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A Bright Future? Prospects for Cosmological Tests of GR with Multimessenger Gravitational Wave Events

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Further bright sirens – gravitational wave events with electromagnetic counterparts – are keenly awaited, but proving elusive. The exceptional event GW170817 had a profound impact on the landscape of viable cosmological extensions of General Relativity (GR); can we expect this kind of shift to be repeated in the next decade? In this work we will assess the potential constraints from bright sirens in the LIGO–Virgo–KAGRA O5 era and third generation detector era. We set up the statistical formalism for our constraints, and generate and analyse simulated data in the context of general scalar-tensor theories. We highlight the important role that gamma-ray burst detection has in breaking key parameter degeneracies. We find that the next ten bright sirens alone will not competitively constrain cosmological gravity, but that one year of third generation observations could confidently detect mild departures from GR, e.g. the Horndeski parameter $\alpha_{\rm M} \neq 0$ is detected at greater than 3σ. This justifies investment in a broad range of methods for gravitational wave cosmology (dark sirens, bright sirens and cross-correlation with large-scale structure) to ensure tests of cosmological gravity advance in both the short-term and the long-term.

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