Ameliorating glitches in gravitational-wave searches for intermediate-mass black holes.

The challenge

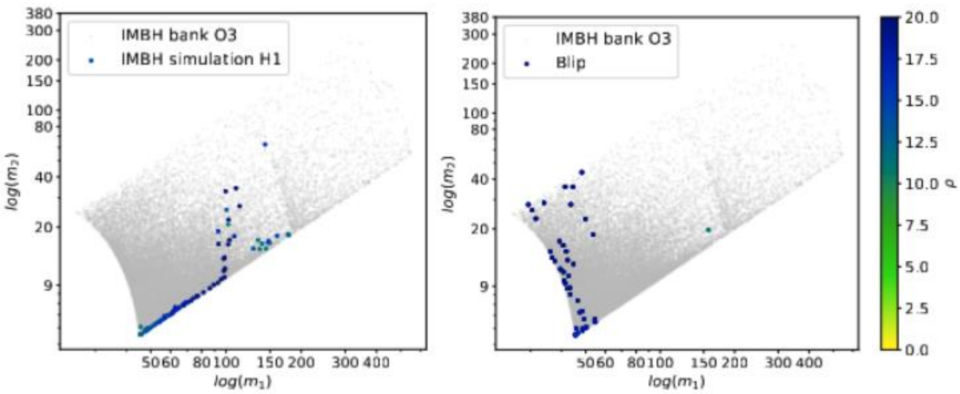
Gravitational wave interferometer data is inherently noisy, with numerous transient noise bursts, or "glitches," that can closely resemble true gravitational wave signals. These glitches, which are typically brief (often lasting only fractions of a second), pose a significant challenge to the sensitivity and reliability of current detection algorithms. Glitches can stem from a variety of environmental and instrumental sources, such as seismic activity, thermal fluctuations, or electrical interference. However, in many instances, the precise cause of a glitch remains unknown, complicating efforts to mitigate their impact.

The presence of glitches is especially problematic when detecting signals from intermediate-mass binary black hole (IMBH) mergers. IMBHs are a particularly intriguing class of black holes, with masses between stellar-mass black holes and supermassive black holes. Detecting IMBHs could provide crucial insights into the formation and evolution of black holes across mass scales and potentially bridge the gap between stellar-mass black holes and supermassive black holes found at the centers of galaxies. The observation of IMBHs would also support theories that suggest hierarchical mergers, where smaller black holes merge to form increasingly massive black holes, as a pathway to forming supermassive black holes.

IMBH signals can appear similar in duration and frequency to these noise bursts, making it difficult to reliably distinguish between the two. This similarity leads to an elevated risk of misidentifying glitches as true IMBH signals, which compromises the accuracy of gravitational wave observations. The challenge, therefore, lies in developing methods that can effectively differentiate genuine IMBH signals from glitch noise, particularly within the context of high-mass, short-duration events.

The project

To address this challenge, our project aims to develop a robust method for distinguishing IMBH signals from glitches in interferometer data. Our approach leverages the triggers generated by current gravitational wave detection pipelines, operating under the hypothesis that genuine high-mass black hole signals and glitches exhibit distinct patterns that can be identified and separated. As an example, in the graph below we plot as a function of the progenitors' masses the triggers associated with a gravitational wave simulation or injection (left) and the triggers associated with a glitch (right). By analyzing these patterns, we aim to create a complementary metric that enhances the performance of existing statistical tests used in gravitational wave data analysis.



(A) Triggers of *Injection* class (B) Triggers of *Blip* class

This project focuses on refining this metric to provide an additional layer of discrimination between IMBH signals and glitch noise. The ultimate goal is to reduce the incidence of false positives and improve the sensitivity of detection algorithms to true IMBH events. By developing and validating this metric, we hope to contribute a valuable tool for gravitational wave astronomy, enhancing the accuracy of interferometer data analysis and supporting the search for intermediate-mass black hole mergers in increasingly noisy data environments.

Bibliography

The paper is on the works but I can provide my thesis chapter on demand.