Personal Statement Sanket Chirame

I am applying to the Ph.D. program of the Department of Physics at the University of Illinois. During my graduate studies, I aspire to make a significant contribution to the field of condensed matter theory (CMT) while gathering skills for a successful academic career in theoretical physics. My theoretical background, developed through various advanced courses, along with the computational skills that I have honed through projects will prove to be assets while pursuing my Ph.D. research. I believe that University of Illinois, with its vibrant research environment, will be a perfect place for laying down the foundation of a successful career in academic research.

I intend to become a theoretical physicist carrying out independent research in the field of CMT with focus on topology of quantum systems. The research of Prof. Taylor Hughes on topological and geometric considerations of quantum systems and quantum Hall physics is of great interest to me. I am interested in working on quantum critical behaviour using field theory methods under the guidance of Prof. Eduardo Fradkin. I also find Prof. Smitha Vishveshwara's work on Majorana bound states very interesting. I am also attracted to Prof. Philip Phillips' recent research predicting Wigner crystals in twisted bilayer graphene. In addition, the Institute for Condensed Matter Theory would offer a unique opportunity of learning through workshops, seminars and collaborations. I seek for a graduate program offering an opportunity to discover various facets of the field with focused research along with guidance from experienced faculty. In this regard, the presence of multiple professors spanning my research interests is a major attraction of UIUC physics department for me.

In order to pursue research in these topics, I have developed my profile through various projects and advanced courses. I am pursuing my Master's thesis on phase transitions in quantum many body systems under the guidance of Prof. Soumya Bera. I am investigating the Aubry-Andre tight binding model driven by an external time-dependent electric field. The goal is to analyze phase transition from extended to localized states and its effect on observables like entanglement entropy and charge current. In the earlier part of the project, I also studied Density Matrix Renormalization Group (DMRG) techniques using matrix product state framework. This project provided me with extensive experience in scientific computation using Python, which is much needed for studying complex condensed matter systems. At the same time, I got to explore a variety of topics in contemporary CMT research bolstering my decision to pursue research in this field.

My interest in quantum mechanics was developed during my 2017 summer internship at the University of Konstanz, Germany under the guidance of Prof. Wolfgang Belzig and Dr. Akashdeep Kamra. I worked on entangling two qubits via their interaction with squeezed light. I employed the perturbation theory to obtain the effective Hamiltonian and analysed implications of disregarding the rotating wave approximation. Getting familiar with new concepts in the second quantization taught me how to quickly grasp new methods and apply them for solving a problem at hand. I also got experience of carrying out rigorous mathematical analysis and interpreting its physical implications. The interactions and discussions with members of the Konstanz quantum transport group strongly influenced me to pursue further research on quantum mechanical applications.

My initial interests in theoretical physics were piqued by my earlier projects on physics of biological systems. In my sophomore year, I worked with Prof. Anirban Sain on understanding the mechanism of the cell wall growth during cell division of Gram-negative bacteria. I studied existing mathematical models of cell wall growth and remodeling. Further, I worked with Prof. Mandar Inamdar on examining the dynamics of cellular networks in the epithelial tissue. I learnt to use CHASTE C++ simulation package to study effects of tensile and motile forces on the closure of a wound in a cellular monolayer . I incorporated curvature dependent motility force and analysed its effect on wound closure dynamics. These two projects made me familiar with the systematic way of theoretical investigation into a problem and the importance of computational techniques for validation of a theory. This swayed my interests further towards theoretical physics.

With the conviction of pursuing research in CMT, I undertook several advanced level courses to equip myself with required concepts, skills and techniques. *Theoretical Condensed Matter Physics* course introduced me to models and techniques frequently used in many body problems. In the course, *Physics of Nanostructures*, I explored spin-orbit interactions in graphene as part of my course project. I also took a course on *Spintronics* where I analysed the decoherence in quantum dots using pseudospin solutions. Undertaking *Advanced Statistical Mechanics* course helped me learn about phase transition and renormalization group methods. I also performed the finite-size scaling analysis of the 2D Ising model using the Metropolis Monte Carlo algorithm. I believe that these courses have introduced me with relevant concepts to tackle more involved problems in my future CMT research.

Apart from academic work, I have been part of IIT Bombay student satellite project which launched *Pratham*, IIT Bombay's first satellite, onboard Indian Space Research Organization's (ISRO's) PSLV C-35. I headed a team of 10 members as a subsystem leader to generate a baseline design of the Attitude Determination and Controls subsystem of the second satellite in the program, *Advitiy*. I also worked on developing a quality assured computational platform for closed-loop simulation of attitude dynamics. Working on such a complex project consisting of five interdependent subsystems made me aware of complexities associated with the application of theory in real systems. I learnt to devise structured agendas for individual and subsystem level tasks to achieve short-term targets while keeping long-term system level goals in mind. I also acquired the ability to successfully interact with a diverse and interdisciplinary group of more than 50 members which, I believe, would be a key strength for Ph.D. research.

Another important aspect of a graduate program, as well as a career in academic setting, is teaching and mentoring. I was a teaching assistant for the Arduino programming laboratory course for third year physics undergraduates. I worked with lab staff members to design assignment problems and answer technical queries of students. As a senior member of the student satellite team, I have mentored 20+ fresh recruits on their initial tasks to prepare them to work as full members of the team.

In summary, theoretical and computational skills acquired during my undergraduate years will be helpful in Ph.D. research. My diverse experience in academic research and technical work has strongly motivated me for graduate studies. The physics Ph.D. program at UIUC has esteemed faculty and thriving research, which will enable me to fulfil my aspirations of a successful academic career. I believe that with hard work and persistence, I will be able to match expectations of the program and make a significant contribution to the scientific community.
