— Personal Statement —

The start of my graduate school experience was marked by uncertainty; I was moving to a new place, living alone for the first time, and beginning the daunting journey into graduate school, all in the midst of a unprecedented pandemic. One thing, however, did seem certain: I was going to be a theoretical astrophysicist. Astrophysics had been my primary academic focus throughout my undergraduate studies, and I felt confident that August 2020 was the beginning of a long career exploring the cosmos. Well, if the lessons of the past two years have taught me anything, it's that everything is subject to change, including ostensibly concrete conclusions about one's career path.

What incited this change was not the pandemic, however, nor was it a new location or school. It was the world around me — the worsening heat waves in Seattle, the floods in Houston, and the fires in California — that forced me to question why I was studying astronomy at all. Indeed, my desire to make advancements in a field with direct applicability to the problems I was witnessing in the world began to outpace my drive to continue studying astrophysics. **I knew it was time for change.** Before I could commit to a research field, I first had to identify the problem that I would dedicate my career to understanding. There are obviously many problems in the world that are worth solving, but I knew that I needed to find one that particularly spoke to my personal experience for me to be truly satisfied.

The personal experience that I leaned on most during this decision process was my experience involving extreme weather. I grew up in western New York, where snowstorms and blizzards ravage the area every winter. I witnessed first hand how devastating these events can be; after every major storm, it would be routine to drive around our town and see roofs collapsed and businesses damaged. More tragically yet just as routinely, we would hear how people had died from being stranded in their cars, buried under feet of snow. Later as an undergraduate at the University of Arizona (UA) I experienced a heat wave that crippled the area. Although I was lucky enough to have functioning air conditioning, numerous individuals were less prepared to deal with the heat, making the heat wave a period of immense stress and physical harm.

What's worse than the tragedy inherent to these events is their potential to worsen and become more frequent under climate change. This chilling reality ultimately decided my research focus: **I want to better understand extreme weather events not just in the present, but how they will evolve in the future as the Earth warms.** This work has the potential to impact human wellbeing directly. By providing communities and elected officials a forecast for how extreme weather will evolve in the future, they can better prepare themselves to combat their often tragic consequences. In particular, I am focusing on developing conceptual physical models for land-atmosphere interactions. These models can be used to probe the underlying physics of heat waves, which are thought to be one of the main impacts of climate change. **My previous research experience makes me well equipped to make strides in this field.**

— Research Experience —

Data Science Experience: My experience in data science is sourced from my first three years as an undergraduate at UA, where I was involved in Prof. Brenda Frye's astronomy group. Our group studied early universe objects using gravitational lensing caused by foreground galaxy clusters. My first contribution to Prof. Frye's group was leading the development of a data reduction and analysis pipeline for observational spectroscopy data. Using the data processed by my pipeline, we were able to measure important properties of gravitational lenses using a suite of statistical and numerical methods. **This work culminated in the coauthorship of a published paper in *The Astrophysical Journal*** [1].

Building off of this success, **I earned a fully funded position as an undergraduate UA/NASA Space Grant Intern**, where I continued to build my data science repertoire. I showcased my coding abilities by developing an expertise in *Theli*, a data reduction software, which I used to investigate images of lensed objects. **I have since written an open source users manual for *Theli*** [2]. This manual contains information on using *Theli* as well as the theory behind it, with the goal of making the software more accessible to amateur astronomers. **My work using *Theli* enabled our group to conduct novel analysis of galaxy clusters, such as estimating their photometric redshift, which will be discussed in an upcoming paper** [3].

Applied Mathematics Experience: After spending my early years at UA as a data scientist, I sought to develop my skills in theory, which prompted me to seek research opportunities at the intersection of astronomy and applied mathematics. My strong research and coursework records earned me an **NSF-funded REU internship with Prof. Paul Carter, where I studied fluid dynamics from a theoretical perspective.** In this project, I rigorously constructed transonic solutions to the Navier-Stokes equations, including viscosity and heat conduction. I worked independently to derive a natural separation of length scales, which allowed me to apply methods from stability theory and geometric singular perturbation theory to obtain a final result. This work places the ejection of gas from the surface of a star, commonly referred to as the solar wind, on a firm mathematical foundation. **I first-authored a published manuscript which carries out this proof in full detail** [4].

Numerical Modeling Experience: Entering graduate school at the University of Illinois Urbana Champaign (UIUC), I hoped to combine my experience in astronomy and mathematics to study black hole accretion physics. Under the supervision of Prof. Charles Gammie and Prof. Nicolas Yunes, **I developed a suite of numerical codes and analytical models to construct synthetic images of black hole shadows.** This project was especially valuable as it trained me in **building numerical models** and **analyzing their outputs**. My software uses ray tracing to generate the intensity profile of infalling plasma onto a black hole. We then used the computed intensity profile to numerically calculate the characteristic radius of emission of the plasma, as well as its sensitivity to various model parameters. **I first-authored a manuscript presenting our results which has been submitted for publication** [5]. Additionally, I have made my code *open source* so that other scientists can learn from and build upon the current model.

— Intellectual Merit —

Astrophysics and climate dynamics share a common struggle: both rely heavily on sparse observational records and numerical simulations to inform their models. Indeed, neither field has the convenience of being able to run experiments in a laboratory to directly test their theories. **This makes my preexisting research skills acquired in astrophysics readily translatable to climate physics.** My research background has given me ample experience in three important areas ubiquitous to climate science research: data science, applied mathematics, and numerical modeling. **With several tools in these areas under my belt, I am poised to make immediate progress in studying extreme weather and climate change.**

— Broader Impacts —

Informing Policy: My primary impetus to go into climate research was to effect change in the world. To this end, I joined a collaboration with Prof. Cristian Proistosescu and Prof. Gernot Wagner (economist at Columbia University) to improve integrated assessment models' (IAMs) estimation of the social cost of carbon (SCC). The SCC is a critical figure when determining important policies such as a carbon tax. My role was to upgrade the climate module in Prof. Wagner's IAM, *EZClimate*, to better represent the probability of extreme climate change. We are now working to determine how this upgraded climate module impacts the SCC for various future CO_2 emission scenarios.

I am not only interested in making an impact through my scientific research, however. I am passionate about *recruiting young scientists* and *improving retention in science*. My zeal for these causes is born out of the endless class, patience, and professionalism of my advisors, without whom I would not be where I am today. My interactions with my advisors showed me that **we in the science community have a duty to usher in the next generation of scientists.** I have taken on this responsibility in a variety of ways.

Recruitment: My main effort to recruit new scientists has been through outreach programs. I volunteered in the Physics Discovery program at UA in my senior year. Members of this program perform scientific demonstrations for local Tucson schools (K-12), many of which have students from underrepresented groups including those from low socioeconomic backgrounds, students of color, and refugee families. It was through this program that I found my passion for scientific outreach. **To help grow this program, I built a new demonstration that explored the wave-particle duality of light and radioactivity.** Programs like Physics Discovery are essential to growing the scientific community to include all people. The COVID-19 pandemic canceled all outreach programs last year at UIUC, but I am looking forward to being involved in outreach as soon as these programs resume. For example, I plan to be involved with the Student Ambassador Program, which sends graduate students to minority serving institutions in the greater Chicago area to recruit individuals from underprivileged backgrounds into careers in science. **I have contacted the organizers of this program and am planning to focus my efforts specifically on working with students interested in physics to inform and advise them on the many career avenues a physics degree can provide.**

Retention: I have worked to increase retention in the sciences through two primary avenues: mentorship and education reform. My motivation to work as a mentor is drawn from my personal experience; as an undergraduate, I was friends with numerous upperclassmen who gave me indispensable advice on furthering my career. Wanting to be a resource for others, I volunteered as an undergraduate peer mentor at UA. My job was to help freshman students make progress in their studies and direct them to resources that would best equip them for success. I directly witnessed the impact of this work when I was able to help one of my students earn a prestigious research internship position. **This experience ignited my passion for mentorship, and motivated me to be a graduate mentor while at UIUC.** To this end, I joined Illinois-GPS, a graduate-undergraduate peer mentorship program at UIUC. As a graduate mentor, I work with undergraduate students and direct them to academic resources, give them advice on applying for graduate school and industry jobs, and help them find success in their careers. **I find this work to be extremely fulfilling, and am looking forward to my continued involvement in this program during my graduate career.**

My work in education reform has focused on mitigating the impact of test anxiety on student assessment. It has been estimated that approximately 16%—20% of students experience high test anxiety; moreover, these students tend to score twelve percentiles lower than their low test anxiety peers [6]. These data, along with my own personal struggles with test anxiety, led me to brainstorm ways for students with test anxiety to showcase their talent in a non-exam environment. **With this in mind, I developed a new assignment for upper division science classes: the Analytic Formal Report (AFR).** An AFR is written in a similar tone as an academic paper, and is graded on the *validity* and *thoroughness* of a student's solution to a challenging problem. I partnered with Prof. Shawn Jackson, professor of physics at UA, to implement this assignment in his spring 2020 electrodynamics class, making a student's cumulative score on AFRs worth 12.5% of the final grade; this 12.5% was taken away from the weight of student exam performance. We found that more than 80% of students preferred AFRs to conventional problem sets, and moreover, a similar number of students thought that AFRs "significantly developed" them as scientific writers. The assignment was such a success that Prof. Jackson invited me to implement the AFR again the following year, where I oversaw its implementation virtually. We again saw success, and **I am currently working to make ARFs a permanent component of Prof. Jackson's classes.**

— Future Goals —

When I envision my future career, I foresee myself with two primary focuses: **researching how climate change will impact human wellbeing** and **working to include all individuals in science**. To achieve these goals, I will pursue a faculty position at a research-active university. Being a professor means more to me than just researching interesting subject matter. It means actively engaging in the collaborative spirit of academic research, therefore enabling my collaborators and I to tackle climate science from a variety of angles. In addition, it means building upon my mentorship skills by working with students of all levels, helping them accomplish their goals as professionals, just as my advisors did for me. Lastly, it means being actively involved in strengthening diversity in science, which I intend to do through outreach programs and implementing innovative educational methods in my classes, such as AFRs. This is perhaps the most exciting component of being a professor: it will give me a platform to make science accessible and enjoyable to each and every student that I interact with. *With support from the NSF GRFP, I can freely dedicate my time to researching climate change, as well as improving recruitment and retention in science, in pursuit of my ultimate goal of becoming a faculty professor.*

References: [1] B. L. Frye et al., *ApJ*, 871(1), 2019 — [2] A. Bauer et al., Posted to cloudynights.com, 2019 — [3] M. Pascale et al., *In preparation*, 2021 — [4] A. Bauer et al., *SIADS*, 20(1), 2021 — [5] A. Bauer et al., *Submitted to ApJ on 10/12/2021* — [6] R. Hembree, *RoER*, 58(1), 1988.