

# Zongqi Shen

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## Education Background

**Department of Physics, Fudan University, Bachelor of Science in Physics**

Sep.2018-Present

- Overall GPA: **3.75/4**, Rank: top 5% in the department of physics
- On track for honor degree in the Major
- Core and Graduate Courses (with grades): Advanced QM(A), Statistical Physics(A), Methods of Mathematical Physics(A), Scattering Physics(A), Superconductivity and Low Temperature Physics(A), Semiconductor Physics(A-), Group Theory(A-), Statistical Physics II(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 material platforms on the atomic level via tear-and-stack technique or epitaxial growth
- Correlated electrons in moiré graphene and TMDC materials
- High T<sub>c</sub> superconductors and topological superconductors
- Theory: Electronic structure calculation and simulation of transport properties

## Publications

1. Jiahui Qian, **Zongqi Shen**, Xinyuan Wei, Wei Li, “**Electronic structure of rare-earth binary oxide superconductor LaO**”, *arXiv*:[2108.10063](https://arxiv.org/abs/2108.10063), under review in *Physical Review B*
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](https://arxiv.org/abs/2106.06948), under review in *Science*
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

**STM study of moiré graphene and TMDC materials**

Aug.2021-Present

Visiting Student Researcher supervised by Prof. [Michael Crommie](#), UC Berkeley

- Learned and mastered the use of STM/STS to image the electronic structure of materials and took charge of the Omicron LT-STM.
- Characterized twisted mono-bilayer graphene and TMDC samples (TaSe<sub>2</sub>, NbSe<sub>2</sub>, FeTe<sub>2</sub> etc.) under gating.
- Measured and confirmed the Mott behavior of monolayer 1T-TaSe<sub>2</sub> and imaged the flower pattern of orbital texture
- Currently working on nontrivial topology in twisted mono-bilayer graphene and strain effect in twisted bilayer graphene.

**Ab-initio study of rare-earth oxide superconductors with nontrivial topology**

June.2021-Aug.2021

RA supervised by Prof. [Wei Li](#), Artificial Interface Lab, 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 5d to 4f orbital transition accounts for the band inversion.
- Co-authored paper: *Electronic structure of rare-earth binary oxide superconductor LaO* now under review in *Physical Review B*

## Two-dimensional superconductivity at oxide interfaces

Sep.2020-Present

RA supervised by Prof. [Wei Li](#), Artificial Interface Lab, Fudan University

- Grew and optimized single crystal oxide thin films on  $\text{SrTiO}_3(111)$  substrates layer-by-layer with pulsed-laser deposition
- Measured the transport and magnetic properties of the heterointerface at low temperatures
- Helped to identify the Bose metallic state with a wide range of temperature-independent resistance associated with vanishing Hall resistance
- Co-authored paper: *Two-dimensional superconductivity at heterostructure of Mott insulating titanium sesquioxide and polar semiconductor* now under review in *Science*

## Time reversal and rotational symmetry breaking in superconductors

Sep.2020-Dec.2020

RA supervised by Prof. [Wei Li](#), Artificial Interface Lab, Fudan University

- Analyzed the pairing symmetry in our sample with group theory and helped to explain the coexistence of ferromagnetism and superconductivity
- Analyzed and fitted STS data and with the calculated LDOS spectrum of triplet-pairing superconductors using Green's function
- Proposed a topological origin of the two-fold symmetry in transverse resistance, which provided a new explanation of similar results reported in *Nature* 547, 432–435 (2017)
- Gained rich experience in combining experiments with theories to better understand the interplay between magnetism and superconductivity

## Fingerprints of Majorana zero mode in topological superconductors

June.2019-Present

RA supervised by Prof. [Wei Li](#), Artificial Interface Lab, Fudan University

- Learned nonequilibrium Green's function method (NEGF) and analytical methods to study the transport properties of p+ip and d+id superconductors
- Developed python codes to simulate Andreev reflection spectrum of metal-superconductor junctions
- Studied the finite-size effects of the zero-bias conductance peaks in topological superconductors and found only quasi-one-dimensional samples can give rise to quantized conductance at  $2e^2/h$ .

## 2D materials and device fabrication

Nov.2018-June.2019

RA supervised by Prof. [Faxian Xiu](#), Nanodevice Lab, Fudan University

- Synthesized high quality  $\text{Bi}_2\text{SeO}_3$  sample using chemical vapor deposition method (CVD)
- Peeled off single-layered graphene for heterostructure fabrication
- Helped establish a platform for stacking layers of 2D materials controlled by LabView
- Received technical training in device fabrication and transport measurement

## Honors & Awards

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| • National Scholarship (Highest honor awarded by Chinese government, 1/115 in Department of Physics) | Dec 2020 |
| • National Top Talent Undergraduate Training Program   | May 2021 |
| • Xiyuan Scholar (UROP funding at Fudan)   | May 2020 |
| • First Prize in Chinese College Physics Competition (rank No.1 in First Prize winners)              | Oct 2020 |
| • Excellent Student Award from Fudan University  | Sep 2019 |

## Skills

### Laboratory:

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

### Theory:

- Programming: python, C, Mathematica
- Simulation: *ab-initio*(VASP), transport simulation, STS spectrum