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Model Parameter Reconstruction of Electroweak Phase Transition with TianQin and LISA: Insights from the Dimension-Six Model

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We investigate the capability of TianQin and LISA to reconstruct the model parameters in
the Lagrangian of new physics scenarios that can generate an electroweak SFOPT. Taking the dimension-six Higgs operator extension of the Standard Model as a representative scenario for a broad class of new physics models, we establish the mapping between the model parameter Λ and the observable spectral features of the stochastic gravitational wave background. We begin by generating simulated data incorporating Time Delay Interferometry channel noise, astrophysical foregrounds, and signals from the dimensional-six model. The data are then compressed and optimized, followed by geometric parameter inference using both Fisher matrix analysis and Bayesian nested sampling with PolyChord, which efficiently handles high-dimensional, multimodal posterior distributions. Finally, machine learning techniques are employed to achieve precise reconstruction of the model parameter Λ. For benchmark points producing strong signals, parameter reconstruction with both TianQin and LISA yields relative uncertainties of approximately 20–30% in the signal amplitude and sub-percent precision in the model parameter Λ. TianQin’s sensitivity is limited to stronger signals within its optimal frequency band, whereas LISA can reconstruct parameters across a broader range of signal strengths. Our results demonstrate that reconstruction precision depends on signal strength, astrophysical foregrounds, and instrumental noise characteristics.

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