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A robust cosmic standard ruler from the cross-correlations of galaxies and dark sirens

Observations of gravitational waves (GWs) from dark sirens measures source locations and distances, whereas galaxies have precise angular positions but no direct measurement of their distances – only redshifts. By cross-correlating GWs from binary black hole mergers, in spherical shells of luminosity distance DL, with galaxies in shells of redshift z, we project a direct measurement of the Hubble diagram DL(z). Since this standard ruler relies only on the statistical proximity of dark sirens and galaxies, our method (dubbed "Peak Sirens") is essentially model-independent.

We make forecast for the method for the observation run 5 of LIGO-Virgo-KAGRA (LVK), as well as for the third-generation observatories Einstein Telescope and Cosmic Explorer. We employ thousands of full-sky light cone simulations with realistic numbers for the tracers, and include masking by the Milky Way, lensing and inhomogeneous GW sky coverage.

We show that future third-generation GW detectors can achieve sub-percent uncertainties in H0 assuming LCDM, and 3% in a more flexible w0waCDM model. The method also shows remarkable robustness against systematic effects such as the modeling of non-linear structure formation.

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