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Glitch Vetoing for Core-Collapse Supernova Gravitational Wave detection via Machine Learning

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The search for gravitational waves (GWs) from astrophysical sources has become a central pursuit in modern astrophysics. Among the most compelling but elusive targets are GWs from core-collapse supernovae (CCSNe), which are expected to produce highly complex and stochastic waveforms. However, the presence of non-Gaussian, transient noise artifacts—commonly referred to as glitches—poses a significant challenge to their detection, especially since glitches often mimic the unpredictable time-frequency structure of CCSN signals. To improve the reliability of CCSN detection in the presence of such artifacts, we developed a supervised machine learning (ML) framework specifically designed to distinguish between glitches and CCSN waveforms. Our approach utilizes 31 distinct CCSN models derived from recent self-consistent simulations to train and evaluate the classifier. We trained various models under different CCSN waveform constraints, and tested their robustness using CCSN signal injections into both glitch-contaminated and stationary noise environments across multiple detectors. Our best-performing model, evaluated at a fixed False Positive Rate of 5%, achieves a True Positive Rate of 50% for signals with a signal-to-noise ratio (SNR) greater than 12.57. This corresponds to a detection horizon of approximately 3.89 kpc for standard CCSN events and up to 80.15 kpc for more energetic explosions. These results highlight the potential of ML-based glitch vetoing to enhance the sensitivity and confidence of CCSN GW searches in real detector data.

Section

Cosmology

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