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Deep Conditional Generative Adversarial Networks for Rapidly Rotating Core-Collapse Supernovae Gravitational Waves

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The generation of synthetic gravitational wave signals from core-collapse supernovae can provide a valuable tool for data augmentation in machine learning pipelines, especially for the training of detection and classification algorithms. These waveforms encode critical astrophysical information, such as the ratio of rotational kinetic to gravitational potential energy at bounce, pre-collapse differential rotation, nuclear equation of state, and explosion mechanism. Recent efforts have explored the use of generative models to synthesize waveform-like data, most existing models lack the ability to condition outputs on specific astrophysical parameters. In this work, we present two conditional generative adversarial network architectures for synthesizing gravitational wave signals from rotating core-collapse supernovae, conditioned on three discrete categories of the ratio of rotational kinetic to gravitational potential energy at bounce parameter. The training data is derived from the Richers et al. catalog, which includes time-series gravitational waveforms and associated physical parameters from numerical simulations. The first model operates directly on raw time-series data. The second model utilizes image-based inputs obtained by converting time series into Gramian Angular Summation Fields. Our results demonstrate that both conditional generative adversarial network architectures successfully learn the underlying structure of gravitational wave signals from rotating core-collapse events, producing synthetic waveforms that are statistically consistent with the original simulation data

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