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Sequential simulation-based inference for gravitational waves of the current and future era

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The current and upcoming generations of gravitational wave experiments represent an exciting step forward in terms of detector sensitivity and performance. Key upgrades at the LIGO, Virgo and KAGRA facilities will see the next observing run (O4) probe a spatial volume around four times larger than the previous run (O3), and design implementations for e.g. the Einstein Telescope, Cosmic Explorer and LISA experiments are taking shape to explore a wider frequency range and probe cosmic distances.

In this context, however, a number of imminent data analysis problems face the gravitational wave community. It will be crucial to develop tools and strategies to analyze (amongst other scenarios) signals that arrive coincidentally in detectors, longer signals that are in the presence of non-stationary noise or other shorter transients, as well as noisy, potentially correlated, coherent stochastic backgrounds. With these challenges in mind, we develop PEREGRINE, a new sequential simulation-based inference approach designed to study broad classes of gravitational wave signal.

In this talk, I discuss the need of the hour for flexible, simulation-efficient, targeted inference tools like PEREGRINE before demonstrating its accuracy and robustness through direct comparison with established likelihood-based methods. Specifically, we show that we are able to fully reconstruct the posterior distributions for every parameter of a spinning, precessing compact binary coalescence using one of the most physically detailed and computationally expensive waveform approximants (SEOBNRv4PHM). Crucially, we are able to do this using only 2% of the waveform evaluations that are required in e.g. nested sampling approaches, highlighting our simulation efficiency as the state-of-the-art when it comes to gravitational waves data analysis.

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