Utkarsh Mali

Letter of Intent – University of Toronto Department of Physics

I am fascinated by using observation and scientific modelling to gain insight into the inner workings of the Universe. I have been able to explore this while obtaining an Honours Bachelor of Science at the University of Toronto, a degree which has included over 11 months of full-time research and rigorous coursework. During this time, I received over $18,000 in grants, scholarships, and award money. I now strive to take on a challenging problem using the skills I have learned in physics. Ultimately, I aim to become an independent researcher of planetary physics with original contributions to the field. I hope to use a broad range of expertise to open new avenues for research.

During the first year of my undergraduate studies, to satisfy my curiosity for space, I joined the University of Toronto Aerospace Team (UTAT), an award-winning student-funded design team led by undergraduate students. There, I had the opportunity to design and build the *Heron Mk-II* satellite, a cube-satellite scheduled for launch in early 2022. In particular, I built the battery and payload insulation. My time with the team has also resulted in a co-authored publication. From early on, UTAT enabled me to gain experience in collaborating and communicating within a team of highly specialised researchers.

My experience in UTAT and curiosity for computation in physics landed me at the Singapore Synchrotron Light Source (SSLS), a research centre at the National University of Singapore (NUS). There, in the summer of my first year, I worked with Dr. Krzysztof Banas. I researched fast authentication of edible birds' nests (EBN), an East Asian culinary delicacy that is prone to adulteration. By applying multivariate analysis on spectral samples in *R,* I developed a model which quickly detects counterfeit EBN. This was converted to a user-friendly software to be used by food agencies. Developing insightful models is something I strive to do more of in graduate studies. I was the lead author for two conference presentations on this work. Now, I want to challenge myself with more demanding projects.

My coursework in quantum mechanics heightened my interest in quantum information. To build on this interest, I spent half of my second-year summer at NUS. Under the supervision of Professor Yvonne Gao, I researched circuit quantum electrodynamics. Collaborating with researchers from Harvard University, I tested the software in the transmon qubit regime. This work showed me the benefits of institutional collaboration. I presented this to both the NUS faculty and at the national CUPC 2020. My time with Professor Gao reinforced my desire to use quantitative methods in solving difficult problems.

Due to COVID-19, I found myself back in Toronto for the latter half of my second-year summer. I was awarded the University of Toronto Natalia Krasnopolskaia fellowship with which I explored the use of scientific computing in planetary physics. Under the supervision of Professor Christopher Lee, I created a machine learning model to classify Martian topographic features such as fans and blotches. This model will allow better prediction of Martian weather patterns. In this work, I developed the ability to formulate different modelling strategies. I hope to replicate this experience and face even more challenging problems at a graduate level.

Last summer, I was selected for the competitive Summer Undergraduate Research Program at the Dunlap Institute. With over 150 applications, 38 students were selected. Working with Dr. Keir Rogers, I created a software by applying machine learning to model kilonovae light curves, the visible counterpart to gravitational waves from compact object mergers. I did this using Gaussian processes and principal component analysis (PCA). I then applied Bayesian inference using Markov chain Monte-Carlo methods to predict merger parameters. The program culminated with a manuscript, a mini-conference at which I presented and a poster presentation in which I won the *Best Poster Award*, a monetary award given to the top three posters of the 38 students in the program as judged by faculty and postdocs. Being able to use my training from previous research demonstrates my enthusiasm for graduate research in this field.

In addition to my research experience, I have served two years in the Singapore Armed Forces with over 60 unique combat missions, and have worked with US, Australian, and Brunei militaries. I am also a senior mentor under the Office of Dean of Students and a Division 1 intramural athlete. I enjoy challenging myself both physically and mentally. In addition to my personal development, I believe inclusion in the lecture room and research is critical for academic success. Through my academics and mentorship, I have worked with students from different cultural and socioeconomic backgrounds and of different gender preference and sexual orientation. As an incoming graduate student, I hope to create an environment in which anyone, from any background, feels valued as a member of the scientific community.

Through a career in academia, I aspire to be an independent researcher. I firmly believe the UofT physics graduate program gives me the opportunity to do so. As an aspiring academic, graduate studies will give me the opportunity to broaden my range of technical expertise and be able to widely apply them. I am confident that my past research experiences demonstrate the curiosity and independence needed for graduate school. I am passionate about the field of computational physics and I expect to be a substantial contributor to it. I look forward to doing so at UofT. Thank you for your time and consideration.