Gravitational waves: a new messenger to explore the universe

Report of Contributions

Contribution ID: **1** Type: **not specified**

Lecture: (Massive) black hole binaries

Presenter: COLPI, Monica

Contribution ID: **2** Type: **not specified**

Seminar

Contribution ID: **3** Type: **not specified**

Seminar

Contribution ID: **4** Type: **not specified**

Lecture: Multi-messenger astrophysics

Presenter: GHIRLANDA, Giancarlo

Contribution ID: **5** Type: **not specified**

Seminar

Contribution ID: **6** Type: **not specified**

Interdisciplinary seminar

Contribution ID: **7** Type: **not specified**

Lecture: Gravitational waves and cosmology

Presenter: STEER, Danièle

Contribution ID: **8** Type: **not specified**

Lecture: (Massive) black hole binaries

Presenter: COLPI, Monica

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

Lecture: Multi-messenger astrophysics

Presenter: GHIRLANDA, Giancarlo

Contribution ID: **10** Type: **not specified**

Lecture: Gravitational waves and cosmology

Presenter: STEER, Danièle

Contribution ID: **11** Type: **not specified**

Seminar

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

Seminar

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

Seminar

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

Mini-conference

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

Lecture: Methods of post-Newtonian expansion

Monday, 1 March 2021 10:00 (2h 30m)

Presenter: BLANCHET, Luc

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

Lecture: Gravitational theories

Tuesday, 2 March 2021 10:00 (2h 30m)

Presenter: MUKOHYAMA, Shinji

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

Lecture: Gravitational waveforms

Tuesday, 2 March 2021 16:00 (2h 30m)

Presenter: BUONANNO, Alessandra

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

Lecture: Gravitational theories

Wednesday, 3 March 2021 10:00 (2h 30m)

Presenter: MUKOHYAMA, Shinji

Contribution ID: **21** Type: **not specified**

Lecture: Gravitational-wave detectors

Wednesday, 3 March 2021 16:00 (2h 30m)

Presenter: SHOEMAKER, David

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

Lecture: Gravitational-wave detectors

Thursday, 4 March 2021 16:00 (2h 30m)

Presenter: SHOEMAKER, David

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

Interdisciplinary seminar: Introduction to astrophysical observations

Friday, 5 March 2021 10:00 (1 hour)

Presenter: VERGANI, Susanna

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

Gather town interaction

Friday, 5 March 2021 17:00 (1h 30m)

Contribution ID: **25** Type: **not specified**

Lecture: Gravitational-wave data analysis

Primary author: Prof. CORNISH, Neil (Montana State Univ.)

Presenter: Prof. CORNISH, Neil (Montana State Univ.)

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

Lecture: Gravitational-wave detectors

Primary author: SHOEMAKER, David (MIT)

Presenter: SHOEMAKER, David (MIT)

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

Lecture: Gravitational-wave detectors

Primary author: SHOEMAKER, David (MIT)

Presenter: SHOEMAKER, David (MIT)

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

Lecture: Gravitational-wave detectors

Primary author: SHOEMAKER, David (MIT)

Presenter: SHOEMAKER, David (MIT)

Contribution ID: **29** Type: **not specified**

Lecture: Gravitational-wave data analysis

Primary author: Prof. CORNISH, Neil (Montana State Univ.)

Presenter: Prof. CORNISH, Neil (Montana State Univ.)

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

Lecture: Gravitational-wave data analysis

Presenter: Prof. CORNISH, Neil (Montana State Univ.)

Contribution ID: **31** Type: **not specified**

Interdisciplinary seminar

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

Seminar

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

Seminar

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

Seminar

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

Mini-conference

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

Lecture: (Massive) black hole binaries

Monday, 8 March 2021 10:00 (2h 30m)

Presenter: COLPI, Monica

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

Lecture: Gravitational waves and cosmology

Tuesday, 9 March 2021 10:00 (2h 30m)

Presenter: STEER, Danièle

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

Lecture: Multi-messenger astrophysics

Wednesday, 10 March 2021 10:00 (2h 30m)

Presenter: GHIRLANDA, Giancarlo

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

Lecture: Gravitational-wave data analysis

Tuesday, 9 March 2021 16:00 (2h 30m)

Presenter: CORNISH, Neil

Contribution ID: **40** Type: **not specified**

Interdisciplinary seminar: Stochastic gravitational wave background – the need of a multifaceted

Friday, 12 March 2021 10:00 (1 hour)

Presenter: NARDINI, Germano

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

Lecture: Multi-messenger astrophysics

Thursday, 11 March 2021 10:00 (2h 30m)

Presenter: GHIRLANDA, Giancarlo

Contribution ID: **42** Type: **not specified**

Lecture: Gravitational waves and cosmology

Thursday, 11 March 2021 16:00 (2h 30m)

Presenter: STEER, Danièle

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

Lecture: (Massive) black hole binaries

Monday, 8 March 2021 16:00 (2h 30m)

Presenter: COLPI, Monica

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

Lecture: Gravitational waveforms

Thursday, 4 March 2021 10:00 (2h 30m)

Presenter: BUONANNO, Alessandra

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

Lecture: Relativistic hydrodynamics

Monday, 1 March 2021 16:00 (2h 30m)

Presenter: REZZOLLA, Luciano

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

Gather town interaction

Friday, 5 March 2021 11:00 (1h 30m)

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

Interdisciplinary seminar: Machine learning for detectors and data analysis

Friday, 5 March 2021 16:00 (1 hour)

Presenter: VAJENTE, Gabriele

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

Lecture: Gravitational-wave data analysis

Wednesday, 10 March 2021 16:00 (2h 30m)

Presenter: CORNISH, Neil

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

Gather town interaction

Friday, 12 March 2021 11:00 (1h 30m)

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

Presentation of the Centre Emile Borel of IHP

Monday, 1 March 2021 09:30 (30 minutes)

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

Gravitational waves from tidal disruption events

If a star gets too close from a black hole (BH), the former can be disrupted by the tidal forces of the latter, resulting in a luminous event known as a tidal disruption event (TDE). Furthermore, the extreme nature of the system also results in the emission of gravitational waves, which carry additional informations about the properties of the BH and the star. As such, TDEs potentially allow observations of BHs and stars both in the electromagnetic and gravitational spectrum. However, not all TDEs may be detectable, and in order to better prepare future gravitational and electromagnetic missions, we need to understand what will be the properties of these observable events as well as their rates. I will first introduce the framework to address these questions and will present the results for the particular case of LISA.

Primary author: Dr PFISTER, Hugo

Co-authors: TOSCANI, martina (Università degli studi di Milano); Mr WONG, Thomas Hong Tsun; Dr DAI, Jane Lixin; Prof. LODATO, Giuseppe; ROSSI, Elena Maria (LeidenObservatory)

Contribution ID: **53** Type: **Poster**

Impact of dark matter on compact stars and their merger dynamics

We study an impact of asymmetric dark matter on properties of the neutron stars and their ability to reach the two solar masses limit, which allows us to present a new range of masses of dark matter particles and their fractions inside the star. Our analysis is based on the observational fact of the existence of two pulsars reaching this limit and on the theoretically predicted reduction of the neutron star maximal mass caused by the accumulation of dark matter in its interior. We also demonstrate that light dark matter particles with masses below 0.2 GeV can create an extended halo around the neutron star leading not to decrease, but to increase of its visible gravitational mass. By using recent results on the spatial distribution of dark matter in the Milky Way, we present an estimate of its fraction inside the neutron stars located in the Galaxy center. We show how the detection of a 2Msun neutron star in the most central region of the Galaxy will impose an upper constraint on the mass of dark matter particles of ~60 GeV. Future high precision measurements of the neutron stars maximal mass near the Galactic center, will put a more stringent constraint on the mass of the dark matter particle. This last result is particularly important to prepare ongoing, and future radio and x-ray surveys, as well as modeling binary neutron stars mergers.

Primary authors: SAGUN, Violetta (University of Coimbra); Dr OLEKSII, Ivanytskyi (University of Coimbra); LOPES, Ilidio (Instituto Superior Técnico)

Contribution ID: **54** Type: **Poster**

Metric reconstruction with gravitational waves and shadows

In this poster I present two recent works [1,2] 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 deviations from simulated quasi-normal modes, as well as the observed size of the shadow of M87*.

[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

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

Co-authors: Prof. BARAUSSE, Enrico (SISSA and IFPU, Trieste, Italy); Dr FRANCHINI, Nicola (SISSA and IFPU, Trieste, Italy); Prof. BRODERICK, Avery E. (Perimeter Institute for Theoretical Physic and Waterloo Centre for Astrophysics, University of Waterloo)

Contribution ID: **55** Type: **Poster**

Revisiting a family of wormholes: geometry, matter, scalar quasi-normal modes and echoes

In our work 'Revisiting a family of wormholes: geometry, matter, scalar quasi-normal modes and echoes (P.D.Roy, S. Aneesh, S. Kar, Eur. Phys. J. C (2020) 80: 850)' we study the behavior of a family of ultrastatic, Lorentzian wormholes having two parameters, namely 'n' that controls the geometry of each member wormhole and throat radius 'b_0', under scalar perturbations. For n=2 we get the well-known Ellis-Bronnikov wormhole. Our wormholes for n>2 are characterised by double barrier effective potential which makes them distinctly different from the special case of Ellis-Bronnikov wormhole. We observe that the associated scalar quasi-normal modes can be used as a tool for distinguishing the smaller 'n' geometry wormholes. On the other hand, large 'n' wormholes are hard to distinguish through their QNMs because of their nearly identical geometries. Hence, for such wormhole members the echo structure plays pivotal role in telling the wormhole members apart from one-another.

Primary authors: Ms DUTTA ROY, Poulami (IIT Kharagpur); Mr S., Aneesh (University of Florida); Prof. KAR, Sayan (IIT Kharagpur)

Contribution ID: **56** Type: **Poster**

Constraining the Hubble constant and modified GW propagation with LIGO-Virgo dark sirens

The recent detections and data releases from LIGO-Virgo enable the first applications of statistical methods for constraining the Hubble parameter with Gravitational Waves (GWs).
Moreover, they open up the possibility of new tests of General Relativity, since modified gravity models predict a non-standard GW luminosity distance, which is measured directly from the GW signal. By adding independent information on the redshift we can thus test this distance-redshift relation.
We present results with ''dark sirens" (namely, compact binary coalescences without an electromagnetic counterpart) from the GWTC-2 catalogue, where the redshift information comes from the GLADE galaxy catalogue.
This leads to the most accurate measurement of H_0 and the first bounds on modified GW propagation from dark sirens alone.

Primary author: Dr MANCARELLA, Michele (Université de Genève)

Co-authors: FINKE, Andreas (Université de Genève); IACOVELLI, Francesco (Université de Genève); Dr FOFFA, Stefano (Université de Genève); Prof. MAGGIORE, Michele (Université de Genève)

Contribution ID: **58** Type: **Poster**

Probing Supermassive blackholes with LISA

We study hydrodynamical simulations of galaxy formation, based on the GADGET-3 code, and investigate supermassive black hole binaries coalescence at $5.5 < z < 14$ and the expected gravitational waves emitted from the binary mergers for different AGN feedback models. A fraction of the accreted rest-mass energy is radiated away by each BH. A fraction of this radiated energy is coupled to the surrounding gas as feedback energy. We consider the cases of thermal feedback, kinetic feedback,which includes AGNcone and AGNsphere,where in the former case the kinetic BH feedback is distributed inside bi-cone (45\textdegree half opening angle) and in latter the kinetic feedback is distributed in sphere (90\textdegree half opening angle). We further consider the case in which no AGN feedback is implemented in the simulation. We find the merger rate for the kinetic feedback of the order between 100 to 1000 mergers per year for the chirpmass range less than 10^6
$msun$
and for the thermal feedback model to be between 100 to 500 in the same chirp mass range. We stress the comparisons to be made between simulations of same resolution: kinetic with R_{smooth}= 1ckpc/h and thermal with R_{smooth}=0.5 ckpc/h.
For each model, we estimate the expected characteristic strain of gravitational waves emitted by supermassive black hole binary mergers, the time to coalesce, and the expected number of resolved events and compare our predictions with the LISA sensitivity and resolution.
We further investigate the host galaxy properties for the events detectable by LISA and make predictions of the electromagnetic counter parts expected events to be detected by other electromagnetic instruments operating along the proposed operational time of LISA and present a panoramic view of merger events through different detectors.

Primary authors: CHAKRABORTY, Srija (Scuola Normale Superiore); Dr GALLERANI, Simona (Scuola Normale Superiore); Dr ZANA, Tommasso (Scuola Normale Superiore); Dr VITO, Fabio (Scuola Normale Superiore); Mr DI MASCIA, Fabio (Scuola Normale Superiore)

Contribution ID: **59** Type: **Poster**

Stacked Search for Gravitatinal Waves

In the last few years, progressively more frequent and precise direct detections of gravitational waves have facilitated sensitive tests of general relativity. Among the most intriguing possibilities is the existence of horizonless objects more compact than the photon ring. If such objects exist, it is inevitable that in addition to a standard ringdown, there will be late-time echoes of gravitational waves. Searches for echoes have so far been inconclusive, but here we propose more sensitive investigations that incorporate stacking of multiple events. We also suggest model-independent search techniques to add robustness and rigor to explorations of the presence of echoes in gravitational wave data.

Primary author: LONGO MICCHI, Luis Felipe (UFABC)

Contribution ID: **60** Type: **Poster**

The impact of common envelope development criteria on the formation of LIGO/Virgo sources

The treatment and criteria for development of unstable Roche lobe overflow (RLOF) that leads to the common envelope (CE) phase have hindered the evolutionary predictions for decades. In particular, the formation of black hole–black hole (BH-BH), black hole–neutron star (BH-NS), and neutron star–neutron star (NS-NS) merging binaries depends sensitively on the CE phase in classical isolated binary evolution model. All these mergers are now reported as LIGO/Virgo sources or source candidates. CE is even considered by some as a mandatory phase in the formation of BH-BH, BH-NS or NS-NS mergers in binary evolution models. At the moment, there is no full first-principles model for development of CE. We employ the Startrack population synthesis code to test the current advancements in studies on stability of RLOF for massive donors to assess their effect on LIGO/Virgo source population. In particular, we allow for more restrictive CE development criteria for massive donors (M>18 Msun). We also test a modified condition for switching between different types of stable mass transfer, thermal or nuclear timescale. Implemented modifications significantly influence basic properties of merging double compact objects, sometimes in non-intuitive way. For one of tested models with restricted CE development criteria, for example, local density merger rates for BH-BH systems increased by a factor of 2-3 due to the emergence of a new dominant formation scenario without any CE phase. We find that the changes in highly uncertain assumptions on RLOF physics may significantly affect (i) local merger rate density, (ii) shape of the mass and mass ratio distributions, and (iii) dominant evolutionary formation (with and without CE) scenarios of LIGO/Virgo sources. Our results demonstrate that without sufficiently strong constraints on RLOF physics, one is not able to draw fully reliable conclusions about the population of double compact object systems based on population synthesis studies.

Primary authors: OLEJAK, Aleksandra (Nicolaus Copernicus Astronomical Center Polish Academy of Sciences); BELCZYNSKI, Krzysztof (Nicolaus Copernicus Astronomical Center, Polish Academy of Sciences); IVANOVA, Natalia (Department of Physics, University of Alberta)

Contribution ID: **61** Type: **Poster**

The cosmic merger rate density of compact binaries

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 by different astrophysical models with the value inferred by the 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 stellar 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: SANTOLIQUIDO, Filippo (University of Padova)

Contribution ID: **62** Type: **Poster**

Simulation-efficient marginal posterior estimation with swyft

We present algorithms (a) for nested neural likelihood-to-evidence ratio estimation, and (b) for simulation reuse via an inhomogeneous Poisson point process cache of parameters and corresponding simulations. Together, these algorithms enable automatic and extremely simulator efficient estimation of marginal and joint posteriors. The algorithms are applicable to a wide range of physics and astronomy problems and typically offer an order of magnitude better simulator efficiency than traditional likelihood-based sampling methods. Our approach is an example of likelihood-free inference, thus it is also applicable to simulators which do not offer a tractable likelihood function. Simulator runs are never rejected and can be automatically reused in future analysis. As functional prototype implementation we provide the open-source software package *swyft.* https://github.com/undark-lab/swyft

Primary author: MILLER, Benjamin (University of Amsterdam)

Co-authors: Dr COLE, Alex (University of Amsterdam); Dr LOUPPE, Gilles (University of Liège); Dr WENIGER, Christoph (University of Amsterdam)

Contribution ID: **63** Type: **Poster**

Multi-messenger probes of extreme gravity around black holes

For nearly a century, Einstein's theory of gravity has been the standard theory for describing gravitational phenomena in our universe. Along with its successes, there are some questions for which it does not provide a satisfactory answer. This has led to proposals that modify or supersede Einstein's theory, and testing these theories against data, especially in the strong-field regime, has emerged as a new paradigm in physics in recent years. Along with the completely new avenue of gravitational waves, new and improved techniques based on electromagnetic waves are being used to test GR ever more stringently. As the realm beyond GR is unknown, a popular approach is to look for theory-agnostic deviations from GR/predictions of GR. In my poster, I describe how I have used gravitational waves, x-rays, and black hole shadows to constraints on some of these theory-agnostic deviations.

Primary author: NAMPALLIWAR, Sourabh (Eberhard Karls University of Tuebingen)

Contribution ID: **64** Type: **Poster**

Higher-curvature variations of R^2-inflation

We sketch the inflationary predictions from a class of higher-curvature corrections to Starobinsky inflation and propose constraints on these theories, inspired by holography.

Primary authors: Dr CANO, Pablo (KU Leuven); Mr FRANSEN, Kwinten (KU Leuven); Prof. HERTOG, Thomas (KU Leuven)

Contribution ID: **65** Type: **Poster**

Gravitational-wave polarimetry with quaternions and application to precessing binaries

In this poster we introduce a new model free polarimetric analysis method based on quaternion Fourier transform and we also present a method to reconstruct both gravitational-wave polarizations from the full network data. Interestingly, this formalism allows to formulate generic priors on the polarization that can guide the problem inversion. As an illustration we perform the polarimetric spectral analysis on precessing BBH signal and show that the precessional motion of the binary orbital plane can be tracked from the polarization time evolution.

Primary authors: CANO, Cyril (Gipsa-lab); CHASSANDE-MOTTIN, Eric (CNRS AstroParticule et Cosmologie); LE BIHAN, Nicolas (CNRS / Gipsa-Lab)

Contribution ID: **66** Type: **Poster**

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

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 χ_{eff} and the effective precessing spin χ_{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, $1 \leq \chi_{\mathrm{p}} \leq 2$, 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

Contribution ID: **67** Type: **Poster**

"How does antimatter fall?": focus on GBAR experiment (CERN)

One of the main questions of fundamental physics is the action of gravity on antimatter. We present here the simulation of the last part of the experiment GBAR at CERN, i.e. the measurement of the free fall acceleration ⊠ of antihydrogen atoms in the gravitational field of Earth. A precision of the measurement beyond the % level is confirmed by taking into account the experimental design.

Primary authors: ROUSSELLE, Olivier (Laboratoire Kastler Brossel (Sorbonne Université)); Dr REYNAUD, Serge (Laboratoire Kastler Brossel (Sorbonne Université))

Contribution ID: **68** 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 $\approx 10^{-3}$, while the remnant model can recover the final mass and dimensionless spin with absolute errors smaller than $\approx 5 \times 10^{-4}M$ and $\approx 2 \times 10^{-3}$ 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, **NRSur2dq1Ecc** can be reasonably extended up to mass ratio $q \approx 3$ with mismatches $\simeq 10^{-2}$ 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: TOUSIF, Islam (UMass Dartmouth); VARMA, Vijay; LODMAN, Jackie; FIELD, Scott; KHANNA, Gaurav; SCHEEL, Mark; PFEIFFER, Harald; GEROSA, Davide; KIDDER, Lawrence

Contribution ID: **69** Type: **Poster**

Workshop_MPETHA_Charlie

With planned future gravitational wave observatories such as LISA and Einstein Telescope, coupled with powerful telescopes such as Euclid, it is vital we explore how these two windows into the content and dynamics of the Universe can complement one another. The weak lensing of gravitational waves found using luminosity distances obtained from compact binary coalescences, and redshifts from galaxy surveys, is an example of such complementary information—this potential will be explored in detail.

Primary author: Mr MPETHA, Charlie (University of Edinburgh)

Co-authors: Mr CONGEDO, Giuseppe (University of Edinburgh); Mr TAYLOR, Andy (University of Edinburgh)

Contribution ID: **70** Type: **Poster**

Predictions for LISA and PTA based on SHARK galaxy simulations

Massive black holes, with masses ranging from tens of thousands to billions of solar masses are undeniably intertwined with their galactic hosts. There are a number of empirical relations linking central black holes with their galactic environment on both large and small scales, including bulge luminosities, stellar velocity dispersion or halo mass just to mention a few. Unfortunately, we are still unable to explain such relations in a detailed and consistent way and thus the origin, properties and evolution of massive black holes and galaxies themselves remain as open questions.
On my poster I will present our analysis of a set of populations of massive black hole binaries generated in the recent semi-analytic model of galaxy evolution (SHARK) in terms of their detectability in the LISA and PTA band. The key advantage of SHARK is that it provides a way to explore a number of distinct models of black hole and galaxy evolution processes within a consistent framework and it was also successfully tested against EM observational data. Together with the number and character of complementary LISA and PTA detections it might help putting more rigorous constraints on our understanding of the birth and co-evolution of galaxies and massive black holes.

Primary authors: Ms CURYŁO, Małgorzata (University of Warsaw, Astronomical Observatory); Prof. BULIK, Tomasz (University of Warsaw, Astronomical Observatory)

Contribution ID: **71** 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 (Bochum University); Prof. PERETS, Hagai (Technion - Israel Institute of Technology)

Contribution ID: **72** Type: **Poster**

Cosmology with low-redshift observations: No signal for new physics

We analyse various low-redshift cosmological data from Type-Ia Supernova, Baryon Acoustic Oscillations, Time-Delay measurements using Strong-Lensing, $H(z)$ measurements using Cosmic Chronometers and growth measurements from large scale structure observations for ΛCDM and some different dark energy models. By calculating the Bayesian Evidence for different dark energy models, we find out that the ΛCDM still gives the best fit to the data with $H_0 = 70.3^{+1.36}_{-1.35}$ Km/s/Mpc (at 1σ). This value is in 2σ or less tension with various low and high redshift measurements for H_0 including SH0ES, Planck-2018 and the recent results from H0LiCOW-XIII. The derived constraint on $S_8 = \sigma_8\sqrt{\Omega_{m0}/0.3}$ from our analysis is $S_8 = 0.76^{+0.03}_{-0.03}$, fully consistent with direct measurement of S_8 by KiDS+VIKING-450+DES1 survey. We hence conclude that the ΛCDM model with parameter constraints obtained in this work is consistent with different early and late Universe observations within 2σ. We therefore, do not find any compelling reason to go beyond concordance ΛCDM model.

Primary authors: Prof. KOUSHIK DUTTA, Koushik (Saha Institute of National Physics, Kolkata); Dr ROY, Anirban (Cornell University); Dr RUCHIKA, Ruchika (IIT Bombay); Prof. ANANDA SEN, Anjan (Jamia Millia Islamia); Prof. SHEIKH JABBARI, Shahin (ICTP)

Contribution ID: **73** Type: **Poster**

GPE: GPU-accelerated parameter estimation for gravitational waves with x360 acceleration

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 up to x360 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.

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

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 paper, 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 $\delta\nu \sim \mathcal{O}(0.1)$ $(99\%\ \mathrm{C.L.})$ 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.

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