Contribution ID: **118** Type: **not specified**

Estimation of the Hubble parameter from compact object catalogues without threshold

Friday 11 July 2025 12:00 (20 minutes)

Gravitational waves from compact binary coalescences offer a promising avenue for inferring the Hubble parameter independently of electromagnetic distance ladders or cosmic microwave background observations. As an independent probe of cosmic expansion, it has the potential to contribute to ongoing efforts to resolve the Hubble tension and to shed light on the properties of the dark sector. In particular, so-called dark sirens – compact binary coalescences events without electromagnetic counterparts – enable statistical inference using galaxy catalogs or population models. Recent studies using dark sirens have typically focused on high signal-to-noise ratio candidates, modelling the signal detection process as a step function in observed signal-to-noise ratio. While these methods have shown considerable utility, potential biases can still remain due to differences between the simulated analysis framework and real detection pipeline behavior.

In this work, we present a framework that estimates the Hubble parameter from a threshold-free catalogue of gravitational wave candidates. Our method makes direct use of detection-level information such as ranking statistic distributions and the probability of astrophysical origin, p(astro), allowing the detection process itself to be integrated into the cosmological inference. Furthermore, the approach avoids the need for individual parameter estimation for each candidate, significantly reducing computational cost and enabling the inclusion of a large number of sub-threshold candidates.

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Session Classification: Parallel 1