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A hybrid time-domain approach to the LISA response: performance and applications

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We address the challenge to evaluate the response of the Laser Interferometer Space Antenna (LISA) in an accurate and computationally efficient way.

Without approximations, the full LISA response is computationally expensive and traditional approaches, such as the long-wavelength approximation, accelerate the response calculation at the cost of reducing accuracy at high frequencies. Here we introduce a novel hybrid time-domain response for LISA, that balances computational efficiency and accuracy across the binary's evolution. Our method implements a fast low-frequency approximation using central finite differences during the early inspiral—where most binaries spend most of the time in the sensitive frequency band of LISA—while reserving the computationally intensive full-response calculations for the late inspiral, merger, and ringdown phases. This hybrid approach supports CPU and GPU implementations, TDI generations 1.5 and 2.0, and flexible time-delay complexity, and has potential to accelerate parts of the global fit, and reduce power consumption.

As an application we present parameter estimation results using state-of-the-art phenomenological waveform models for LISA, which include orbital eccentricity, and the oscillatory and memory parts of the $(2,0)$ spherical harmonic. Additionally, we evaluate the low-frequency response efficacy in early-warning pipelines by performing inspiral-only Bayesian inference.

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