Brandon Barker - Personal Statement

As a first generation college student who grew up in a rural community, raised by a single mother in a lower class household, each stage of life has produced new obstacles directly related to my background. Upon my entry to university, I was already at a distinct disadvantage compared to my peers, who had far more resources available to them previously. My high school was small and, unfortunately, lacked any advanced science and mathematics courses such as basic calculus. This combination of factors made my adjustment to university honors coursework difficult. These struggles, however challenging to overcome, have helped to shape me into the industrious student I am today. Navigating and eventually learning to succeed in the university setting with my background has helped to curate my interests and fortified my desire to achieve a career in astrophysics. **I will pursue a Ph.D. in astrophysics followed by postdoctoral research and eventually a teaching and research position at a university.** Alongside my career, I will continue my involvement in scientific outreach while advocating for educational equity and equal rights of marginalized groups within academia.

Intellectual Merit

Having grown up in rural Tennessee, with the night sky laid bare, I knew when I went to college that I wanted to learn more about astrophysics research. It was to this end that in the spring of my freshman year I sought out Dr. Anthony Mezzacappa. Over the course of the semester we had several meetings discussing his research into the explosion mechanisms of core-collapse supernovae (CCSNe). **These meetings culminated in a fully funded summer research experience at the Joint Institute for Computational Sciences at Oak Ridge National Lab (ORNL).**

This research project focused on evaluating the role of turbulence in the revival of the stalled shock that drives a core-collapse supernova. Previous [4] and recent work [3] had shown that turbulence played a significant role, but we wished to further quantify that statement. I created analysis software that decomposed the fluid fields to better understand the dominant effects present. For two weeks I struggled with errors and null results. Finally, late one night, I had a small, yet life-changing, breakthrough as I had finally created a working version of the code. The euphoria that followed after I visualized the results of the analysis for the first time was a feeling that I will not forget. This victory, however small, had a profound effect on me: I had created a tool that would be used by myself and other scientists to analyze simulation data. Moments like these have continually inspired me to pursue a career in research. Unfortunately, as is often the case, this research project did not produce the results originally planned. After a considerable amount of time, several conferences, and numerous presentations, our new analysis technique produced few useful results. While this certainly was disheartening, I did not let it deter me from my goals. My first research experience had provided me with countless insights into research and introduced me to the joy of discovery and, yes, it had also showed me the less glamorous side of research. As a result, **I have come to appreciate the excitement of discovery, but also the failures that will inevitably accompany a career in research.**

After the end of my first research project analyzing simulation results, I wanted to gain a better understanding of the inner workings of CCSNe simulations. To this end, I began working with Dr. Eirik Endeve, a staff scientist at ORNL. This project has involved the development of new hydrodynamics algorithms utilizing more advanced numerical methods than those commonly used in the field. My contribution to the project focused on generalization of the code to a nuclear equation of state (EOS). This demanded an intimate knowledge of numerical

analysis and stellar structure. **From this project I have gained extensive exposure to advanced computational methods that far exceed the scope of undergraduate courses.** This work has resulted in a forthcoming publication submitted to the Journal of Physics: Conference Series (proceedings of Astronum 2018).

By my junior year I had acquired ample exposure to supernova theory and computational methods and wished to expand my horizons. I applied to numerous domestic and international summer research programs including the Department of Energy - Instituto Nazionale di Fisica Nucleare (INFN) Student Exchange Program. **I was one of 11 students selected to participate in research projects at various INFN national lab locations around Italy in the summer of 2017.** In my work under Dr. Barbara Patricelli and Dr. Massimiliano Razzano, I estimated joint detection rates of gravitational waves (GWs) and gamma ray bursts from binary neutron star mergers. Just two weeks after the conclusion of my program, the first joint detection of GW and gamma ray signals was made with GW170817 [1]. This project introduced me to the new and exciting field of multimessenger astronomy while developing my data analysis skills. **My contributions to this work led to my selection as a 2018 Barry Goldwater Award Honorable Mention.**

This summer I was chosen for the Advanced Computational Research Experience 2018 REU program at Michigan State University. I worked under Dr. Sean Couch exploring the sensitivity of CCSNe to variations in input nuclear physics characterized by uncertainties in nuclear physics at astrophysical densities. This project was the culmination of all of my previous experiences; I used a new model for driving explosions in 1D that included crucial effects of turbulence, I was able to apply my knowledge of computational methods, and I studied the effects of the nuclear EOS on the multimessenger signals produced in great detail. My experience here has affirmed the notion that I wish to study CCSNe in graduate school and **will result in a publication in The Astrophysical Journal.**

I have worked with several leaders in the field of supernova theory. Under their guidance I have become intimately acquainted with the current status of the field and, when combined with my other experiences, am well posed to begin graduate work. I have also partaken in numerous opportunities to present my work at the local, regional, and national levels, thus allowing me to greatly develop my communication skills.

Broader Impacts

I entered the university setting with no understanding of how to succeed in academia. I have been fortunate to have had mentors at various stages of my undergraduate career guiding me, though many are denied this mentorship. Through this I have learned the necessity of proper mentorship, and as such, am dedicated to mentoring the next generation of scientists. Therefore, I have made considerable efforts to engage with both the campus community and the general public. My involvement with organizations such as the Society of Physics Students (SPS), Women in Physics, Pipeline: Vols for Women in STEM, and Ask a Scientist have given me an exceptional platform for science communication through public demos, events, and school visits. In particular, I am interested in outreach focused around first generation students from rural communities, who are often overlooked despite the unique challenges that they face. **In the U.S., 29.8% of adults over age 25 have a Bachelor's degree or higher; while in rural Appalachia, it is only 15.9%.**[1] This trend is certainly not unique to Appalachia. Often, rural students do not see a college education as an attainable goal. Research [2] has shown that as high as 1 in 5 low income high school graduates unenroll

[1] https://www.arc.gov/assets/research_reports/DataOverviewfrom2011to2015ACS.pdf

from college during the summer following graduation due to a lack of support. Furthermore, those that *do* attend college have difficulties adjusting and are more likely to drop out in their first year than other students. For these reasons, **I am committed to supporting first generation and low income students in their transition to academia.**

During my first semester of college I began participating in Saturday Science, a program jointly organized by our chapter of SPS. Here, volunteers from various fields and backgrounds go to Pond Gap Elementary, a local Title I community school, to conduct hands on science experiments and activities with the students. Most of the students participating in the program are from underrepresented groups including those from low socioeconomic backgrounds, students of color, and refugee families. Programs like this are absolutely critical to promoting science among marginalized groups to give them the resources that they deserve, and it was through this program that I found my passion for outreach.

According to the National Survey of Student Engagement, participation in undergraduate research by underrepresented groups is positively correlated with higher retention rates, persistence to graduation, and motivation to pursue graduate education. My initial involvement in research gave me a sense of belonging and accomplishment that was vital to my long term success. Therefore, commitment to undergraduate research has been a pivotal part of my outreach mission. I have joined the executive boards of *Pursuit - The Journal of Undergraduate Research at the University of Tennessee* and the Undergraduate Research Students' Association (URSA). *Pursuit* is a peer-reviewed undergraduate research journal open to all disciplines allowing students the opportunity to publish their work. My responsibilities have included leading a peer-review team and screening all Sciences and Engineering submissions for plagiarism. Meanwhile, URSA promotes undergraduate research across campus, hosts an annual research symposium, and has advocated for the inception of an undergraduate research fund. Resources such as these are key to connecting students to research opportunities; as a freshman, I wasn't even aware that research was something that was available to me, and it was these programs which opened that door. **These activities have given me the opportunity to promote undergraduate research directly to students who have the most to gain.**

Future Goals

As I move forward in my career I will continue to develop my research and communication skills while becoming more involved in science outreach and education. **I hope to join the SNAPhU research group under Dr. Sean Couch at Michigan State University to investigate electromagnetic signals generated by core-collapse supernovae.** This, combined with ongoing work in the research group on GW and neutrino signals from CCSNe, places the group's work firmly within the context of the new field of multimessenger astronomy. A career in academia is about more than just doing and communicating research; as scientists **we have a responsibility to nurture the next generation of scientists from all backgrounds.** It is important to me that I succeed at both of these goals, and the NSF GRFP will give me the resources and support that I need to do both effectively.

---

[1] Abbott, B. P., et al. 2017, Phys. Rev. Lett., 119, 161101

[2] Castleman, B. L., & Page, L. C. 2013, Social Science Quarterly, 95, 202

[3] Couch, S., & Ott, C. 2015, Astrophysical Journal, 799

[4] Dolence, J. C., Burrows, A., Murphy, J. W., & Nordhaus, J. 2013, The Astrophysical Journal, 765, 110