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Accelerated MBH population estimation from EMRI detections

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Multiple detections of extreme mass ratio inspirals (EMRIs) offer a unique opportunity to probe the population of massive black holes (MBHs). Maximizing the scientific potential of these observations requires a robust inference framework capable of handling computational challenges in likelihood evaluation and observational biases. In this work, we present a Bayesian hierarchical inference framework designed to constrain the MBH population parameters. We introduce a feed-forward neural network, achieving ~5 orders of magnitude speed-up in signal-to-noise ratio (SNR) computations for EMRI waveforms. These SNR calculations are a bottleneck in the likelihood evaluation and SNR-based selection effect, which we have included in our analysis. We validate our method using phenomenological, astrophysically motivated MBH population models. Our results demonstrate the framework's ability to tightly constrain mass and spin distributions and the branching fractions associated with different MBH formation channels, further driving investigation into the origins and evolution of MBHs.

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