Many of the critical processes of core collapse supernovae (CCSN) are hydrodynamical in nature; therefore, a problem of high importance in stellar astrophysics is obtaining accurate solutions to the Euler equations of hydrodynamics. Most current solutions to these equations employ finite volume methods, which have several undesirable drawbacks. We explore the use of Discontinuous Galerkin (DG) methods in solving the Euler equations in the context of CCSN. DG methods lack the drawbacks associated with finite volume methods, and have other desirable qualities. My contribution to this project has been on generalizing the DG method implementation to a nuclear equation of state required by the stellar environment. This has demanded an intimate knowledge of linear algebra, numerical analysis, and stellar structure. I have gained extensive experience with relevant mathematical methods, as well as exposure to advanced computational methods that far exceed the scope of undergraduate courses.

As Advanced Virgo and Advanced LIGO reach their design sensitivities, a new lens into our universe will become available. The mergers of binary neutron stars (BNS) are sources of gravitational waves (GWs) and are also believed to be connected with Gamma Ray Bursts (GRBs). Joint observations of electromagnetic and GW signals will provide an ideal opportunity to study the physics of these transient events and their sources, while also helping prove the connection between these events. Supported by a competitive Department of Energy international exchange scholarship, I spent my summer in Pisa, Italy investigating the effects of galaxy distributions on the detection rates by implementing a galaxy catalog into the pipeline. This research experience provided me with an introduction to modern research on compact mergers, while also sharpening my theoretical and computational skills by introducing me to complex probability theory and computational methods.

Often in condensed matter experiments, samples will need to be transported from one apparatus to another without contamination. To help facilitate this process, I developed a portable vacuum suitcase for use in experiments in our lab (UT-ORNL Joint Institute for Advanced Materials) and between other labs in the institute. This device is still being used by my mentors and their students, as well as other research groups in the joint institute for safe handling of their samples. In addition, I assisted in several X-ray photoelectron spectroscopy (XPS) experiments and developed programs to aid in the subsequent data analysis. During this time I expanded my knowledge of condensed matter physics while gaining experience working in an experimental physics setting. While I gained many useful collaborative and experimental skills over the course of this summer, this research experience also confirmed for me that my passion was for theoretical astrophysics.

Computational models have shown that the shock formed at core bounce during core collapse supernovae (CCSN) always runs out of energy and, subsequently, stalls. Modern simulations have granted some insight into the mechanisms of shock revival. Neutrino-driven convection and the standing accretion shock instability play pivotal roles in reviving the stalled shock. These mechanisms can increase the time material spends in the heating layer near the stalled shock. This layer is dominated by turbulent flow, which is necessary for maximizing the efficiency of the neutrino heating mechanism. I developed an analysis software which allowed us to decompose the entropy and energy fields of the supernova by the most contributing modes. Using this, I attempted to quantitatively weigh the contributions to shock revival from each of the mechanisms. This project introduced me to current CCSN theory, while also expanding my mathematical foundations through an introduction to eigen-analyses.