**Critical Phenomena in Gravitational Collapse**

**Chloe Richards, 2021**

This summer I have been working closely with Professor Baumgarte in the Physics department to evolve and observe black holes and neutron stars through numerical modeling. The foundation of the project is exploring the evolution of a neutron star with a tiny black hole (a fraction of the mass of the neutron star) at the center. We do this by creating an initial data profile describing our system by defining density, mass, and grid setup for the code and then evolving the code. Through our evolutions, we record changes in various properties (accretion, density, mass, etc.) of the neutron star with a black hole.

Our goals include calculating accretion rate (the rate at which the black hole absorbs the neutron star), lifespan of this neutron star with a black hole (is it the age of the universe?), and exploring the possibilities of primordial black holes (which are raising many questions in the physics world today). To accomplish these goals, initially I analyzed the initial density profile equation to describe our unique system by combining solutions for both neutron stars and black holes. Moving forward, I evolve my code with increasingly smaller black holes masses while observing how the mass changes over time, which is known as accretion. Recently, with the help of our colleague Stu Shapiro (at the University of Illinois), I was able to find an analytical accretion rate equation to compare to our numerical results. Additionally, we consider the cases of a neutron star and black hole individually in order to confirm our results of the two combined.

Furthermore, as I strive to connect our work to the larger physics world, reading articles related to primordial black holes, black hole and neutron star evolution, and other related material has become an integral part of the project as well. As I continue this as an honors project, I focus on continuing to evolve the code for black holes as small as possible and produce insightful (and beautiful) graphs along with new insights on both neutron stars and black holes.

**Faculty Mentor: Thomas Baumgarte**

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