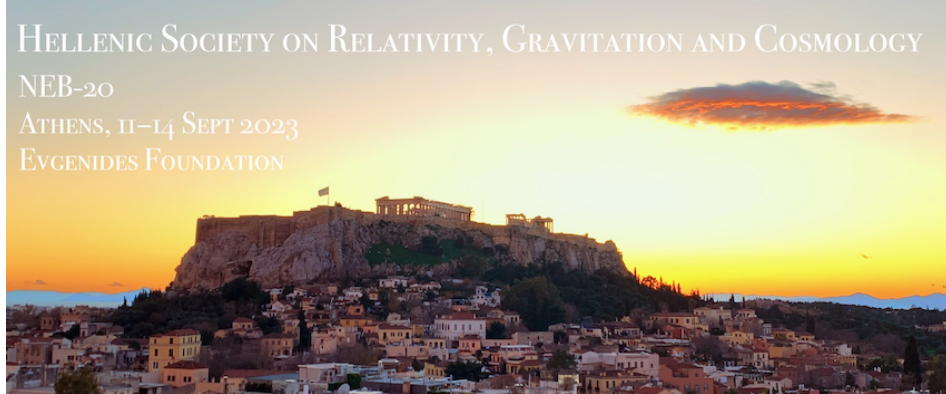# NEB-20

Report of Contributions

Contribution ID: **15**   Type: **not specified**

Rotational motion of three gravitating neutrinos: Newtonian Gravity, Relativity and the Strong Force

We examine the rotational motion of three gravitating neutrinos which are rotating on a circular path. We use Newton's gravitational Law with gravitational masses and Special Relativity to compute relativistic masses (γm_o) and inertial or gravitational mass ($\gamma^3 m_o$). By utilizing, as in the Bohr model of the H atom, the de Broglie equation $\gamma m_o \mathrm{v} r = \hbar$, we obtain the formula

$$m = 3\gamma m_o = 3^{13/12}(m_{Pl}m_o^2)^{1/3} \; ; r = 3\hbar/m_n c$$

which for $m = 939.565$ MeV/c^2 (the neutron mass) gives $m_o = 0.0437$ eV/c^2 (the heaviest neutrino mass) and $r = 0.63$ fm.
Results will be presented from this Rotating Lepton Model (RLM) for computing the masses of several other hadrons, as well as of the W, Z and Higgs bosons. It is found that relativistic neutrino-neutrino bonds give the Strong Force value, $\hbar c/r^2$, and relativistic neutrino-electron bonds give the same Weak force value, but at higher particle energies.
The same force value is obtained via the Schwarzschild geodesics of General Relativity albeit at much shorter distances, i.e. $r = r_S/2 = Gm_{Pl}/c^2 \approx 10^{-35}$ m

[1] C.G. Vayenas, S. N.-A. Souentie, Gravity, special relativity and the strong force: A Bohr-Einstein-de Broglie model for the formation of hadrons. (Springer, NY, 2012).

[2] C.G. Vayenas, S. Souentie, A. Fokas, "A Bohr-type model of a composite particle using gravity as the attractive force", Physica A, 405, 360-379 (2014).

[3] C.G. Vayenas, D. Tsousis and D. Grigoriou, "Computation of the masses, energies and internal pressures of hadrons, mesons and bosons via the Rotating Lepton Model", Physica A, 545 (2020) 123679.

Primary author: Prof. VAYENAS, Constantinos (University of Patras, Academy of Athens)

Co-authors: Mr TSOUSIS, Dionysios (Stanford University); Mr GALLIOS, Aristotle (University of Patras)

Contribution ID: **33**   Type: **not specified**

High precision waveforms: the frontier in gravitational-wave source modeling

Monday 11 September 2023 09:30 (1 hour)

Since 2015's celebrated first detection of gravitational waves from merging black holes, detectors have measured waves from nearly a hundred different events. Many current detectors are being upgraded, improving their sensitivity and broadening their sensitive wave bands; future detectors are planned which will likewise have wider bands and deeper sensitivity. These future instruments will be able to measure more cycles of detector waves, and to measure each cycle more precisely than those we measure today. Measurements with these future detectors will be able to teach us even more about their sources than current measurements —but only if theoretical modeling is able to match the advances in measurement science that make possible these improved detectors. As we measure more of the waveform with better precision, the likelihood increases that systematic modeling errors will affect our inferences about what we measure. In this talk, I will discuss the challenge of making gravitational waveforms for the future detector era, and discuss the different methods being brought to bear to solve this challenging problem. I will conclude with cautious optimism that theorists will be able to keep up with the instrument builders, and provide precise waveforms for next generation gravitational-wave astronomy.

Presenter: HUGHES, Scott (Massachusetts Institute of Technology)

Session Classification: Plenary

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

Progress in gravitational self-force theory: recent advances in modelling asymmetric binaries

Monday 11 September 2023 10:30 (1 hour)

As gravitational-wave detectors become more sensitive to lower frequencies, they will increasingly detect binaries with smaller mass ratios, larger spins, and higher eccentricities. In this talk I describe how gravitational self-force theory, when combined with a method of multiscale expansions, provides an ideal framework for modelling these systems. The framework proceeds from first principles while simultaneously enabling rapid generation of waveforms on a timescale of milliseconds. I discuss the state of the art in this method: nonspinning, quasicircular waveforms at second perturbative order in the mass ratio. I present progress toward extending this second-order model to include spins and to include the final merger and ringdown. I also discuss the domain of validity of these models, focusing on their accuracy for mass ratios in the intermediate regime ~1:10 to 1:100.

Presenter: POUND, Adam

Session Classification: Plenary

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

A survey of compact objects in scalar tensor theories

Wednesday 13 September 2023 10:30 (1 hour)

I will discuss some explicit solutions of higher order scalar tensor theories. We will start by reviewing classical GR solutions and some of their key properties such as integrability of geodesics in Kerr spacetime. We will then construct stealth solutions, i.e. solutions that are still Einstein metrics but with a non trivial scalar field. We will construct solutions which are distinct from GR, static and stationary by employing transformations and using the key works of Carter on Kerr geodesics. We will briefly discuss vacuum regular wormhole solutions as well as examples of static neutron star metrics that allow significantly higher compactness than GR.

Primary author: CHARMOUSIS, Christos (LPT)

Presenter: CHARMOUSIS, Christos (LPT)

Session Classification: Plenary

Contribution ID: **37**   Type: **not specified**

Cosmological perturbations in Bianchi-V spacetimes with evolving gravitational and cosmological parameters

Monday 11 September 2023 15:30 (20 minutes)

TBA

Presenter: ABEBE, Amare

Session Classification: Parallel Session A

Contribution ID: **38** Type: **not specified**

Critical phenomena of a complex scalar field using pseudospectral methods

Monday 11 September 2023 15:50 (20 minutes)

It has been thirty years since the breakthrough paper of M. Choptuik on critical phenomena in the gravitational collapse of a real massless scalar field in spherical symmetry. This celebrated paper led to a rich exploration of different extreme spacetimes in numerical relativity in the years following its publication. Those numerical studies persist in questioning the weak cosmic censorship conjecture, contributing to our understanding of spacetime singularities, as well as constructing new avenues for the mathematical relativity community. One would naively expect that the phenomena witnessed by Choptuik would generalize to full 3+1 dimensions. However, recent research has indicated that the universality of the critical solution breaks down already in axisymmetry, for instance, in the case of vacuum collapse of gravitational waves. In our work, we examine the gravitational collapse of a massless complex scalar field minimally coupled to GR, for the first time using a pseudospectral code (bamps), in spherical symmetry and beyond. We focus on that particular region in the phase space of initial data that captures deviations from spherical symmetry, following closely the relevant recent study of the real scalar field case for comparison. In this talk, I will show some results in spherical symmetry and departures from it, in an attempt to merge the gap in the literature regarding the genericity of the critical solution.

Primary author: MAROUDA, Krinio (CENTRA, Instituto Superior Técnico)

Presenter: MAROUDA, Krinio (CENTRA, Instituto Superior Técnico)

Session Classification: Parallel Session A

Contribution ID: **39**   Type: **not specified**

Neutron star scalarization with Gauss-Bonnet and Ricci scalar couplings

Monday 11 September 2023 16:10 (20 minutes)

Spontaneous scalarization of neutron stars has been extensively studied in the Damour and Esposito-Farèse model, in which a scalar field couples to the Ricci scalar or, equivalently, to the trace of the energy-momentum tensor. However, scalarization of both black holes and neutron stars may also be triggered by a coupling of the scalar field to the Gauss-Bonnet invariant. The case of the Gauss-Bonnet coupling has also received a lot of attention lately, but the synergy of the Ricci and Gauss-Bonnet couplings has been overlooked for neutron stars. In this talk, I will show that combining both couplings has interesting effects on the properties of scalarized neutron stars, such as affecting their domain of existence or the amount of scalar charge they carry.

Presenter: VENTAGLI, Giulia (CEICO, Institute of Physics of the Czech Academy of Sciences)

Session Classification: Parallel Session A

Contribution ID: **41** Type: **not specified**

Cosmological solutions in Einstein-Gauss-Bonnet gravity with static curved extra dimensions

Monday 11 September 2023 17:00 (20 minutes)

In this talk we perform a systematic investigation of all possible solutions with static compact extra dimensions and expanding three-dimensional subspace. We will consider extra-dimensional subspace to be constant-curvature manifold with both signs of spatial curvature. We provide a scheme how to build solutions in all possible number of extra dimensions and perform stability analysis for the solutions found. Our study suggests that the solutions with negative spatial curvature of extra dimensions are always stable while those with positive curvature are stable for a narrow range of the parameters and the width of this range shrinks with growth of the number of extra dimensions. Another interesting feature which distinguish cases with positive and negative curvatures is that the latter do not coexist with maximally-symmetric solutions leading to "geometric frustration" while the former could.

Presenter: GIACOMINI, Alex

Session Classification: Parallel Session A

Contribution ID: 43 Type: **not specified**

Resonant orbits and chaos of rotating black holes beyond circularity

Monday 11 September 2023 15:30 (20 minutes)

According to General Relativity, an isolated black hole in vacuum shall be described by the Kerr metric, whose geodesic equations are integrable. The violation of integrability leads to chaos for particles moving around the black hole. This chaotic dynamics could leave imprints on the associated gravitational waveform and could be tested with upcoming observations. In this talk, we discuss the chaotic orbital dynamics induced by the violation of a certain spacetime symmetry, the circularity. Specifically, we focus on the resonant orbits of a particular noncircular spacetime as an example and find that they form chains of Birkhoff islands on Poincaré surfaces of section. We compare the island structures with those generated in typical nonintegrable but circular spacetimes. The islands of stability induced by noncircularity appear asymmetric on the most common Poincaré surface of section at the equatorial plane. The asymmetric patterns of islands vary discontinuously when the spacetime parameters transit through integrable regions. Possible observational implications about testing circularity through gravitational wave detection are discussed.

Presenter: CHEN, Che-Yu (iTHEMS, RIKEN)

Session Classification: Parallel Session B

Contribution ID: 44 Type: **not specified**

Parameter estimation of binary black holes in the endpoint of the up–down instability

Monday 11 September 2023 17:00 (20 minutes)

Black-hole binary spin precession admits equilibrium solutions corresponding to systems with (anti-) aligned spins. Among these, binaries in the up–down configuration, where the spin of the heavier (lighter) black hole is co- (counter-) aligned with the orbital angular momentum, might be unstable to small perturbations of the spin directions. The occurrence of the up–down instability leads to gravitational-wave sources that formed with aligned spins but are detected with precessing spins. We present a Bayesian procedure based on the Savage-Dickey density ratio to test the up–down origin of gravitational-wave events. This is applied to both simulated signals, which indicate that achieving strong evidence is within the reach of current experiments, and the LIGO/Virgo events released to date, which indicate that current data are not informative enough.

Primary author: DE RENZIS, Viola (University of Milano-Bicocca)

Presenter: DE RENZIS, Viola (University of Milano-Bicocca)

Session Classification: Parallel Session B

Contribution ID: **45** Type: **not specified**

Second-order gravitational self-force in a highly regular gauge: Covariant and coordinate punctures

Monday 11 September 2023 17:20 (20 minutes)

Gravitational self-force theory is the primary way of modelling extreme-mass-ratio inspirals (EM-RIs). One difficulty that appears in second-order self-force calculations is the strong divergence at the worldline of the small object, which causes both numerical and analytical issues. Previous work [Phys. Rev. D 95, 104056 (2017); ibid. 103, 124016 (2021)] demonstrated that this could be alleviated within a class of highly regular gauges and presented the metric perturbations in these gauges in a local coordinate form. We build on this previous work by deriving expressions for the highly regular gauge metric perturbations in both fully covariant form and as a generic coordinate expansion. With the metric perturbations in covariant or generic coordinate form, they can easily be expressed in any convenient coordinate system. These results can then be used as input into a puncture scheme in order to solve the field equations describing an EMRI.

Primary author: Dr UPTON, Samuel (Astronomical Institute of the Czech Academy of Sciences)

Presenter: Dr UPTON, Samuel (Astronomical Institute of the Czech Academy of Sciences)

Session Classification: Parallel Session B

Contribution ID: **46** Type: **not specified**

Supermassive boson stars in extreme-mass-ratio inspirals: resonances and gravitational waves

Monday 11 September 2023 15:50 (20 minutes)

The historic detection of gravitational waves paved the way for precision gravitational-wave astrophysics to blossom at unprecedented proportions. In this talk, I will focus on extreme-mass-ratio inspirals (EMRIs) that consist of a primary supermassive compact object, and a stellar-mass secondary companion. Even though we are currently performing pertinent tests on order to characterize the Kerrness of astrophysical compact objects that reside in galactic cores, environmental effects, quantum corrections and generic multipolar deformations can significantly affect the gravitational-wave emission from these EMRIs. I will discuss the rich orbital and waveform phenomenology of non-Kerr inspirals as well as potential observables of orbital resonances in EMRIs with a supermassive rotating boson star primary. Finally, I will briefly discuss the impact of exotic horizonless objects on the gravitational radiation emitted from such binaries, in order to shed more light into the electromagnetic degeneracies that currently exist between black holes and exotic compact objects.

Primary author: Dr DESTOUNIS, Kyriakos (Sapienza University of Rome)

Presenter: Dr DESTOUNIS, Kyriakos (Sapienza University of Rome)

Session Classification: Parallel Session B

Contribution ID: **47** Type: **not specified**

Asymptotic gravitational-wave fluxes from a spinning test body on generic orbits around a Kerr black hole

Monday 11 September 2023 17:40 (20 minutes)

This work provides gravitational wave energy and angular momentum asymptotic fluxes from a spinning body moving on generic orbits in a Kerr spacetime up to linear in spin approximation. To achieve this, we have developed a new frequency domain Teukolsky equation solver that calculates asymptotic amplitudes from generic orbits of spinning bodies with their spin aligned with the total orbital angular momentum. However, the energy and angular momentum fluxes from these orbits in the linear in spin approximation are appropriate for adiabatic models of extreme mass ratio inspirals even for spins non-aligned to the orbital angular momentum. To check the newly obtained fluxes, they were compared with already known frequency domain results for equatorial orbits and with results from a time domain Teukolsky equation solver called Teukode for off-equatorial orbits. The spinning body framework of our work is based on the Mathisson-Papapetrou-Dixon equations under the Tulczyjew-Dixon spin supplementary condition.

Primary author: SKOUPÝ, Viktor

Presenter: SKOUPÝ, Viktor

Session Classification: Parallel Session B

Contribution ID: **48** Type: **not specified**

An effective-one-body waveform model for extreme-mass-ratio inspirals

Monday 11 September 2023 18:00 (20 minutes)

I will present a waveform model for the inspiral of extreme-mass-ratio black hole binaries based on the effective-one-body approach to the two-body problem in general relativity. By means of a gauge-invariant analysis, I will show the agreement of the model with second-order gravitational self-force results for quasi-circular nonspinning binaries. I will then briefly discuss the work in progress to improve the model for spinning binaries.

Primary author: ALBERTINI, Angelica

Presenter: ALBERTINI, Angelica

Session Classification: Parallel Session B

Contribution ID: **49**   Type: **not specified**

Extreme mass ratio inspirals and action-angle coordinates

Monday 11 September 2023 18:20 (20 minutes)

Action-angle (AA) coordinates are commonly used in theoretical description of extreme mass ratio inspirals (EMRI), as they are naturally associated with the two dynamical timescales present in EMRI. However the AA coordinates are rarely used in practical calculations. In our work we implemented analytic methods of canonical perturbation theory to transform geodesic Hamiltonian into AA coordinates and then proceeded by calculating gravitational-wave fluxes which were then used to adiabatically evolve the EMRIs. The methods are demonstrated on two axially symmetric spacetimes, Schwarzschild black hole perturbed by an external quadrupole and secondly the Kerr spacetime.

Primary author: POLCAR, Lukáš (Charles University)

Presenter: POLCAR, Lukáš (Charles University)

Session Classification: Parallel Session B

Contribution ID: **50** Type: **not specified**

TBA

Monday 11 September 2023 16:10 (20 minutes)

TBA

Presenter: ELENI, Areti

Session Classification: Parallel Session B

Contribution ID: **51** Type: **not specified**

Instability of Extremal black holes

Tuesday 12 September 2023 09:30 (1 hour)

We will present results regarding the instability of extremal black holes. We will show how these results can be used to derive observational signatures for extremal black holes.

Presenter: ARETAKIS, Stefanos

Session Classification: Plenary

Contribution ID: **52** Type: **not specified**

The threshold of gravitational collapse in vacuum

Tuesday 12 September 2023 10:30 (1 hour)

Working within the space of smooth solutions of GR and tuning to the threshold of black hole formation, we arrive at extreme spacetimes which are generally expected to contain naked singularities. In the spherical setting such configurations have been accurately studied by numerical work for three decades. This resulted in a beautiful understanding of the threshold of collapse through a mathematical analogy to critical phenomena in statistical physics. Relaxing these symmetry assumptions, the story becomes more challenging numerically and phenomenologically much more complicated. In my talk I will review both the development of the topic and the current state of the art in tackling the problem for gravitational waves.

Presenter: HILDITCH, David (CENTRA, Tecnico Lisbon)

Session Classification: Plenary

Contribution ID: **53**   Type: **not specified**

Exploring the Potential for Detecting Dynamical Shear Instabilities in Neutron Star Merger Remnants with Future Gravitational Wave Detectors

Tuesday 12 September 2023 12:00 (20 minutes)

We explore the potential for detecting low-$|T/W|$ rotational instabilities (known also as dynamical shear instabilities) with future gravitational wave observatories. Our study employs numerically generated post-merger waveforms, which reveal the re-excitation of the l=m=2 f-mode. We evaluate the detectability of these signals by injecting them into colored Gaussian noise. The signals are reconstructed as a sum of wavelets using Bayesian inference. Computing the overlap and the recovered frequency peak for various models and network configurations, we find that the instability part of the post-merger signal could be detectable by a network of 3G broadband detectors, if the distance is 40Mpc. For a newly suggested high-frequency detector, we find that the instability part is detectable even at 200 Mpc, significantly increasing the anticipated detection rate. For a network consisting of the existing HLV detectors, but upgraded to twice the A+ sensitivity, we confirm that the peak frequency of the whole post-merger gravitational-wave emission will be detectable with a network SNR of 8 at a distance of 40Mpc.

Primary author: SASLI, Argyro (Aristotle University of Thessaloniki)

Presenter: SASLI, Argyro (Aristotle University of Thessaloniki)

Session Classification: Parallel Session A

Contribution ID: **54** Type: **not specified**

A Multi-step Regression-based Approach to Predict Binary Neutron Star Post-merger Spectra Using a Feedforward Neural Network

Tuesday 12 September 2023 12:20 (20 minutes)

Gravitational waves in the post-merger phase of binary neutron star mergers may become detectable with planned upgrades of existing gravitational-wave detectors or with the more sensitive next-generation detectors. A template bank of predicted waveforms can facilitate detection and parameter estimation. However, todate, only a relatively small number of waveforms have been constructed through numerical simulations. Here, we investigate the performance of an artificial neural network in constructing a simulation-based template bank in the frequency domain (restricted to the magnitude of the frequency spectrum and to equal-mass models) that depends on three parameters that can be inferred through observations, neutron star mass, tidal deformability and the gradient of radius versus mass. In comparison to multiple linear regression, we find that the artificial neural network can predict waveforms with higher fidelity and with more consistent performance in a cross-validation study.

Presenter: PESIOS, Dimitrios

Session Classification: Parallel Session A

Contribution ID: **55** Type: **not specified**

Rapidly rotating neutron stars: Universal relations and EOS inference

Tuesday 12 September 2023 12:40 (20 minutes)

We provide accurate universal relations that allow to estimate the moment of inertia I and the ratio of kinetic to gravitational binding energy T/W of uniformly rotating neutron stars from the knowledge of mass, radius, and moment of inertia of some related non-rotating neutron star. Based on these, several other fluid quantities can be estimated as well. Astrophysical neutron stars rotate to varying degrees and although rotational effects may be neglected in some cases, not modeling them will inevitably introduce bias when performing parameter estimation. This is especially important for future, high-precision measurements coming from electromagnetic and gravitational wave observations. The proposed universal relations facilitate computationally cheap EOS inference codes that permit the inclusion of observations of rotating neutron stars. To demonstrate this, we deploy them into a recent Bayesian framework for equation of state parameter estimation that is now valid for arbitrary, uniform rotation. Our inference results are robust up to around percent level precision for the generated neutron star observations, consisting of the mass, equatorial radius, rotation rate, as well as co- and counter-rotating f-mode frequencies, that enter the framework as data.

Primary author: KRUEGER, Christian (University of Tuebingen)

Presenter: KRUEGER, Christian (University of Tuebingen)

Session Classification: Parallel Session A

Contribution ID: **56**   Type: **not specified**

Dynamical tides in neutron star binaries

Tuesday 12 September 2023 13:00 (20 minutes)

During the late stages of a neutron star binary inspiral finite-size effects come into play, with the tidal deformability of the supranuclear density matter leaving an imprint on the gravitational-wave signal. As demonstrated in the case of GW170817—the first direct detection of gravitational waves from a neutron star binary—this can lead to constraints on the neutron star equation of state. As detectors become more sensitive, the hydrostatic response of the neutron star to the tidal field of its companion (equilibrium tide) needs to be supplemented by dynamical effects, such as oscillation mode resonances triggered by the orbital motion (dynamical tide). We calculate the contribution of the various stellar oscillation modes to the tidal deformability and demonstrate the (anticipated) dominance of the fundamental mode. We show what the impact of the matter composition is on the tidal deformability, as well as the changes induced by more realistic additions to the problem, e.g. the presence of an elastic crust, superfluidity, and rotation. Finally, based on this formulation, we develop a simple phenomenological model describing the effective tidal deformability of neutron stars and show that it provides a surprisingly accurate representation of the dynamical tide close to merger.

Primary author: PNIGOURAS, Pantelis (University of Alicante)

Presenter: PNIGOURAS, Pantelis (University of Alicante)

Session Classification: Parallel Session A

Contribution ID: **57** Type: **not specified**

Cosmic inflation with inhomogeneous initial conditions

Tuesday 12 September 2023 12:00 (20 minutes)

We investigate the robustness of inflation models to inhomogeneous initial conditions. In the simplest case inflation is described by a single scalar field ϕ minimally coupled to gravity with homogeneous initial value $\phi_0 and canonical momentum \Pi_0 = 0. However, there is no fundamental reason to reckon that inflati 1 decomposition to study fast-roll initial conditions i.e., nontrivial \phi_0 and \Pi_0 for -attractor (small-field model) and Starobinsky (large-field). We find that for small field inflation, with initial inhomogeneous scalar inflating bubbles while for non-homogeneous 0 evolution depends on the relative phase between initial scalar field pro$ (\phi_0)$ confirming previous results that large field model is more robust than small field one.

Primary author: GIANNADAKIS, Panagiotis (King's College London)

Presenter: GIANNADAKIS, Panagiotis (King's College London)

Session Classification: Parallel Session B

Contribution ID: **58** Type: **not specified**

TBA

Tuesday 12 September 2023 12:20 (20 minutes)

TBA

Primary author: ANTON, Theodore (Queen Mary University of London)

Presenter: ANTON, Theodore (Queen Mary University of London)

Session Classification: Parallel Session B

Contribution ID: **60** Type: **not specified**

Dynamical Analysis in Varying Vacuum Cosmological models

Tuesday 12 September 2023 12:40 (20 minutes)

TBA

Presenter: PAPAGIANNOPOULOS, Giannis

Session Classification: Parallel Session B

Contribution ID: **61**   Type: **not specified**

LISA: Observing the Universe with Gravitational Waves from Space

Wednesday 13 September 2023 09:30 (1 hour)

LISA (Laser Interferometer Space Antenna) is the future large mission by the European Space Agency aimed at observing the Universe with gravitational waves. It was approved in 2017 following the success of the technological demonstrator LISAPathfinder and the detection of gravitational waves by ground-based observatories LIGO-Virgo. LISA has nearly completed its detailed definition phase (phase B1) and will be formally adopted in January 2024 to commence the full building phase. It is scheduled for launch in 2035 and will operate for a minimum of 4.5 years starting from 2037. LISA will observe a wide range of Gravitational Wave sources, including SuperMassive Black Hole Binaries up to very high redshift, Extreme and Intermediate Mass Ratio Inspirals, Stellar Mass Black Hole Binaries, Galactic Binaries, Stochastic Gravitational Wave Background from the early Universe, and various foregrounds. It is expected to have a huge scientific impact in Astrophysics, Fundamental Physics and Cosmology. In this talk, we will first present the mission, the instrument, the data analysis, the planning and the organisation of LISA. We will then review the gravitational wave sources in the milliHertz band and discuss LISA's observation capabilities for these sources. Finally, we will conclude by highlighting the scientific objectives of the mission.

Primary author: PETITEAU, Antoine (CEA/IRFU/DPhP)

Presenter: PETITEAU, Antoine (CEA/IRFU/DPhP)

Session Classification: Plenary

Contribution ID: **62**   Type: **not specified**

New asteroseismic tests of gravity and dark matter

Thursday 14 September 2023 09:30 (1 hour)

I will review recently proposed probes of gravity and dark matter based on the oscillations of stars. In this regard, I explain how current and future solar/stellar oscillations can place tight constraints on the properties of dark energy and dark matter.

Presenter: SALTAS, Ippocratis

Session Classification: Plenary

Contribution ID: **63** Type: **not specified**

Non-Noetherian conformal scalar fields

Wednesday 13 September 2023 12:00 (30 minutes)

Recently, an extension of the standard four-dimensional scalar conformal action, yielding a second-order field equation that remains conformally invariant, was proposed. In spite of this, the corresponding action is not invariant under conformal transformations and this motivates us to define the notion of non-Noetherian conformal scalar field. In this article, we go further by determining the most general action in four dimensions that gives rise to a non-Noetherian conformal scalar field satisfying a second-order equation. This task is achieved by using the solution to the inverse problem of the calculus of variations. Surprisingly enough, the standard equation is shown to be extended by a non-Noetherian conformal piece involving a nonminimal coupling with a very particular combination of squared curvature terms, which is none other than the one defining the so-called Critical Gravity. We also prove that the most general second-order Euler-Lagrange equation for a conformal scalar field involves additional Noetherian conformal nonminimal couplings defined by an arbitrary function of the Weyl tensor. The recently proposed non-Noetherian conformal extension is recovered as a particular example of this function.

Primary author: HASSAINE, Mokhtar

Presenter: HASSAINE, Mokhtar

Session Classification: Keynote

Contribution ID: 64 Type: **not specified**

Searches for low-frequency gravitational waves with pulsar timing arrays

Wednesday 13 September 2023 12:30 (30 minutes)

I will describe recent developments related to the search for low-frequency gravitational waves with pulsar timing arrays

Primary author: ANTONIADIS, John

Presenter: ANTONIADIS, John

Session Classification: Keynote

Contribution ID: **65** Type: **not specified**

Hidden symmetries from distortions of the conformal structure

Wednesday 13 September 2023 15:00 (30 minutes)

In this work we explore the motion of massive particles in curved backgrounds. We demonstrate how new symmetries emerge by distorting the conformal vectors of the spacetime metric and how they lead to additional conserved quantities. Beside (pseudo-)Riemannian geometry, we also apply this scheme to certain Finslerian extensions. Finally, we explain how the emergence of these symmetries is inherently linked to a process of an explicit symmetry breaking.

Primary author: DIMAKIS, Nikolaos (Center for Theoretical Physics, College of Physical Science and Technology, Sichuan University, China)

Presenter: DIMAKIS, Nikolaos (Center for Theoretical Physics, College of Physical Science and Technology, Sichuan University, China)

Session Classification: Keynote

Contribution ID: **66** Type: **not specified**

Ehlers Transformations as a Tool for Constructing Accelerating NUT Black Holes

Wednesday 13 September 2023 15:30 (20 minutes)

This paper investigates the integrability properties of Einstein's theory of gravity in the context of accelerating NUT spacetimes by utilizing Ernst's description of stationary and axially symmetric electro-vacuum solutions. We employ Ehlers transformations, Lie point symmetries of the Einstein field equations, to efficiently endorse accelerating metrics with a nontrivial NUT charge. Under this context, we begin by re-deriving the known C-metric NUT spacetime described by Chng, Mann, and Stelea in a straightforward manner, and in the new form of the solution introduced by Podolský and Vrátný. Next, we construct for the first time an accelerating NUT black hole dressed with a conformally coupled scalar field. These solutions belong to the general class of type I spacetimes, therefore cannot be obtained from any limit of the Plebański-Demiański family whatsoever and their integration needs to be carried out independently. Including Maxwell fields is certainly permitted, however, the use of Ehlers transformations is subtle and requires further modifications. Ehlers transformations do not only partially rotate the mass parameter such that its magnetic component appears, but also rotate the corresponding gauge fields. Notwithstanding, the alignment of the electromagnetic potentials can be successfully performed via a duality transformation, hence providing a novel Reissner-Nordström-C-metric NUT black hole that correctly reproduces the Reissner-Nordström-C-metric and Reissner-Nordström-NUT configurations in the corresponding limiting cases. We describe the main geometric features of these solutions and discuss possible embeddings of our geometries in external electromagnetic and rotating backgrounds.

Presenter: CISTERNA, Adolfo (Charles University, Institute of Theoretical Physics)

Session Classification: Parallel Session A

Contribution ID: **67** Type: **not specified**

Perturbative aspects and entropy features of GB-BTZ black holes

Wednesday 13 September 2023 15:50 (20 minutes)

We investigate some aspects of GB-BTZ black holes. Perturbations associated to scalar and massless spinorial fields are studied suggesting the dynamical stability of the geometry. Moreover, the quasinormal modes are found for different parameters, mainly exploring the influence of the coupling constant of the theory. The hydrodynamical modes are also obtained in the small coupling limit. Furthermore, the entropy bound and the dominant semiclassical correction to the black hole entropy are calculated.

Primary author: CUADROS-MELGAR, Bertha (University of Sao Paulo)

Presenter: CUADROS-MELGAR, Bertha (University of Sao Paulo)

Session Classification: Parallel Session A

Contribution ID: **68** Type: **not specified**

Stealth Ellis Wormholes In Horndeski theories

Wednesday 13 September 2023 16:10 (20 minutes)

In this work we are revisiting the well studied Ellis wormhole solution in a generalized Horndeski theory motivated from the Kaluza-Klein compactification procedure of the more fundamental higher dimensional Lovelock gravity. We show that the Ellis wormhole is analytically supported by a gravitational theory with a non-trivial coupling to the Gauss-Bonnet term and we expand upon this notion by introducing higher derivative contributions of the scalar field. The extension of the gravitational theory does not yield any back-reacting component on the spacetime metric, which establishes the Ellis wormhole as a stealth solution in the generalized framework. We propose two simple mechanisms that dress the wormhole with an effective ADM mass. The first procedure is related to a conformal transformation of the metric which maps the theory to another Horndeski subclass, while the second one is inspired by the spontaneous scalarization effect on black holes.

Primary author: BAKOPOULOS, Athanasios (University of Ioannina)

Presenter: BAKOPOULOS, Athanasios (University of Ioannina)

Session Classification: Parallel Session A

Contribution ID: **69** Type: **not specified**

Regular charged black holes, energy conditions and quasinormal modes

Wednesday 13 September 2023 17:00 (20 minutes)

We discuss energy conditions and quasinormal modes for scalar perturbations of regular charged black holes within the framework of General Relativity coupled to non-linear electrodynamics. The frequencies are computed numerically adopting the WKB method, while in the eikonal limit an analytic expression for the spectra is obtained. The impact of the electric charge, the angular degree, and the overtone number on the spectra is investigated in detail. We find that all frequencies are characterized by a negative imaginary part, and that each type of energy conditions imply a different quasinormal spectrum.

Primary author: RINCON, Angel

Presenter: RINCON, Angel

Session Classification: Parallel Session A

Contribution ID: **70** Type: **not specified**

Black holes without Cauchy horizons: the role of integrable singularities

Wednesday 13 September 2023 17:20 (20 minutes)

Although we cannot understand the true nature of singularities in the framework of GR, it is possible to evade them by following a fairly simple strategy: generate regular BHs by filling the spacetime around the central singularity with some physically reasonable source of matter (which could be consequence of some new gravitational sector). This has produced a plethora of new regular BH solutions in recent years, mainly because the matter source used to evade the central singularity can be interpreted in terms of nonlinear electrodynamics. However, all these regular BH solutions contain a Cauchy horizon, a null hyper-surface beyond which predictability breaks down, and also leads to mass inflation at the perturbative level, a pathology which occurs even in loop quantum gravity inspired models. Even though the strong cosmic censorship conjecture establish the impossibility of extending spacetime beyond this region, in this talk we show how far we can go, without invoking this conjecture, in the building of a physically reasonable black hole without a Cauchy hyper-surface. Following this reasoning, we find a black hole lacking of Cauchy horizon, asymptotically flat and satisfying either the strong or dominant energy condition. The above is possible by demanding integrable singularity for the Ricci scalar, whose direct consequence is the appearance of finite tidal forces.

Presenter: OVALLE, Jorge

Session Classification: Parallel Session A

Contribution ID: **72** Type: **not specified**

Bridging Dimensions: General Embedding Algorithm and Field-Theory Reconstruction in 5D Braneworld Models

Wednesday 13 September 2023 17:40 (20 minutes)

We develop a general algorithm that enables the consistent embedding of any four-dimensional static and spherically symmetric geometry into any five-dimensional single-brane braneworld model, characterized by an injective and nonsingular warp factor. Furthermore, we supplement the algorithm by introducing a method that allows one to, in principle, reconstruct 5D field theories that support the aforementioned geometries.

Primary author: NAKAS, Theodoros (National Technical University of Athens)

Presenter: NAKAS, Theodoros (National Technical University of Athens)

Session Classification: Parallel Session A

Contribution ID: **73** Type: **not specified**

The Study of the Canonical Forms of the Killing Tensor in the frame of General Theory of Relativity

Wednesday 13 September 2023 18:00 (20 minutes)

There are various ways to deploy symmetries in order to extract exact solutions of Einstein's Field Equations. The Study of the Canonical forms of Killing Tensor in the frame of General Theory of Relativity proved fruitful in the past providing new solutions or general families of already known spacetimes. Regarding the latter the most general versions of Killing Tensor, its four Canonical Forms are employed for this purpose.

This work concerns the simultaneous resolving of the Integrability Conditions of the 2nd and 3rd Killing Tensor along with the Einstein's Field Equations using the framework of Newman-Penrose Formalism. We present all the Petrov Types that admit these Canonical Forms in Vaccuum. Our interesting focuses on type D solutions bringing to surface the Carter's Case [D].

Presenter: KOKKINOS, Dionysios (University of the Aegean)

Session Classification: Parallel Session A

Contribution ID: **74** Type: **not specified**

Testing the speed of gravity with black hole ringdown

Wednesday 13 September 2023 15:30 (20 minutes)

A nonluminal speed of gravitational waves is a smoking gun signal for the presence of new gravitational physics and hence measurements of this speed can place strong constraints on the theoretical landscape of modified gravity. The ringdown phase of binary black hole mergers, characterised by the so-called quasinormal modes, promises a clean and analytic understanding of deviations from Einstein's gravity. In this talk, I will present new ringdown constraints on the speed of gravitational waves in light of present and upcoming detectors. I will discuss and motivate the theoretical context in which these results are obtained. This involves hairy black holes, where the hair is associated with a new scalar degree of freedom of the Horndeski type. We forecast that from a single supermassive black hole merger, LISA will be able to constrain deviations of the speed of gravity from the speed of light to the 10^{-4} level. While these are weaker than existing constraints (e.g. GW170817), they importantly probe different frequency ranges, which is particularly relevant for dark energy models.

Presenter: SIRERA LAHOZ, Sergi

Session Classification: Parallel Session B

Contribution ID: **75** Type: **not specified**

Study of magnetized disk's environmental effect on gravitational waves from supermassive binary black hole systems

Wednesday 13 September 2023 15:50 (20 minutes)

The merger of supermassive black holes (BBH) produces mHz gravitational waves (GW), which are potentially detectable by future Laser Interferometer Space Antenna (LISA). Such binary systems are usually embedded in an accretion disk environment at the center of the active galactic nuclei (AGNs). Recent studies suggest the plasma environment imposes measurable imprints on the GW signal for extreme mass ratio binaries. The effect of the gaseous environment on the GW signal is strongly dependent on the disk's parameters, therefore it is believed that future low-frequency GW detections will provide us with precious information about the physics of AGN accretion disks. We investigate this effect by measuring the disk torques on the binary system by modeling several magnetized tori. Using GRMHD HARM-COOL code, we perform 2D simulations of weakly-magnetized thin accretion disks, with a possible truncation and transition to advection dominated accretion flow (ADAF). We study the angular momentum transport and turbulence generated by the magnetorotational instability (MRI) in our numerical simulations. We quantify the disk's effective alpha viscosity and its evolution over time.

Presenter: HOSSEIN-NOURI, Fatemeh

Session Classification: Parallel Session B

Contribution ID: **76**   Type: **not specified**

Is the choice of the center of mass of a spinning extended body just a gauge?

Wednesday 13 September 2023 16:10 (20 minutes)

In this talk we discuss the issue whether the center of the mass of a spinning extended test body moving in a black hole background is just a gauge. The discussion is in the framework of the Mathisson-Papapetrou-Dixon equations, for which a spin supplementary condition is used in order to fix the center of the mass. To get the answer we employ novel and in principle analytical methods of finding circular equatorial orbits of spinning extended bodies around a black hole for different spin supplementary conditions.

Presenter: LOUKES-GERAKOPOULOS, Georgios (Astronomical Institute, Czech Academy of Sciences)

Session Classification: Parallel Session B

Contribution ID: **77** Type: **not specified**

Gravitational waves from magnetised primordial black holes

Wednesday 13 September 2023 17:00 (20 minutes)

Primordial black holes (PBH) can account for a wide variety of cosmic conundra, among which the origin of the primordial magnetic fields threading the intergalactic medium. In this talk, by considering PBHs naturally furnished with a disk due to the vortexlike motion of the primordial plasma around them, we will propose a novel natural ab initio mechanism for the generation a battery induced seed magnetic field (MF) which can be later amplified by various dynamo/instability processes and provide the seed for the present day MF on intergalactic scales. Finally, we will derive the GW signal induced by the magnetic anisotropic stress of such a population of magnetised PBHs checking at the end their detectability by GW observational probes.

Primary author: PAPANIKOLAOU, Theodoros (National Observatory of Athens)

Presenter: PAPANIKOLAOU, Theodoros (National Observatory of Athens)

Session Classification: Parallel Session B

Contribution ID: **78** Type: **not specified**

A new approach to core-collapse supernovae gravitational wave asteroseismology

Wednesday 13 September 2023 17:20 (20 minutes)

Core-collapse supernovae are among the most promising future gravitational wave (GW) sources. GW emission is mainly due to the excitation of oscillation modes of the proto-neutron star (PNS) and the stalled accretion shock. Those oscillations will allow in future GW observations to perform asteroseismology to infer properties of the PNS. These oscillations can be represented by a system of equations that can be solved as an eigenvalue problem. Using Physics Informed Neural Networks (PINNs) we introduce a machine learning technique to solve this problem. The advantage of the PINNs over standard methods is that it simplifies the implementation of differential equations and complex boundary conditions. These features of PINNs will allow us to lift some approximations made in previous studies and obtain a more realistic system.

Presenter: TSENEKLIDOU, Dimitra

Session Classification: Parallel Session B

Contribution ID: **79** Type: **not specified**

Characterizing Burst with Linear Memory Events with LIGO-Virgo-KAGRA and Pulsar Timing Array Observatories

Wednesday 13 September 2023 17:40 (20 minutes)

Close hyperbolic encounters of black holes (BHs) generate certain Burst With Memory (BWM) events in the frequency windows of the operational, planned, and proposed gravitational wave (GW) observatories. We provide details of our HyperbolicTD & GW_hyp packages that should allow both LIGO-Virgo-KAGRA (LVK) and Pulsar Timing Array (PTA) consortia to search for such BWM events in their respective datasets. Further, we present detailed explorations of the detectable parameter space of such events, relevant for these collaborations. Preliminary investigations reveal that optimally placed BWM events should be visible to megaparsec distances for the existing ground-based observatories. In contrast, maturing PTA datasets should be able to provide constraints on the occurrences of hyperbolic encounters between supermassive BHs to gigaparsec distances. Some preliminary findings from our ongoing injection studies using simulated LVK and PTA datasets will be provided.

Presenter: DANDAPAT, Subhajit

Session Classification: Parallel Session B

Contribution ID: **80** Type: **not specified**

Measuring Parity Asymmetry of Gravitational Wave Backgrounds with a Heliocentric Detector Network in the mHz Band

Wednesday 13 September 2023 18:00 (20 minutes)

We discuss exploration for isotropic gravitational wave backgrounds around 1 mHz by correlation analysis, targeting both parity odd and even polarization modes. Even though the space interferometer LISA alone cannot probe the two modes due to cancellations, the outlook is being changed drastically by the strong development of other space detectors such as Taiji. In fact, a heliocentric interferometer network holds a preferable geometrical symmetry illuminated by a virtual sphere off-center from the Sun. By utilizing an internal symmetry of data streams, we can optimally decompose the odd and even parity modes at correlation analysis. By simultaneously using LISA and Taiji for 10 years, our sensitivity to the two modes could reach ~10^{-12} in terms of the normalized energy density.

Primary author: SETO, Naoki (Kyoto University)

Presenter: SETO, Naoki (Kyoto University)

Session Classification: Parallel Session B

Contribution ID: **81**   Type: **not specified**

Testing the Cosmological Principle: a new cosmic tension?

Monday 11 September 2023 12:00 (1 hour)

Tensions in the observed values of the Hubble constant and other key parameters of the concordance model of cosmology may indicate problems in the model itself. This motivates further independent tests of the model. I will describe a test of a key foundation of the concordance model - the Cosmological Principle. According to the Cosmological Principle, the Universe should be statistically isotropic. In particular, isotropy in the CMB must be consistent with isotropy in the galaxy distribution. This means that the kinematic dipole in the CMB should agree in direction and amplitude with the dipole in the galaxies. Current results suggest that there is a significant tension between the amplitudes of these dipoles. I will discuss some theoretical issues that remain to be clarified before this can be declared as a new tension.

Presenter: MAARTENS, Roy

Session Classification: Plenary

Contribution ID: **82**   Type: **not specified**

Singularities in classical and quantum cosmology

Thursday 14 September 2023 10:30 (1 hour)

We consider some cosmological models where soft future singularities arise and discuss how the crossing of these singularities can change the properties of matter fields. We also compare different approaches to the possibility of the crossing of the singularities of the Big Bang –Big Crunch type. We discuss what happens with the singularities in quantum cosmology and study what happens with the quantum particles when a universe crosses a singularity. We briefly review recent attempts to develop a general approach studying the singularities in the functional space.

Primary author: KAMENSHCHIK, Alexander (University of Bologna)

Presenter: KAMENSHCHIK, Alexander (University of Bologna)

Session Classification: Plenary

Contribution ID: **83** Type: **not specified**

Rotating black holes embedded in a cosmological background for scalar-tensor theories

Thursday 14 September 2023 12:00 (30 minutes)

I will present solutions of DHOST theories describing a rotating black hole embedded in an expanding universe. The solution is constructed by conformal transformation of a stealth Kerr(-de Sitter) black hole. The conformal factor depends explicitly on the scalar field - but not on its derivative - and defines the new theory. The scalar field of the stealth Kerr(-de Sitter) solution depends on time, leading to the time-dependence of the obtained conformal metric, with cosmological asymptotics at large distances. I will discuss the properties of the obtained metric by considering regular null geodesic congruences, and identify trapping black hole and cosmological horizons.

Presenter: BABICHEV, Eugeny

Session Classification: Keynote

Contribution ID: **84** Type: **not specified**

Renormalized Volume/Area from Conformal Gravity

Thursday 14 September 2023 12:30 (30 minutes)

Within a holographic framework, we explore the physical consequences of embedding Einstein gravity with negative cosmological constant in Conformal Gravity in four dimensions. In the bulk, the procedure is equivalent to Holographic Renormalization, as the Einstein-AdS action appears augmented by the correct boundary counterterms. In codimension-2, 4D Conformal Gravity induces a 2D conformal invariant leads to a Renormalized Area for minimal surfaces. For arbitrary surfaces, this proposal extends the notion of renormalized area to other energy functionals as Willmore Energy and Reduced Hawking Mass. In particular, this procedure may be thought as a more geometric approach to the computation of Holographic Entanglement Entropy for CFTs dual to 4D Einstein gravity.

Presenter: OLEA, Rodrigo

Session Classification: Keynote

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

Automorphisms in Bianchi (-like) geometries

Thursday 14 September 2023 15:00 (30 minutes)

The relevant time-depended automorphisms are used to reduce the form of the line-element. There are, thus revealed, enough first integrals of motion which enable the presentation of the entire solution space for the 5-dim Kasner (4 A_1) and/or Type V (A^{1,1}_{4,5}) models.

Presenter: CHRISTODOULAKIS, Theodosios (National and Kapodistrian University of Athens)

Session Classification: Keynote

Contribution ID: **86** Type: **not specified**

Update on the use of Artificial Neural Networks in cosmology

Thursday 14 September 2023 15:30 (20 minutes)

Nonparametric reconstructions of cosmological parameters from observational data sets are usually associated with Gaussian processes (GP). It is known though, that GPs are plagued with overfitting issues and they introduce some statistical bias through the selection of the kernel. The last few years, with the advent of Machine Learning, artifical neural networks are being used in cosmology for the reconstruction of parameters in a model independent way, both from the physical and from the statistical point of view. In this talk, I will present the use of ANNs in cosmology and I will show how we expanded an existing neural network, to include non-Gaussian data points, as well as data sets with covariance matrices. I will also apply our algorithm in scalar-tensor models and I will present the stricter bounds we found on their arbitrary functions, compared to Gaussian processes.

Presenter: DIALEKTOPOULOS, Konstantinos

Session Classification: Parallel Session A

Contribution ID: **87** Type: **not specified**

Alleviating both H0 and σ8 tensions through modified entropies

Thursday 14 September 2023 15:50 (20 minutes)

We investigate the alleviation of both H0 and σ8 tensions simultaneously within the framework of Tsallis cosmology. Such a modified cosmological scenario is obtained by the application of the gravity-thermodynamics conjecture, but using the non-additive Tsallis entropy, instead of the standard Bekenstein-Hawking one. Hence, one obtains modified Friedmann equations, with extra terms that depend on the new Tsallis exponent δ. By selecting specific values for the δ parameter we can obtain a phantom effective dark energy, which implies faster expansion, which is one of the sufficient mechanisms that are capable of alleviating the H0 tension. Additionally, for the same parameter choice we obtain an increased friction term and an effective Newton's constant smaller than the usual one, and thus the σ8 tension is also solved. These features act as a significant advantage of Tsallis modified cosmology.

Presenter: PETRONIKOLOU, Maria (National Technical University of Athens)

Session Classification: Parallel Session A

Contribution ID: **88** Type: **not specified**

Signatures of no-scale supergravity in Nanograv and beyond

Thursday 14 September 2023 16:10 (20 minutes)

In this talk I am going to present our recent work where we derive for the first time a three-peaked GW signal associated to no-scale Supergravity within the frequency ranges of nHz, Hz and kHz, with the former being in excellent agreement with NANOGrav/PTA GW data. We concentrate on the primordial gravitational wave (GW) spectrum induced due to second-order gravitational interactions by inflationary curvature perturbations as well as by isocurvature energy density perturbations of primordial black holes (PBHs) which are produced naturally within the framework of no-scale Supergravity. In particular, we work within Wess-Zumino type no-scale Supergravity and its naturally realised inflection-point inflationary potentials, which can give rise to the formation of microscopic PBHs which trigger an early matter-dominated era (eMD) and evaporate before Big Bang Nucleosythesis (BBN). Remarkably, we obtain an abundant production of gravitational waves at three different frequency ranges: 1) a resonantly amplified GW signal in the nHz frequency range induced by enhanced inflationary adiabatic perturbations and in strong agreement with NANOGrav/PTA data 2) a GW spectrum peaked at the Hz frequency range induced by isocurvature PBH fluctuations 3) a GW signal induced by the enhanced primordial curvature power spectrum around the characteristic PBH scale, being within the kHz frequency range and potentially detectable by electromagnetic GW detectors. The simultaneous detection of all three nHz, Hz and kHz GW peaks can constitute a clear indication in favor of no-scale Supergravity.

Presenter: TZEREFOS, Charalampos (University of Athens)

Session Classification: Parallel Session A

Contribution ID: **89** Type: **not specified**

Fractional Cosmology with conformal and nonminimal couplings: a possible resolution to H0 tension?

Thursday 14 September 2023 17:00 (20 minutes)

Various studies, such as references 2207.00878 [gr-qc], 2304.14465 [gr-qc], and 2304.14465 [gr-qc], have explored the potential of Fractional Cosmology to address the H0 tension. They have analyzed the Equation of State's value attained from the Supernova H0 and Planck's value for z<1.5 and have reported a trend of H0 that aligns with these values. However, there is still a discrepancy between the 1.5<z<2.5 range values, indicating that the H0 tension has not been entirely resolved. To expand on this theory, we may assume the Einstein-Hilbert action and a scalar field φ to create a nonminimal coupling theory with the coupling $\xi R \varphi^2$ of gravity and the scalar field. ξ is the coupling constant, and the simplest and most natural case is minimal coupling where $\xi=0$. Another viable option is $\xi=1/6$, known as conformal coupling because the action is unchanged under conformal transformations of the metric. Any value of $\xi \neq 0$ is nonminimal coupling. A fractional version of the conformal and nonminimal coupling theory employs fractional calculus to modify the standard derivative equations and alter the Friedmann and Klein-Gordon equations. The μ fractional parameter and the age of the Universe t0 affect the evolution of cosmic species densities. This new approach to cosmology modifies the Friedmann equations and allows for late cosmic acceleration without a dark energy component. Fractional cosmology could solve cosmological problems, including the H0 tension.

Presenter: LEON, Genly (Universidad Catolica del Norte)

Session Classification: Parallel Session A

Contribution ID: **90**   Type: **not specified**

Entropy as shock indicator for conservation laws

Thursday 14 September 2023 17:20 (20 minutes)

Entropy is a physical shock detector. Entropy is only produced during irreversible processes, like shocks, therefore it can be used to flag and track highly non-smooth features present in the solution space of the problem we are investigating. In this talk, I will demonstrate how entropy can be employed in the design of a flux-limiter for a number of different problems that can be written in conservation form. I will show that this entropy based flux-limiting scheme effectively tracks the physical shocks during the evolution of a variety of different conservation laws (scalar equations, special and general relativistic hydrodynamics, binary neutron star mergers). Finally, I will present the first neutron star merger simulations with such a method and will demonstrate up to fourth-order convergence in the gravitational waveform phase.

Presenter: DOULIS, Georgios (FSU Jena)

Session Classification: Parallel Session A

Contribution ID: **92** Type: **not specified**

Binary neutron star mergers with a non-convex equation of state

Thursday 14 September 2023 17:40 (20 minutes)

Binary neutron star mergers can provide new insights about the equation of state (EoS) above supranuclear densities. Therefore many gravitational wave template banks are under construction. However, it has been suggested that a naive numerical treatment of regions where the sound speed has a non-monotonic dependence with the rest-mass density (the so-called non-convex regions), as the ones appearing during first-order hadron-quark phase transitions, may lead to wrong conclusions. We consider binary neutron star mergers undergoing merger. The stars are modeled using a phenomenological, non-convex EoS. Following merger, we identify an observable imprint of the appearance of non-convex regions on the gravitational waves. In particular, we observe that the appearance of these regions induce a significant shift in the GW fpeak with respect to that of a large set of convex, nuclear (piecewise) EoS. These changes in the GW frequency may be incorrectly interpreted as the imprint of ongoing physical processes in the binary remnant.

Presenter: RUIZ, Milton

Session Classification: Parallel Session A

Contribution ID: **93** Type: **not specified**

Tensions in Cosmology: Are we Approaching New Physics?

Thursday 14 September 2023 18:00 (20 minutes)

We summarize the famous tensions between various observational datasets and theoretical predictions of the Standard Model of Cosmology, such as the H0 and S8 tensions, that could be a sign that we are approaching New Physics. Then we provide possible solutions, arising from modifications /extensions of the standard lore.

Presenter: SARIDAKIS, Emmanuel

Session Classification: Parallel Session A

Contribution ID: **95** Type: **not specified**

Towards the phase structure and continuum limit of the Barrett-Crane model for first order Lorentzian Palatini gravity

Monday 11 September 2023 17:20 (20 minutes)

The Barrett-Crane (BC) spin foam and GFT model is a state-sum model which provides a tentative quantization of first order Lorentzian Palatini gravity written as a constrained BF-theory. It is conjectured that this model gives rise to continuum spacetime with General Relativity as an effective description for the dynamics at criticality via phase transition. In this talk, we discuss how phase transitions in this model can be studied using Landau-Ginzburg mean-field theory. In a first step, we demonstrate this by restricting the building blocks of the model such that the Feynman diagrams are dual to spacelike triangulations. This setting lays the groundwork to study the critical behavior when arbitrary Lorentzian building blocks are incorporated and also paves the way for the analysis of the phase structure of the complete model via functional renormalization group techniques in future research. This work is based on arXiv:2112.00091, arXiv:2206.15442, arXiv:2209.04297 and arXiv:2211.12768.

Presenter: PITHIS, Andreas

Session Classification: Parallel Session A

Contribution ID: 96 Type: **not specified**

New avenues and observational constraints on functors of actions theories

Wednesday 13 September 2023 18:20 (20 minutes)

In this talk, I will introduce a novel formalism for any field theory and apply it to the effective field theories of large-scale structure. The new formalism is based on functors of actions composing those theories. This new formalism predicts the actionic fields. Furthermore, I will discuss a generalised manifold with N-correlators of Nt- objects with or without contaminants. I will discuss our findings in a cosmological gravitology framework. We present these results with a cosmological inference approach and give guidelines on how we can choose the best candidate between those models with some latest understanding of model selection using Bayesian inference. references: https://arxiv.org/abs/2209.07472 A generalised manifold with N-correlators of Nt- objects, under review https://arxiv.org/abs/2010.06707 Functors of actions, published in Foundations of Physics journal

Presenter: NTELIS, Pierros (Aix-Marseille University)

Session Classification: Parallel Session A

Contribution ID: 97 Type: **not specified**

Spin and integrability in the relativistic two-body problem

Monday 11 September 2023 15:00 (30 minutes)

As the reach and sensitivity of gravitational-wave detectors continues to grow, so do the requirements on our understanding of the evolution of compact binaries. When the components of the binary spin at general inclinations, there is, in principle, a sufficient number of degrees of freedom to break integrability of the evolution. However, layer after layer various integrable structures appear in the equations of motion and it is unclear in which regime exactly non-integrability might emerge in binary inspirals. In this talk, I will discuss the exploration of the frontiers of integrability in the two-body problem both in the post-Newtonian as well as the large-mass-ratio regimes.

Presenter: WITZANY, Vojtěch

Session Classification: Keynote

Contribution ID: **98** Type: **not specified**

Rapid calculation of the signal-to-noise ratio of gravitational-wave sources using artificial neural networks

In parameter estimation calculations of gravitational wave sources, it is useful to know the optimal signal-to-noise ratio of an individual model waveform. We train an artificial neural network on a random sample of one million theoretical waveforms of binary black hole systems with random spins and achieve an accuracy of 97\% in predicting the signal-to-noise ratio. The neural network evaluates the results orders of magnitude faster than the original calculation. We show the results of the optimization of different hyperparameters with a grid search and with selective searches. Finally, we show that the logarithm of the accuracy is linearly related to the logarithm of the number of points in the dataset. This allows us to predict that a dataset size of about 7 million data points will be required to achieve an accuracy of 99\% in predicting the SNR with the neural network that we constructed.

Presenter: TSIOULIS, IOANNIS

Session Classification: Parallel Session B

Contribution ID: **99** Type: **not specified**

An analytic frequency-domain model for the post-merger gravitational wave emission in neutron star mergers

We construct an analytic frequency-domain model for gravitational waves in the post-merger phase of binary neutron star mergers. The model is based on an analytic continuous Fourier Transform of the time-domain model presented by Soultanis, Bauswein & Stergioulas (2022). We demonstrate perfect agreement with a numerical FFT in a representative case. We are planning to implement the frequency-domain post-merger model in a complete inspiral-merger-post-merger waveform model, to be used in Bayesian parameter estimation for future detections.

Presenter: MARINITSI, Anna

Contribution ID: **100** Type: **not specified**

Interpolated spline knots for the unmodeled simultaneous characterisation of a Stochastic Gravitational Wave Background and the LISA instrumental noise

The goal of this work is to investigate whether it is possible or not to separate and identify an isotropic, Gaussian, Stochastic Gravitational Wave Background (SGWB) from the LISA instrument noise, without making any assumptions about the spectral shapes of both. And, if not, to test whether keeping one shape unknown and using prior knowledge about the shape of the other would allow for an identification.

Primary author: GALANIS, Nikiforos

Co-author: Dr KARNESIS, Nikolaos

Presenters: GALANIS, Nikiforos; Dr KARNESIS, Nikolaos

Contribution ID: **101** Type: **not specified**

Heavy-tailed likelihoods for robustness against data outliers: Applications to the analysis of gravitational wave data

In recent years, the field of Gravitational Wave Astronomy has flourished. With the advent of more sophisticated ground-based detectors and space-based observatories, it is anticipated that Gravitational Wave events will be detected at a much higher rate in the near future. One of the future data analysis challenges is performing robust statistical inference in the presence of detector noise transients or non-stationarities, as well as in the presence of stochastic Gravitational Wave signals of possible astrophysical \textbf{and/or cosmological} origin. The incomplete knowledge of the total noise of the observatory can \textbf{introduce challenges} in parameter estimation of detected sources. In this work, we propose a heavy-tailed, Hyperbolic likelihood, based on the Generalized Hyperbolic distribution. With the Hyperbolic likelihood we obtain a robust data analysis framework against data outliers, noise non-stationarities, and possible inaccurate modeling of the noise power spectral density. We apply this methodology to examples drawn from gravitational wave astronomy, and in particular to synthetic data sets from the planned LISA mission.

Primary author: SASLI, Argyro (Aristotle University of Thessaloniki)

Co-authors: Dr KARNESIS, Nikolaos; Prof. STERGIOULAS, Nikolaos (Aristotle University of Thessaloniki)

Presenter: SASLI, Argyro (Aristotle University of Thessaloniki)