A Bayesian method to test the binary black hole nature of gravitational wave events by measuring spin-induced quadrupole moments

Presentation: Oral

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The Advanced LIGO and Advanced Virgo gravitational wave detectors have made firm detections of at least ten binary black hole mergers during their first two observing runs and we expect many more such detections in the future. While these detected signals are consistent with the merger of binary black holes in general relativity, alternatives which mimic the features of a binary black hole merger cannot be completely ruled out. As per the No-hair conjecture, a Kerr black hole in general relativity can be completely described by its mass and spin. As a consequence of this, the spin-induced moment coefficients of a Kerr BH have unique values. This property of a Kerr black hole has been suggested to be used as a probe for distinguishing them from other exotic compact objects such as boson stars, gravastars etc [1, 2]. We present a detailed Bayesian inference study to assess how accurately the spin-induced quadrupole moment parameter of the binary system can be measured for black hole mergers detected by the Advanced LIGO-Advanced Virgo-KAGRA detectors and show that the proposed method offers a novel way to constrain the parameter space of black hole mimickers. We also demonstrate a Bayesian model selection analysis to quantify the ability of the method to detect a deviation from the binary black hole nature of gravitational wave events.

[1] Krishnendu et. al., PRL 119, 091101 (2017)

[2] Krishnendu et. al., PRD 99, 064008 (2019)