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Variational inference for correlated gravitational wave detector network noise

Gravitational wave detectors like the Einstein Telescope and LISA generate long multivariate time series, which pose significant challenges in spectral density estimation due to the large number of observations as well as the presence of correlated noise. Addressing both issues is crucial for accurately interpreting the signals detected by these instruments. A variational inference method for spectral density estimation is applied to address correlated noise in gravitational-wave data. It uses a cosine-spline basis to represent the PSD, providing a flexible parametrization. To handle very long time series, the method employs a blocked multivariate Whittle likelihood approximation for stationary time series. Instead of MCMC, a surrogate posterior is optimized via stochastic-gradient variational Bayes and then sampled directly, thereby recasting complex posterior sampling into an optimization problem. The method is demonstrated by analyzing 2000 s of simulated Einstein Telescope noise, which shows its ability to produce accurate spectral density estimates and quantify coherence between time series components. This method is particularly effective in addressing correlated noise, a significant challenge in the analysis of multivariate data from collocated detectors.

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