

I grew up in Rajshahi, a small city in Bangladesh next to the Padma River. Sometimes in the evening, I would go to the river bank with friends. With no light pollution to block our view, we had breathtaking views of the night sky filled with stars. I remember wanting to know everything there was to know about them, but I needed to figure out where to start.

I was fortunate to find a mentor in high school who encouraged and guided my budding interest in astronomy. With his mentorship, I won the Bangladesh Astronomy Olympiad and gained the opportunity to travel to Romania, where I saw an observatory for the first time and met students from across the world with a similar passion for astronomy. This transformative experience is what fueled my resolve to not only pursue a career in astronomy but also to make it accessible to others.

Throughout my academic career, I have striven to build accessible and inclusive spaces of learning for students as my mentor did for me. During my college, I mentored high school students as a team leader for the Bangladesh Astronomy Olympiad. I was fortunate to have the opportunity to learn English, but I was also acutely aware of the lack of Bangla-language textbooks in astronomy, creating a language barrier for many students. A fellow team leader and I began writing the first-ever astronomy textbook in Bangla for high school and early undergraduates. I also collaborated with Dr. Asad of Independent University, Bangladesh (IUB) to create a curriculum for the Astronomy minor, the first of its kind in any Bangladeshi university. Teaching, designing courses and writing the astronomy textbook gave me the opportunity to go deeper into many astronomy topics ranging from stellar systems and structures to spectroscopy, multi-wavelength instrumentation, and more. The process of creating educational materials for others broadened my research horizons and enhanced my knowledge and skill set for graduate studies.

At Minerva University, I pursued research opportunities around the world, including in the United States, South Korea, and India. The most rewarding experience was my research collaboration with Dr. Priya Hasan and Dr. Najam Hasan in India. We sought to understand the mass segregation mechanism of open star clusters by studying their initial mass functions and relaxation time. A significant challenge we faced in our project was the limited number of members in the clusters. Then, we shifted our focus to increasing the reliable members using the recently released Gaia DR2 dataset and a supervised machine-learning model, Random Forest. We increased members up to 200% and found substructures within some open clusters (e.g., NGC 2244). The experience taught me the importance of improvising within research while not sacrificing sound, methodological practice. After the start of the COVID-19 pandemic, I continued my research remotely with Dr. Hasan and published the paper during the pandemic. I also continued to prioritize my educational outreach activities. We had the longest astronomy training camp, and for the first time, Bangladesh won medals in the international olympiad. In addition, our astronomy textbook project progressed significantly, putting us well on track to publish the first part by February of next year.

The diverse research opportunities I have had throughout my undergraduate molded my research interests in observational astronomy using machine learning-based approaches. In

collaboration with Assistant Professor of the Islamic University of Technology (IUT) Mr. Kabir, I joined the astronomy research club of IUT as the first-ever student advisor and led a team to track near-earth asteroids using a CNN-based approach. Potential asteroids will change their position in the same sky-field image at regular intervals. We wanted to automate their detection and predict their trajectories using convolutional neural networks. Our model was able to detect the points and predict the trajectory of a single asteroid; but for multiple asteroids, we need a more sophisticated model. This research not only allowed me to build my leadership and collaboration skills, but I also gained insight into how widely machine learning can be applied in astronomy.

As an undergraduate, I tailored my program to double major in physics and data science with the goal of improving my skills in machine learning. For my thesis, I developed an automated semi-supervised pipeline to detect members of open star clusters from observed data. The primary layer of the pipeline had an unsupervised model followed by a supervised model. I developed a quantifiable metric for model selection and optimization. The final model found twice as many members with a 91% performance score. During my thesis, I learned the importance of understanding the underlying model (assumptions, parameters) to interpret the outcome of any machine learning algorithm.

I would be thrilled to bring in my expertise in machine learning and deep learning in the exoplanet searching project of Dr. Aigrain and Dr. Lintott. Similar to my research work, I can develop a pipeline to train and optimize a supervised deep learning model (comparing models including Bayesian CNN used in Galaxy Zoo DECaLS) to detect exoplanets using the volunteer response as training data. I want to also explore the possibility of using deep representation learning model (similar to Walmsley et al. 2021) to cluster different type of exoplanets.

Similarly I can collaborate with Dr. Ferreira, Dr. Desmond and Dr. Bartlett in their project to improve and generalize Exhaustive Symbolic Regression algorithm to predict complex relationships, particularly in cosmology. Using my experience working with genetic algorithm and genetic matching, I specially want to explore the tradeoffs between providing some basic assumptions while doing exhaustive search and no assumptions with genetic regression model.

Lastly I can bring my work with numerical simulations from N-body to computational fluid dynamics model to work with Dr. Slyz and Dr. Devriendt's project to investigate the connection between nuclear and globular star clusters and supermassive black holes. I want to particularly explore how to optimize the parameters of sub-grid semi-analytical simulations to understand the evolution of the clusters and supermassive black holes.

My academic and professional activities demonstrate a lifelong commitment to advancing astronomy research and increasing accessibility in astronomy education through global collaboration. Just as my first mentor opened a world of opportunity for me, I want to do the same for other students. I am confident that the graduate program at the University of Oxford will give me the knowledge, skills, and resources to achieve my dream.