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Estimating the General Evolution of the Core-collapse Supernova High Frequency Feature in Interferometric Noise

Abstract

Galactic core-collapse supernovae (CCSNe) are highly anticipated multi-messenger events, providing a natural laboratory where neutrinos, photons, and gravitational waves (GWs) can be observed together. Numerical simulations indicate that CCSN GW signals are inherently non-deterministic; however, they consistently exhibit a promising observable: the High-Frequency Feature (HFF), seen in time–frequency spectrograms as a rising track between 200 Hz and 2 kHz. We introduce a framework to extract and model the HFF directly from coherent WaveBurst (cWB) reconstructed data in LIGO interferometers. Building on previous linear-growth studies, we fit analytic first- and second-order approximations to the HFF, recovering both its slope and a newly characterized curvature that describes the feature’s nonlinear evolution across different SNRs. Applied to state-of-the-art CCSN waveforms, our method identifies the functional form of the HFF growth and determines the frequency at which it saturates. This provides a more complete description of the HFF and enhances its utility for CCSN parameter inference in future GW detections.