, X. L., Shen, Z. X., Zhang, S. C., and Molenkamp, L. W., *Quantum Hall Effect from the Topological Surface States of Strained Bulk HgTe* , Phys. Rev. Lett., **106**, (2011) 126803. (DOI: 10.1103/PhysRevLett.106.126803)
5. Liu, C. X., Zhang, H., Yan, B., Qi, X. L., Frauenheim, T., Dai, X., Fang, Z., and Zhang, S. C., *Oscillatory Crossover from Two Dimensional to Three Dimensional Topological Insulators,* Phys. Rev. B, **81**, (2010) 041307(R). (DOI: 10.1103/PhysRevB.81.041307)

Topological Order and Quantum Entanglement

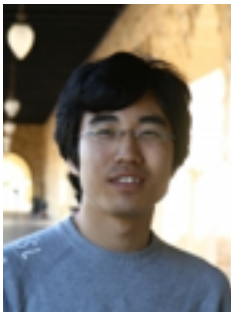
Xiao-Liang Qi（祁晓亮）
Department of Physics, Stanford University

Abstract

Topologically ordered states are novel states of matter that are distinct from ordinary states by topological measures, such as ground state degeneracy and fractionalized particles, instead of conventional mechanism such as spontaneous symmetry breaking. Since the discovery of fractional quantum Hall states in 1980's, topologically ordered states have been studied extensively theoretically and experimentally. Since it is difficult to characterize topological order in ordinary measures, it is essential to investigate new measures that distinguish topological states from ordinary states of matter. In particular, quantum entanglement provides very useful tools to describe topological order. In this talk I will first give an overview of topological order and quantum entanglement, and the review a few entanglement measures of topological order, such as topological entanglement entropy and momentum polarization. In the later part of the talk I will introduce a new work in which we propose general quantum entanglement measures of topological order and conventional long range order.

Reference:
[1] Hong-Hao Tu, Yi Zhang, and Xiao-Liang Qi, Phys. Rev. B 88, 195412
[2] Yi Zhang and Xiao-Liang Qi, Phys. Rev. B 89, 195144
[3] Chao-Ming Jian, Issac Kim and Xiao-Liang Qi, in preparation

Biography



Career History
- 1999-2003, Bachelor, Tsinghua University
- 2003-2007, Ph.D., Institute for Advanced Study, Tsinghua University
- 2007-2009, Research Associate, SLAC, Stanford University
- 2009-2010, Postdoctoral researcher, Microsoft Station Q, UCSB
- 2009-2014, Assistant Professor of Physics, Stanford University
- 2014-present, Associate Professor of Physics, Stanford University

Honors
- 2014 Sackler International Price in Physics
- 2011 Hermann Kümmel Early Achievement Award in Many-Body Physics
- 2011 Packard Fellowship
- 2010 Sloan Research Fellowship

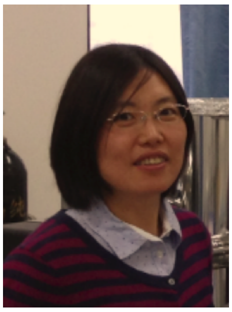
Searching High T_c at Interface

Lili Wang（王立莉）
Department of Physics, Tsinghua University

Abstract

According to BCS theory, T_c of a superconductor depends on the Fermi surface area and on the electron–phonon coupling strength. On the other hand, high temperature superconductors are intrinsically multilayered materials where metallic CuO_2 (FeAs/FeSe) layers are stacked with other metal-oxide layers, so-called “charge-reservoir blocks” that provide mobile holes/electrons to CuO_2 (FeAs/FeSe) layers, and the superconductivity is realized by doping charge carriers into the parent Mott insulators (metallic) compounds. Inspired by the above phenomena, we search high Tc by fabricating hetero-structure of metal and dielectric/ceramic materials by using molecular beam epitaxial growth. In this talk, I will present our work on Pb/Si and FeSe/$SrTiO_3$ interfaces. Especially in the latter case, signatures of T_c above liquid nitrogen boiling point has been observed.

Biography



Lili Wang received her Ph.D degree in physics from Institute of Physics, Chinese Academy of Sciences in 2006. She has been a postdoctoral research fellow in Rice University from 2006 to 2008, an associate professor at Institute of Physics, CAS from 2009 to 2013. From September 2013, she moved to Department of Physics, Tsinghua University as an associate professor.

Her current research focuses on low temperature scanning tunneling microscopy, molecular beam epitaxial growth and low dimensional superconductivity.

Dephasing and Disorder Effects in Topological Systems

X. C. Xie（谢心澄）

International Center for Quantum Materials and School of Physics, Peking University

Abstract

We analyze the dephasing and disorder effects in 2D quantum spin Hall insulators (QSHI) and 3D topological insulators. For the QSHI, we find that the quantum resistance plateaus are robust against the normal dephasing but fragile with the spin dephasing. For 3D topological insulators, we show that the combination of dephasing and impurity scattering can cause backscattering in the helical states. Especially for the charge impurity case, the backscattering cross-section becomes extremely large around the Dirac point, which can lead to the anomalous `gap-like' features found in recent experiments [Nat. Phys. {\bf7}, 840 (2011)]. Moreover, we study the disorder effects in Bernevig-Hughes-Zhang (BHZ) model (unitary system), and find that the Anderson transition of QSHI is determined by the model parameters. In contrast to the common belief that 2D unitary system scales to insulator except at certain critical points, we find that an exotic metallic phase emerges between QSHI and normal insulator phases in InAs/GaSb-type BHZ model. Furthermore, we investigate disorder induced metal-insulator transitions in Weyl semimetals and find a various of multiple metal-insulator transitions.

Biography

Prof. Xie obtained his B.Sc. in physics from University of Science and Technology of China in 1982 and Ph. D. from University of Maryland in 1988. He became a faculty member in Department of Physics at Oklahoma State University in USA since 1991 and was named Regents Professor in 2004. He worked as a Chief Scientist and Director of Laboratory of Condensed Matter Theory and Computation at the Institute of Physics, Chinese Academy of Sciences in 2005-2010. Prof. Xin-Cheng Xie joined Peking University in 2010 as a Chair Professor and the Founding Director of International Center for Quantum Materials. In 2011 he was appointed as Dean of School of Physics at Peking University, and a Co-Director of National “2011 project” Collaborative Innovation Center of Quantum Matter.

Prof. Xie’s main research focuses include quantum Hall effect, quantum transport, topological matter and strongly correlated electron systems. He is an author of more than 180 scholarly articles and has delivered more than 160 invited talks at universities and conferences worldwide. Prof. Xie was elected as a Fellow of American Physical Society in 2008. He is a Divisional Associate Editor for Condensed Matter Division of Physical Review Letters, and an editorial board member of 7 other international peer-reviewed journals. He also serves as a member of international advisory committee of many international conferences and institutes.

Transport Properties of Topological Insulators and a Candidate Material for Magnetic Weyl Semimetals

Yongqing Li（李永庆）
Institute of Physics, Chinese Academy of Science

Abstract
This seminar contains two parts: (1) an introduction to electron localization phenomena in low dimensional systems and overview of the latest advances in studies of the localization in 3D topological insulator thin films, (2) an introduction to our recent experimental work on $HgCr_2Se_4$, a candidate for magnetic Weyl semimetals (Chern semimetals).

Biography

Yongqing Li received his B.S. degree at Tianjin University, and Ph.D. degree at Florida State University. He was a postdoctoral researcher at the Center for Spintronics and Quantum Computation, University of California, Santa Barbara during 2003-2005. Then he worked as a visiting scientist in the Max Planck Institute for Solid State Research in Stuttgart. In July 2008，he joined the Dan Tsui Laboratory, Institute of Physics (IOP), Chinese Academy of Sciences (CAS) and was supported by the Hundred-Talents-Program of CAS. He was appointed as a professor of physics in July 2009. He is now the head of a research group working on low dimensional electronic systems in the Laboratory of Nanoscale Physics & Devices at IOP. His current research interest includes topological insulators, semiconductor 2D electron systems, and magnetic semiconductors and semimetals.

Helical Luttinger-Liquid in InAs/GaSb Quantum Spin Hall Edges

Rui-Rui Du（杜瑞瑞）

International Center for Quantum Materials, School of Physics, Peking University

Abstract

Tomonaga-Luttinger liquid is a theoretical model describing the ground state of a correlated 1D electronic system. Confirmations of this ground state have been examined in various materials, such as carbon nanotubes, semiconductor nanowires, cleaved-edge-overgrowth 1D channel, as well as fractional quantum Hall edge states, respectively for spin-full or chiral Luttinger liquids. The quantum spin Hall insulator (QSHI) is a topological nontrivial state of matter supporting the helical edge states, which are counter-propagating, spin-momentum locked 1D modes protected by time reversal symmetry. In this tutorial we will introduce the InAs/GaSb materials system hosting the QSHI and the helical edge states, and the interesting Luttinger properties revealed by ultralow temperature transport experiments in ICQM.

Biography

Rui-Rui Du Graduated from Fudan University 1982; Ph. D in Physics 1990 from University of Illinois at Urbana-Champaign; Postdoctoral Research Fellow 1990-1994, Princeton/Bell Labs (with Dan Tsui and Horst Stormer, Nobel Laureates in Physics 1998); Professor 1994-2004, University of Utah; Professor 2004-present, Rice University; Chair Professor 2011- present, Director, 2015- present, International Center for Quantum Materials; Sloan Research Fellow 1996; OCPA Award 1997; APS Fellow 2003. Visiting Professor, Ludwig Maximillian University in Munich, 2002; Visiting Scientist, NTT Central Research Lab, Japan, 2005.

Research Interests

Experiments on Quantum Transport in Condensed Matter, in particular the Fractional Quantum Hall Effect, Quantum Spin Hall Effect, topological superconductor, and other emergent phenomena

Excited State Electron-Ion Dynamics at Interface

Sheng Meng（孟胜）

Institute of Physics, Chinese Academy of Science

Abstract

Real-time time-dependent density functional theory (TDDFT) has been implemented using local atomic basis, which enables large scale simulations on electron-ion dynamics at more realistic complex interface systems. The electron-ion evolution is driven by a Hamiltonian that build upon excited state electron density. This allows us to demonstrate the working principles of hybrid solar cells especially that involving charge separation and collection dynamics purely based on quantum mechanics. The method also yields precise prediction of the timescale for ultrafast electron injection from chromophores to semiconductors, in response to various interface structural details (molecular size, anchor group, binding mode, defects) and environment (excitation level, solvents). Consequently we could build a “virtual solar cell” producing macroscopic current-voltage relationships with only input being molecular composition. The methods are also used for investigating ultrafast electron transfer in dichalcogenides heterostructures, solvated electrons supported on surfaces, and plasmonic water splitting.

Biography

Dr. Sheng Meng is a professor and head of the Surface Quantum Dynamics group at Beijing National Laboratory for Condensed Matter Physics, and Institute of Physics, Chinese Academy of Sciences since 2009. He obtained his Bachelor degree in physics from University of Science and Technology of China (USTC) in 2000, and Ph.D. degree in applied physics from Chalmers University of Technology, Sweden in 2004. During 2005-2009, he worked at Harvard University’s Department of Physics first as a post-doctoral researcher then a research associate.

Research Interests:
Dr. Meng’s research interests focus on quantum interaction and dynamics of molecules on materials surface. His previous work started with the simplest but most mysterious molecule in nature: water. Current interests include excited state dynamics, ambient quantum materials, DNA-nanotube interaction, and energy conversion mechanisms in artificial photosynthesis. He has published ~80 technical papers in peer-reviewed journals, and has received 2000+ citations.

Topological Insulating States in Honeycomb Lattice

Xiao Hu（胡 晓）

International Center for Materials Nanoarchitectonics (WPI-MANA)

National Institute for Materials Science (NIMS), Tsukuba, Japan

Abstract

Topology becomes ubiquitous in condensed matter physics in recent years. How simple can a useful topological system be? This question is meaningful since its answer on one hand is related to the essence of topology, and on the other hand may give hints for experimental implementation and potential application. In this talk I try to answer this question based on our recent work on achieving quantum spin Hall effects by simply deforming honeycomb lattice. We observe that honeycomb lattice is equivalent to triangle lattice of hexagons formed by six neighboring sites. When the triangle lattice is squeezed with the hexagons fixed and C_6 symmetry preserved, a gap will be opened in the Dirac energy dispersion, and simultaneously a pseudo spin degree of freedom will be generated in the system. The first implementation of this idea is a topological photonic crystal based on conventional dielectric material, such as silicon, which carries on edge counter-propagation of electromagnetic waves with opposite pseudo spins. In the second example, we modify the electron hopping integral between nearest-neighboring sites of honeycomb lattice in a way to build Kekule hopping texture. It is shown that an effective spin-orbit coupling (SOC) is generated, larger than the intrinsic SOC by several orders of magnitude, which may make helical edge currents available at high temperature. If time permits, I will discuss several related topics including quantum anomalous Hall effect in transition metal oxides, topology of non-Dirac electrons and topological nodal-line-semimetals.

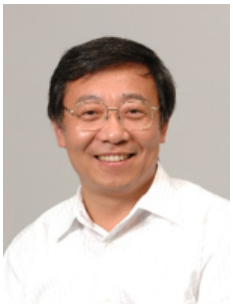
Reference:

[1] L.-H. Wu and X. Hu, “A Scheme for Achieving Topological Photonic Crystal by Using Dielectric Material”, Phys. Rev. Lett. vol. 114, 223901 (2015).

[2] Q. –F. Liang, L. H. Wu, and X. Hu, “Electrically tunable topological state in [111] perovskite materials with an antiferromagnetic exchange field”, New J. Phys. Vol. 15, 063031 (2013).

[3] R. Yu, H.-M. Weng, Z. Fang, X. Dai and X. Hu: “Topological Nodal Line Semimetal and Dirac Semimetal States in Anti-Perovskite Cu_3PdN”, Phys. Rev. Lett. (in press).

Biography



Ph.D.
PI of International Center for Materials Nanoarchitectonics (WPI-MANA)
Unit Director of National Institute for Materials Science (NIMS)
Adjunct professor of Tsukuba of University
1000-Talent Program distinguished Professor

He has been engaging in study of theoretical physics. After working in University of Tokyo, Tohoku University, and National Institute for Standard and Technology (US), he joined NIMS in 1996, and has been a PI in WPI-MANA since its establishment in 2007. He has accomplished a series of important achievements, including the first demonstration of the first-order melting transition of Abrikosov vortex lattice in high-Tc cuprate superconductors by MC simulation, discovery of the novel Pi-kink state in phase dynamics of intrinsic Josephson junctions in cuprate superconductors and its application for coherent THz radiation, proposal of the antiferromagnetic topological insulator carrying both charge and spin Chern numbers, design of nano devices for braiding of Majorana bound states in topological superconductors, to name a few. He has contributed review articles in Superconductor Science and Technology, Advanced Materials, Science and Technology of Advanced Materials, and Advances in Physics.

Superconductivity at 2D Limit and Potential to Topological Superconductivity

Jian Wang（王健）

International Center for Quantum Materials and School of Physics, Peking University

Abstract

A brief introduction to superconductivity and two dimensional (2D) superconductivity is given. After that, previous experimental studies for 2D superconductors are introduced including recent progress of interface superconductivity in oxides. Then, the focus of this presentation is current new discoveries and achievements of superconductivity at 2D limit for the crystalline films. In the end, it is a perspective for 2D superconductors and potential to topological superconductivity.

Biography

Dr. Jian Wang is a young experimentalist in condensed matter physics. He has been awarded with the 2015 Sir Martin Wood Science Prize in recognition of his outstanding achievement on the study of interface-enhanced superconductivity at 2D limit and potential to topological superconductivity. Dr. Wang gained a Ph.D under the supervision of Professor Qi-Kun Xue at the Institute of Physics, Chinese Academy of Sciences. Then, he spent five years in Professor Moses Chan's group at the Pennsylvania State University as a Post Doctorate Researcher and Research Associate. In 2010, he joined the International Center for Quantum Materials, School of Physics, Peking University as an Associate Professor. In 2011, he was selected as the Fellow of China Thousand Talents Program for Young Scientists. In 2012, he was selected as the Leader for National Young Scientists Projects and supported by the National Natural Science Foundation of China for Excellent Young Scientists.

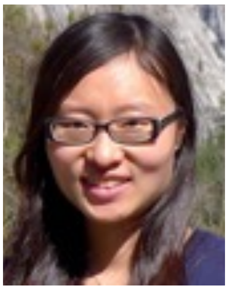
Symmetry Protected Topological Phases

Xie Chen（陈谐）
California Institute of Science and Technology

Abstract

Symmetry protected topological (SPT) phases generalize the nontrivial properties of topological insulators and superconductors from free fermion systems to interacting boson / fermion / spin systems. They have a gapped, symmetric bulk and gapless, nontrivial edge state which cannot be removed without breaking the symmetry. Simple models of SPT phases in 1D, 2D and 3D interacting systems will be introduced and their exotic physical properties explained.

Biography



Xie Chen got her B.Sc. degree from Tsinghua University in 2006 and her Ph.D. from MIT in 2012. She was a Miller research fellow at the University of California Berkeley from 2012 to 2014 and joined Caltech as an assistant professor in 2014. Xie's research focuses on strongly interacting topological phases and takes a quantum information perspective, especially the entanglement perspective, in studying such systems.

Spintronics in Two Dimensional Quantum Materials

Wei Han （韩伟）

International Center for Quantum Materials and School of Physics, Peking University

Abstract

Spintronics aims to use spin for information storage and logic applications. Recently, the discovery of two dimensional quantum materials has provided new platforms for the spintronics. In this lecture, I will discuss recent progresses of the spintronics in two dimensional quantum materials, focusing on spin injection, spin relaxation, spin momentum locking, spin Hall effect and spin orbit torque in these materials.

Biography

Prof. Wei Han is the group leader of the lab for spintronics and emergent materials at the international center for quantum materials (ICQM) of Peking University. He studied physics at the University of California, Riverside, and completed his doctorate there in 2012. After postdoctoral fellowships at the IBM Almaden research center, he joined the ICQM in 2014. Prof. Han's research interests include spintronics, two dimensional quantum materials, spin orbit couplings, and spintronics devices for advanced information storage and logic applications. Prof. Han has published 32 scientific papers, which has been cited for more than 1400 times (h-index: 18, Google scholar).

High-Tc Superconductivity and Strong Correlations

Zheng-Yu Weng（翁征宇）
Institute for Advanced Study, Tsinghua University

Abstract

The discoveries of high-temperature superconductivity in the cuprate and iron-based materials have inspired intense interest and efforts in search for microscopic mechanisms based on strong correlations. I will introduce and review some of the key experimental evidence and important theoretical endeavors in studying these novel superconductors, which are among the most challenging issues in condensed matter physics. I will then try to provide a systematic theoretical picture for the cuprate superconductivity to exemplify a possible understanding for such a correlated system.

Biography

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2001	Chang-Jiang Professor, Tsinghua University
2004	C N Yang Chair Professor, Tsinghua University
1987-2001	Postdoctoral Associate/Research Assistant Professor, Texas Center for Superconductivity at University of Houston

Education:
B. S. 1982, University of Science and Technology of China
Ph. D. 1987, University of Science and Technology of China

Research interests:
Strongly correlated electrons; high-Tc superconductivity; Topological characterizations in condensed matter physics

Visualizing electronic structures of topological quantum materials
By Angle Resolved Photoemission Spectroscopy (ARPES)

Yulin Chen（陈宇林）
Physics Department, University of Oxford

Abstract

The discovery of materials with novel properties is one of the most fascinating aspects of physics, and such findings have always played important roles in the development of science and human life. In this lecture, I will do a brief introduction to a powerful experimental technique: Angle Resolved Photoemission Spectroscopy (ARPES) and its application in the exploration of topological quantum materials, such as topological insulators and topological Dirac semimetals. In the second part, I will briefly introduce the advances of ARPES recently and in the near future by incorporating the time, spatial, and spin- degrees of freedom.

Biography

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Research Experience:

2014- Associate Professor & Fellow of Jesus College, University of Oxford
2012-2013 University Lecturer & Fellow of Jesus College, University of Oxford
2008-2009 Postdoctoral Associate/Research Assistant Professor,
Texas Center for Superconductivity at University of Houston

Education:

B. S. 2000, University of Science and Technology of China
Ph. D. 2008, Stanford University

Honors and Awards:

Outstanding Young Researcher Award (Macronix Prize) 2012
William E. and Diane M. Spicer Young Investigator Award 2009
ABC interview on realization of topological insulator Bi2Te3 2009
Video link: http://abclocal.go.com/kgo/story?section=news/technology&id=6871012

Research interests:

ARPES, Topological insulators

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