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The Effect of Primordial Binaries and Cluster Dynamics on Binary Black Hole Mergers

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Dense stellar clusters are prime environments for the formation and evolution of bound binary black hole (BBH) systems, leading to eventual mergers. These BBHs can form through direct interactions among stellar objects or evolve from primordial binaries —binaries that originated within the cluster. Importantly, the dynamical interactions within these clusters have the potential to significantly influence BBH evolution by altering their orbital properties. This talk presents our recent research on how stellar cluster dynamics affect BBH populations and, consequently, the characteristics of their merger events. We employ N-body simulations, isolated stellar evolution models, and theoretical arguments to model stellar clusters with masses up to $M_{cl} = 10^5 \, M_\odot$, both with and without primordial binaries. Our findings reveal that including a primordial binary population results in these BBHs dominating the merger numbers. Furthermore, in clusters with an initial mass of $M_{cl} \leq 10^5 \, M_\odot$, approximately 50% of all the BBH mergers are influenced by dynamical interactions that either directly formed these systems or significantly altered the merger times of BBHs from primordial binaries. Despite this, we find that clusters born with a high primordial binary fraction still exhibit a merger efficiency consistent with isolated binary population models.

Affiliation

Cardiff University

Current Position

PhD Student

Primary author: BARBER, Jordan (Cardiff University)

Presenter: BARBER, Jordan (Cardiff University)

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