Brandon Barker - Previous Research and Scholarly Productivity

Curiosity has always played a central role in my life. Early in my college career I grew unsatisfied with that I was learning in the classroom, and 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 work had shown that turbulence played a significant role, but we wished to further quantify that statement. I created analysis software that broke down various quantities of interest 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 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.

By the end of the project, 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, in June 2016. Our work involved the development of new hydrodynamics algorithms utilizing more advanced numerical methods than those commonly used in the field, and I focused on the generalization of the code to a nuclear equation of state (EOS). From this I gained a deeper understanding of the numerical methods necessary in the field.

By the summer of 2017, I had acquired ample training in supernova theory and wished to further expand my horizons. I was accepted to the Department of Energy - Instituto Nazionale di Fisica Nucleare Student Exchange Program to work under Dr. Barbara Patricelli and Dr. Massimiliano Razzano. This served as my introduction to the exciting world of multimessenger astronomy, wherein I estimated joint detection rates of gravitational waves and gamma ray bursts from binary neutron star mergers. 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. Working under Dr. Sean Couch, I explored the sensitivity of CCSNe to variations in input nuclear physics characterized by uncertainties in experimental constraints. 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. It was this work that ultimately convinced me that this field is where my passion lies. The vast beauty and complexity of CCSNe paired with how much we have to learn from them is why I wish to study these phenomena in graduate school.

Presentations and Publications

Under the guidance of several leaders in CCSN theory and multimessenger astrophysics, 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. However, I have also partaken in numerous opportunities to present my work at local, regional, and national levels, thus allowing me to greatly develop my communication skills and aide in the dissemination of knowledge. A list of publications and selected presentations is given below.

Publications

1. *Equation of State Dependence of the Observable Properties of Turbulence-aided Neutrino-driven Core-collapse Supernovae.* M. Warren, **B. Barker**, T. Cooper, S. Couch, J. Ranta, M. Pajkos, E. O'Connor. 2018. (in prep).
2. *thornado-hydro: towards discontinuous galerkin methods for supernova hydrodynamics.* E. Endeve, J. Buffaloe, S. Dunham, N. Roberts, K. Andrew, **B. Barker**, D. Pochik, J. Pulsinelli, A. Mezzacappa. 2018. (in review).

Selected Presentations

- *Effects of Input Nuclear Physics on Core Collapse Supernova Simulations*, Fifth Joint Meeting of the Nuclear Physics Divisions of the APS and JPS, Waikoloa, HI. (poster). 2018.
- *Effects of Input Nuclear Physics on Core Collapse Supernova Simulations*, Mid-Michigan Symposium for Undergraduate Research Experiences (Mid-SURE), Michigan State University. (poster). 2018.
- *High Energy Follow-up Study of Gravitational Wave Transients*, 231st Meeting of the American Astronomical Society, National Harbor, MD. (poster) 2018.
- *Discontinuous Galerkin Methods in Nuclear Astrophysics Simulations*, Sigma Pi Sigma Quadrennial Physics Conference , San Francisco, CA (poster). 2016.
- *A Singular Value Decomposition of $15M_{\odot}$ CHIMERA Entropy Data*, Southeast Section of the American Physical Society Annual Meeting, Mobile, Al. (talk). 2015.