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Bayesian framework to infer the Hubble constant from cross-correlation of individual gravitational wave events with galaxies

Gravitational waves (GW) from the inspiral of binary compact objects offer a one-step measurement of the luminosity distance to the event, which is essential for estimating the Hubble constant, H_0, that characterizes the expansion rate of the Universe. However, unlike binary neutron stars, the inspiral of binary black holes is not expected to be accompanied by electromagnetic radiation and, thus, a subsequent determination of its redshift using the traditional host identification method is not possible. Consequently, independent redshift measurements of such GW events are necessary to measure H_0. In this study, we present a novel Bayesian approach to infer H_0 from the cross-correlation between galaxies with known redshifts and individual binary black hole merger events. We demonstrate the efficacy of our method with 250 simulated GW events distributed within 1 Gpc in colored Gaussian noise of Advanced LIGO and Advanced Virgo detectors operating at O4 sensitivity. We show that such measurements can constrain the Hubble constant with a precision of $lesssim10\%$ (90% highest density interval). We highlight the potential improvements that are required before the method can be applied to real data.

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