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Model-independent constraints in the context of multi-messenger cosmology

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Gravitational wave (GW) and multi-messenger (MM) astronomy provides new ways to gain insights into the Dark Energy (DE) phenomenology, through the distance-redshift relation, as well as into potential deviations from General Relativity (GR), via the distance duality relation. Both analyses involve the same astrophysical observables, making MM astronomy a powerful tool to explore simultaneously the nature of DE and gravity.

To this end, provided our current ability to localize γ-ray bursts (GRBs), we employ a catalog of 38 of these events supposedly originated from binary neutron star (BNS) mergers detected by the Fermi Gamma-ray Space Telescope and the Neil Gehrels Swift Observatory. We generate a mock dataset of MM events by means of a prior-informed Fisher matrix approach and forecast the sensitivity of the Einstein Telescope (ET) to constrain cosmological and modified gravity (MG) parameters.

We compare the performance of standard DE and MG parametrizations with a more flexible, model-independent method based on Gaussian Processes (GP). We examine synergies among next-generation GW interferometers and cosmological probes such as Cosmic Microwave Background (CMB), Type IA Supernovae (SnIA) and Baryon Acoustic Oscillation (BAO) data. We capitalize on their complementarity to break parameter degeneracies, showing that fewer than 40 GRB-GW events will provide unprecedented accuracy in constraining the DE phenomenology as well as potential departures from GR.

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