**Personal, Background, and Future Goals Statement – Sean MacBride**

Standing atop a hill in the shadow of an astronomy dome, two words lit the fuse that refined my scattered work ethic towards studying the cosmos: “look up.” As my eyes adjusted to the velvety darkness, many of the scientific phenomena that command my curiosity today came into focus. During the remainder of the night, a survey list of Messier objects I selected would be imaged by the telescope. The seed of my interest in physics and astronomy began to grow as I processed the images the next day. Once my fervor was uncovered, I not only followed my passion, but strived to share my enthusiasm with different minds - starting with my family. My father is a high-school educated immigrant in his late seventies who continues to work over forty hours a week at a blue-collar job, while my mother with advanced degrees set aside her career to raise my sister with autism. When the time for selecting a college arrived, I opted to study at a small liberal arts college instead of a large research university to minimize the financial stress on my family.

**Intellectual Merit:** I sought out research opportunities within the first month of arriving at Wheaton College. I elected to stay at school during my first winter break to build solid-state lasers under the guidance of my undergraduate advisor, Prof. John Collins. The meticulous endeavor of laser development, operation, and characterization offered my first experience observing and exercising the techniques and methods used in professional physics research. I took the skills from Prof. Collins’ lab to an internship at NASA Langley Research Center in the summer of 2017. I worked with Dr. Brian Walsh to build and demonstrate a proof-of-concept mid-infrared laser to monitor the atmosphere. I developed models to predict the characteristics of the laser source and performed spectroscopy on different resonator components to determine key parameters. Despite having less than a week to operate the mid-infrared component of the laser due to logistical slowdowns, I built and tested the near-infrared pump source and proved the practicality of the design using photothermal sheets.

Upon returning to Wheaton as a sophomore, I shifted my focus towards astronomy. I sought out the only astronomy expert at Wheaton, Prof. Dipankar Maitra. Prof. Maitra connected me with software engineer James Synge of Google and another Wheaton student to begin working on a citizen-science exoplanet telescope called project PANOPTES. PANOPTES uses a network of smaller, cost-effective telescopes to detect exoplanets using transit photometry. We installed a robotic telescope inside an observatory dome at Wheaton. When installing the unit, it became clear that some modifications to the magnetic sensors in the dome were necessary to ensure continuous compatibility. After amending the sensor placement with hand tools, I aligned the unit over three nights of precise adjustments in the frigid February weather of Massachusetts while the PANOPTES team communicated through an online chat.

In the summer following my sophomore year, I earned a position in the National Science Foundation Research Experiences for Undergraduates program at Rutgers University. I was paired with Prof. Carlton Pryor to study dwarf satellite galaxies of the Milky Way using astrometry from the second data release of the Gaia space observatory. Developing a data pipeline to select member stars using photometric and kinematic filters served as my first experience working with data analysis tools like NumPy, MatPlotLib, and Pandas. After failing to discover a structural disruption in the Boötes dwarf satellite, I confirmed a previous result of a tidal tail induced by the proper motion of the dwarf satellite Carina. Accepting and working through the minor setbacks that preceded success was a crucial moment that pivoted my research philosophy towards appreciating every step of the process.

I studied at University College London (UCL) in early 2019. The pinnacle achievement in London came during a Group Project with Prof. Thanh Nguyen, other UCL students, and research staff at the Royal Institute of London, where we determined the limit of detection for diagnostic devices doped with different types of magnetic nanoparticles. I seized this opportunity to test my intellectual flexibility and management skills in an unfamiliar environment. I took a leading role - coordinating laboratory logistics, maintaining safety measures, and preparing solutions and samples for observation. I aided in the design of the sample and laser apparatus, conducted sample experiments, and analyzed photothermal heating data to determine the optimal solution concentration and membrane type to maximize the photothermal signal. The results of this study were documented in a report, presented at a poster session, and received the highest marks from UCL and Royal Institute faculty.[1]

I studied in London to seek a deeper exposure to astrophysics than Wheaton could provide. I enrolled in challenging graduate courses at UCL in Interstellar Physics and Cosmology. The immersion led to an honors thesis between Prof. Amélie Saintonge of UCL and Prof. Maitra at Wheaton. I investigated cold-gas and dust scaling relationships in star-forming galaxies, starting with building a data pipeline to use with galaxy morphology measurements from several different galaxy surveys. I developed a Markov-chain Monte-Carlo sampler to constrain the relationship between different matter components and the Balmer emission of star-forming galaxies in the xCOLD GASS and JINGLE surveys. When the full effects of the COVID-19 pandemic began to impact the world, I adjusted to working from home to complete the project within the modified school year. I applied the smaller survey calibration to a wider set of galaxies in SDSS to discover a bias from galactic inclination. Through a virtual thesis defense, I presented these results to faculty and peers at Wheaton College and UCL. I submitted a final report that earned the highest distinction from the faculty of both colleges.[2] Following this presentation, I generalized the calibration to include the effects of galactic inclination to better constrain the galactic contents. This study will be used with the Bright Galaxy Survey from the newly commissioned Dark Energy Spectroscopy Instrument to better understand the evolution of baryons and gas quenching in the dark-energy-dominated universe (see research statement).

Each experience I pursued at Wheaton and beyond has thoroughly prepared me for future research. I have seized every opportunity to expand my skills in physics and astronomy research. As a result of these efforts, I was awarded the Boggess Family Foundation scholarship for achievements in physics and graduated cum laude with departmental honors in Physics in May of 2020.

I earned the opportunity to showcase these skills when I joined the Astronomical Instrumentation Team (AIT) at the Massachusetts Institute of Technology in November 2020, under principal investigator Gábor Fûresz and faculty lead Rob Simcoe. AIT is building the LLAMAS instrument for the Magellan Telescopes at Las Campanas Observatory in Chile, scheduled to be installed in July 2022. LLAMAS is an integral field spectrograph with tremendous science capabilities, including spatially resolved spectroscopy of z<0.5 galaxies. I assembled optical mounts and ground support equipment, designed optical mounting fixtures, and tested diffraction gratings to ensure they met optical-design requirements. My principal responsibility was integrating the fiber run of the spectrograph by bonding optical fibers. I found that my early attempt to bond fibers with the required precision was too slow to meet our project deadlines. To remedy this, I wrote LabView code to allow for simple DC motor control through a computer interface, removing a critical project bottleneck.

In parallel to LLAMAS, I am developing software tools to support a research proposal for AIT, concentrating on using solar spectrophotometry to extend photosphere and chromosphere events on the sun to activity on exoplanet host stars. To perform a preliminary study, AIT has installed a multi-channel solar spectrometer at Lowell Observatory in Flagstaff Arizona. I created analysis tools and organized meetings between AIT members and collaborators at other institutions. Early in the project, I struggled with developing a data pipeline that maintained compatibility with all the observations, as their file structure was constantly being modified to balance the high data volume. After iteration, I constructed a robust and flexible data pipeline with the capability to accurately represent all solar observations. This pipeline enabled detailed analysis of several solar events in the second half of 2021 and served as supporting evidence in several forthcoming publications that describe the project scope. While developing analysis tools and a data pipeline, I encountered the critical nature of establishing efficient infrastructure early to support a research project.

**Broader Impacts:** My family and local community imbued the importance of developing a relationship with colleagues and the public, built without bias to economic class, gender, race, sexual orientation, cultural background, or intellectual facility. Despite being in a refugee resettlement city, Burlington (Vermont) High School lacked substantial support for English-language learners, as well as students with individual education plans (IEP). The abhorrent lack of support left many of these students unprepared for advanced and honors classes, resulting in Advanced Placement (AP) classes without a single IEP student and less than one percent of the total AP enrollment learning the English language.[3] I will devote myself to a lifelong program creating educational content at all levels to best meet the learning patterns of different students. Beyond my graduate studies I will continue to build a more open and welcoming scientific community by expanding this network to ensure that any student seeking advanced scientific study will have the opportunity to learn, regardless of their cultural, intellectual, or economic background.

A responsible scientific scholar carries an incontrovertible obligation to engage in research at the cutting edge and to communicate information to those eager to learn. Alongside my research engagements at Wheaton, I worked with local families on Friday evenings to lead tours of the college observatory. The opportunity to demonstrate the details of telescopes to the local community solidified the importance of robust scientific discussion with wider society. I thrived once given the chance to narrow my engagement to introductory physics students as a tutor and teaching assistant. The teaching skills I practiced with my peers blended seamlessly with the lessons learned from my research when I began advising students in the physics department on a formal and informal basis. I met with my peers at Wheaton, gave guidance on finding experience outside of Wheaton College, and sat on career-panels to share what I had learned in my research opportunities. One-on-one peer-advising solidified a desire to guide the scientists and leaders of the future, something I will continue in my graduate studies.

I collaborated with technical experts at the Northeast Astronomy Forum (NEAF) 2018 in Suffern, New York while showcasing project PANOPTES. At NEAF, I discussed the mission of project PANOPTES with amateur and professional astronomers to expand the PANOPTES network. The opportunity to engage with both knowledgeable and general audiences strengthened the importance of healthy scientific communication and outreach, particularly in citizen-science projects. Exhibiting a low-cost scientific platform to the public encourages contributions from active scientists from all economic backgrounds and helps build a stronger network to augment the scientific mission of PANOPTES. In the following summer, I presented a poster detailing my dwarf satellite galaxy research at the Rutgers Summer Research Symposium. The following year, I presented the same research at the 234th meeting of the American Astronomical Society in St. Louis, Missouri.[4] I also delivered oral presentations to faculty and peers at both Rutgers University and Wheaton College. Following a recent virtual visit to Wheaton to discuss LLAMAS with an astronomy class, I recognized the crucial importance of using my graduate research as a platform to continue engaging with individuals passionate about astronomy, no matter their economic, academic, or social background.

**Future Goals:** In the fall of 2022 I will enroll in a Ph.D. program to study astrophysics, conducting original research investigating the evolution of structure in the universe. Gaining experience through a doctoral program will prepare me for a postdoctoral position, and ultimately a teaching and research position at a university. With this opportunity at hand, I will contribute to astrophysics at the cutting edge and communicate complex topics clearly and concisely to the next generation of STEM leaders. I will not limit my studies to the cosmos and train undergraduates to solve problems outside of astrophysics using big data methods. I will build upon my previous experience in education and public outreach to create a healthy culture that increases participation in STEM by historically under-represented groups. Support from the National Science Foundation will allow me to achieve these goals to create a better future for all.

**References**

[1] S. P. MacBride, seanmacb/groupprojectucl (2020).

[2] S. P. MacBride, Wheaton College Digital Repository (2020).

[3] O. of Diversity and Equity (Burlington School District, (2019).

[4] S. P. MacBride, in American Astronomical Society Meeting Abstracts #234 (2019), vol. 234 of AmericanAstronomical Society Meeting Abstracts, p. 202.01.