Contribution ID: **110** Type: **Poster**

Revisiting Predictions for Eccentric Blak Hole Merger Rates

Black hole binary mergers in dense stellar environments (such as globular clusters or galactic nuclei) are expected to retain non-negligible orbital eccentricity up to the point of gravitational-wave emission. Detecting residual eccentricity at merger would provide a clear signature of dynamical formation channels. Previous studies have suggested that a few percent of stellar-born binary black hole (BBH) mergers could enter the LIGO/Virgo band with measurable eccentricity, making this an important observable for formation scenarios. However, these predictions often rely on simplified assumptions and eccentricity definitions. Here, we present a systematic investigation using post-Newtonian N-body simulations (including terms up to 3.5PN) of BBH encounters in dense clusters. This approach allows us to accurately model gravitational radiation reaction and relativistic dynamics during close encounters, leading to binary captures and inspirals. We adopt a consistent post-Newtonian definition of orbital eccentricity, measuring it at specified gravitational-wave reference frequencies (such as the dominant f22 mode frequency and the peak GW frequency) to robustly characterize residual eccentricity at merger.
Using this numerical framework, we re-evaluate the fraction of eccentric GW merger events that would be detectable by current (LVK) and future (ET) observatories. Our preliminary results indicate that previously reported high eccentric merger rates were likely overestimated. We find that a substantial subset of events initially classified as eccentric mergers are in fact direct plunge events –single-pass gravitational wave captures that merge on the first close encounter –rather than long-lived eccentric inspirals. When these prompt mergers are accounted for separately, the remaining population of true eccentric inspirals entering the detector band is significantly smaller. This distinction is crucial: direct plunges produce burst-like waveforms with little inspiral phase, whereas eccentric inspirals exhibit extended chirps with orbital modulations. Consequently, the occurrence of detectably eccentric inspiral signals is lower than earlier predictions.

Primary author: TRANI, Alessandro Alberto

Presenter: TRANI, Alessandro Alberto

Session Classification: Poster Session

Track Classification: Observational Science (OSB): Div3