Pranjal Bordia, Statement of Purpose

Applying for PhD in Physics

I am interested in the field of Atomic, Molecular, Optical and Laser physics; I'm very excited by this leading-edge research area of modern experimental physics. I feel confident that with my research experience and interests, I would be able to contribute positively towards it. As a long term goal, I'd like to work on problems such as research on interactions at ultra-cold temperatures, condensed matter problems addressed through optical lattices, superconductivity and superfluidity, fusion using lasers, precision measurements using lasers.

After my junior year of undergraduate studies, I did a summer internship at the Max Planck Institute for Quantum Optics (MPQ) in Prof. Immanuel Bloch's group working on "Quantum Many Body Systems". During my stay there, I built a setup for Raman cooling of atoms. I worked with optics, built lasers from scratch, and gained considerable experience working in a laboratory environment. I believe that the experimental skills I developed by working in the labs would always be a key asset for me. I found the research environment very stimulating and exciting. The weekly seminars on topics like frequency combs, optical nano-devices, experiments to control and understand interactions at very small scales, etc. gave me a broad perspective of the field. I was fascinated by magnetic atom traps and the techniques of laser cooling. My stay at MPQ has strongly motivated me to pursue experimental physics as a career.

My liking for science developed during my school days, and I used to have a special appetite for mathematics, physics and astronomy. I particularly enjoyed the experience of solving challenging problems in the International Astronomy Olympiad selection camp, competing with some of the brightest people from across the country. I've handled and gathered data from Radio & Optical telescopes: hands-on work has always appealed me. I have learned how to process the data using astronomical data processing tools.

I've also had exposure to particle physics through a year-long project on neutrino oscillations. To do detector simulations, I needed to learn the theory in detail first. One very illuminating experimental methodology I picked up from the project was addressing the measurement limits of experimental setups. While reconstructing neutrino parameters, I realised how experimental errors add at different levels and what overall sigma level would be associated with the detector. I realised that such calculations were indispensible before any experimental design is proposed.

During my Quantum Mechanics course, I got deeply interested in the fundamentals of quantum mechanics. I did some extra reading on single photon experiments, Bell's inequalities and similar areas. The understanding that at quantum levels things can behave in an extremely different way intrigued me a lot.

Through the project in quantum many body systems I first really appreciated the power of numerical recipes. I recognised that these techniques serve as the workhorse for modern day solutions in addressing a variety of problems. I was especially impressed by methods of sparse matrix manipulation, steepest descent method, iterative convergence, etc. It was really soothing to see the computation time reduce drastically by using novel methods and using parallel processing. I also learned to utilize a large amount of computing power efficiently. At the same time, my understanding of the physics of Bose and Fermi gases became clearer.

After my course on Computational Electromagnetics, a friend of mine used my "waveguide eigenvalue finder" code to solve Schrodinger's equation. I then realised that my code is actually more generic and could be used to solve a class of problems. This was a unique experience where I learnt how solving a specific problem could help in addressing a broader class of problems.

During my final year at IIT Bombay, I volunteered as a tutor for freshmen course on Electricity and Magnetism. This involved classroom interaction with first year undergraduates from all disciplines. During this interaction, I helped the students solve homework assignments and clarified their doubts in theory. This was a rather enjoyable and learning experience.

My knowledge in the field of light matter interactions has strengthened through courses on Light Matter Interactions, Quantum Electronics, and through my Senior Thesis, for which I'm studying relativistic regime single atom-light interactions. I am looking forward to participate in the international Conference on Research Frontiers in Ultra-Cold Atomic and Molecular Gases organised by ICTP in Goa, India in 2011. It will further add to my knowledge of the subject and also give me an opportunity to interact with leading researchers in the field.

My stay at IIT Bombay has been very fruitful for my undergraduate career. I've developed a strong background in fundamental physics through both theory and laboratory courses. Through projects and additional learning, I've acquired a good amount of breadth in physics.

I have excelled in all the theoretical physics courses during my undergraduate studies. I believe that my clear understanding of fundamental theoretical concepts will be a valuable asset when I work in experimental physics. Having done two projects on computational physics, I have learnt numerical techniques which can be applied to problems that lack analytical solutions. My lab courses gave me hands-on experience in electronics and I possess a fair amount of knowledge of microprocessor control systems. Overall, I believe, a healthy balance of engineering and physics gives me a solid foundation to build upon as an experimental physicist.

An opportunity to study at Stanford University would allow me to build upon my current skills and at the same time give me exposure to new concepts and techniques which will enable me to tackle new problems. As I went through the atomic and molecular physics section of the applied physics department, I really liked the works of Prof. Mark Kasevich and Prof. Bucksbaum. I'd also be really interested in exploring interdisciplinary research and precision measurements using lasers; e.g. at Hansel Experimental Physics Lab. Stanford University, with its dynamic research environment, would be a perfect place for me to start my foray into academic research world.