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Pulsar Timing Array Parameter Inference with Neural Networks

Recent evidence for a stochastic gravitational-wave background (SGWB) by pulsar timing arrays (PTAs) has opened new avenues for probing physics beyond the Standard Model. However, Bayesian analyses of PTA data remain computationally demanding. Building on earlier work, we leverage simulation-based inference based on neural networks to accelerate SGWB parameter estimation. We explore state-of-the-art transformer encoder networks and observe significantly improved marginal posterior estimates, while maintaining a computational advantage over conventional Markov chain Monte Carlo methods. These techniques are further applied to more complex SGWB models, including higher-order polynomials and signals from early universe phase transitions. Our results show that neural inference can recover key parameters and generalize beyond simple power-law models, indicating promise as a scalable, model-flexible auxiliary method in PTA analyses.

Hauptautor: KNETSCH, Jan-Christopher

Vortragende(r): KNETSCH, Jan-Christopher