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Model-independent cosmology with joint observations of gravitational waves and γ-ray bursts

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The multi-messenger (MM) observations of binary neutron star (BNS) mergers provide a novel approach to trace the distance-redshift relation, crucial for understanding the expansion history of the Universe and, consequently, testing the presence of Dark Energy (DE). While the gravitational wave (GW) signal offers a direct measure of the distance to the source, the combined efforts of wide-field X-/gamma- ray observations and ground-based optical telescopes yield the redshift of the host galaxy. In my presentation, I will discuss the use of gamma-ray bursts from BNS mergers observed by high-energy satellites, such as the Fermi Gamma-ray Space Telescope and the Neil Gehrels Swift Observatory, to construct a large set of mock MM data through a complete posterior reconstruction of the GW parameters beyond the standard Fisher matrix approach. We explore combinations of current and future generations of GW detectors and work within various underlying cosmologies. I will present how these mock data are used to perform an agnostic reconstruction of the DE phenomenology, thanks to Machine Learning and Gaussian Process techniques. Our study highlights that the bottleneck in combined GRB-GW detection for generating meaningful cosmological inferences lies in the availability of GRBs with known redshifts in the coming years. We stress the need to couple future interferometers, like the Einstein Telescope, with a new set of high-energy satellites that can improve the sky localization of the events.

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