

# 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 T<sub>c</sub> superconductors and complex oxides
- Theory: First-principle calculation of electronic structures

## Publications

1. Jiahui Qian, **Zongqi Shen**, Xinyuan Wei, Wei Li, “Electronic structure 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<sub>2</sub>, NbSe<sub>2</sub>, TaTe<sub>2</sub>, etc.) grown by MBE. Studied the evolution of electronic structures with back gate.
- Imaged the Mott insulating behavior of monolayer 1T-TaSe<sub>2</sub> with ‘flower pattern’ orbital texture.
- Proved the existence of localized spins by observing Kondo resonance peak in the STS spectra of 1T/1H-TaSe<sub>2</sub>.
- Discovered exotic  $\sqrt{19} \times \sqrt{19}$  charge density wave in monolayer 1T-TaTe<sub>2</sub> in collaboration with LBNL group.
- Currently working on the nontrivial topology in twisted mono-bilayer graphene and potential T<sub>c</sub> enhancement in NbSe<sub>2</sub>/SrTiO<sub>3</sub>.

**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  $\text{Ti}_2\text{O}_3/\text{GaN}$  layer-by-layer with pulsed-laser deposition.
- Helped to identify the Bose metallic state in  $\text{Ti}_2\text{O}_3/\text{GaN}$  with temperature-independent resistance in a wide range associated with vanishing Hall resistance.
- Analyzed the pairing symmetry in  $\text{LiTi}_2\text{O}_4$  with group theory and helped to explain the coexistence of ferromagnetism and superconductivity.
- Fitted STS data of  $\text{LiTi}_2\text{O}_4$  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  $\text{LiTi}_2\text{O}_4$ , 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  $\text{Bi}_2\text{SeO}_2$  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

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|---|-----------|
| • 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