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Model-independent anomaly detection in gravitational waves

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Extended theories of gravity motivated by large-scale cosmological observations as well as quantum structure at black hole horizons, which has been proposed as a solution to Hawking's information paradox, may produce detectable signatures in gravitational waves (GW) emitted by compact binary mergers. The growing number of events reported by the increasingly sensitive network of earth-based GW detectors may therefore contain precious information on fundamental physics beyond current reference models. However, existing model-based tests of general relativity (GR) might remain insensitive to features which have not been fully theorized yet.

We propose a model-independent approach in which arbitrary deviations from the predictions of GR are parametrized by an artificial neural network. Training is performed on a confidently detected GW event, and we then use the Akaike Information Criterion (AIC) to select either the GR template or the NN output as the best fit to the data. Assessed on a simplified waveform toy model, our pipeline is able to detect several qualitatively distinct features with strong confidence levels. These results are in agreement with p-values obtained with Monte Carlo simulations.

Ongoing work is dedicated to application to actual GW data, which presents additional challenges related to the increased complexity of full GR waveforms and realistic detector injections.

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