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Rapid Accessing Explosion Properties in a Core-Collapse Supernova - Oscillations of the Newly Formed Proto-Neutron Star

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Core-collapse supernova (CCSN) marks the final stage of massive stars ($M > 8M_{\odot}$) entering in a violent and energetic explosion process that might be considered as one of the most anticipated astrophysical events of the century. Following the collapse of the star's core, a dense proto-neutron star (PNS) forms. Within this PNS, complex dynamics involving convection instabilities, accretion, and accretion funnels are believed to excite the high-frequency gravitational wave (GW) emissions, particularly the distinctive high frequency feature (HFF) known as the "g-mode". This HFF can be recognized in a time-frequency spectrogram as a continuous, approximately linear feature, typically starting around 100 Hz and rising to 1–2 kHz over time after the stellar core bounce.This project expands upon the recent advancements detailed in (Phys.Rev.D108.8(2023)), which introduced an algorithm for estimating parameters of CCSN GW HFF using model-independent coherent WaveBurst (cWB) and machine learning. Our primary objective is to study these HFF from CCSN GW signals to provide insight into the complex physical processes occurring deep within CCSN during stellar collapse. Furthermore, we seek to identify potential correlations between these features and key astrophysical parameters of the source, including the nuclear equation of state. To accomplish this, we will integrate and comprehensively test these improved techniques with state-of-the-art waveforms derived from three-dimensional numerical CCSN simulations, with a particular focus on optimizing performance for low-latency cWB operations.

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