

Statement of Purpose

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Condensed Matter Physics, notable for its plethora of novel phenomena, is probably the most colorful and comprehensive one. It is therefore my first field of interest for Ph.D. study. As an undergraduate, I was fortunate to participate in several research projects at both Xi'an Jiaotong University and the University of California, Berkeley, from which I realized the importance of condensed matter physics, especially those related to the physical properties of nanostructures and novel materials.

I first became interested in physical research when I participated in the China Undergraduate Physics Tournament (CUPT). By collaborating with another undergraduate, I explored an unexpected phenomenon in fluid mechanics: A light cylinder starts to spin while being suspended near the edge of a water jet aiming upward. I used the Navier-Stokes equation and boundary layer theory to build a physical model. I found that this effect is caused by the pressure difference. Furthermore, we experimentally evaluated the stability of the cylinder. Our work led to a publication in a domestic physics journal, *Physics Experimentation*. I am the first author of this paper. This was the first time I went through the whole process of a research project, from identifying the problem to proposing a solution and finally publishing a paper. This experience sparked my passion for physical research and gave me confidence in my abilities to conduct novel research and fruitful collaborations.

To obtain more professional research experiences in condensed matter physics, in the Fall 2021 semester, I was selected and fully financially supported by Xi'an Jiaotong University to study at the University of California, Berkeley. I joined Prof. Michael Crommie's group of condensed matter experiments to start research on scanning tunneling microscopy (STM) and nanostructures, such as Graphene nanoribbons (GNRs).

In the first project, I studied the behavior of the magnetic ground state of dibenzoquateranthene (DBQA) on a gold surface. I learned to use Matrix-Assisted Direct (MAD) Transfer and Bottom-Up Approach to achieve an on-surface synthesis of poly-DBQA from precursor iodophenyl-bromobianthryl (PBA). By collaborating with my colleagues, I successfully got a topographic image of poly-DBQA chains by scanning tunneling microscopy. I was fascinated by these delicate nanostructures. This work led to a manuscript entitled "Decoupling localized modes in nanographene", which is prepared to be submitted to *Nature Communication*.

I mastered many experimental skills in the first project, which enabled me to undertake more tasks independently, such as annealing, sputtering, scanning probe measurements, molecular evaporation, and refilling liquid Helium and liquid Nitrogen. etc. I was eager to explore more surprising phenomena of condensed matter physics. Therefore, this impetus led me to start another project about the five-fold structure. In this project, I applied the Evaporation method and Bottom-Up approach to synthesize five-fold structures from five-membered ring molecules. Finally, we

obtained STM topographic images showing five-point star structures. This project provided new ideas for the synthesis of 2D quasicrystals.

In the third project, my colleagues and I designed and co-proposed a possible pathway for the ordered synthesis of GNRs assisted by single strands of DNA which might enable us to precisely control the length, orientation, and order of nanostructures. I used MAD Transfer to complete the on-surface synthesis. Nevertheless, STM topographic images showed that single strands of DNA were all bent and twisted which were not good candidates for ordered synthesis. Therefore, we found that DNA single strands are not suitable as templates for the ordered synthesis of GNRs. Through this research experience, I have mastered many experimental skills which are commonly used in condensed matter experiments, such as scanning probe measurement and on-surface synthesis. I also developed a better understanding of the physical properties of nanostructures.

The research projects mentioned above sparked my interest in condensed matter physics. Therefore, I want to explore this field at a more fundamental level. Consequently, in the Spring 2022 semester, I joined a group about Rydberg atoms and quantum nonlinear optics at Xi'an Jiaotong University. Under the guidance of Prof. Yongchang Zhang, I performed a theoretical study on Rydberg atomic system and quantum nonlinear optics. My colleagues and I designed and co-proposed a scheme to realize the function of qubit gates through the interaction of Rydberg atomic systems coupled with photons. Specifically, I reproduced the derivation of the Hamiltonian matrix of the Rydberg atomic system. I also conducted many numerical simulations, such as the energy distance relationship of the two-atom model and the time evolution of the polyatomic system under the condition of dark-state polariton. In this project, I completed a lot of complex theoretical derivations and numerical simulations, which improved my theoretical foundation and coding ability.

Curiosity had driven me beyond the curricular requirements of my undergraduate program. In my senior year, I took some graduate-level courses, such as semiconductor physics. This course helped me to re-understand many concepts in previous research projects, such as heterostructure, N-doped GNRs, and P-doped GNRs.

Diverse experiences in research and advanced studies armed me with great confidence and unyielding zeal to work on physics as a life career, and consequently, I would like to further improve my insight, knowledge, and skills through your prestigious Ph.D. program.