Gravitational wave cosmology - Journée du groupe de travail sur la cosmologie du GdR ondes gravitationnelles

Rapport sur les contributions

https://indico.in2p3.fr/e/36685

ID de Contribution: **1** Type: **Non spécifié**

An Open System Approach to Gravitational Waves

vendredi 17 octobre 2025 16:30 (30 minutes)

Several open problems in cosmology —including the nature of inflation, dark matter, and dark energy —involve spacetime-filling media with unknown microphysics, and can be probed so far only through their gravitational effects. This observation motivates a systematic open-system approach, in which gravity evolves in the presence of a generic, unobservable environment. In this talk, I will present a general framework for open gravitational dynamics based on General Relativity and the Schwinger-Keldysh formalism. As an application, I will describe the most general conservative and dissipative corrections to gravitational wave propagation in such media. I will conclude by discussing the phenomenological implications, highlighting potential observational signatures of these effects.

Auteur: Dr COLAS, Thomas (DAMTP - University of Cambridge)

Orateur: Dr COLAS, Thomas (DAMTP - University of Cambridge)

Classification de Session: Contributed talks

ID de Contribution: **2** Type: **Non spécifié**

Beyond GR tests with Einstein Telescope

vendredi 17 octobre 2025 16:00 (30 minutes)

Gravitational waves from compact binary coalescences (CBCs) have become a robust and powerful tool for testing General Relativity (GR), in fact, to date, the LIGO-Virgo-KAGRA collaboration has provided significant consistency tests of GR.
In this talk, I will present forecasts for the precision with which GR can be tested using third-generation interferometers, such as the Einstein Telescope. The anticipated large number of detected sources makes full Bayesian analyses computationally infeasible. To address this, I employ the newly released GWJulia code, which enables studies of large CBC populations using the Fisher information formalism.
Using this framework, I explore the constraints that the Einstein Telescope could place on post-Newtonian (PN) coefficients within a hierarchical Bayesian approach. In addition, I will discuss the number of events required to identify deviations from GR at various PN orders and under different detector configurations.

Auteur: BEGNONI, Andrea (University of Padova, INFN Padova)

Orateur: BEGNONI, Andrea (University of Padova, INFN Padova)

Classification de Session: Contributed talks

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.

Auteur: BERTHEAS, Tom (L2IT, LPENS)

Co-auteurs: Dr TAMANINI, Nicola (L2IT); M. GENNARI, Vasco (L2IT)

Orateur: BERTHEAS, Tom (L2IT, LPENS)

Classification de Session: Contributed talks

ID de Contribution: **4** Type: **Non spécifié**

Cosmological Inference with Gravitational Waves and Euclid Galaxy Surveys

vendredi 17 octobre 2025 14:30 (30 minutes)

We present a preliminary study of cosmology with gravitational waves from LIGO–Virgo–KAGRA using the most recent Euclid catalogs. By cross-matching the latest gravitational-wave event catalog with Euclid data, we identified five candidate events with significant spatial overlap. These cases are currently under investigation within the framework of a dedicated Euclid collaboration project. Our results represent an initial step toward establishing Euclid as a key resource for dark siren analyses in gravitational-wave cosmology.

Auteur: FERRAIUOLO, Sarah (CPPM at Aix-Marseille University (AMU) & Università di Roma, La Sapienza)

Orateur: FERRAIUOLO, Sarah (CPPM at Aix-Marseille University (AMU) & Università di Roma, La Sapienza)

Classification de Session: Contributed talks

ID de Contribution: **5** Type: **Non spécifié**

Inferring host galaxy probablities with a systematics-free approach in dark siren cosmology

vendredi 17 octobre 2025 15:00 (30 minutes)

The rapidly growing field of dark siren cosmology, driven by advances in gravitational wave detection campaigns and galaxy surveys, is progressing towards independent and increasingly precise measurements of the Hubble constant.
As statistical uncertainties shrink, it becomes crucial to address and eliminate potential dominant systematics. A key source of bias, investigated in previous studies, arises from the currently unknown probability that a merger occurs in a given host galaxy as a function of its physical properties such as its absolute luminosity raised to some power, referred to as *galaxy weight*.
In this presentation, we show that galaxy weights can be treated as population-level hyperparameters and jointly inferred from data, rather than fixed *a priori*, with a consistent and rigorous population-based weighting scheme for compact-binary host galaxies. We perform the inference in the high dimensional parameter space ($>> 100$) that also includes single-event and cosmological parameters, e.g. the Hubble constant. On one hand, this approach allows us to consistently estimate the host probabilities for each event, thereby identifying the most likely host galaxies and potentially uncovering links between their astrophysical properties and those of the hosted events. On the other hand, by exploiting Hamiltonian Monte Carlo algorithms, we are able to sample the full hierarchical population posterior and investigate correlations across parameters at all levels. At the same time, we avoid sources of numerical systematics associated with multi-dimensional Monte Carlo integrals in the likelihood, which could soon become a limiting factor for current analysis pipelines.

Auteur: AGAPITO, Alessandro (Centre de Physique Théorique (CPT), Aix-Marseille Université (AMU))

Co-auteur: MANCARELLA, Michele (Centre de Physique Théorique (CPT), Aix-Marseille Université (AMU))

Orateur: AGAPITO, Alessandro (Centre de Physique Théorique (CPT), Aix-Marseille Université (AMU))

Classification de Session: Contributed talks

ID de Contribution: **6** Type: **Non spécifié**

IAP Colloquium

vendredi 17 octobre 2025 11:00 (1h 30m)

Orateur: MANCARELLA, Michele (Centre de Physique Théorique (CPT), Aix-Marseille Université (AMU))

Classification de Session: IAP Colloquium on GW cosmology

ID de Contribution: **7** Type: **Non spécifié**

Cosmological Inference with Gravitational Waves and Euclid Galaxy Surveys

We present a preliminary study aimed at using the galaxy catalog released by Euclid for Gravitational-wave (GW) cosmology. I will firstly present an overview of the galaxy catalogs released and planned to be released with Euclid, focusing on their overlap with current GW detections. We identified six candidate events with significant spatial overlap with Euclid. I will then focus on presenting the characterization of the luminosity function and completeness of galaxies reported in Euclid Data Release 1 (DR1) and explain how these key studies are at the base of the dark siren method for GW cosmology. Our results represent an initial step toward establishing Euclid as a key resource for dark siren analyses in gravitational-wave cosmology

Auteur: FERRAIUOLO, Sarah (CPPM at Aix-Marseille University (AMU) & Università di Roma, La Sapienza)

Orateur: FERRAIUOLO, Sarah (CPPM at Aix-Marseille University (AMU) & Università di Roma, La Sapienza)

Classification de Session: Contributed talks