Personal, Background, and Future Goals Statement

Background

Hands shaking, I nervously selected the next target and hit slew. The telescope came to life, whirring and slowly swinging into place. Stopping to confirm nothing had broken, I made eye contact with the other college freshman sitting next to me. After a long silence, still uncertain of every action, I reached for the mouse and clicked observe. With that click, I cemented my love for astronomy, affirming all the decisions I had made up to that point. Throughout my experiences during my undergraduate career at the University of Wyoming and my graduate career at the University of Arizona, I have dedicated myself to making a future in UV and detector instrumentation.

Intellectual Merit

Like many others, I was inspired by the night sky, visible from my backyard every night. Armed with a small telescope, I spent countless nights gazing into the great abyss of space. Nearly ten years later, Dr.\ Chip Kobulnicky, a professor at the University of Wyoming, had a full night on the 3.5-meter Apache Point Observatory (APO), and hosted an observing open house for any interested students. I enthusiastically attended, eager to dip my toes in observing. Over the next few hours, my soon-to-be advisor demonstrated all the observatory operations and protocols. I was hooked from the start. As all but one other student went home for the night, Dr. Kobulnicky invited us to operate the telescope solo, stating he would be in his office if anything went wrong. Terrified, all I could do was keep observing, anxiously waiting for him to return. Deep down, however, my itch for astronomy had been scratched, and I eagerly pursued every opportunity to continue my astronomy research.

One of the best parts about attending college in Wyoming was taking charge of reviving one of their observatories. Upon my arrival, the 0.6 meter Red Buttes Observatory was out of commission, having recently been struck by lightning. Under the guidance of Dr. Chip Kobulnicky, I worked to resurrect RBO, piece by piece. This included replacing motors, troubleshooting power outages, repairing broken rollers, and fixing a filter wheel. I learned ASCOM client-server sockets to integrate a secondary computer to operate the camera. I assisted in the installation of a new weather station and facilitated an upgrade for the wireless connection to the telescope. This hands-on work required countless trips to the observatory, often late in the night after discovering a failure. To economize the task of observing one target a night, I modernized an automated observing script, consisting of full telescope limits, real-time pointing corrections using astrometry.net, live weather conditions, and nightly email reports. Since I had never worked in Python previously, this project was both my introduction to Python and my means to teach it to myself. This involved learning proper syntax, technical packages such as ASCOM and Astropy, and observatory control specifics. After putting all of my effort into the observatory for nearly two years, I knew all of its intricacies, cementing my love for observatory operation in our quest for automated data collection. This automated script is still used nightly by the next generation of astronomers at Wyoming.

During the summer after my third year, I attended the Montana State University Solar Physics REU. My project, supervised by Dr. Chunming Zhu, was to visually simulate solar flares and their

evolution using a novel flare loop heating method. However, all of the code was written in IDL, and I had to painstakingly convert this into Python. As such, I had to become self-sufficient, with only general ideas to guide me. I presented the results of this project at the American Geophysical Union Fall Meeting 2022. While I gained valuable experience in coding and solar physics, applicable in many fields, I missed working hands on, taking data and operating observatories. Whether in UV instrumentation, detector development, observatory construction, or instrument commissioning, my true home is in an astronomy lab.

As a graduate student at the University of Arizona, I am taking full advantage of the myriad of available resources to advance my laboratory skills. Working with Dr. Erika Hamden, I am developing new UV detector technologies and loving every minute. Modern CCDs, the cornerstone for all astronomical measurements, read the charge in each pixel once, whereas Skipper CCDs read each pixel numerous times, reducing the total noise. As part of this work, I am quickly becoming familiar with a number of new tools, methods, and software. To design the vacuum-sealed cryostat, I am learning Solidworks and commissioning parts to be machined based on my designs. I am proficient in software-hardware communication and operating multiple devices together, such as a vacuum pump, pressure sensor, temperature sensors, heaters, and cyrocoolers. Since this work is a collaboration between many individuals, I am mastering code version control and proper documentation, striving to make our code available to lay down the path for future Skipper research to launch from. Our code will be available on Github by request when complete. Additionally, I am performing detailed detector simulations to estimate the noise performance of a multiplexed, 128-amplifier readout Skipper CCD. These simulations predict optimum readout times and clock speeds to achieve required noise thresholds. These results will motivate future use of Skipper CCDs in astronomy, as typical applications have been limited by read times. I will present the results at the 2024 SPIE Astronomical Telescopes and Instrumentation Conference. Skipper CCDs are already ubiquitous in the dark matter community and are quickly breaking ground into traditional astronomical applications. With typical photon-counting read times of less than 2 minutes, Skipper CCDs open a world of possibilities for astronomy in the near future. With effectively zero read noise, spectrographs are no longer flux limited; the light can be spread out across dozens of detectors to achieve incredibly high resolution. Similarly, measurements of ultra-diffuse objects, such as the warm-hot CGM or exoplanet atmospheres, become possible with fast, low-noise Skipper CCDs. Eventually, these detectors promise to replace traditional CCDs with little-to-no modifications needed in existing instruments, giving all of the benefits with little effort. I plan to be at the forefront of this advancement.

Broader Impacts

Advancing through my career, I am striving to both give back to the general community and inspire the next generation of scientists through astronomy outreach and service. I, myself, was first introduced to astronomy through an outreach program at our local zoo. My elementary school teachers partnered with the local zoo for discovery days, which included the opportunity to look through a telescope. For most, this was the first time to ever see space up close, inspiring me to get my own telescope, kick-starting my eventual path in astronomy. I plan to create similar opportunities for a

multitude of other peoples and groups, not just high school and college students. I believe encouraging and nourishing the natural curiosity of all people is paramount for the future of all science.

While at the University of Wyoming, I was elected president of our local Society of Physics Students chapter. I helped to organize outreach events such as downtown astronomy, where our chapter brought small telescopes to downtown Laramie to share astronomy with the public. These events opened my eyes to the wonders of public outreach. I looked forward to these events every month, as it was another chance to share my love of astronomy with others. Every public observing night, I got to watch as countless people gazed in wonder into the sky, and I wished nothing more than to keep that child-like fascination alive. I also assisted with public observing nights, both on campus and at the local observatories. Through these, I ran both physics and astronomy demonstrations, like freezing marshmallows with dry ice and demonstrating the double-slit experiment. As part of this outreach, I greatly improved my public communication skills, often practicing the same presentation dozens of times, often improvising stories and answering questions I had never thought about. Additionally, I faced unique challenges coordinating these events, like acquiring proper permission from the city, transporting and operating small telescopes, and organizing a group of observers.

For three of my four years in undergrad, I tutored students in math, physics, and astronomy, both paid and volunteer, working to share my love for science with others, an experience which I have cherished. Teaching is an integral aspect of academia, from which I have grown significantly and learned even more. I seek not to make students memorize facts and solutions because they must, but learn how to solve the problems because the problems are interesting. I find great joy when a frustrated student is finally able to understand the problem, and I base my teaching and mentoring off of this philosophy. I strive not to make students get the right answer, but to encourage them to think critically and ask questions. I aspire not to crush the love for learning that most students enter school with. Similarly, I myself am not afraid to ask questions or admit when I am mistaken. While I am required to be a teaching assistant for at least two semesters, I plan to do more, in the hopes of improving my teaching and communication skills. Additionally, I will apply for the TIMESTEP program, a research-oriented program that offers professional and educational development opportunities for under represented STEM students by placing each student with a graduate student mentor.

Future Goals

Moving forward, I hope to continue my career as an astronomer, giving back not only to the astronomy community but to the general public. My work on Skipper CCDs is happening at the beginning of a revolution in astronomy detectors that will benefit all fields of astronomy. Throughout my career, I plan to give back to the community that helped me so much along my career path, whether as a professor at a prestigious university, a researcher at a national lab, or a beloved mentor. My skill set lies uniquely at the intersection of astronomy, instrumentation, and outreach, and with these skills I will help to advance both astronomical instrumentation and how we influence the next generation of scientists. Perhaps one day I too will leave the room of two scared young freshman, eagerly waiting for them to click slew.