

Abstract

The origin of binary black hole mergers detected by gravitational wave detectors remains unknown and puzzles the astrophysical community. The literature suggests several possibly contributing formation channels. The most popular are the isolated evolution of massive binary star systems in galactic fields and dynamical pairing in dense clusters of stars.

In my thesis, I study the properties of gravitational wave sources formed via the isolated binary evolution channel. The two main scientific projects of my doctoral research concerned the influence of the criteria for unstable mass transfer (i.e., common envelope) development in massive stellar systems and the core-collapse supernovae physics on the population of compact object mergers. Especially, my interest focuses on evolutionary scenarios leading to the formation of binary black hole mergers with parameters similar to the detected population, including unusual events involving systems with unequal mass components or high inspiral effective spin parameters.

Both stability of mass transfer and core-collapse supernovae physics are poorly understood, with theory not well constrained by observations. In my doctoral research, I implement advancements in the studies of those highly uncertain astrophysical processes and examine the effect of various models on the synthetic population of gravitational wave sources. Different assumptions for the physics of the core-collapse supernova as well as the choice of criteria for common envelope development change the properties of compact object mergers, affecting the event rates, distribution of masses, systems' mass ratios, and spins. The choice of core-collapse supernova engine also affects the depth of the lower mass gap in the mass distribution between massive neutron stars and low-mass black holes. Restrictive criteria for common envelope development change the dominant formation scenario for binary black hole mergers. I present evolutionary scenarios with and without a common envelope phase, which reproduce a fraction of high-spinning binary black hole mergers consistent with gravitational wave detections.