Brandon Barker - Research Statement

Core-collapse supernovae (CCSNe) are the spectacular explosions that accompany the deaths of massive stars. CCSNe have been the subject of ongoing research for decades but *the explosion mechanism is still not fully understood*. Many of the elements heavier than H and He are synthesized here, those necessary to life in particular. Furthermore, a complete view of CCSNe is necessary for understanding the compact objects that arise from core-collapse, such as the binary neutron stars and stellar mass black holes that have been detected by Advanced LIGO and Advanced Virgo[1].

I propose to investigate the explosion mechanism driving CCSNe by further developing the current CCSN simulation capabilities to provide accurate electromagnetic emission predictions. I hope to join the SNAPhU research group at Michigan State University to work under Dr. Sean Couch while pursuing my Ph.D in Astrophysics. The computing allocations avaiable to Dr. Couch combined with the expertise available in both the group and department will support me. My coursework will advance my expertise in this area through classes in topics such as *Radiation Astrophysics*, *Stellar Astrophysics*, and *General Relativity*.

Upgrading our nuclear physics. In the hot interior of massive stars, material is said to be in nuclear statistical equilibrium (NSE), meaning that forward and backward reactions are balanced such that elemental abundances are given by relatively simple statistical relations. Current high-fidelity CCSN simulations assume that NSE is satisfied throughout the entire star. While this is a good approximation in the interior regions of interest most pertinent to the explosion, it fails at large radii so that only the central regions can be accurately modelled. I will work to transition the equation of state (EOS) to the non-NSE regime in the FLASH code, allowing for whole-star simulations and more accurate nucleosynthesis calculations.

Getting 1D EM information. The ultimate goal of the study of the CCSN explosion mechanism is the ability to *make predictions* and *understand observations*. Armed with a more realistic EOS and accurate nucleosynthesis, I will study the EM signals emitted during a CCSN. To achieve this, I will use a new model for driving 1D explosions that includes the crucial effects of turbulence and convection in tandem with SuperNu[2], an open source software, to produce the EM signals.

These are broad questions requiring interdisciplinary collaboration from leaders in several fields. The work presented here will result in the advancement of our understanding of the CCSN explosion mechanism, galactic evolution, and ultimately, the origin of the elements. We can begin to make direct connections between physical conditions of the explosion and what is observed, allowing us to compare our findings to observations and promote much needed collaboration between theoretical astrophysicists and observational astronomers.

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. Astronomy has amazing potential to transform both lives and communities. The FORD Foundation Predoctoral Fellowship would give me the resources necessary to accelerate my career by allowing me to begin research during my first year of graduate school while using my research as a tool for change.

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[1] Abbott, B. P., Abbott, R., Abbott, T. D., et al. 2016, Phys. Rev. Lett., 116, 061102

[2] Wollaeger, R. T., van Rossum, D. R., Graziani, C., et al. 2013, The Astrophysical Journal Supplement Series, 209, 36