Rencontre commune des groupes de travail ”Cosmologie” et “Tests de la relativité générale et théories alternatives”du GdR Ondes Gravitationnelles

Rapport sur les contributions

https://indico.in2p3.fr/e/27239

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

Cosmology prospects with massive black hole binaries in LISA

lundi 20 juin 2022 16:40 (25 minutes)

In ~ 2034 the Laser Interferometer Space Antenna (LISA) will detect the coalescence of massive black hole binaries (MBHBs) from 10^5 to $10^7 \mathrm{M}_\odot$ up to $z \sim 10$. The gravitational wave (GWs) signal is expected to be accompanied by an electromagnetic (EM) counterpart, from radio to X-ray, generated by the gas accreting on the binary.
In this talk, I present some recent results on the standard sirens rates detectable jointly by LISA and EM telescopes. We combine state-of-the-art models for the galaxy formation and evolution with Bayesian tools to perform the parameter estimation of the GW event and estimate the cosmological parameters.
We explore three different astrophysical scenarios employing different seed formation (light or heavy seeds) and delay-time models, in order to have realistic predictions on the expected number of events. We estimate the detectability of the sources in terms of its signal-to-noise ratio in LISA and perform parameter estimation, focusing especially on the sky localization of the source. Exploiting the additional information from the astrophysical models, such as the amount of accreted gas and BH spins, we model the expected EM counterpart to the GW signal in soft X-ray, optical and radio.
Overall, we predict ~ 14 standard sirens (stsi) with detectable counterparts over 4 yr of LISA time mission and ~ 6 (~ 20) in the pessimistic (optimistic) scenario.
We also explore the impact of absorption from the surrounding gas both for optical and X-ray emission: assuming typical hydrogen and metal column density distribution, we estimate only ~ 3 stsi in 4 yr.
Finally we combined the redshift and luminosity distance information to estimate cosmological parameters: we find that H_0 can be constrained to few percent precision thanks to few sources whose redshift is measured spectroscopically.

Auteur principal: MANGIAGLI, Alberto (APC)

Co-auteurs: Dr TAMANINI, Nicola; Dr CAPRINI, Chiara; Dr MARSAT, Sylvain; Prof. VOLONTERI, Marta; Dr VERGANI, Susanna; SPERI, Lorenzo

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

Constructing wormholes from black holes

lundi 20 juin 2022 12:35 (25 minutes)

TBA

Auteur principal: LECOEUR, Nicolas (Université Paris-Saclay, IJCLab, Orsay)

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

Constraining spontaneous black hole scalarization with gravitational waves

lundi 20 juin 2022 10:00 (25 minutes)

Certain scalar-tensor theories remain viable despite stringent observational constraints from the Solar System due to a Z_2 symmetry that keeps the scalar field dormant in the weak-field regime. However, extreme-gravity environments can trigger a phase transition that promotes a spontaneous growth of the scalar field around compact objects like black holes and neutron stars. This is the phenomenon of spontaneous scalarization. In this talk, I will discuss how certain scalar-tensor-Gauss-Bonnet theories, which allow for the spontaneous scalarization of black holes, can be constrained using current gravitational-wave data.

Auteur principal: WONG, Leong Khim (IPhT, Université Paris-Saclay)

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

Cosmology with LISA standard sirens and their host galaxies

lundi 20 juin 2022 17:05 (25 minutes)

LISA is expected to deliver unprecedented information on the gravitational wave sources emitting in the mHz frequency band. Extreme mass-ratio inspirals are amongst the main LISA sources and their parameters will be measured with precision, notably their sky localisation. We show that, using the best-localised events as dark standard sirens in combination with a realistic galaxy catalog, these systems will give accurate estimates of the Hubble constant in a ΛCDM scenario as well as valuable information on the equation-of-state parameter w0 in a redshift-dependent dark energy model. We also discuss the potential of combining these estimates with those coming from LISA bright standard siren observations, like massive black hole binaries having an electromagnetic counterpart.

Auteur principal: LAGHI, Danny (L2I Toulouse, CNRS/IN2P3)

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

Cosmological Master Equations

lundi 20 juin 2022 12:10 (25 minutes)

Nearly scale-invariant, Gaussian and adiabatic scalar perturbations from quantum mechanical origin have been extensively tested in cosmology using CMB and LSS data. Effective field theories aim at providing a systematic way to consider extensions to this adiabatic evolution, incorporating the knowledge of unknown physics in a parametrically controlled manner. In order to grasp the implications of some hidden sector on observable scalar and tensor perturbations, the formalism needs to incorporate non-unitary effects such as dissipation. To achieve this goal, master equations can be a valuable tool. Ubiquitous in quantum optics where they describe the effects of an almost unspecified environment on the evolution of measurable degrees of freedom, they rely on assumptions that do not straightforwardly extend to cosmology where the background is curved and dynamical, the Hamiltonian time-dependent and the environment out-of-equilibrium. In this talk, I will present their implementation in cosmology and benchmark their efficiency on solvable models.

Auteur principal: COLAS, Thomas (IAS/APC)

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

Gravitational waveforms for compact binaries in Einstein-Aether theory

lundi 20 juin 2022 09:35 (25 minutes)

We use the post-Minkowskian approach to analyze the Einstein-Aether(AE)/Khronometric theories of gravity. These theories add to the spacetime metric a long-range "aether" vector field, constrained to have unit norm. We constrain one of the four free parameters of the theory to guarantee that light and tensor gravitational waves propagate at the same speed, as seen in the multimessenger event GW170817. We study the PN expansion of Einstein-Aether gravity using direct integration of the relaxed Einstein equations and we employ the usual "Eardley" convention for treating non-spinning compact objects whose masses are sensitive to the vector field. We have found a field redefinition that converts the field equations into decoupled, flat-spacetime wave equations for the components of the perturbations of the metric and aether field, with right-hand sides that contain matter terms and field terms that are quadratic and higher order in the small perturbations, precisely paralleling the "relaxed Einstein equations"of general relativity. We report on progress toward obtaining the near-zone metric and the equations of motion for compact binaries to 2.5 PN order. The ultimate goal is to develop gravitational waveforms to 1.5PN order, including the effects of dipole gravitational radiation

Auteur principal: WILL, Clifford (University of Florida & Institut d'Astrophysique)

Co-auteur: TAHERASGHARI, Fatemeh (University of Florida)

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

Current and future constraints on cosmology and modified gravitational-wave friction from binary black holes

lundi 20 juin 2022 15:20 (25 minutes)

Gravitational wave (GW) standard sirens are well-established probes with which one can measure cosmological parameters, and are complementary to other probes like the cosmic microwave background or supernovae standard candles. In my talk I will focus on dark GW sirens, specifically binary black holes (BBHs) for which there is only GW data. The approach relies on the assumption of a source frame mass model for the BBH distribution, and we consider four models that are representative of the BBH population observed so far. In addition to inferring cosmological and mass model parameters, we use dark sirens to test modified gravity theories. These theories often predict different GW propagation equations on cosmological scales, leading to a different GW luminosity distance which in some cases can be parametrized by variables Ξ_0 and n. General relativity (GR) corresponds to $\Xi_0 = 1$. We perform a joint estimate of the population parameters governing mass, redshift, the cosmology, and the modified GW luminosity distance. We use data from the third LIGO-Virgo-Kagra observation run (O3) and find - for the four mass models and for three SNR cuts of 10, 11, 12 - that GR is consistently the preferred model to describe all observed BBH GW signals to date. Furthermore, all modified gravity parameters have posteriors that are compatible with the values predicted by GR at the 90% confidence interval (CI). We then focus on future observation runs O4 and O5: We show that there are strong correlations between cosmological, astrophysical and modified gravity parameters. If GR is the correct theory of gravity, and assuming narrow priors on the cosmological parameters, we recover the modified gravity parameter Ξ_0 with a precision of 51% with O4, and 20% with O4 and O5. If, however, Nature follows a specific modified gravity model we exclude GR at the $1.7\,\sigma$ level with O4 and at the $2.3\,\sigma$ level with O4 and O5 combined.

Auteurs principaux: LEYDE, Konstantin (APC Université de Paris); MASTROGIOVANNI, Simone (Astroparticule et cosmologie, Paris Diderot university); STEER, Danièle (APC); CHASSANDE-MOTTIN, Eric (CNRS AstroParticule et Cosmologie); M. KARATHANASIS, Christos

ID de Contribution: **8** Type: **Non spécifié**

Primordial gravitational waves from excited states

lundi 20 juin 2022 11:45 (25 minutes)

How the stochastic gravitational wave background offers one to probe inflation on small scales has been a subject of active research in recent years. However, most studies focus on one specific aspect: the often called scalar induced gravitational-waves, generated after inflation from large primordial density fluctuations. Yet, the phenomenon that generates these large density fluctuations also generates in general gravitational waves during inflation. I will characterize the corresponding stochastic gravitational wave background in this talk, focusing on the signatures of dynamically generated scalar excited states.

Auteur principal: RENAUX-PETEL, Sébastien (IAP-CNRS)

ID de Contribution: **9** Type: **Non spécifié**

The gravitational wave signal from primordial magnetic fields in the Pulsar Timing Array frequency band

lundi 20 juin 2022 16:15 (25 minutes)

The NANOGrav, Parkes, European, and the International pulsar timing array (PTA) collaborations have reported evidence for a common-spectrum process that can potentially correspond to a stochastic gravitational wave background (SGWB) in the 1-100 nHz frequency range. I will present the scenario in which this signal is produced by magnetohydrodynamic (MHD) turbulence in the early universe, induced by a non-helical primordial magnetic field at the energy scale corresponding to the quark confinement phase transition. I will present the results of MHD simulations using the Pencil Code studying the dynamical evolution of the magnetic field and the resulting SGWB. The SGWB output from the simulations can be very well approximated by assuming that the magnetic anisotropic stress is constant in time, over a time interval related to the eddy turnover time. The analytical spectrum derived under this assumption features a change of slope at a frequency corresponding to the GW source duration that is confirmed with the numerical simulations. The SGWB signal can be compared with the PTA data to constrain the temperature scale at which the SGWB is sourced, as well as the amplitude and characteristic scale of the initial magnetic field. The generation temperature is constrained by PTA to be in the 2-200 MeV range, the magnetic field amplitude must be > 1% of the radiation energy density at that time, and the magnetic field characteristic scale is constrained to be > 10% of the horizon scale. The turbulent decay of this magnetic field will lead to a field at recombination that can help to alleviate the Hubble tension and can be tested by measurements in the voids of the Large Scale Structure with gamma-ray telescopes like the Cherenkov Telescope Array. arXiv:2201.05630

Auteur principal: ROPER POL, Alberto (APC)

Co-auteurs: CAPRINI, Chiara (APC); NERONOV, Andrii (APC Paris and Geneva University); SEMIKOZ, Dmitri (APC, Paris)

ID de Contribution: **10** Type: **Non spécifié**

The H0 Olympics: a fair ranking of proposed models

lundi 20 juin 2022 14:55 (25 minutes)

Despite the remarkable success of the Λ Cold Dark Matter (ΛCDM) cosmological model, a growing discrepancy has emerged between the value of the Hubble constant H0 measured using the local distance ladder and the value inferred using the cosmic microwave background and galaxy surveys. While a vast array of ΛCDM extensions have been proposed to explain these discordant observations, understanding the (relative) success of these models in resolving the tension has proven difficult – this is a direct consequence of the fact that each model has been subjected to differing, and typically incomplete, compilations of cosmological data. In this talk, I discuss a systematic comparison of seventeen different models which have been proposed to resolve the H0 tension, and explain how to quantify the relative success of each using a series of metrics and a vast array of data combinations.

Auteur principal: FRANCO ABELLAN, Guillermo ({UAI}0342321N)

Co-auteurs: Dr POULIN, Vivian; Dr SCHÖNEBERG, Nils; Prof. LESGOURGUES, Julien; Mme PÉREZ SÁNCHEZ, Andrea; Dr WITTE, Sam

ID de Contribution: **11** Type: **Non spécifié**

Schwarzschild-like Smooth Geometries in Supergravity

lundi 20 juin 2022 10:50 (25 minutes)

A new approach to solve Einstein equations in higher dimensions will be discussed. It consists in decomposing the equations into several sectors with known integrable structure. I will construct large classes of non-supersymmetric smooth solutions that are asymptotic to four-dimensional Minkowski spacetime with additional compact circles. They are induced by bubbles of spacetime supported by electromagnetic flux and look like Reissner-Nordström black holes but are smooth and horizonless. I will pay particular attention to the neutral solutions and compare their geometries to Schwarzschild black holes. I will also briefly discuss the stability of the solutions.

Auteur principal: Dr HEIDMANN, Pierre (Johns Hopkins University)

Co-auteurs: Prof. BAH, Ibrahima (Johns Hopkins University); M. WECK, Peter (Johns Hopkins University)

ID de Contribution: **12** Type: **Non spécifié**

Tension en Cosmologie sur la valeur de la constante de Hubble-Lemaître, nouvelle physique ou biais astrophysiques ?

lundi 20 juin 2022 14:30 (25 minutes)

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Auteur principal: RIGAULT, Mickael (IP2I)

ID de Contribution: **13** Type: **Non spécifié**

Metric reconstruction for non-radiative spacetimes

lundi 20 juin 2022 10:25 (25 minutes)

Multipole moments are important quantities to characterize spacetimes. In General Relativity, the most general vacuum solution with no incoming radiation is parametrized by two sets of infinite multipole moments. In this talk, we focus on non-radiative spacetimes and provide a characterization thereof in terms of a tower of multipole moments. This tower encodes non-radiative and non-stationary features of the gravitational field at null infinity, and generalizes the Geroch-Hansen moments for stationary spacetimes. Moreover, such a tower of moments is identified with charges associated to the $Lw_{1+\infty}$ algebra recently discovered in the structure of asymptotically flat spacetimes.

Auteurs principaux: COMPÈRE, Geoffrey (ULB); OLIVERI, Roberto (LUTH, Observatoire de Paris, CNRS); SERAJ, Ali (ULB)