Conference: Meeting of the National Research Group on Gravitational Waves

Report of Contributions

https://indico.math.cnrs.fr/e/5766

Contribution ID: **1** Type: **poster**

Double black hole 3C 434.3 and powerful gravitational wave radiation

A.E. Volvach, L.N. Volvach, M. G. Larionov

Estimates of the level of gravitational wave (GW) coming from 3C 454.3 show that 3C 454.3 is currently the most powerful GW emitter. Based on the obtained data, we consider the characteristics of the gravitational radiation of this system, as well as the lifetime before merging, and possible variations in companion orbits.
Due to the constant presence of companions in a dense inhomogeneous AD environment, the role of dynamic friction increases for dynamics of all system. In the first of all that connection with the process of calculate of the GWs level radiation, which increase in that case. This situation allows us to suggests for an increase in the probability of detecting GWs radiating from 3C 454.3.

Primary author: Dr VOLVACH, Alexandr (Radio Astronomy CrAO)

Presenter: Dr VOLVACH, Alexandr (Radio Astronomy CrAO)

Contribution ID: **2** Type: **FORMES D'ONDE**

Effective two-body approach to the hierarchical three-body problem

Tuesday, March 30, 2021 9:45 AM (15 minutes)

The three body-problem, even in the simple Newtonian case, exhibits very rich dynamical behaviors. The study of a hierachical configuration, in which a close inner binary is orbited by a distant perturber, has been initiated by Lidov and Kozai in the 60's. The eccentricity oscillations that they discovered is particularly relevant to gravitational wave astronomy. On the other hand, several efficient tools have been developed to study the general relativistic two-body problem. In this talk, I will present how one can extend the two-body effective field theory (EFT) approach to the setup of a hierarchical three-body problem. Besides introducing a new expansion parameter consisting in the ratio of semimajor axes of the two orbits, our approach builds on the fact that one can treat the inner binary itself as an effective spinning point-particle. I will present in some details how this identification is performed.

Primary author: KUNTZ, Adrien (Scuola Normale Superiore, Pisa)

Presenter: KUNTZ, Adrien (Scuola Normale Superiore, Pisa)

Session Classification: Contributed talks: Waveforms

Contribution ID: **3** Type: **poster**

Seismic characterization of Virgo: space-time spectral analysis

Mixed space-time spectral analysis was applied for the detection of seismic waves passing through the west-end building of the Virgo interferometer. The method enables detection of every single passing wave, including its frequency, length, direction, and amplitude. A thorough analysis aimed to improving sensitivity of the Virgo detector was made for the data gathered by 38 seismic sensors, in the two-week measurement period, from 24 January to 6 February 2018, and for frequency range 5–20 Hz. Two dominant seismic-wave frequencies were found: 5.5 Hz and 17.1 Hz. The possible sources of these waves were identified, that is, the nearby industrial complex for the frequency 5.5 Hz and a small object 100 m away from the west-end buiding for 17.1 Hz. The obtained results are going to be used to provide better estimation of the newtonian noise near the Virgo interferometer.

Primary author: Dr DENYS, Mateusz (AstroCeNT, Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences)

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Presenter: Dr DENYS, Mateusz (AstroCeNT, Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences)

Contribution ID: **4** Type: **MÉTHODES D'ANALYSE DES DONNÉES**

GPE: GPU-accelerated parameter estimation for gravitational waves

Tuesday, March 30, 2021 2:00 PM (15 minutes)

We present GPE, a GPU-accelerated parameter estimation package for gravitational waves from compact binary coalescence sources. This stand-alone program is adapted from the nested sampling flavor of LALInference. Two main parallelization methods are implemented: (1) the frequency-domain waveform and likelihood calculations, (2) and the prior sampling portion in the nested sampling algorithm. We show that GPE can produce consistent results compared to LALInference, while demonstrating a 200-400 times speedup on one GPU compared to LALInference on one CPU. The high acceleration of GPE can facilitate the data-analysis of detected events, simulations for detector observing scenarios, and production of sky localization regions for EM follow-up.

Primary author: Ms HUANG, Yun-Jing (Academia Sinica, Taiwan)

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Presenter: Ms HUANG, Yun-Jing (Academia Sinica, Taiwan)

Session Classification: Contributed talks: Data analysis methods

Contribution ID: **6** Type: **FORMES D'ONDE**

Schwarzschild-Tangherlini metric from scattering amplitudes in various dimensions

Tuesday, March 30, 2021 10:00 AM (15 minutes)

We derive the static Schwarzschild-Tangherlini metric by extracting the classical contributions from the multiloop vertex functions of a graviton emitted from a massive scalar field. At each loop order the classical contribution is proportional to a unique master integral given by the massless sunset integral. By computing the scattering amplitudes up to three-loop order in general dimension, we explicitly derive the expansion of the metric up to the fourth post-Minkowskian order O(GN4) in four, five and six dimensions. There are ultraviolet divergences that are cancelled with the introduction of higher-derivative nonminimal couplings. The standard Schwarzschild-Tangherlini is recovered by absorbing their effects by an appropriate coordinate transformation induced from the de Donder gauge condition.

Primary author: MOUGIAKAKOS, Stavros (IPhT,CEA-Saclay)

Co-author: VANHOVE, Pierre

Presenter: MOUGIAKAKOS, Stavros (IPhT,CEA-Saclay)

Session Classification: Contributed talks: Waveforms

Contribution ID: **7** Type: **FORMES D'ONDE**

Spinning black holes fall in Love

Tuesday, March 30, 2021 9:30 AM (15 minutes)

The open question of whether a black hole can become tidally deformed by an external gravitational field has profound implications for fundamental physics, astrophysics and gravitational-wave astronomy. Love tensors characterize the tidal deformability of compact objects such as astrophysical (Kerr) black holes under an external static tidal field. We prove that all Love tensors vanish identically for a Kerr black hole in the nonspinning limit or for an axisymmetric tidal perturbation. In contrast to this result, we show that Love tensors are generically nonzero for a spinning black hole. Specifically, to linear order in the Kerr black hole spin and the weak perturbing tidal field, we compute in closed form the Love tensors that couple the mass-type and current-type quadrupole moments to the electric-type and magnetic-type quadrupolar tidal fields. For a dimensionless spin ~ 0.1, the nonvanishing quadrupolar Love tensors are ~ 0.002, thus showing that black holes are particularly "rigid" compact objects.

Primary authors: Dr LE TIEC, Alexandre (Observatoire de Paris); Dr CASALS, Marc (Centro Brasileiro de Pesquisas Fisicas); Dr FRANZIN, Edgardo (Scuola Internazionale Superiore di Studi Avanzati)

Presenter: Dr LE TIEC, Alexandre (Observatoire de Paris)

Session Classification: Contributed talks: Waveforms

Contribution ID: **8** Type: **poster**

An AGN disk channel for binary black hole mergers

Active galactic nucleus (AGN) disks have been proposed as promising locations for producing some of the detected stellar mass binary black hole (BBH) mergers since the first discovery of a transient gravitational-wave (GW) signal by the two detectors of the Laser Interferometer Gravitational-Wave Observatory. However, the validity of the AGN disk channel for BBH mergers remains unconfirmed due to the recent isolated binary simulations. In this work, we perform a series of high-resolution 2D hydrodynamical simulations of equal-mass binary black holes (BBHs) embedded in AGN disks to study whether these binaries can be driven to merger by the surrounding gas. We find that the gravitational softening adopted for the BBH has a profound impact on this result. When the softening is less than ten percent of the binary separation, we show that, in agreement with recent simulations of isolated equal-mass binaries, prograde BBHs expand in time rather than contract. Eventually, however, the binary separation becomes large enough that the tidal force of the central AGN disrupts them. Only when the softening is relatively large do we find that prograde BBHs harden. We determine through detailed analysis of the binary torque, that this dichotomy is due to a loss of spiral structure in the circum-single disks orbiting each BH when the softening is a significant fraction of the binary separation. Properly resolving these spirals – both with high resolution and small softening – results in a significant source of binary angular momentum. Only for retrograde BBHs do we find consistent hardening, regardless of softening, as these BBHs lack the important spiral structure in their circum-single disks. This suggests that the gas-driven inspiral of retrograde binaries can produce a population of compact BBHs in the GW-emitting regime in AGN disks, which may contribute a large fraction to the observed BBH mergers.

Primary author: Dr LI, Yaping (LANL)

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Presenter: Dr LI, Yaping (LANL)

Contribution ID: **9** Type: **not specified**

Primordial Black Holes and Cosmological Gravitational Waves

Tuesday, March 30, 2021 9:00 AM (30 minutes)

Presenter: SASAKI, Misao (IPMU)

Contribution ID: **12** Type: **not specified**

Expected properties of electromagnetic counterparts of BHNS mergers

Tuesday, March 30, 2021 11:00 AM (30 minutes)

Presenter: GHIRLANDA, Giancarlo

Contribution ID: **13** Type: **not specified**

Probing subatomic physics with gravitational waves from neutron star binary inspirals

Tuesday, March 30, 2021 11:30 AM (30 minutes)

Presenter: HINDERER, Tania

Contribution ID: **14** Type: **not specified**

Multimessenger astronomy with massive black hole binaries

Tuesday, March 30, 2021 12:00 PM (30 minutes)

Presenter: SESANA, Alberto

Contribution ID: **16** Type: **not specified**

Experimental challenges to astrophysical reach of ground-based detectors

Tuesday, March 30, 2021 5:00 PM (30 minutes)

Presenter: GONZALEZ, Gabriela

Contribution ID: **17** Type: **not specified**

Flexible analysis of gravitational wave data: signal polarization and detector glitches

Tuesday, March 30, 2021 5:30 PM (30 minutes)

Presenter: CHATZIOANNOU, Katerina

Contribution ID: **18** Type: **not specified**

Minimalism in modified gravity

Wednesday, March 31, 2021 9:00 AM (30 minutes)

Presenter: MUKOHYAMA, Shinji

Contribution ID: **19** Type: **not specified**

The Speed of Gravity

Wednesday, March 31, 2021 9:30 AM (30 minutes)

Presenter: DE RHAM, Claudia

Contribution ID: **20** Type: **not specified**

From Amplitudes to Waveforms

Wednesday, March 31, 2021 10:00 AM (30 minutes)

Presenter: KOSOWER, David

Contribution ID: **22** Type: **not specified**

Testing strong gravity with quasi-normal-modes

Wednesday, March 31, 2021 11:00 AM (30 minutes)

Quasinormal modes in the ringdowns are powerful probes for testing the behaviour of strong-field gravity around the black holes. In this talk, first, I want to quickly review the tests of gravity that are being done using the binary black-hole quasi-normal modes currently. Then I will discuss some possible tests of gravity that can be performed using the next-generation detectors using the quasi-normal modes.

Presenter: BHAGWAT, Sweta

Contribution ID: **23** Type: **not specified**

Gravitational waves as probe of the very early universe

Wednesday, March 31, 2021 11:30 AM (30 minutes)

Presenter: DOMCKE, Valerie

Contribution ID: **24** Type: **not specified**

Primordial Nano Black Holes

Wednesday, March 31, 2021 12:00 PM (30 minutes)

Presenter: RIOTTO, Antonio

Contribution ID: **26** Type: **not specified**

Quantum noise in interferometric gravitational-wave detectors

Wednesday, March 31, 2021 4:30 PM (30 minutes)

Presenter: CAPOCASA, Eleonora

Contribution ID: **27** Type: **not specified**

A global perspective on LISA analysis and cosmological backgrounds

Wednesday, March 31, 2021 5:00 PM (30 minutes)

Presenter: CORNISH, Neil

Contribution ID: **28** Type: **not specified**

Gravitational-wave background mapping: investigations in LIGO and prospects for LISA

Wednesday, March 31, 2021 5:30 PM (30 minutes)

Presenter: RENZINI, Arianna

Contribution ID: **30** Type: **not specified**

Lessons on the equation of state from binary neutron stars

Thursday, April 1, 2021 11:00 AM (30 minutes)

Presenter: REZZOLLA, Luciano

Contribution ID: **32** Type: **not specified**

Towards a gravitational wave map of the Local Group of galaxies

Thursday, April 1, 2021 11:30 AM (30 minutes)

Presenter: ROSSI, Elena

Contribution ID: **34** Type: **not specified**

Some recent results in GW astrophysics

Thursday, April 1, 2021 4:30 PM (30 minutes)

Presenter: HOLZ, Daniel

Contribution ID: **35** Type: **not specified**

Some thoughts on the properties of the population of BBH mergers

Thursday, April 1, 2021 5:00 PM (30 minutes)

Presenter: ZALDARRIAGA, Matias

Contribution ID: **36** Type: **not specified**

Prospects for the future of gravitational-wave observation

Thursday, April 1, 2021 5:30 PM (30 minutes)

Presenter: SHOEMAKER, David

Contribution ID: **38** Type: **poster**

The Probability Distribution of Astrophysical Gravitational-Wave Background Fluctuations

The coalescence of compact binary stars is expected to produce a stochastic background of gravitational waves (GW) observable with future GW detectors. Such backgrounds are usually characterized by their power spectrum as a function of frequency. Here, we present a method to calculate the full 1-point distribution of strain fluctuations. We focus on time series data, but our approach generalizes to the frequency domain. We illustrate how this probability distribution can be evaluated numerically. In addition, we derive accurate analytical asymptotic expressions for the large strain tail, which demonstrate that it is dominated by the nearest source. As an application, we also calculate the distribution of strain fluctuations for the astrophysical GW background produced by binary mergers of compact stars in the Universe, and quantify the extent to which it deviates from a Gaussian distribution. Our approach could be useful for the spectral shape reconstruction of stochastic GW backgrounds.

Primary author: GINAT, Barry

Co-authors: Prof. DESJACQUES, Vincent (Technion - Israel Institute of Technology); Dr REISCHKE, Robert (Ruhr-Universität Bochum); Prof. PERETS, Hagai (Technion - Israel Institute of Technology)

Presenter: GINAT, Barry

Contribution ID: **39** Type: **POPULATIONS DES SOURCES**

Hierarchical triples can explain LIGO-Virgo mergers

Thursday, April 1, 2021 9:00 AM (15 minutes)

The recent discovery of gravitational waves has opened new horizons. The LIGO-Virgo events have made possible to estimate rates, masses, eccentricities, and projected spins of merging black holes (BHs) for the fist time. The astrophysical origin of these mergers is among the most puzzling open questions of our time. Two primary channels have been proposed to explain the observed population of merging BHs and NSs: field binary evolution and dynamical formation in a cluster environment. Observations show that about one fourth of massive stars is in triple systems, comprised of an inner binary orbited by a third companion. Despite being rarer than binaries, a large fraction of triples can merge as a result of the Kozai-Lidov mechanism, imposed on the inner binary by the field of the third companion. Within current uncertainties, triples can potentially account for most of the observed events. Remarkably, triples are expected to produce many mergers with relatively high total mass and low mass ratios relative to the other formation channels. The triple scenario is definitively the third pathway to compact object mergers.

Primary author: FRAGIONE, Giacomo (Northwestern University)

Presenter: FRAGIONE, Giacomo (Northwestern University)

Session Classification: Contributed talks: populations of sources

Contribution ID: **40** Type: **COSMOLOGIE**

Gravitational radiation from MHD turbulence in the early universe

Wednesday, March 31, 2021 2:30 PM (15 minutes)

The generation of primordial magnetic fields and its interaction with the primordial plasma during cosmological phase transitions is turbulent in nature. I will describe and discuss results of direct numerical simulations of magnetohydrodynamic (MHD) turbulence in the early universe and the resulting stochastic gravitational wave background (SGWB). In addition to the SGWB, the primordial magnetic field will evolve up to our present time and its relics can explain indirect observations of weak magnetic fields coherent on very large scales. I will apply the numerical results to magnetic fields produced at the electroweak and the QCD phase transitions and show that these signals may be detectable by the planned Laser Interferometer Space Antenna and by Pulsar Timing Array. The detection of these signals would lead to the understanding of cosmological phase transition physics, which can have consequences on the baryon asymmetry problem and on the origin seed of observed magnetic fields coherent over very large scales at the present time.

Primary author: ROPER POL, Alberto (APC)

Co-author: CAPRINI, Chiara (CNRS APC)

Presenter: ROPER POL, Alberto (APC)

Session Classification: Contributed talks: Cosmology

Contribution ID: **41** Type: **COSMOLOGIE**

Study of Neutron Star in the presence of Dark Matter

Wednesday, March 31, 2021 3:45 PM (15 minutes)

Neutron stars (NSs), being one of the most enigmatic stellar remnants with incredibly dense core and sturdy crust, can be considered as the best laboratory in the universe to appraise many astrophysical models of the strong gravitational field regime. We analyse the effects of dark matter on the properties and curvature of the NS with the help of relativistic mean-field (RMF) formalism using NL3, G3 and IOPB-I parameter sets. We thoroughly investigate the influence of dark matter candidate on the mass-radius profile of the NS. The impact of dark matter on the moment of inertia for static and rotating NS has also been calculated and studied [1]. We calculate and examine the Riemann tensor, Kretschmann scalar, Ricci tensor and RicciScalar along with the variation of baryon density, mass and radius of the NS in the presence of the dark matter [2]. The dependence of curvature of the NS on the nature of the RMF parameter set has also been explored with the softer and stiffer equation of state.

[1] H. C. Das, A. Kumar, B. Kumar, et al., MNRAS 495, 4893 (2020).
[2] H. C. Das, A. Kumar, B. Kumar, S. Biswal, and S. Patra, Journal of Cosmology and Astroparticle Physics2021, 007 (2021).

Primary author: DAS, Harish Chandra (Institute of Physics, Bhubaneswar, Odisha, India)

Co-authors: KUMAR, Ankit (Institute of Physics); Prof. PATRA, Suresh Kumar (Institute of Physics, Bhubaneswar)

Presenter: DAS, Harish Chandra (Institute of Physics, Bhubaneswar, Odisha, India)

Session Classification: Contributed talks: Cosmology

Contribution ID: **42** Type: **TESTS DE LA RELATIVITÉ GÉNÉRALE ET THÉORIES ALTERNATIVES**

Dynamics of Screening in Modified Gravity

Thursday, April 1, 2021 2:30 PM (15 minutes)

Gravitational theories differing from General Relativity may explain the accelerated expansion of the Universe without a cosmological constant. However, their viability crucially depends on a "screening mechanism"needed to suppress, on small scales, the fifth force driving the cosmological acceleration. I will discuss a scalar-tensor theory with first-order derivative self-interactions exhibiting such a mechanism, and present screened solutions in this theory for both non-relativistic and relativistic stars. Then, I will discuss the stability of these solutions and present our results from numerically evolving them in the strong-field, highly dynamical regime.

Primary author: TER HAAR, Lotte (SISSA)

Co-authors: BEZARES, Miguel; CRISOSTOMI, Marco; PALENZUELA, Carlos; BARAUSSE, Enrico

Presenter: TER HAAR, Lotte (SISSA)

Session Classification: Contributed talks: Tests of GR and alternative theories

Contribution ID: **43** Type: **poster**

Study of the hot nuclear matter and supernovae remnants using relativistic mean field model

Modern study of infinite nuclear matter based on relativistic mean-field (RMF) model bestow us with new dimensions in understanding the nature and behavioral aspects of compact astrophysical objects. It is well known that the compact stars are the remnants of the supernova explosion and ideal laboratory to explore the formulated theories of dense matter objects. We provide an approach to explore the nuclear and thermal properties of hot nuclear matter and newly born proto-neutron star with equation of state (EoS) being the main ingredient. We extend the RMF formalism to finite temperature and examine the variation of various nuclear and thermal properties like phase transition temperature, incompressibility, symmetry energy and its derivatives for infinite nuclear matter. We studied all these properties using most popular NL3, IU-FSUand recently developed G3 parameter sets. We did a comparative analyzation i.e. how differently these nuclear properties varies for the prescribed NL3, G3 and IU-FSU forces. The cooling mechanism of the newly born proto-neutron star through direct Urca process has also been explored. The observation of Einstein Observatory (HEAO-2) first supported the fact that neutrino emissivity enhanced by direct Urcaprocess is mainly responsible for the rapid cooling of newly born dense star. We observed here that the EoS plays an important role to investigate the cooling rate of hot dense object and neutrino emissivity is higher for that parameter set which provides softer EoS. Different cooling rates for NL3, G3 and IU-FSU parameter sets emphasized on the importance of EoS in the dynamics of supernova explosion and thermal stabilization of the newly born star. We also deliberate the effect of temperature on the Mass-Radius profile of Proto-Neutron star with two different perspectives i.e. fixed temperature and constant entropy.

Reference:- Ankit Kumar, H. C. Das, S. K. Biswal, Bharat Kumar and S. K. Patra, Eur. Phys. J.C (2020) 80, 775; DOI: https://doi.org/10.1140/epjc/s10052-020-8353-4

Primary author: KUMAR, Ankit (Institute of Physics)

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Presenter: KUMAR, Ankit (Institute of Physics)

Contribution ID: **44** Type: **ÉTOILES A NEUTRONS, SUPERNOVÆ ET SYNTHÈSES DES ÉLÉMENTS LOURDS**

GW190814: On the properties of the secondary component of the binary

Tuesday, March 30, 2021 3:30 PM (15 minutes)

We show that the odds of the mass-gap (secondary) object in GW190814 being a neutron star (NS) improve if one allows for a stiff high-density equation of state (EoS) or a large spin. Since its mass is $\in (2.50, 2.67) M_{\odot}$, establishing its true nature will make it either the heaviest NS or the lightest black hole (BH), and can have far-reaching implications on NS EoS and compact object formation channels. When limiting oneself to the NS hypothesis, we deduce the secondary's properties by using a Bayesian framework with a hybrid EoS formulation that employs a parabolic expansion-based nuclear empirical parameterization around the nuclear saturation density augmented by a generic 3-segment piecewise polytrope (PP) model at higher densities and combining a variety of astrophysical observations. For the slow-rotation scenario, GW190814 implies a very stiff EoS and a stringent constraint on the EoS specially in the high-density region. On the other hand assuming the secondary object is a rapidly rotating NS, we constrain its rotational frequency to be $f = 1170^{+389}_{-495}$ Hz, within a 90% confidence interval. In this scenario, the secondary object in GW190814 would qualify as the fastest rotating NS ever observed. However, for this scenario to be viable, rotational instabilities would have to be suppressed both during formation and the subsequent evolution until merger, otherwise the secondary of GW190814 is more likely to be a BH.

Primary author: Mr BISWAS, BHASKAR (IUCAA, Pune)

Presenter: Mr BISWAS, BHASKAR (IUCAA, Pune)

Session Classification: Contributed talks: Neutron stars, supernovae and heavy elements

Contribution ID: **45** Type: **POPULATIONS DES SOURCES**

The cosmic merger rate density of compact binaries

Thursday, April 1, 2021 9:15 AM (15 minutes)

With the recent publication of the second gravitational wave transient catalog by the LIGO-Virgo collaboration (LVC), the number of binary compact object mergers has risen dramatically, from a dozen to ~ 50 events. From these detections, the LVC inferred the merger rate density both in the local Universe and as a function of redshift. It is then of foremost importance to compare the merger rate density predicted with different astrophysical models with the value inferred by LVC. In my talk, I will present a semi-analytic model that evaluates the cosmic merge rate density, by taking into account the cosmic star formation rate density and the metallicity evolution of stars across cosmic time. These are then combined with catalogues of merging compact binaries. I have considered binaries that form in isolation versus dynamical binaries. My results indicate that dynamical binaries are much less sensitive to metallicity than isolated binaries (Santoliquido et al. 2020 - arXiv: 2004.09533). Furthermore, I have explored the impact of various binary evolution processes on the merger rate density. For example, when I vary the common envelope ejection efficiency parameter from α_{CE}=7 to 0.5, the local merger rate density of binary neutron stars varies from 10^3 to 20 Gpc^{-3} yr^{-1}, whereas the local merger rates of binary black holes and black hole - neutron star binaries vary just by a factor of ~2-3. I will also show that by propagating the uncertainties of the metallicity evolution model on the merger rate density, the binary black hole merger rate can change by one order of magnitude within 50% credible interval (Santoliquido et al. 2021 - arXiv: 2009.03911).

Primary author: Mr SANTOLIQUIDO, Filippo (University of Padova)

Presenter: Mr SANTOLIQUIDO, Filippo (University of Padova)

Session Classification: Contributed talks: populations of sources

Contribution ID: **46** Type: **POPULATIONS DES SOURCES**

Discriminating between different scenarios for the formation and evolution of massive black holes with LISA

Thursday, April 1, 2021 9:30 AM (15 minutes)

Different scenarios for the formation and evolution of massive black holes lead to different predictions for the population of massive black holes in the Universe. By reverse engineering the problem, we can use LISA observations to discriminate between different scenarios. However, the Universe is unlikely to be described by a single model. This can be accounted for by introducing mixing fractions between the different models.
In this talk, I will present simulated results for the inference of the mixing fraction between two models from LISA observations using a hierarchical Bayesian framework. I will also discuss of the robustness of this approach by using different models to generate the simulated data.

Primary author: TOUBIANA, Alexandre (APC/IAP)

Presenter: TOUBIANA, Alexandre (APC/IAP)

Session Classification: Contributed talks: populations of sources

Contribution ID: **48** Type: **TESTS DE LA RELATIVITÉ GÉNÉRALE ET THÉORIES ALTERNATIVES**

Detecting scalar field with extreme mass ratio inspirals

Thursday, April 1, 2021 2:45 PM (15 minutes)

I will present extreme mass ratio inspirals (EMRIs), during which a small body spirals into a supermassive black hole, in gravity theories with additional scalar fields. No-hair theorems and properties of known theories that manage to circumvent them introduce a drastic simplification to the problem: the effects of the scalar on supermassive black holes, if any, are mostly negligible for EMRIs in vast classes of theories. I will show how to exploit this simplification to model the inspiral perturbatively and demonstrate that the scalar charge of the small body leaves a significant imprint on gravitational wave emission. This result is particularly appealing, as this imprint is observable with LISA, rendering EMRIs promising probes of scalar fields.

Primary author: FRANCHINI, Nicola (Sissa)

Presenter: FRANCHINI, Nicola (Sissa)

Session Classification: Contributed talks: Tests of GR and alternative theories

Contribution ID: **50** Type: **TESTS DE LA RELATIVITÉ GÉNÉRALE ET THÉORIES ALTERNATIVES**

Metric reconstruction with gravitational waves and shadows

Thursday, April 1, 2021 3:00 PM (15 minutes)

In this talk I present three recent works [1,2,3] that aim to enhance our understanding of reconstructing black hole space-times from different type of observations. While gravitational wave detectors like LIGO/Virgo allow to perform black hole spectroscopy of stellar mass black holes, images such as those produced by the Event Horizon Telescope provide information of the shadow from super massive black holes. A theory agnostic approach starting from a parametrized metric is combined with Bayesian analysis to infer possible metric deviations from simulated quasi-normal modes, as well as from the observed size of the shadow of M87*. It is demonstrated under what simplifying assumptions both type of inverse problems can be studied, as well as what conceptual difficulties arise in a theory agnostic approach. Finally, it is highlighted how both type of observations are complementary to each other and how consistent calculations for parametrized metrics can be done in alternative theories of gravity.

[1] Bayesian Metric Reconstruction with Gravitational Wave Observations, Sebastian H. Völkel and Enrico Barausse, Phys. Rev. D 102, 084025, 2020, https://arxiv.org/abs/2007.02986

[2] EHT tests of the strong-field regime of General Relativity, Sebastian H. Völkel, Enrico Barausse, Nicola Franchini and Avery E. Broderick, in review, https://arxiv.org/abs/2011.06812

[3] An exact theory for the Rezzolla-Zhidenko metric and self-consistent calculation of quasi-normal modes, Arthur G. Suvorov and Sebastian H. Völkel, Phys. Rev. D 103, 044027, 2021, https://arxiv.org/abs/2101.09697

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Presenter: Dr VÖLKEL, Sebastian (SISSA and IFPU, Trieste, Italy)

Session Classification: Contributed talks: Tests of GR and alternative theories

Contribution ID: **51** Type: **PRÉDICTION ET SUIVI DES SIGNAUX MULTI-MESSAGER**

Catching black holes with tidal disruption events

Thursday, April 1, 2021 2:00 PM (15 minutes)

Tidal disruption events (TDEs) take place when a star orbiting around a black hole (BH) is fully or partially disrupted by the black hole tides. This occurrence can be used as a way to reveal the presence of quiescent BHs through the Universe. With this talk, I will first describe general features of TDEs. Then, I will explore the possibility of detecting them via gravitational waves (GWs) with future space-based interferometers. Finally, I will illustrate how the GW background from these events could allow us to better constrain the elusive population of intermediate-mass BHs and to map their distribution up to redshift 3.

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Co-authors: Prof. LODATO, Giuseppe (Università degli Studi di Milano); Prof. ROSSI, Elena Maria (Leiden Observatory)

Presenter: TOSCANI, martina (Università degli studi di Milano)

Session Classification: Contributed talks: Multi-messenger signals

Contribution ID: **52** Type: **MÉTHODES D'ANALYSE DES DONNÉES**

DeepHMC: a deep neural network enhanced Hamiltonian Monte Carlo algorithm for accelerated Bayesian inference of binary neutron star parameters

Tuesday, March 30, 2021 2:15 PM (15 minutes)

A major activity of the LIGO-Virgo-KAGRA collaboration is to build algorithms able to infer from the detected gravitational wave signals the posterior distributions of the parameters defining their sources: angles in the sky, distance from us, masses etc. Current algorithms like MCMC and Nested Sampling have already demonstrated with success their ability to do so during the first three runs of observations of the detectors.

Nonetheless the latter remain computationally expensive as they require from weeks to months of CPU time when analyzing long duration signals, typically BNS ones, and when using advanced waveform models.
As the sensitivity of GW interferometers is being improved years after years, the duration of exploitable signal and rate of detection increase (10^{+52}_{-10} y^{-1} BNS expected during O4), requiring more and longer analysis which creates an important tension with the time required to perform each of them.

To respond to this challenge we will present DeepHMC, a Hamiltonian Monte Carlo (HMC) algorithm boosted by a Deep Neural Network (DNN).
Contrary to currently used algorithms, the HMC is a non random-walk sampler as it uses the gradient of the posterior distribution to make new chain proposals, making it more efficient than MCMC or Nested Sampling.
To circumvent the computational bottleneck of numerical gradients which require many waveform generations and prevented an earlier use of the HMC, we train a DNN to predict gradients at new points in parameter space.
Tested on the BNS GW170817, we compare DeepHMC's results with those produced by LALInferenceMCMC and show that DeepHMC is ~80 times faster.

Primary authors: ARÈNE, Marc (APC); Dr PORTER, Ed (APC)

Presenter: ARÈNE, Marc (APC)

Session Classification: Contributed talks: Data analysis methods

Contribution ID: **53** Type: **poster**

Eccentric binary black hole surrogate models for the gravitational waveform andremnant properties: comparable mass, nonspinning case

We develop new strategies to build numerical relativity surrogate models for eccentric binary black hole systems, which are expected to play an increasingly important role in current and future gravitational-wave detectors. We introduce a new surrogate waveform model, **NRSur2dq1Ecc**, using 47 nonspinning, equal-mass waveforms with eccentricities up to 0.2 when measured at a reference time of 5500M before merger. This is the first waveform model that is directly trained on eccentric numerical relativity simulations and does not require that the binary circularizes before merger. The model includes the (2,2), (3,2), and (4,4) spin-weighted spherical harmonic modes. We also build a final black hole model, **NRSur2dq1EccRemnant**, which models the mass, and spin of the remnant black hole. We show that our waveform model can accurately predict numerical relativity waveforms with mismatches ~0.001, while the remnant model can recover the final mass and dimensionless spin with errors smaller than ≈0.0005M and≈0.002 respectively. We demonstrate that the waveform model can also recover subtle effects like mode-mixing in the ringdown signal without any special ad-hoc modeling steps. Finally, we show that despite being trained only on equal-mass binaries, **NRSur2dq1Eccc** an be reasonably extended up to mass ratio q≈3 with mismatches ~0.01 for eccentricities smaller than ~0.05 as measured at a reference time of 2000M before merger. The methods developed here should prove useful in the building of future eccentric surrogate models over larger regions of the parameter space.

Primary authors: Mr ISLAM, Tousif (UMass); Dr VARMA, Vijay (Cornell); Mr LODMAN, Jackie; FIELD, Scott; KHANNA, Gaurav; SCHEEL, Mark; PFEIFFER, Harald; GEROSA, Davide; KIDDER, Lawrence

Presenter: Mr ISLAM, Tousif (UMass)

Contribution ID: **54** Type: **TESTS DE LA RELATIVITÉ GÉNÉRALE ET THÉORIES ALTERNATIVES**

How does a dark compact object ringdown?

Thursday, April 1, 2021 3:15 PM (15 minutes)

Gravitational waves from the coalescence of compact binaries provide a unique opportunity to test gravity in strong field regime. In particular, the postmerger phase of the gravitational signal is a proxy for the nature of the remnant.
This is of particular interest in view of some quantum-gravity models which predict the existence of horizonless compact objects that overcome the paradoxes associated to black holes. Such dark compact objects can emit a modified ringdown with respect to the black hole case and late-time gravitational wave echoes as characteristic fingerprints.
In this talk, I develop a generic framework to the study of the ringdown of dark compact objects and provide a gravitational-wave template for the echo signal. Finally, I assess the detectability of dark compact objects with current and future gravitational-wave detectors.

Primary author: MAGGIO, Elisa (Sapienza University of Rome)

Presenter: MAGGIO, Elisa (Sapienza University of Rome)

Session Classification: Contributed talks: Tests of GR and alternative theories

Contribution ID: **55** Type: **FORMES D'ONDE**

Gravitational Bremsstrahlung in the Post-Minkowskian Effective Field Theory

Tuesday, March 30, 2021 10:15 AM (15 minutes)

We study the gravitational radiation emitted during the scattering of two spinless bodies in the post-Minkowskian Effective Field Theory approach. We derive the conserved stress-energy tensor linearly coupled to gravity and the classical probability amplitude of graviton emission at leading and next-to-leading order in the Newton's constant G. The amplitude can be expressed in compact form as one-dimensional integrals over a Feynman parameter involving Bessel functions. We use it to recover the leading-order radiated angular momentum. Upon expanding it in the relative velocity between the two bodies v, we compute the total four-momentum radiated into gravitational waves at leading-order in G and up to order v 8, finding agreement with what recently computed using scattering amplitude methods. Our results also allow to investigate the zero frequency limit of the emitted energy spectrum.

Primary authors: MOUGIAKAKOS, Stavros (IPhT,CEA-Saclay); RIVA, Massimiliano Maria; VERNIZZI, Filippo

Presenter: RIVA, Massimiliano Maria

Session Classification: Contributed talks: Waveforms

Contribution ID: **56** Type: **COSMOLOGIE**

Kination cosmology from scalar fields and gravitational-wave signatures

Wednesday, March 31, 2021 2:15 PM (15 minutes)

A scalar field with large kinetic energy can dominate the Universe at early times and generates the so-called kination era. We present a natural and well-motivated particle physics realization, based simply on a Peccei-Quinn mechanism. The presence of kination imprints a smoking-gun spectral enhancement in the stochastic gravitational-wave (GW) background. Current and future-planned GW observatories could constrain particle theories that generate the kination phase. This work explores kination from a complex scalar field responsible for spontaneous symmetry-breaking of a U(1)-symmetry related to baryogenesis and axion physics. Surprisingly, the viable parameter space allows for a kination era at the TeV scale and generates a peaked spectrum of GW from either cosmic strings or primordial inflation, which lies inside ET and CE windows.

Primary authors: SIMAKACHORN, Peera (Universität Hamburg and DESY); Prof. SERVANT, Geraldine (Universität Hamburg and DESY); Dr GOUTTENOIRE, Yann (Tel Aviv University and DESY)

Presenter: SIMAKACHORN, Peera (Universität Hamburg and DESY)

Session Classification: Contributed talks: Cosmology

Contribution ID: **58** Type: **POPULATIONS DES SOURCES**

Searching binary black holes in Milky Way and other nearby galaxies with LISA

Thursday, April 1, 2021 9:45 AM (15 minutes)

In 2034, within the rapidly changing landscape of gravitational-wave astronomy, the Laser interferometer Space Antenna will be the first space-based detector that will observe the gravitational spectra in the millihertz frequency band. It has recently been proposed that numerous LIGO/VIRGO sources will also be detectable by LISA. LISA will be able to detect binary black holes from our Milky Way galaxy and its neighbourhood, evolving from their early inspiral stages. Interestingly, the sources that appear to be circular in the LIGO band may be eccentric in the LISA band, depending on the earlier stages of their evolution. We aim to explore the gravitational-waves emitted from black hole binaries in our Milky Way galaxy and its neighbourhood, as they are expected to be observable with LISA. The study of the properties of these gravitational-waves will enable us to predict their progenitor stars, formation channels, metallicities, astrophysical conditions of the formation of these binaries, and traceback earlier stages of their evolution. We combine the Latte simulation from the Feedback in relativistic environments (FIRE-2) project with the next-generation population synthesis code POSYDON to investigate the detectability of the binary black hole population in both the LISA and the LIGO frequency bands, as a function of eccentricity and their horizon distances, using a Monte-Carlo approach. Also, we study how one can disentangle different formation channels of these binaries using LISA, and estimate the rate at which these binaries form in the Milky Way galaxy and other nearby galaxies. These explorations will identify the primary properties of the binary systems that will be detectable within the range of LISA.

Primary author: SARWAR, Rafia (Institute of Space Technology, Islamabad, Pakistan)

Co-authors: S. BAVERA, Simone (Geneva Observatory, University of Geneva, Switzerland); Prof. FRAGOS, Tassos (Observatoire Astronomique de l'Université de Genève)

Presenter: SARWAR, Rafia (Institute of Space Technology, Islamabad, Pakistan)

Session Classification: Contributed talks: populations of sources

Contribution ID: **61** Type: **COSMOLOGIE**

Cosmology with dark gravitational wave sources

Wednesday, March 31, 2021 3:00 PM (15 minutes)

Several observations using electromagnetic signal have led to a paradigm shift in our understanding of the Universe, with the realization that two unknown quantities - namely dark matter and dark energy - constitute about 95% of the Universe, even though their existence could not be explained by the known laws of physics and fundamental particles discovered until now. Moreover, measurements of the current expansion rate of the Universe, known as the Hubble constant - using several independent methods based on observations of different cosmological probes have reached an enigmatic and startling conclusion. These Hubble constant measurements are strongly inconsistent with each other. This discrepancy has led us to question the foundations of cosmology, indicating either an entirely new physics or unknown systematics. I will discuss how the gravitational wave observations can play a pivotal role in resolving the tension in the value of the Hubble constant and provide a better understanding of the constituents of the Universe. I will explain novel techniques that will enable us to map the expansion history of the Universe up to high redshift using binary black holes and how it can peer into new territories of fundamental physics that are currently unexplored from electromagnetic observations.

Primary author: MUKHERJEE, Suvodip (University of Amsterdam)

Presenter: MUKHERJEE, Suvodip (University of Amsterdam)

Session Classification: Contributed talks: Cosmology

Contribution ID: **62** Type: **MÉTHODES D'ANALYSE DES DONNÉES**

It takes two (spins) to tango: Interpreting gravitational-wave data with a generalized effective precession parameter

Tuesday, March 30, 2021 2:30 PM (15 minutes)

Current gravitational-wave data analysis of merging binary black holes accounts for two precessing spins, allowing inference of the six spin degrees of freedom. Nonetheless, it is convenient to use effective parameters to interpret detections; the effective aligned spin $\chi_{\rm eff}$ and the effective precessing spin $\chi_{\rm p}$ measure components parallel and perpendicular to the orbital angular momentum, with measurements away from zero indicating large spins and significant precession, respectively. While the aligned spin is conserved during an inspiral, the precessing spin is not; furthermore, its definition employs a single-spin approximation that retains some, but not all, precession-timescale variations. To rectify this inconsistency, we propose two-spin definitions that either fully consider or fully average those variations. The generalized parameter presents an exclusive region, $1 \leq \chi_{\rm p} \leq 2$, accessible only to binaries with two precessing spins. For current LIGO/Virgo events, our generalized parameter indicates that, while (i) previous measurement errors on the effective precessing spin may be underestimated, (ii) the evidence for spin precession may be stronger than suggested previously.

Primary authors: GEROSA, Davide; MOULD, Matthew; GANGARDT, Daria; SCHMIDT, Patricia; PRATTEN, Geraint; THOMAS, Lucy

Presenter: MOULD, Matthew

Session Classification: Contributed talks: Data analysis methods

Contribution ID: **63** Type: **ÉTOILES A NEUTRONS, SUPERNOVÆ ET SYNTHÈSES DES ÉLÉMENTS LOURDS**

What can be learned from a proto-neutron star's mass and radius ?

Tuesday, March 30, 2021 3:45 PM (15 minutes)

We make extensive numerical studies of masses and radii of proto-neutron stars during the first second after their birth in core-collapse supernova events. We use a quasi-static approach for the computation of proto-neutron star structure, built on parameterized entropy and electron fraction profiles, that are then evolved with neutrino cooling processes. We vary the equation of state of nuclear matter, the proto-neutron star mass and the parameters of the initial profiles, to take into account our ignorance of the supernova progenitor properties. We show that if masses and radii of a proto-neutron star can be determined in the first second after the birth, e.g. from gravitational wave emission, no information could be obtained on the corresponding cold neutron star and therefore on the cold nuclear equation of state. Similarly, it seems unlikely that any property of the proto-neutron star equation of state (hot and not beta-equilibrated) could be determined either, mostly due to the lack of information on the entropy, or equivalently temperature, distribution in such objects.

Primary author: PREAU, Edwan (APC)

Presenter: PREAU, Edwan (APC)

Session Classification: Contributed talks: Neutron stars, supernovae and heavy elements

Contribution ID: **64** Type: **TESTS DE LA RELATIVITÉ GÉNÉRALE ET THÉORIES ALTERNATIVES**

The onset of spontaneous scalarization in generalised scalar-tensor theories

Thursday, April 1, 2021 3:30 PM (15 minutes)

In gravity theories that exhibit spontaneous scalarization, astrophysical objects are identical to their general relativistic counterpart until they reach a certain threshold in compactness or curvature. Beyond this threshold, they acquire a non-trivial scalar configuration, which also affects their structure. The onset of scalarization is controlled only by terms that contribute to linear perturbation around solutions of general relativity. The complete set of these terms has been identified for generalized scalar-tensor theories. Stepping on this result, we study the onset on scalarization in generalized scalar-tensor theories and determine the relevant thresholds in terms of the contributing coupling constants and the properties of the compact object.

Primary authors: VENTAGLI, Giulia (University of Nottingham); Dr LEHÉBEL, Antoine (IST Lisbon); SOTIRIOU, Thomas (University of Nottingham)

Presenter: VENTAGLI, Giulia (University of Nottingham)

Session Classification: Contributed talks: Tests of GR and alternative theories

Contribution ID: **67** Type: **ÉTOILES A NEUTRONS, SUPERNOVÆ ET SYNTHÈSES DES ÉLÉMENTS LOURDS**

Gravitational wave signature of proto-neutron star convection

Tuesday, March 30, 2021 4:30 PM (15 minutes)

Gravitational waves provide a unique opportunity to better constrain the dynamics in the interior of proto-neutron stars during core collapse supernovae. Convective motions inside the proto-neutron star play an important role in determining neutron star magnetic fields. In paticular, numerical models suggest that a convective dynamo could explain magnetar formation in presence of fast rotation. Using 3D MHD simulations of proto-neutron star convective zones, we compute the gravitational wave emission from turbulent convection and study the impacts of both rotation and dynamo action. We derive physical scalings that reproduce quantitatively several aspects of the numerical results. Given the potentially long duration of the signal, we find that the typical strain and frequency range could allow its detection by current GW detectors in a nearby supernova explosion, and may be a primary target for next generation of GW detectors. In some cases, the signal may even capture the growth of a magnetic field due to dynamo action.

Primary author: RAYNAUD, Raphaël (CEA Saclay)

Co-author: Dr GUILET, Jérôme (CEA Saclay)

Presenter: RAYNAUD, Raphaël (CEA Saclay)

Session Classification: Contributed talks: Neutron stars, supernovae and heavy elements

Contribution ID: **70** Type: **COSMOLOGIE**

Probing the inflationary particle content with gravitational waves

Wednesday, March 31, 2021 2:00 PM (15 minutes)

I will highlight the immense discovery potential on early universe physics stemming from gravitational wave probes. To this aim, I will survey two approaches to inflation, from the particular (axion inflation models) to the general (an EFT approach).
I will show how a characterisation of the GW signal that includes (i) frequency profile, (ii) chirality, (iii) higher-point functions, (iv) anisotropies, will deliver invaluable information on the inflationary particle content.
Upcoming gravitational wave probes hold the key to turn inflationary observables into a direct portal to high energy physics.

Primary author: FASIELLO, Matteo (IFT UAM-CSIC, Madrid)

Co-authors: Prof. WANDS, David (ICG Portsmouth); Prof. DIMASTROGIOVANNI, Ema (Groningen and UNSW)

Presenter: FASIELLO, Matteo (IFT UAM-CSIC, Madrid)

Session Classification: Contributed talks: Cosmology

Contribution ID: **71** Type: **COSMOLOGIE**

Mapping the inhomogeneous Universe with Standard Sirens: Degeneracy between inhomogeneity and modified gravity theories

Wednesday, March 31, 2021 3:30 PM (15 minutes)

The detection of gravitational waves (GWs) and an accompanying electromagnetic (E/M) counterpart have been suggested as a future probe for cosmology and theories of gravity. In this work, we present calculations of the luminosity distance of sources taking into account inhomogeneities in the matter distribution that are predicted in numerical simulations of structure formation. In addition, we show that inhomogeneities resulting from clustering of matter can mimic certain classes of modified gravity theories, or other effects that dampen GW amplitudes, and deviations larger than $\delta\nu \sim \mathcal{O}(0.1)$ $(99\%$ C.L.$)$ to the extra friction term ν, from zero, would be necessary to distinguish them. For these, we assume mock GWs sources, with known redshift, based on binary population synthesis models, between redshifts $z = 0$ and $z = 5$. We show that future GW detectors, like Einstein Telescope or Cosmic Explorer, will be needed for strong constraints on the inhomogeneity parameters and breaking the degeneracy between modified gravity effects and matter anisotropies by measuring ν at 5% and 1% level with 100 and 350 events respectively.

Primary authors: KALOMENOPOULOS, Marios (University of Edinburgh); KHOCHFAR , Sadegh (Royal Observatory Edinburgh); GAIR, Jonathan (Max Planck, Institute of Gravitational Physics, Potsdam); ARAI, Shun (Kyoto University)

Presenter: KALOMENOPOULOS, Marios (University of Edinburgh)

Session Classification: Contributed talks: Cosmology

Contribution ID: **72** Type: **MÉTHODES D'ANALYSE DES DONNÉES**

Sparse Data Inpainting for LISA gapped data

Tuesday, March 30, 2021 2:45 PM (15 minutes)

With LISA mission, the detection of galactic binaries as sources of gravitational waves promises an unprecedented wealth of information about these systems, but also raises several challenges in signal processing. In particular, the variety of sources and the presence of both planned and unplanned gaps call for the development of robust methods. We describe here an original non-parametric joint reconstruction (data inpainting) of both the imprint of galactic binaries and adequate instrumental noise in the data gaps. We carefully show that a sparse data representation gives a reliable access to the physical content of the interferometric measurement, even when the data is gapped, and that the recovered noise distribution matches with the expected noise distribution for LISA.
We demonstrate the successful data recovery on a simple yet realistic example involving verification galactic binaries recently proposed in LISA data challenges. We also propose a first assessment of the impact of gaps on LISA data.

Primary authors: BLELLY, Aurore (CEA/IRFU); BOBIN, Jerome (CEA); MOUTARDE, Hervé (IRFU, CEA)

Presenter: BLELLY, Aurore (CEA/IRFU)

Session Classification: Contributed talks: Data analysis methods

Contribution ID: **73** Type: **POPULATIONS DES SOURCES**

Dynamical process impact on CBC GW background

Thursday, April 1, 2021 10:15 AM (15 minutes)

Nowdays we are able to resolve more and more compact binary merger events as our detector sensitivities improve. However the detected sources are loud and close events, suggesting a large number of non-resolved binary mergers participating to a CBC background. I will present this background computed from a population I/II stars ehanced with a young cluster population simulated from dynamical processes in the 2G detectors (LIGO, Virgo, KAGRA) frequency range. I will focus in particular on the contribution of BBHs that is expected to dominate. Finally I will discuss the detectability of the background with 2G detectors.

Primary authors: PERIGOIS, Carole (LAPP, Annecy); Dr BOUFFANAIS, Yann (INAF, INFN); GIACCOBO, Nicola (INAF, INFN); RASTELLO, Sara (INAF, INFN); SANTOLIQUIDO, Filippo (University of Padova); MAPELLI, Michela (INAF,INFN); REGIMBAU, Tania (LAPP)

Presenter: PERIGOIS, Carole (LAPP, Annecy)

Session Classification: Contributed talks: populations of sources

Contribution ID: **74** Type: **ÉTOILES A NEUTRONS, SUPERNOVÆ ET SYNTHÈSES DES ÉLÉMENTS LOURDS**

Influence of the crust on neutron star macrophysical quantities and universal relations

Tuesday, March 30, 2021 4:45 PM (15 minutes)

Measurements of neutron star macrophysical properties thanks to multi-messenger observations offer the possibility to constrain the properties of nuclear matter. Indeed cold and dense matter as found inside neutron stars, in particular in their core, is not accessible to terrestrial laboratories.

We investigate the consequences of using equations of state that employ models for the core and the crust that are not calculated consistently on the neutron star macrophysical properties, on some of the so-called universal relations and on the constraints obtained from gravitational wave observations. Various treatments found in the literature are used to connect together non-consistent core and crust equations of state. We assess the discrepancies in the neutron star macrophysical properties obtained when consistent models for the whole star and non-consistent ones are employed.

The use of crust models non consistent with the core introduces an error on the macrophysical parameters which can be as large as the estimated accuracy of current and next generation telescopes. The precision of some of the universal relations reported in the literature is found to be overestimated. We confirm that the equation of the crust has limited influence on the macrophysical properties.

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Presenter: SULEIMAN, Lami (Laboratoire Univers et Théories et Centre d'Astronomie Nicolas Copernic (Pologne))

Session Classification: Contributed talks: Neutron stars, supernovae and heavy elements

Contribution ID: **75** Type: **POPULATIONS DES SOURCES**

The massive binary black hole population across cosmic time seen under a semi-analytical perspective

Thursday, April 1, 2021 10:00 AM (15 minutes)

Current and future surveys are going to shed light on the formation and evolution of massive black hole binaries. While current pulsar-timing experiments will detect a gravitational wave (GW) background signal generated by the incoherent superposition of GWs from the whole population of massive binary black holes, the forthcoming LISA experiment will likely detect singular coalescences events. In this scenario, theoretical studies are vital to provide forecasts for these experiments and to help to interpret their results within a consistent cosmological picture. In this work, we contribute to these theoretical works by presenting preliminary results about binary black hole evolution by using the state-of-the-art semianalytical model L-Galaxies. The main advantage of this model is its flexibility to be run on the dark matter merger trees of the Millennium suite of simulations whose different box sizes and dark matter mass resolution offer the capability to explore different physical processes undergone by galaxies over a wide range of scales and environments. In particular, L-Galaxies includes a proper treatment for the spin and growth evolution presented in Izquierdo-Villalba et al. 2020, generating a reliable population of massive black holes at z<4. By linking this model with some physically-motivated assumptions about the pairing and hardening phase evolution of the binary systems, we can obtain predictions about how the massive binary population evolves with time, their expected merger rates and what are the exact properties of their hosting galaxies.

Primary author: IZQUIERDO-VILLALBA, David (Università degli studi di Milano-Bicocca)

Presenter: IZQUIERDO-VILLALBA, David (Università degli studi di Milano-Bicocca)

Session Classification: Contributed talks: populations of sources

Contribution ID: **76** Type: **MÉTHODES D'ANALYSE DES DONNÉES**

Localizing massive binary black holes with LISA

Tuesday, March 30, 2021 3:00 PM (15 minutes)

LISA is a future space-based gravitational wave detector that will a new window into the gravitational universe in the mHz range. Among LISA targets, coalescences of massive black hole binaries (MBHB) will be detected with unprecedented signal-to-noise ratios, and might enable multimessenger observations with instruments such as Athena, LSST and SKA. Modelling LISA's ability to locate these MBHB signals, both during their inspiral and after coalescence, is crucial to understand this synergy. We investigate this question using tools for Bayesian inference that allow to go beyond Fisher-matrix based estimates. We highlight the role of higher harmonics in the signal as well as the role of the time- and frquency-dependency in the instrumental response in breaking degeneracies in parameter space, and discuss the occurence of multimodalities in the recovered sky position.

Primary author: MARSAT, Sylvain (APC)

Presenter: MARSAT, Sylvain (APC)

Session Classification: Contributed talks: Data analysis methods

Contribution ID: **77** Type: **PRÉDICTION ET SUIVI DES SIGNAUX MULTI-MESSAGER**

Multi-messenger studies with GRANDMA

Thursday, April 1, 2021 12:15 PM (15 minutes)

Multi-messenger studies have been vitalized by GW170817 in which diverse messengers - photons and gravitational waves - provide a new picture of the collision of two neutron stars. In this talk, I will first review briefly how coherent analysis of the messengers can not only better constrain the astrophysical scenarios at play, but also further knowledge on the cosmology and nuclear physics side. In a second half, I will present the Global Rapid Advanced Network Devoted to the Multi-messenger Addicts (GRANDMA, PI Sarah Antier), which aims to identify and characterize the electromagnetic counterparts of gravitational-wave sources. I will detail the consortium, its characteristics and public tools provided for time-domain astronomy. I will finish with a summary of our scientific achievements and future prospects for GRANDMA.

Primary author: Dr ANTIER, Sarah (APC)

Presenter: Dr ANTIER, Sarah (APC)

Session Classification: Contributed talks: Multi-messenger signals

Contribution ID: **78** Type: **TESTS DE LA RELATIVITÉ GÉNÉRALE ET THÉORIES ALTERNATIVES**

Perturbing binary black holes with effective field theory

Thursday, April 1, 2021 3:45 PM (15 minutes)

Effective field theories (EFTs) facilitate what might otherwise be completely untenable calculations by helping us focus on only the most relevant physics at hand. Applied to general relativity, these techniques have famously improved our handle on post-Newtonian theory over the last decade, and extensions of these ideas are now also being developed to study how binary systems evolve when they are not isolated in empty space but subjected to external perturbations. One scenario of particular interest is the "gravitational molecule,"wherein a light bosonic field (like a string-theory axion) forms a cloud that is gravitationally bound to a binary black hole. In this talk, I will sketch how an EFT allows us to solve for the evolution of this system analytically (under certain approximations), and will discuss a number of its key predictions: beating patterns, a partial upscattering of the cloud into radiation, and a novel guise of superradiance.

Primary author: WONG, Leong Khim

Presenter: WONG, Leong Khim

Session Classification: Contributed talks: Tests of GR and alternative theories

Contribution ID: **79** Type: **COSMOLOGIE**

Theoretical uncertainties for cosmological phase transitions

Wednesday, March 31, 2021 2:45 PM (15 minutes)

A first-order phase transition in the early universe would have given rise to a stochastic gravitational wave background which may be observable today. Starting from a particle physics Lagrangian, the first step in making predictions of the gravitational wave signal is to understand the thermodynamics of the phase transition. In this talk, I will discuss the current situation regarding the theory of the thermodynamics of cosmological phase transitions. In particular, I will focus on the crucial problem of making reliable predictions in the face of infrared Bose enhancements at high temperature. Such enhancements lead to stronger effective couplings, and consequently to large theoretical uncertainties in perturbative calculations. I will outline recent developments in overcoming these problems, and will comment on open questions and future directions.

Primary author: GOULD, Oliver (University of Nottingham)

Presenter: GOULD, Oliver (University of Nottingham)

Session Classification: Contributed talks: Cosmology

Contribution ID: **80** Type: **PRÉDICTION ET SUIVI DES SIGNAUX MULTI-MESSAGER**

Parameter estimation for inspiralling MBH binaries in LISA

Thursday, April 1, 2021 2:15 PM (15 minutes)

Massive black hole binaries (MBHBs) of $10^5\,\mathrm{M}_\odot - 3\times10^7\,\mathrm{M}_\odot$ merging in low redshift galaxies ($z \leq 4$) are sufficiently loud to be detected weeks before coalescence with LISA. This allows us to perform the parameter estimation *on the fly*, i.e. as a function of the time to coalescence during the inspiral phase, relevant for early warning of the planned LISA protected periods and for searches of electromagnetic counterparts.
I will present the results for the estimates of the sky position, luminosity distance, chirp mass and mass ratio uncertainties as function of time left before merger for a wide range of sources. While we find generally good constrains for the latter three, the sky position appears to be determined with sufficient accuracy only for relatively light and nearby systems and only close to merger. I will also discuss the multi-messenger potentials and possible synergies with electromagnetic facilities.

Primary author: Dr MANGIAGLI, Alberto (APC)

Co-authors: Dr KLEIN, Antoine; Dr BONETTI, Matteo; Mr KATZ, Michael; SESANA, Alberto; VOLONTERI, Marta; COLPI, Monica (Department of Physics-University of Milano Bicocca); MARSAT, Sylvain (APC); Dr BABAK, Stas

Presenter: Dr MANGIAGLI, Alberto (APC)

Session Classification: Contributed talks: Multi-messenger signals

Contribution ID: **81** Type: **COSMOLOGIE**

Constraining the Hubble constant and modified GW propagation with LIGO/Virgo dark sirens and galaxy catalogs

Wednesday, March 31, 2021 3:15 PM (15 minutes)

I will present the methodology for constraining the Hubble parameter and modified GW propagation with "dark sirens"(namely, compact binary coalescences without an electromagnetic counterpart) and galaxy catalogs.
I will introduce in particular some relevant improvements to the treatment of the latter, such as their completeness, and discuss the correct treatment of selection bias. I will then show results that make use of the recent GWTC-2 catalogue, presenting the most accurate measurement of H0 from dark sirens alone, new bounds on modified GW propagation, commenting on the role of EM counterparts and discussing relevant systematics and the interplay with astrophysical parameters.

Primary author: MICHELE, Mancarella (Université de Genève)

Presenter: MICHELE, Mancarella (Université de Genève)

Session Classification: Contributed talks: Cosmology

Contribution ID: **83** Type: **MÉTHODES D'ANALYSE DES DONNÉES**

Rapid Identification of continuous gravitational-wave signals

Tuesday, March 30, 2021 3:15 PM (15 minutes)

Continuous gravitational waves (CWs) from asymmetric spinning neutron stars are among the most interesting, although still undetected, targets of the Advanced LIGO-Virgo detectors. The search for this class of signals is difficult due to their expected weakness, and can be very computationally expensive when the source parameters are not known.
The stochastic group uses fast and consolidated cross-correlation techniques to search for either a stochastic background of gravitational waves (SGWB) or persistent gravitational waves in specific directions. Recent investigations have shown that stochastic directional searches have the ability to detect CWs as well, with less sensitivity than CWs searches, but with low computing requirements.
We present a joint SGWB-CW pipeline chain that uses the robustness of SGWB cross-correlation algorithms to quickly identify CW signals, and the accuracy of CW matched-filtering-based codes to properly follow up interesting CW candidates.

Primary author: LA ROSA, Iuri (LAPP, CNRS, La Sapienza)

Presenter: LA ROSA, Iuri (LAPP, CNRS, La Sapienza)

Session Classification: Contributed talks: Data analysis methods

Contribution ID: **85** Type: **not specified**

Einstein Telescope

Thursday, April 1, 2021 12:00 PM (15 minutes)

Presenter: PORTER, Edward