An Analytic Approximation to the Bayesian Detection Statistic for Continuous Gravitational Waves

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We consider the Bayesian detection statistic for a targeted search for continuous gravitational waves, known as the $\mathcal{B}$-statistic. This is a Bayes factor between signal and noise hypotheses, produced by marginalizing over the four amplitude parameters of the signal. We show that by Taylor-expanding to first order in certain averaged combinations of antenna patterns (elements of the parameter space metric), the marginalization integral can be performed analytically, producing a closed-form approximation in terms of confluent hypergeometric functions. We demonstrate using Monte Carlo simulations that this approximation is as powerful as the full B-statistic, and outperforms the traditional maximum-likelihood F-statistic, for several observing scenarios which involve an average over sidereal times. We also show that the approximation does not perform well for a near-instantaneous observation, so the approximation is suited to continuous wave observations rather than transient modelled signals such as compact binary inspiral.