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Data span and frequency coverage requirements for robust detection and inference in PTAs - A case study with EPTA DR2

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Pulsar Timing Arrays (PTAs) are approaching the sensitivity required to make a 5-σ detection of the nanohertz stochastic gravitational wave background (GWB), making it crucial to develop a comprehensive understanding of our data and of the outcomes of our analysis pipelines. Thus, it becomes essential to understand a counterintuitive feature revealed in the recent results from the European Pulsar Timing Array (EPTA) second data release (DR2): when restricting the dataset to its ultimate ~10.3 years (DR2new), the inferred GWB significance increases from ⪆ 2σ for the full 25-year dataset (DR2full), to ⪆ 3.5σ for DR2new. In this talk, we show that this behaviour does not reflect an anomaly in the data, but it is a possible outcome of the analysis pipeline. This is done by using realistic DR2-like simulations. We also show that, regardless of the significance, DR2new yields biased GWB parameter estimates, primarily due to spectral leakage effects that are usually disregarded in the analysis and tend to flatten the inferred power-law spectrum. Including leakage in the model, returns unbiased parameter estimates, demonstrating that DR2new is reliable when the signal is appropriately modelled. Furthermore, we show that combining EPTA DR2full data with complementary long-baseline observations from NANOGrav and PPTA and with low frequency observations from LOFAR and NenuFAR significantly improves the GWB evidence and precision and accuracy in the parameter estimation, supporting the case of combining DR2full within the IPTA framework.

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