Zongqi Shen

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Education Background

Department of Physics, Fudan University *Sep.2018-Present*

Bachelor of Science in Physics

- Overall GPA: **3.75**/4, Rank: 5% in the department of physics
- On track for honor degree in the Major
- Core and Graduate Courses (with grades): Advanced QM(A), Solid State Physics(A), Statistical Physics(A), Methods of Mathematical Physics(A), Scattering Physics(A), Superconductivity and Low Temperature Physics(A)
- Standard Tests: TOEFL 104 (Reading 28+ Listening 26 + Speaking 23 + Writing 27)

Research Interests

Emergent phenomena in strongly correlated electron systems including topology, superconductivity and magnetism

- Design, craft and control materials on the atomic level via tear-and-stack technique or epitaxial growth
- Correlated electrons in moiré graphene and transition metal dichalcogenides (TMDC) materials
- High Tc superconductors and complex oxides
- Theory: First-principle calculation of electronic structures

Publications

1. Jiahui Qian, **Zongqi Shen**, Xinyuan Wei, Wei Li, "**Z_2 nontrivial topology of rare-earth binary oxide superconductor LaO**", *arXiv:2108.10063*, accepted by *Physical Review B* as *Letter*
2. Lijie Wang, Huanyi Xue, Guanqun Zhang, **Zongqi Shen**, Gang Mu, Shiwei Wu, Zhenghua An, Yan Chen and Wei Li, "**Two-dimensional superconductivity at heterostructure of Mott insulating titanium sesquioxide and polar semiconductor**", *arXiv:2106.06948*, under review in *Nature Materials*
3. Huanyi Xue*, Lijie Wang*, **Zongqi Shen***, Guanqun Zhang, Gang Mu, Wei Peng, Xinyuan Wei, Shiwei Wu, Zhenghua An, Yan Chen and Wei Li, "**Time-reversal and rotational symmetries breaking in a spinel superconductor**", *in preparation*

Research Experience

Scanning tunneling microscopy(STM) study of moiré graphene and TMDC materials *Aug.2021-Present*

Supervisor: Prof. Michael F. Crommie, UC Berkeley

- Mastered STM/S to image the electronic structure of materials and took charge of an Omicron LT-STM machine.
- Constructed a continuum model to simulate the LDOS of twisted bilayer graphene aligned with hBN.
- Characterized twisted bilayer graphene and transition metal dichalcogenides (TMDC) devices ($TaSe_2$, $NbSe_2$, $TaTe_2$, etc.) grown by MBE. Studied the evolution of electronic structures with back gate.
- Imaged the Mott insulating behavior of monolayer 1T-$TaSe_2$ with 'flower pattern' orbital texture.
- Proved the existence of localized spins by observing Kondo resonance peak in the STS spectra of 1T/1H-$TaSe_2$.
- Discovered exotic $\sqrt{19} \times \sqrt{19}$ charge density wave in monolayer 1T-$TaTe_2$ in collaboration with LBNL group.
- Currently working on the nontrivial topology in twisted mono-bilayer graphene and potential Tc enhancement in $NbSe_2$/$SrTiO_3$.

***Ab-initio* study of rare-earth oxide superconductors with nontrivial topology** *May.2021-Aug.2021*

Supervisor: Prof. Wei Li, Fudan University

- Learned and mastered first-principle calculation of electronic structures and phonon spectrum using VASP.
- Developed python codes to study the nontrivial topology of rare-earth oxide superconductor LaO and found non-zero $\mathbb{Z}_2$ invariant together with topologically protected surface states.
- Analyzed the energy splitting of La orbitals in oxygen octahedron crystal fields with group theory and identified the origin of band inversion as the 5d→4f orbital transition.

Unconventional superconductivity in oxide heterostructures *Apr.2020-Aug.2021*

Supervisor: Prof. Wei Li, Fudan University

- Grew and optimized single crystal oxide thin films Ti_2O_3/GaN layer-by-layer with pulsed-laser deposition.
- Helped to identify the Bose metallic state in Ti_2O_3/GaN with temperature-independent resistance in a wide range associated with vanishing Hall resistance.
- Analyzed the pairing symmetry in $LiTi_2O_4$ with group theory and helped to explain the coexistence of ferromagnetism and superconductivity.
- Fitted STS data of $LiTi_2O_4$ with the calculated LDOS spectrum of triplet-pairing superconductors using Green's function method.
- Proposed a topological origin of the two-fold symmetry in transverse resistance of $LiTi_2O_4$, providing a new explanation for similar results reported in *Nature* 547, 432–435 (2017).

Theoretical study of Majorana zero modes in topological superconductors *May.2019-Apr.2020*

Supervisor: Prof. Wei Li, Fudan University

- Learned lattice Green's function method to study the transport properties of topological superconductors.
- Constructed a lattice model of metal-superconductor junctions and developed python codes to simulate Andreev reflection spectrum.
- Studied the finite-size effects of the zero-bias conductance peak in topological superconductors and found that only quasi-one-dimensional materials can exhibit quantized conductance at $2e^2/h$

CVD growth of 2D materials and device fabrication *Nov.2018-May.2019*

Supervisor: Prof. Faxian Xiu, Fudan University

- Synthesized high quality Bi_2SeO_2 sample using chemical vapor deposition (CVD) method.
- Peeled off single-layered graphene for heterostructure fabrication.
- Helped to establish a platform for stacking layers of 2D materials controlled by LabView.

Honors & Awards

- Excellent Student Award from Fudan University *Sept.2021*
- Selected for National Top Talent Undergraduate Training Program *May.2021*
- National Scholarship (1/115 in the Department of Physics) *Dec.2020*
- Xiyuan Scholar (UROP funding at Fudan) *May.2020*
- First Prize in Chinese College Physics Competition (ranked No.1 in First Prize winners) *Oct.2019*
- Excellent Student Award of Fudan University *Sept.2019*

Skills

Laboratory:

- Material Growth: PLD and CVD growth of thin films
- Micro- and Nano-fabrication skills: Electron Beam Lithography, Wire Bonding
- Characterization skills: STM/STS, AFM, Cryogenic Transport Measurements, MPMS, X-Ray Diffraction, Raman Spectroscopy

Theory:

- Programming: Python, C, Mathematica
- Simulation: *ab-initio*(VASP), transport properties(Kwant), STS spectrum