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Forecast cosmological constraints from the number counts of Gravitational Waves events

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We present a forecast for the upcoming Einstein Telescope (ET) interferometer with two new methods to infer cosmological parameters. We consider the emission of Gravitational Waves (GWs) from compact binary coalescences, whose electromagnetic counterpart is missing, namely Dark Sirens events. Most of the methods used to infer cosmological information from GW observations rely on the availability of a redshift measurement, usually obtained with the help of external data, such as galaxy catalogues used to identify the most likely galaxy to host the emission of the observed GWs. Instead, our approach is based only on the GW survey itself and exploits the information on the distance of the GW rather than on its redshift. Since a large dataset spanning the whole distance interval is expected to fully represent the distribution, we applied our methods to the expected ET's far-reaching measuring capabilities. We simulate a dataset of observations with ET using the package `darksirens`, assuming an underlying ΛCDM cosmology, and including the possibility to choose between three possible Star Formation Rate density (SFR) models, also accounting for possible population III stars (PopIII). We test two independent statistical methods: one based on a likelihood approach on the theoretical expectation of observed events, and another applying the \emph{cut-and-count method}, a simpler method to compare the observed number of events with the predicted counts. Both methods are consistent in their final results, and also show the potential to distinguish an incorrect SFR model from the data, but not the presence of a possible PopIII. Concerning the cosmological parameters, we find instead that ET observations by themselves would suffer from strong degeneracies, but have the potential to significantly contribute to parameter estimation if used in synergy with other surveys.

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