ID de Contribution: **3** Type: **Non spécifié**

Towards a few percent measurement of the Hubble constant with the current network of gravitational wave detectors without using electromagnetic information

vendredi 17 octobre 2025 14:00 (30 minutes)

Gravitational waves (GWs) provide a novel and independent way to measure cosmological parameters, offering a promising avenue to address the Hubble tension alongside traditional electromagnetic (EM) observations. The current scarcity of EM counterparts - which nonetheless provide the most stringent constraints on cosmological parameters from GWs to date - and the low completeness of galaxy catalogs at high redshift, motivate the use of population-based methods that statistically combine black hole merger events, circumventing the need for EM information to probe the expansion of the Universe. The corresponding statistical framework, called hierarchical inference, requires accurate modelling of the black holes binaries'population distribution, currently described in the majority of analyses by phenomenological parametric models. Building on recent models which incorporate additional structure in the primary black hole mass distribution, using public data from the LIGO–Virgo–KAGRA collaboration's (LVK) third observing run (O3), we obtain a ~30% accuracy improvement on the measurement of the Hubble constant with respect to the result reported by LVK. Then, employing realistic simulations that include full Bayesian single-event inference, we present forecasts for the upcoming LVK observation runs, O4 and O5. Using a three power-law mass model, we project a measurement of the Hubble constant with 20% accuracy at O4 sensitivity, improving to 2.7% accuracy at O5 sensitivity. Our findings demonstrate the potential for GWs to provide a substantial contribution to solving the Hubble tension within the next decade of observations.

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Classification de Session: Contributed talks