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(G*) A Complex Window-Based Joint-Chirp-Rate-Time-Frequency Transform for BBH Merger Gravitational Wave Signal Detection

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Low-latency detection of Binary Black Hole (BBH) and Binary Neutron Star (BNS) merger Gravitational Wave (GW) signals is essential for enabling multi-messenger observations of such systems. The merger GW signals have changing frequencies and are contaminated by non-stationary noises. Earlier studies of non-templated merger signal detection techniques used traditional Fourier transform-based time-frequency decomposition methods for spectrogram generation, which have had difficulties identifying rapid frequency changes in merger signals with heavy background noise. To address the problem, we introduce the Joint-Chirp-rate-Time-Frequency Transform (JCTFT), in which complex-valued window functions are used to modulate the amplitude, frequency, and phase of the input signal. In addition, we outline the techniques for generating chirp-rate-enhanced time-frequency spectrograms from the results of a JCTFT. We demonstrate an average of 14% improved merger detectability among simulated detector signals with Signal-to-Noise Ratios between 6 and 10 using the InceptionV3 image classification neural network when compared to the same network trained with Q-transform spectrograms. The JCTFT is a general transformation technique that can be applied to existing and third-generation GW detector signals. We aim to analyze the characteristics of the complex window functions through the study of the Wigner distribution and the Fresnel functions.

Keyword-1

Gravitational Waves

Keyword-2

Fourier Transform

Keyword-3

Binary Black Hole Merger

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