Kaifa Luo

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Education

Hong Kong University of Science and Technology *Sep 2019 – Present*
Visiting Internship Student (Research Only) | Advisor: Prof. *Xi Dai*

Research Assistant to Prof. *Rui Yu* at **Wuhan University** *Mar 2017 – Aug 2019*

B.Sc. at **Wuhan University** | Major in Physics | Minor in Computer Science *Sep 2014 – Jun 2018*
Thesis: "Topological States in Electric Circuits"[4] | Advisor: Prof. *Rui Yu*
Honor: "*Yugang·Songxiao*" Scholarship (Highest Honor, top 0.3% in *Dec 2016*) and graduated *summa cum laude*.

Publication

[1] "Topological nodal states in circuit lattice,"
Kaifa Luo, Rui Yu, Hongming Weng, *Research* 2018, 6793752 (2018). (cited by 24)

[2] "Nodal Manifolds Bounded by Exceptional Points and Electrical-Circuit Realizations,"
Kaifa Luo, Jiajin Feng, Yuxin Zhao, Rui Yu, Submitted. Preprint: *arXiv*:1810.09231. (cited by 8)

[3] "Large Fermi-arc and robust Weyl semimetal phase in Ag_2S,"
Zhenwei Wang*, **Kaifa Luo***, Jianzhou Zhao, Rui Yu, *Phys. Rev. B* 100, 205117 (2019).

[4] "Topological states in electric circuits,"(in Chinese)
Kaifa Luo, Rui Yu, *Acta Phys. Sin.* 68, 220305 (2019). (invited article)

[5] "Topological phases in pyrochlore thallium niobate $Tl_2Nb_2O_{6+x}$,"
Wei Zhang, **Kaifa Luo**, et. al., *npj Comput. Mater.* 5, 105 (2019).

[6] "Observation of multiple types of topological fermions in PdBiSe,"
BQ Lv, ZL Feng, JZ Zhao, Noah FQ Yuan, A Zong, **KF Luo**, et. al., *Phys. Rev. B* 99, 241104(R) (2019).

*Joint first author; full list: My personal Google scholar page

Research Experience

Tight-binding Model for Twistronics (Ongoing) *Sep 2019 – Present*
Advisor: *Xi Dai*; Collaborator(CL): *Jian-Peng Liu*@HKUST

Instability of nodal-ring semimetal under a strong magnetic field (Ongoing) *Jun 2019 – Present*
Advisors: *Xi Dai*, *Rui Yu*; CLs: *Tao Wu*, *Li-Xuan Zheng*@USTC
Overview: This project focuses on Fermi surface instability of nodal-ring semimetal beyond quantum limit.

- Extracted an effective Hamiltonian to capture band structure of the lowest Landau levels(LLLs) of a symmetry-protected nodal-ring semimetal under a strong magnetic field;
- Calculated effective screening potential for the LLLs through Random Phase Approximation;
- Going to computate the gap of charge density wave phase transited from effective 1D Weyl semimetal when electron-electron scattering considered by applying standard Hartree-Fock method.

Keywords: Nodal-ring semimetal, Landau level, Charge density wave, RPA

Construction of effective Hamiltonians for quantum materials *May 2018 – Apr 2019*
Advisor: *Rui Yu*; CLs: *Wei Zhang*@FJNU, *Jian-Zhou Zhao*@ETHz→SUTD, *Zhen-Wei Wang*@WHU
Overview: This project focuses on the construction of effective Hamiltonian starting with the atomic orbitals and symmetry groups, for non-magnetic quantum materials searched by the first-principles calculations.

- Verified existence of charge-2 Dirac Fermions protected by TRS and point group D_2 in spin-orbit-free Ag_2S[3], and its spiltting to Weyl semimetal(WSM) with large Fermi-arcs by symmetry-constrained SOC;
- Specified the phase transition from double-Weyl Fermions protected by TRS and point group O_h in $Tl_2Nb_2O_{6+x}$[5], to Dirac SM/topological insulator by in-plane strain and to spin-1 WSM by oxidation;
- Explained the coexisted Weyl, Rarita-Schwinger-Weyl, double class-II three-component, and charge-2 four-fold Fermions protected by TRS and non-symmorphic space group $P2_13$ (No.198) in PdBiSe[6].

Keywords: $k \cdot p$ method, Spin-orbit coupling, Unconventional Fermion, Non-symmorphic symmetry

Open nodal manifolds bounded by exceptional points[2] *May 2018 – Nov 2018*
Advisor: *Rui Yu*; CLs: *Jia-Jin Feng*@SYSU→PKU, *Yu-Xin Zhao*@NJU
Overview: This project focuses on the exotic open bulk nodal states in non-Hermitian perturbated topological nodal-line and Weyl semimetals with periodic boundary condition, and their feasible realizations in LC circuits.

- Devised 2D and 3D non-Hermtian honeycomb LC lattices by introducing effective asymmetric capacitors;
- Computated open bulk Fermi-arcs and drum-head states bounded by exceptional points and lines;
- Demonstrated breakdown of bulk-boundary correspondence between non-Hermitian bulk degeneracies and surface states, and its recovery through similarity transformation and non-Hermitian winding number;
- Specified a physical picture of non-Hermitian skin effect originated from asymmetric hopping.

Keywords: Exceptional point, Bulk Fermi-arc, Open nodal surface, Bulk-boundary correspondence, LC circuit

Symmetry protected topological states of coupled harmonic oscillators[1] *Apr 2017 – Apr 2018*
Advisor: *Rui Yu*; CL: *Hong-Ming Weng*@IoP CAS
Overview: This project focuses on emulation of topological states protected by local and spatical symmetries in linear electric circuits, including nodal-line, Weyl and non-trivial insulating states.

- Mapped linear electric circuits composed of LC resonators to corresponding tight-binding Hamiltonians;
- Devised a 3D periodic LC lattice, to emulate topological nodal-line or Weyl states by retaining or breaking spatial inversion symmetry under proper parameters of electric elements;
- Computated the drum-head surface states and surface Fermi-arcs by surface Green function method, and corresponding winding number and the first Chern number from bulk states;
- Proposed spring-mass and LC circuit realizations of 1-3D Harper models and Fibonacci quasicrytals, which are characterized by the non-zero first, second, and third Chern number;
- Explored RLC circuit proposals of 1D and 3D topological insulators of AIII class in ten-fold way;

Keywords: Topological nodal state, Topological phase transition, Quasi-crystal

Observation of topological valley transport of sound in sonic crystals *Aug 2016 - Jan 2017*
Overview: This project focuses on the chiral transport induced by Berry curvature near valleys in a sonic crystal, in which I am being a research assistant to Dr. *Jiu-Yang Lu* supervised by Prof. *Chun-Yin Qiu*(@WHU).

- Assembled a 2D artificial sonic crystal arrayed as triangular lattice, in which the little group at $K(K')$ valley can be continuously tuned from C_{3v} to C_3, to lift the mirror symmetry-protected two-fold Dirac degeneracies;
- Measured the sound intensity distribution data of valley states to demonstrate acoustic valley transport phenomena and valley Hall phase transition.

Keywords: Sonic crystal, Valley Hall effect, Valley transport

Summer/Winter School & Contest

Winter School on New Progress of Quantum Materials and Quantum Technologies *Nov 2019*
South Bay Interdisciplinary Science Center, Songshan Lake

Summer School on Machine Learning in Physics *Aug 2018*
Department of Physics, Wuhan University | Lecturer: Prof. *Bin Xi*@YZU
Topic: Introduction to Recursive/Convolutional Neural Networks and their applications in physics.

Summer School on Condensed Matter Theory (CMT2018) *Jul 2018*
Qinghuangdao, Funded by National Natural Science Foundation of China (NSFC)
Topic: Superconductivity and correlated electrons, Cold atoms and quantum simulation.

Summer School on Condensed Matter Physics *Jul 2017*
Department of Physics, Fudan University | Lecturer: Prof. *Zhen-Yu Zhang*@USTC
Topic: Predictive design of advanced materials for clean energy and quantum information.

Mathematical Modeling
National Third Prize in "HUAWEI Cup" to solve a dynamic programming problem. *Sep 2018*
Meritorious Winner in Interdisciplinary Contest to solve an optimization problem. *Apr 2016*

Miscellaneous

Programming: Python (numpy, matplotlib), C, LaTeX and Java(beginner)
Software: MATLAB (extensively), Wolfram Mathematica, Adobe Photoshop and Premiere
Language: Mandarin Chinese (native), English (professional)