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Gravitational Wave Cosmology in the age of wide-field spectroscopic surveys

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Gravitational waves (GWs) from compact binary coalescences provide direct luminosity distance measurements, making them ideal "standard sirens". However, to be used as cosmological probes information on source redshifts has to be included with priors on the astrophysical populations and external electromagnetic data. In a recent analysis of LIGO-Virgo-KAGRA O4 and O5 scenarios, we demonstrate the critical importance of spectroscopic surveys to maximize the scientific return of standard sirens (Borghi et al. 2024). In particular, we find that O5 best 100 binary black holes could enable a percent-level H_0 measurement with a complete spectroscopic galaxy catalog. The precision drops by a factor of ~10 with photometric data, requiring more careful modeling of the astrophysical population to avoid bias. Notably, the O4 configuration with spectroscopic data outperforms O5 with photometric data for H_0 constraints. To address the methodological and computational challenges of future surveys, we release CHIMERA, a hierarchical Bayesian pipeline enabling joint cosmological and astrophysical population parameter constraints. This novel framework represents a significant step forward in preparing for wide-field spectroscopic surveys, such as WST, which could play a key role in the future of gravitational-wave cosmology.

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