Tales of Gravity

Report of Contributions

https://indico.global/e/talesofgravity

Contribution ID: **5** Type: **Talk**

A Bright Future? Prospects for Cosmological Tests of GR with Multimessenger Gravitational Wave Events

Tuesday 8 April 2025 10:50 (20 minutes)

Further bright sirens – gravitational wave events with electromagnetic counterparts – are keenly awaited, but proving elusive. The exceptional event GW170817 had a profound impact on the landscape of viable cosmological extensions of General Relativity (GR); can we expect this kind of shift to be repeated in the next decade? In this work we will assess the potential constraints from bright sirens in the LIGO–Virgo–KAGRA O5 era and third generation detector era. We set up the statistical formalism for our constraints, and generate and analyse simulated data in the context of general scalar-tensor theories. We highlight the important role that gamma-ray burst detection has in breaking key parameter degeneracies. We find that the next ten bright sirens alone will not competitively constrain cosmological gravity, but that one year of third generation observations could confidently detect mild departures from GR, e.g. the Horndeski parameter $\alpha_{\rm M} \neq 0$ is detected at greater than 3σ. This justifies investment in a broad range of methods for gravitational wave cosmology (dark sirens, bright sirens and cross-correlation with large-scale structure) to ensure tests of cosmological gravity advance in both the short-term and the long-term.

Author: COLANGELI, Elena (ICG - University of Portsmouth)

Co-authors: Dr LEYDE, Konstantin; Prof. BAKER, Tessa

Presenter: COLANGELI, Elena (ICG - University of Portsmouth)

Session Classification: Contributed talks

Track Classification: UK Cosmo

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

Constraining modified gravity using all astrophysical and cosmological scales: A new paradigm.

Precision tests of General Relativity (GR) are a cornerstone of modern physics, however they are typically discipline and context specific. Based on the successful Parameterised Post Newtonian (PPN) approach, I will present a holistic framework for constraining theory agnostic modifications to GR that allows astrophysical and Solar system tests to be combined with cosmological tests using a single unified set of parameters. Using this framework I will show constraints on deviations from General Relativity with a combination of Cosmological (Cosmic Microwave Background and Baryon Acoustic oscillation) and Solar System (Cassini probe and Mars Ephemeris) data. These results demonstrate the ability of this framework to combine astrophysical, Solar System and cosmological tests of gravity into a single unified approach to precision tests of gravity.

Author: THOMAS, Daniel (University of Manchester)

Presenter: THOMAS, Daniel (University of Manchester)

Session Classification: Flash talks

Track Classification: UK Cosmo

Contribution ID: **8** Type: **Talk**

Weak Gravity from Horndeski Theories

Monday 7 April 2025 14:48 (8 minutes)

Modifications of General Relativity have been widely studied to alleviate cosmological tensions. Most of these models lead to an effective strengthening of gravity and enhanced growth. However, the S8 tension —arising from weak-lensing observations that suggest less structure formation than predicted by ΛCDM —points to a different scenario. In this talk, we will investigate stable subclasses of scalar-tensor theories that effectively weaken gravity. Starting from the stable parameterisation of linear Horndeski theory we explore possibilities to suppress the linear growth of structure at late times and compare it to current observational constraints for Modified Gravity.

Author: THUMMEL, Linus (University of Edinburgh)

Presenter: THUMMEL, Linus (University of Edinburgh)

Session Classification: Flash talks

Track Classification: UK Cosmo

Contribution ID: **9** Type: **Talk**

Impact of non-Gaussian Galactic foregrounds on measurements of CMB lensing and primordial gravitational waves

Monday 7 April 2025 15:50 (20 minutes)

A major challenge in the analysis of Cosmic Microwave Background (CMB) data is posed by the presence of Galactic foregrounds, especially thermal dust emission. Both the search for primordial B-modes and measurements of structure growth rely on foreground modelling, for which most works implicitly assume that all sky components follow Gaussian statistics. However, we know that this is a poor description for Galactic dust, which, for instance, exhibits non-Gaussian filamentary structure that cannot be reproduced from random Gaussian statistics. In this talk, I will begin by briefly discussing an in-depth study of whether dust non-Gaussianity can bias searches for primordial gravitational waves using CMB B-modes [1]. I will then focus on the impact it has on CMB lensing reconstruction analyses, with a particular focus on the final Atacama Cosmology Telescope CMB lensing power spectrum measurement.

[1] I. Abril-Cabezas, C. Hervías-Caimapo, S. von Hausegger, B. D. Sherwin and D. Alonso (2024) MNRAS, 527, 5751, arXiv: 2309.09978

Author: ABRIL-CABEZAS, Irene (University of Cambridge)

Presenter: ABRIL-CABEZAS, Irene (University of Cambridge)

Session Classification: Contributed talks

Track Classification: UK Cosmo

Contribution ID: **10** Type: **Talk**

Probing Graviton Mass Through Strong Lensed Gravitational Waves with Next-Generation Detectors

Wednesday 9 April 2025 16:56 (2 minutes)

Gravitational-wave (GW) astronomy is an established field that is rapidly expanding with increasing detections from merging compact binary systems. The next generation of GW detectors promises a tenfold increase in sensitivity, leading to a thousandfold increase in the observable volume of the Universe and a corresponding rise in detection rates. This growing dataset provides a unique opportunity to investigate fundamental aspects of physics, including probing the properties of gravitons through the study of strongly lensed gravitational waves.

In this work, we explore constraints on the mass of the graviton by analyzing strongly lensed GW signals from typical binary black hole mergers, using different gravitational lens models. Specifically, we use the point mass model for black holes and the singular isothermal sphere (SIS) model for galaxies to determine limits on the graviton mass. Additionally, we simulate the detector response for both next-generation ground-based GW detectors (e.g., Einstein Telescope) and space-based detectors (e.g., LISA) to further assess the capabilities of future observations. We evaluate the potential of future GW observations to provide meaningful constraints on the graviton mass, offering new insights into the nature of gravity at cosmic scales.

Author: GENG, Shuaibo (National Center for Nuclear Research)

Presenter: GENG, Shuaibo (National Center for Nuclear Research)

Session Classification: Flash talks

Track Classification: Gravitational waves

Contribution ID: **11** Type: **Talk**

The 3+1 formalism in torsion and nonmetricity-based theories of gravity

Thursday 10 April 2025 17:30 (20 minutes)

We present recent advancements in the 3+1 formalism within two reformulations of general relativity: the teleparallel equivalent of general relativity, and the symmetric teleparallel equivalent of general relativity. Both theories are based on the torsion and nonmetricity of a flat connection, respectively, and their Lagrangians are expressed in terms of the torsion scalar T and the nonmetricity scalar Q. These differ from the Ricci scalar R of general relativity by boundary terms. The bulk equations of motion in these theories are equivalent to those of Einstein's gravity; however, the fundamental fields comprehend not only the tetrad or the metric but also gauge degrees of freedom encoded in the connection. This inclusion can alter the canonical structure and the gauge sector of the 3+1 evolution. We investigate Hamilton's equations of these reformulations of general relativity to facilitate future research on the strong hyperbolicity of the dynamical equations, and to explore novel reformulations of the numerical relativity framework.

Author: GUZMAN, Maria Jose (University of Tartu, Estonia)

Presenter: GUZMAN, Maria Jose (University of Tartu, Estonia)

Session Classification: Contributed talks

Track Classification: Mathematics

Contribution ID: **12** Type: **Talk**

Penrose and super-Penrose energy extraction from a Reissner-Nordström black hole spacetime with a cosmological constant through the Bañados-Silk-West mechanism

Wednesday 9 April 2025 16:58 (2 minutes)

The Penrose process consists of transferring energy from a black hole to infinity. This process can be studied in a combined description with the Bañados-Silk-West (BSW) mechanism, which uses collisions of ingoing particles at the event horizon of a black hole to locally produce large amounts of energy. In this talk, the blending of the Penrose process with BSW mechanism is described for a d dimensional extremal Reissner-Nordström black hole spacetime with negative, zero, or positive cosmological constant, i.e., for an asymptotically anti-de Sitter (AdS), flat, or de Sitter (dS) spacetime. In an extremal Reissner-Nordström black hole background, in the vicinity of the horizon, several types of radial collisions between electrically charged particles can be considered. The most interesting one is between a critical particle, with its electric charge adjusted in a specific way, and a usual particle. This gives a divergent center of mass frame energy locally, which is a favorable but not sufficient condition to extract energy from the black hole. To find if energy can be extracted in such a collisional Penrose process, one must consider a collision in general between ingoing particles 1 and 2, from which particles 3 and 4 emerge, with the possibility that particle 3 can carry energy far out from the black hole horizon. One finds that the mass, energy, electric charge, and initial direction of motion of particle 3 can have different values, depending on the collision internal process. However, the different possible values lie within some range. Moreover, the energy of particle 3 can, in some cases, be arbitrarily high but not infinite, which characterizes a super-Penrose process. It is also shown that particle 4 has negative energy, as required in a Penrose process. For zero cosmological constant the results do not depend on the number of dimensions, but they do for nonzero cosmological constant, which also introduces differences in the lower bound for the energy extracted.

Authors: FEITEIRA, Duarte (Department of Physics, University of Helsinki); Prof. P. S. LEMOS, José (Centro de Astrofísica e Gravitação - CENTRA, Departamento de Física, Instituto Superior Técnico - IST, Universidade de Lisboa - UL); Prof. ZASLAVSKII, Oleg B. (Department of Physics and Technology, Kharkov V. N. Karazin National University)

Presenter: FEITEIRA, Duarte (Department of Physics, University of Helsinki)

Session Classification: Flash talks

Track Classification: Fundamental physics

Contribution ID: **13** Type: **Talk**

A simple model for curved inflation

In general relativity, inflationary models with a non-zero background curvature require additional parameters or fine-tuning compared to flat inflation. For this reason, there is no consensus on the primordial power spectrum that should be considered at large scales in a curved Universe. I will present a model of curved inflation not requiring additional parameters and in which the usual canonical quantization and Bunch–Davies vacuum of the flat case can be considered. The framework is a recently proposed parameter-free modification of general relativity in which a topological term is added to the Einstein equation. This model gives a natural and simple solution to the problem of constructing curved inflation, and at the same time provides an additional argument for this topological modification of general relativity.

Author: VIGNERON, Quentin (Nicolas Copernicus University of Toruń)

Presenter: VIGNERON, Quentin (Nicolas Copernicus University of Toruń)

Session Classification: Flash talks

Track Classification: UK Cosmo

Contribution ID: **14** Type: **Talk**

Screening mechanisms in scalar-tensor theories from a particle perspective

Wednesday 9 April 2025 17:00 (2 minutes)

Scalar-tensor theories are a popular extension of gravity where an extra scalar degree of freedom non-minimally couples to the gravitational sector. Despite existing experimental tests for such modifications from general relativity, there is still no conclusive evidence for or against these theories. A possible reason for this is the presence of screening mechanisms, which can hide the scalar field's effects (such as long-range forces) in high-density environments. In this talk, I will use field theory to demonstrate that screening mechanisms can also be expressed as Beyond Standard Model physics. This perspective reveals possible phenomenological implications that don't rely on new long-range forces. In particular, I will focus on how screening mechanisms can lead to spatially dependent masses for elementary particles in the Standard Model.

Author: SEVILLANO, Sergio (Durham University)

Presenter: SEVILLANO, Sergio (Durham University)

Session Classification: Flash talks

Track Classification: Fundamental physics

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

Uplifting Massive Graphs from Minkowski to de Sitter

Identifying useful flat-space limits for cosmological correlators—where they can be expressed in terms of observables in Minkowski space—is nontrivial due to their scale-invariant nature. In this talk, I present a massive flat-space limit in which cosmological correlators, induced by the exchange of heavy fields, can be expressed in terms of massive Feynman graphs in flat space. As a phenomenological application, I use this limit to compute specific one-loop contributions from heavy fields to primordial non-Gaussianity.

Author: JAZAYERI, Sadra (Imperial College London)

Presenter: JAZAYERI, Sadra (Imperial College London)

Session Classification: Flash talks

Track Classification: UK Cosmo

Contribution ID: **16** Type: **Talk**

Gravitational Fixed Point for a Standard Model like Theory

Wednesday 9 April 2025 17:04 (2 minutes)

Quantum field theories on curved space have a diverging effective action that depends purely on the polynomials of the curvature tensor. One needs to add higher derivative terms in the bare gravitational action to renormalize these divergences. In this setting it becomes reasonable to calculate how the gravitational couplings run with the cut-off scale. It turns out that for a Standard Model like theory with 12 gauge bosons and 48 Weyl fermions all the gravitational beta functions precisely vanish! The caveat is that one also needs to include 36 Fradkin-Tseytlin like scalars that have a fourth derivative action. However, these scalars have logarithmic propagators that can be used to explain primordial perturbations in the early universe.

Author: VAIBHAV, Vatsalya (University of Edinburgh)

Co-authors: Prof. BOYLE, Latham (University of Edinburgh); Prof. TUROK, Neil (University of Edinburgh)

Presenter: VAIBHAV, Vatsalya (University of Edinburgh)

Session Classification: Flash talks

Track Classification: Fundamental physics

Contribution ID: **17** Type: **Talk**

Simulating curved spacetimes in superfluid helium

Thursday 10 April 2025 10:00 (20 minutes)

I will present a newly established, Nottingham-based experimental platform for simulating rotating curved spacetimes in superfluid helium - a quantum liquid with vanishing viscosity. The effective curved spacetime, induced by the most extensive quantum vortex flows ever created, is probed via micrometre-scale surface waves. These reveal intricate wave-vortex interactions, including the occurrence of bound states and black-hole ringdown signals. Through black-hole spectroscopy, we link these signals with the inherent presence of boundaries in our experiment, highlighting the versatility of quantum liquids for testing spectral stability and simulating both rotating curved spacetimes and their astrophysical environments.

Author: SVANCARA, Patrik (University of Nottingham)

Presenter: SVANCARA, Patrik (University of Nottingham)

Session Classification: Contributed talks

Track Classification: Experiments

Contribution ID: **18** Type: **Talk**

A new look at multi-gravity and dimensional deconstruction

Wednesday 9 April 2025 17:10 (2 minutes)

It has long been understood that certain theories of ghost free massive gravity and their multi-graviton extensions can be thought of as arising from a higher dimensional theory of gravity, upon discretising the extra dimension. However, this correspondence between standard multi-gravity and extra dimensional gravity holds only when one discretises the extra dimension *after* gauge fixing the lapse function associated to the various lower dimensional hypersurfaces. The lapse provides crucial structure to the extra dimensional theory: in pure general relativity (GR), it ensures full diffeomorphism invariance of the theory, and enforces its Hamiltonian constraint. Thus, upon deconstruction, important information related to the extra dimension is missing in the resulting multi-gravity theory; as a result, one could never hope to recover higher dimensional GR in its entirety upon taking the appropriate continuum limit. In this talk, I develop an improved deconstruction procedure that maintains the free lapse, and show that the correct deconstructed theory should actually be multi-gravity equipped with additional dynamical scalar fields, whose field equations encode the Hamiltonian constraint in the extra dimensional theory; I use the example of Randall-Sundrum brane cosmology to demonstrate this correspondence explicitly. This opens up a number of interesting avenues for studies of new and potentially viable theories of modified gravity, as well as providing a means by which one may begin to rephrase questions more typically asked in the context of extra dimensions in a purely 4-dimensional language.

Author: WOOD, Kieran (University Of Nottingham)

Presenter: WOOD, Kieran (University Of Nottingham)

Session Classification: Flash talks

Track Classification: Fundamental physics

Contribution ID: **19** Type: **Talk**

Dark energy with the help of interacting dark sectors

Monday 7 April 2025 10:50 (20 minutes)

We analyze theories that do not have a de Sitter vacuum and cannot lead to slow-roll quintessence, but which nevertheless support a transient era of accelerated cosmological expansion due to interactions between a scalar ϕ and either a hidden sector thermal bath, which evolves as dark radiation, or an extremely light component of dark matter. We show that simple models can explain the present-day dark energy of the Universe consistently with current observations. This is possible both when ϕ's potential has a hilltop form and when it has a steep exponential runaway, as might naturally arise from string theory. We also discuss a related theory of multifield quintessence, in which ϕ is coupled to a sector that sources a subdominant component of dark energy, which overcomes many of the challenges of slow-roll quintessence.

Authors: GOMES, Joaquim (University of Liverpool); HARDY, Edward; PARAMESWARAN, Susha Louise (University of Liverpool)

Presenter: GOMES, Joaquim (University of Liverpool)

Session Classification: Contributed talks

Track Classification: UK Cosmo

Contribution ID: **20** Type: **Talk**

Functors of action theories and alternative dynamics to ΛCDM cosmology

In the era of upcoming cosmic surveys, the bright sky will be more revealing than ever, allowing us to disentangle the most intriguing mysteries of the origins, content, and evolution of the universe. In this talk, I will highlight the fundamentals of extended gravity theories, and I will focus on the quintessence, probabilistic gravity, and functors of action theories (FAT). I will emphasize the uniqueness of actionions, particles emerging from FAT frameworks, and how other extended gravity theories are connected with FAT. Then I will discuss and present results on the dynamics of cosmologies in these 3 frameworks, in comparison to ΛCDM. I will discuss the uniqueness of re-modifying the quintessence, using 2 distinct dynamical system formalisms of the φΛCDM model. Finally, I will conclude and give some outlook.

Author: NTELIS, Pierros (Aix-Marseille University)

Presenter: NTELIS, Pierros (Aix-Marseille University)

Session Classification: Flash talks

Track Classification: UK Cosmo

Contribution ID: **21** Type: **Talk**

Cosmological correlators with massive spinning fields

Tuesday 8 April 2025 16:10 (20 minutes)

Primordial perturbations observed on the CMB are thought to come from cosmological correlators during inflation. While massive (spinning) fields lead to vanishing correlators, their interaction with massless ones can alter the massless field correlators. These changes can be used to infer existence of massive spinning fields during inflation. We will compare two main models of massive spinning fields during inflation, and discuss the similarities and differences of their cosmological signatures. A good part of the talk will also be dedicated to the accurate Feynman rules for computing these correlators, which have not been properly explored in the literature.

Authors: STEFANYSZYN, David (DAMTP); CHEUNG, Trevor (University of Nottingham)

Presenter: CHEUNG, Trevor (University of Nottingham)

Session Classification: Contributed talks

Track Classification: UK Cosmo

Contribution ID: **22** Type: **Talk**

Relativistic effects in galaxy clustering with DESI

Monday 7 April 2025 16:30 (20 minutes)

Understanding the accelerated expansion of the Universe remains as one of the key challenges in cosmology. The main candidates to explain this observation, which do not rely on a cosmological constant, are dark energy and modifications of General Relativity, but they require robust tests on cosmological scales. The Dark Energy Spectroscopic Instrument offers unprecedented precision in measuring galaxy clustering from spectroscopic data, allowing for the detection of relativistic features beyond the standard redshift-space distortions. In particular, relativistic effects generate a dipole in the cross-power spectrum of two galaxy populations. Using mock catalogues of synthetic galaxies which mimic the DESI Bright Galaxy Survey (BGS), we analyse ways to amplify the relativistic dipole by separating these galaxies into bright and faint populations, while conserving their redshift distribution. We also examine techniques to accurately estimate the magnification bias, a key parameter entering the amplitude of the dipole signal. Our results indicate an improved detectability of the relativistic dipole with fewer bright sources and that the measured distortions are well described by the predictions of linear theory.

Author: PIAT, Jade (University of Edinburgh)

Presenter: PIAT, Jade (University of Edinburgh)

Session Classification: Contributed talks

Track Classification: UK Cosmo

Contribution ID: **23** Type: **Talk**

Gravitational Radiation and Charges on de Sitter

Tuesday 8 April 2025 15:50 (20 minutes)

We write a closed form expression for the metric perturbation around de Sitter that describes gravitational radiation from a compact and slowly varying source, in terms of a consistent multipolar expansion at quadrupolar order. We show that the corresponding displacement memory effect with both the even and odd parities is at a higher order in the radial expansion compared to their flat counter-parts. Using the form of the metric perturbation we obtained, we write expressions for SO(1,4) charges at future infinity that reduce to the correct expressions in the flat limit, which also includes a definition of mass that strictly decreases in the presence of gravitational radiation.

Authors: Dr KUTLUK, Emine Şeyma (Scuola Normale Superiore); Prof. COMPÈRE, Geoffrey (Universite Libre de Bruxelles); HOQUE, Sk Jahanur (BITS Pilani, Hyderabad campus)

Presenter: Dr KUTLUK, Emine Şeyma (Scuola Normale Superiore)

Session Classification: Contributed talks

Track Classification: UK Cosmo

Contribution ID: **24** Type: **Talk**

Self-force-based merger-ringdown waveforms in scalar-tensor theories of gravity

Wednesday 9 April 2025 11:50 (20 minutes)

Gravitational self-force theory (GSF) has proved to be a viable method of solving the general relativistic 2-body problem for asymmetric binaries, with state-of-the-art GSF inspiral waveforms now exhibiting minimal phase error across all mass ratios smaller than ˜1/10. Recent work has extended these GSF inspiral waveforms to include beyond-GR effects in a broad class of scalar-tensor theories. At the same time, GSF inspiral models have now also been extended to include the final merger and ringdown. In this talk we tie together these two themes by calculating first-principles GSF merger-ringdown waveforms in scalar-tensor gravity.

Authors: Prof. POUND, Adam (University of Southampton); Mr ROY, Ayush (University of Southampton); Dr MAXIMILIAN KUCHLER, Lorenzo (University of Southampton); Dr PANOSSO MACEDO, Rodrigo (Niels Bohr Institute)

Presenter: Mr ROY, Ayush (University of Southampton)

Session Classification: Contributed talks

Track Classification: Gravitational waves

Contribution ID: **25** Type: **Talk**

Fix the Frame, Resolve the Memory: the Bondi–Sachs gauge in Black Hole Perturbation Theory

Wednesday 9 April 2025 17:08 (2 minutes)

Understanding gauge and frame dependence is crucial for comparing black hole perturbation theory results at future null infinity. At second order, new challenges arise: gauge-invariant quantities in linear theory lose their invariance, and the nonlinear source terms can lead to infrared divergences. We address these issues by constructing an invariant second-order field equation in the perturbative Bondi–Sachs gauge, which naturally describes gravitational waves at null infinity. Our framework provides a systematic way to transform from any gauge to Bondi–Sachs and fix the BMS frame (the symmetry group of future null infinity and the Bondi–Sachs gauge). Our formalism could resolve tensions between second-order self-force and post-Newtonian results and help align ringdown calculations with numerical relativity waveforms.

Authors: SPIERS, Andrew (University of Nottingham); Dr MOXON, Jordan (CalTech)

Presenter: SPIERS, Andrew (University of Nottingham)

Session Classification: Flash talks

Track Classification: Gravitational waves

Contribution ID: **26** Type: **Talk**

Extremal Black Branes from the Near-Horizon

Wednesday 9 April 2025 17:02 (2 minutes)

In this talk, I will present the Kaluza-Klein spectrum of background perturbations to Freund-Rubin compactifications, which are the near-horizon geometry of a class of extremal black branes. The purpose of this is twofold.

The effective masses of fields in the near-horizon geometry determine the scaling exponents of (tidal) deformations to extremal black branes, so the spectrum characterises the horizon of certain extremal black branes which are continuously connected to the undeformed geometry. A large class turns out to be non-smooth or singular, generalising a recent result for extremal black holes.

We also argue that the severity of the Aretakis instability of black branes is determined by the scaling dimensions of the perturbations on the Anti-de Sitter factor in the near-horizon geometry. Our results therefore show that extremal black branes suffer from an Aretakis instability even in the absence of additional fields — in some cases, the dominant mode itself is non-decaying.

Author: CHEN, Calvin (National Taiwan University)

Presenter: CHEN, Calvin (National Taiwan University)

Session Classification: Flash talks

Track Classification: Fundamental physics

Contribution ID: **28** Type: **Talk**

Understanding acoustic scale observations: the one-sided fight against Λ

Monday 7 April 2025 15:04 (8 minutes)

The cosmic microwave backround (CMB) and baryon acoustic oscillations (BAO) provide precise benchmarks for measuring the expansion history of the universe. In particular, the CMB angular scale measurement θ_*, which determines the ratio of the sound horizon to the angular diameter distance to the last scattering surface, offers a robust constraint on cosmological models independent of late-time physics. We show that the null energy condition of general relativity imposes strict limits on the BAO observables used by DESI. We also identify which regions of parameter space in the CPL parameterization $w(a) = w_0 + w_a(1 - a)$ remain viable while satisfying these conditions.

Author: Prof. LEWIS, Antony (University of Sussex)

Co-author: CHAMBERLAIN, Ewan (University of Sussex)

Presenter: CHAMBERLAIN, Ewan (University of Sussex)

Session Classification: Flash talks

Track Classification: UK Cosmo

Contribution ID: **29** Type: **Talk**

Gravitational Turbulence: the Small-Scale Limit of the Cold-Dark-Matter Power Spectrum

Monday 7 April 2025 11:50 (20 minutes)

The matter power spectrum, $P(k)$, is one of the fundamental quantities in the study of large-scale structure in cosmology. In this talk, I will study its small-scale asymptotic limit, and give a theoretical argument to the effect that, for cold dark matter in d spatial dimensions, $P(k)$ has a universal k^{-d} asymptotic scaling with the wave-number k, for $k \gg k_{\rm nl}$, where $k_{\rm nl}^{-1}$ denotes the length scale at which non-linearities in gravitational interactions become important. I will explain how gravitational collapse drives a turbulent phase-space flow of the quadratic Casimir invariant, where the linear and non-linear time scales are balanced, and this balance dictates the k dependence of the power spectrum. The k^{-d} scaling can also be derived by expressing $P(k)$ as a phase-space integral in the framework of kinetic field theory, analysing it by the saddle-point method; the dominant critical points of this integral are precisely those where the time scales are balanced. The coldness of the dark-matter distribution function - its non-vanishing only on a d-dimensional sub-manifold of phase-space - underpins both approaches. I will show Vlasov-Poisson simulations to support the theory.

Author: GINAT, Barry (University of Oxford)

Co-authors: NASTAC, Michael (University of Oxford); Dr EWART, Robert (Princeton University); Dr KONRAD, Sara (Heidelberg University); Prof. BARTELMANN, Matthias (Heidelberg University); Prof. SCHEKOCHIHIN, Alexander (University of Oxford)

Presenter: GINAT, Barry (University of Oxford)

Session Classification: Contributed talks

Track Classification: UK Cosmo

Contribution ID: **30** Type: **Talk**

Induced second-order gravitational waves as a probe of the early universe

Gravitational waves provide a new observational tool to study the universe. Second-order cosmological perturbation theory allows to study gravitational waves sourced by terms quadratic in first order quantities. For example, so-called scalar induced gravitational waves are sourced by first order scalar fluctuations and have been studied extensively. In this presentation I discuss the implications and possibilities of including tensor fluctuations at first order in the source term. I will show how the tensor fluctuations change the spectral energy density of the induced waves, particularly on small scales. Furthermore, I will discuss my ongoing work focused on resolving the 'divergences' that arise in the spectral density.

Author: PICARD, Raphael (Queen Mary University London)

Presenter: PICARD, Raphael (Queen Mary University London)

Session Classification: Flash talks

Track Classification: UK Cosmo

Contribution ID: **31** Type: **Talk**

Gravitational waves and galaxies cross-correlations: a forecast on GW biases for future detectors

Gravitational waves (GWs) have rapidly become important cosmological probes since their first detection in 2015. As the number of detected events continues to rise, upcoming instruments like Einstein Telescope (ET) and Cosmic Explorer (CE) will observe millions of compact binary (CB) mergers. As GWs carry information on their luminosity distance, but remain uninformative about their redshifts, I present the difference between clustering analysis in luminosity distance space as opposed to the traditional galaxy clustering in redshift space. These detections, coupled with galaxy surveys by instruments such as DESI, Euclid, and the Vera Rubin Observatory, will provide unique information on the large-scale structure of the universe by cross-correlating GWs with the distribution of galaxies hosting them. In this talk, I focus on how cross-correlations constrain the clustering bias of GWs emitted by the coalescence of binary black holes (BBH). This parameter links BBHs to the underlying dark matter distribution, hence informing us how they populate galaxies. Using a multi-tracer approach, we forecast the precision of these measurements under different survey combinations. Our results indicate that current GW detectors will have limited precision, with measurement errors as high as $\sim 50\%$. However, third-generation detectors like ET, when cross-correlated with LSST data, can improve clustering bias measurements to within 2.5%. Furthermore, we demonstrate that these cross-correlations can enable a percent-level measurement of the magnification lensing effect on GWs. Our analysis opens new avenues for studying the distribution of BBHs and testing the nature of gravity through large-scale structure.

Authors: CLARKSON, Chris (University of Cape Town); FONSECA, José (Institute of Astrophysics and Space Sciences); ZAZZERA, Stefano (Queen Mary University of London); BAKER, Tessa

Presenter: ZAZZERA, Stefano (Queen Mary University of London)

Session Classification: Flash talks

Track Classification: UK Cosmo

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

Bayesian Optimisation for Bayesian Evidence

Monday 7 April 2025 15:12 (8 minutes)

Cosmological model selection, in the framework of Bayesian inference requires the calculation of the Bayesian evidence. This can often be quite challenging, especially if the underlying likelihood function is expensive to evaluate. I will discuss how a technique called Bayesian Optimisation, based on Gaussian Process regression, can be used to calculate this evidence in far fewer likelihood evaluations, offering a much more efficient approach compared to traditional methods.

Author: MALHOTRA, Ameek

Presenter: MALHOTRA, Ameek

Session Classification: Flash talks

Track Classification: UK Cosmo

Contribution ID: **33** Type: **Talk**

Probing Gravity Through Light Bending

Wednesday 9 April 2025 17:12 (2 minutes)

The gravitational deflection of light is a key phenomenon for testing gravitational theories. Recently, a novel method was introduced to compute the angular deflection in non-asymptotically flat spacetimes, based on the construction of null geodesic polygons. Building on this approach, we apply this technique to analyze the angular difference in null geodesic triangles, providing a systematic way to extend the definition of the deflection angle.
In this talk, we explore this method in detail and demonstrate its application in different gravitational models, including Schwarzschild-de Sitter, Einsteinian Cubic Gravity and a spherically symmetric, static Horndeski spacetime. Our results highlight how this framework allows us to obtain the specific contributions of these gravity models, distinguishing them from General Relativity.

Author: Mr SANCHEZ, Flavio (Swansea University)

Co-authors: Dr ROQUE, Armando (Universidad Autónoma de Zacatecas); CHAGOYA, Javier (Universidad Autónoma de Zacatecas)

Presenter: Mr SANCHEZ, Flavio (Swansea University)

Session Classification: Flash talks

Track Classification: Fundamental physics

Contribution ID: **35** Type: **Talk**

Multi-point propagator approach to inflationary correlators

Tuesday 8 April 2025 16:30 (20 minutes)

A key step in the comparison between inflationary predictions and cosmological observations resides in the computation of primordial correlators.
Numerical methods have been developed, which allow to overcome some of the difficulties arising in analytical calculations when the models considered are complex.
The \texttt{PyTransport} package, which implements the transport formalism, allows computation of the tree-level 2- and 3-point correlation functions for multi-field models, with arbitrary potentials and curved field space.
In this work we investigate an alternative numerical implementation of the transport approach, based on the use of transfer "matrices" called \textit{multi-point propagators} (MPP).
We test the novel MPP method, and extensively compare it with the traditional implementation of the transport approach provided in \texttt{PyTransport}.
We highlight advantages of the former, discussing its performance as a function of the number of sub-horizon e-folds of evolution and tolerance settings.
For topical ultra-slow-roll models of inflation we show that MPPs (i) precisely track the decay of correlators when \texttt{PyTransport} fails, (ii) extend the computation of squeezed bispectra for squeezing values at least one decade beyond those attainable with \texttt{PyTransport}.

Author: COSTANTINI, Andrea (Queen Mary University of London)

Co-authors: Dr MULRYNE, David (Queen Mary University of London); Dr IACCONI, Laura (Queen Mary University of London)

Presenter: COSTANTINI, Andrea (Queen Mary University of London)

Session Classification: Contributed talks

Track Classification: UK Cosmo

Contribution ID: **36** Type: **Talk**

Waveform systematic bias in the ringdown analysis with LISA

Thursday 10 April 2025 11:50 (20 minutes)

The inaccurate modeling of the gravitational wave templates that are used for analysing gravitational wave signals can lead to a systematic bias in the parameter estimation. This inaccuracy can be related to the lack of terms in the waveform coming from fundamental physics or astrophysical environments or to some truncation in perturbation theory. This issue is going to be more relevant for upcoming detectors, given the large signal-to-noise ratios that they will be able to reach. In this work, we focus on LISA and compute the bias arising from an incomplete description of the ringdown waveform, due to the exclusion of some modes. We first study the hierarchy of the modes for different events and then compare a template including 12 modes to incomplete templates with N<12 modes. We define the minimum N needed for having an unbiased parameter estimation and discuss how this quantity varies across the parameter space.

Authors: Dr KUNTZ, Adrien; Dr PITTE, Chantal; Prof. BARAUSSE, Enrico; CAPUANO, Lodovico (Scuola Internazionale Superiore di Studi Avanzati); Dr VAGLIO, Massimo; Dr CHANDRAMOULI, Rohit

Presenter: CAPUANO, Lodovico (Scuola Internazionale Superiore di Studi Avanzati)

Session Classification: Contributed talks

Track Classification: Gravitational waves

Contribution ID: **38** Type: **Talk**

Singularity Resolution of Quantum Black Holes in (A)dS

Thursday 10 April 2025 17:10 (20 minutes)

Black holes serve as key testing grounds for quantum gravity due to their singular nature and have been extensively studied in various quantum gravity approaches. In this talk, I apply the Henneaux-Teitelboim formulation of unimodular gravity to the symmetry-reduced Schwarzschild-(Anti-)de Sitter model. We perform a canonical quantization, leading to a Wheeler-DeWitt equation that takes the form of a Schrödinger equation in unimodular time. By enforcing unitary evolution in this time coordinate, we naturally treat the cosmological constant as an observable. We find a family of quantum theories in each of which the classical singularity is resolved, and we derive an analytical expression for the quantum-corrected Schwarzschild-(Anti-)de Sitter metric. Furthermore, we show that each quantum theory permits only semi-classical states corresponding to either positive, negative, or zero-mass black holes. Therefor we avoid problems that would otherwise occur in singularity free theories with arbitrarily large negative energy states.

Author: RIED, Sofie (Univesity of Sheffield)

Co-author: GIELEN, Steffen (University of Sheffield)

Presenter: RIED, Sofie (Univesity of Sheffield)

Session Classification: Contributed talks

Track Classification: Fundamental physics

Contribution ID: **40** Type: **Talk**

Axion-dilaton interactions in the dark sector

Monday 7 April 2025 11:30 (20 minutes)

Axion-dilaton models provide a well-motivated, minimal class of models
for which kinetic interactions between multiple scalar fields and their
predictions can be explored, in particular in late time cosmology. I will present the cosmological implications of these interactions when prescribing an axion and a dilaton field to describe dark matter and dark energy, respectively, including the predicted effects on the CMB, late time structure growth, and particle mass evolution.

Authors: SMITH, Adam (University of Sheffield); DAVIS, Anne; VAN DE BRUCK, Carsten (University of Sheffield); BURGESS, Cliff (McMaster University (CA)); Ms MYLOVA, Maria (Ewha Womans University); BRAX, philippe (CEA)

Presenter: SMITH, Adam (University of Sheffield)

Session Classification: Contributed talks

Track Classification: UK Cosmo

Contribution ID: **43** Type: **Talk**

The impact of theoretical priors on cosmological modified gravity constraints

Monday 7 April 2025 11:10 (20 minutes)

Cosmological constraints on modified gravity typically need to assume parametrisations that heavily restrict the functional forms of the independent degrees of freedom. They are also subject to assumptions about the background expansion history, the speed of gravitational waves, and theoretical priors such as shift symmetry and stability in a gravitational wave background. I show the impact of these choices on constraints on modified gravity in both the EFT of Dark Energy and phenomenological $\mu_0 - \Sigma_0$ formalisms, using CMB anisotropies and lensing, the ISW effect, galaxy clustering, and Type IA supernovae as probes.

Author: SHAH, Neel (University of Portsmouth)

Co-authors: Dr NOLLER, Johannes (University College London); Prof. KOYAMA, Kazuya (University of Portsmouth)

Presenter: SHAH, Neel (University of Portsmouth)

Session Classification: Contributed talks

Track Classification: UK Cosmo

Contribution ID: **45** Type: **Talk**

Kinematic Anisotropies in the SGWB: detection from PTA-Astrometry synergies

Tuesday 8 April 2025 11:10 (20 minutes)

Recent Pulsar Timing Array (PTA) observations provide strong evidence for a stochastic gravitational wave background (SGWB), potentially originating from astrophysical sources or early universe phenomena. If the SGWB is cosmological, our relative motion with respect to the SGWB rest frame induces a kinematic anisotropy, which could dominate over intrinsic anisotropies, similar to the cosmic microwave background dipole. We studied PTA sensitivity to this dipole and forecasted its detectability with future experiments like SKA. Additionally, astrometry is a complementary method to PTA observations, and by cross-correlating astrometric and PTA data, constraints on SGWB properties can be improved, aiding in determining its origin.

Author: JIMENEZ CRUZ, Nayeli Marisol (Swansea University)

Presenter: JIMENEZ CRUZ, Nayeli Marisol (Swansea University)

Session Classification: Contributed talks

Track Classification: UK Cosmo

Contribution ID: **46** Type: **Talk**

Fast Generation of Weak Lensing Maps in Modified Gravity with COLA

Monday 7 April 2025 16:50 (20 minutes)

Accurate predictions of weak lensing observables are essential for understanding the large-scale structure of the Universe and probing the nature of gravity. In this talk, I will present a lightcone implementation to generate maps of the weak lensing convergence field using the COmoving Lagrangian Acceleration (COLA) method. The lightcone is constructed in spherical shells from the source to the observer following an onion representation of the Universe.

We validate the COLA-generated maps in General Relativity by comparing five statistics - the power spectrum, bispectrum, probability distribution function, peak counts, and Minkowski functionals - to the high-resolution N-body simulations presented in Takahashi $et\ al.$ (2017). These validation tests provide a baseline for the map specifications required for COLA to capture the statistical features of the N-body maps. Using these map specifications, we extend our analyses to two theories of Modified Gravity, demonstrating their imprints on the five convergence statistics considered. This work represents a step towards precise weak lensing predictions under both General Relativity and Modified Gravity with reduced computational cost, providing a robust framework to explore the nature of gravity with field-level inference.

Author: HOYLAND, Sophie (Institute of Cosmology and Gravitation, University of Portsmouth)

Co-authors: IZARD, Albert; SAADEH, Daniela (daniela.saadeh@port.ac.uk); WINTHER, Hans A. (University of Oslo); KOYAMA, Kazuya

Presenter: HOYLAND, Sophie (Institute of Cosmology and Gravitation, University of Portsmouth)

Session Classification: Contributed talks

Track Classification: UK Cosmo

Contribution ID: **47** Type: **Talk**

Inflation in non-local hybrid metric-Palatini gravity

Within the framework of hybrid metric-Palatini gravity, we incorporate non-localities introduced via the inverse of the d'Alembert operators acting on the scalar curvature. We analyse the dynamical structure of the theory and, adopting a scalar-tensor perspective, assess the stability conditions to ensure the absence of ghost instabilities. Focusing on a special class of well-defined hybrid actions – where local and non-local contributions are carried by distinct types of curvature – we investigate the feasibility of inflation within the resulting Einstein-frame multi-field scenario. We examine how the non-minimal kinetic couplings between the fields, reflecting the non-local structure of the original frame, influence the number of e-folds and the field trajectories. To clarify the physical interpretation of our results, we draw analogies with benchmark single-field inflation scenarios that include spectator fields.

Authors: Prof. VAN DE BRUCK, Carsten (University of Sheffield); Dr BOMBACIGNO, Flavio (Centro Mixto Universitat de Valencia); DE ANGELIS, Mariaveronica (University of Sheffield); Dr GIARÈ, William (University of Sheffield)

Presenter: DE ANGELIS, Mariaveronica (University of Sheffield)

Session Classification: Flash talks

Track Classification: UK Cosmo

Contribution ID: **48** Type: **Talk**

Post-Newtonian gravitational waveforms in scalar-tensor theories: elliptic and hyperbolic orbits

Wednesday 9 April 2025 16:50 (2 minutes)

In this talk, I will precent recent work on gravitational waves generated by compact binaires in a class of scalar tensor theories within the post-Newtonian (PN) approximation. I will briefly review the waveform generation formalism in these theories and waveforms for circular orbits. I will then discuss recent work on extending these waveforms to elliptic and hyperbolic orbits. I will first discuss how to construct the 2PN-accurate quasi-Keplerian parametrization, which explicitly solves the equations of motion at that order, both in the elliptic and hyperbolic case. In the case of elliptic orbits, I will detail how I obtained the amplitude at subleading post-Newtonian order and the fluxes of energy and angular momentum at 1.5PN (i.e. 2.5PN beyond the leading dipolar radiation), which finally lead to the secular evolution of the orbital elements at the corresponding order. I will in particular discuss subtleties in the treatment of hereditary terms (such as the tails, the memory and center-of-mass frame issues). Finally, I will discuss ongoing work concerning gravitational radiation for hyperbolic encounters, which leads to the completion of the dissipative contributions to the 3PN scattering angle.

Author: TRESTINI, David (University of Southampton)

Presenter: TRESTINI, David (University of Southampton)

Session Classification: Flash talks

Track Classification: Gravitational waves

Contribution ID: **49** Type: **Talk**

A flexible parameterization to test early physics solutions to the Hubble tension with future CMB data

Monday 7 April 2025 16:10 (20 minutes)

The discrepancy between local measurements of the Hubble constant and inferences from CMB and galaxy clustering data, known as the 'Hubble tension', has motivated numerous models introducing additional components active before recombination. While many such models have been proposed, none are currently strongly favoured by data. This highlights the critical role of upcoming CMB experiments, which aim to achieve higher precision in measuring small-scale acoustic peaks and polarization signals, in detecting or constraining deviations from ΛCDM.
We present a phenomenological parameterization based on the generalized dark matter framework and specifically tailored for Simons Observatory. We show that this model is able to reproduce a wide range of theoretical models and forecast how well Simons Observatory will be able to constrain it.
When applied to Planck data, we find good consistency with the
ΛCDM model, but the data also allows for a large Hubble parameter, especially if the sound speed of the additional component is not too different to that of radiation. This approach offers a flexible and general framework to interpret data from upcoming CMB experiments, providing valuable insights into potential resolutions of the Hubble tension.

Author: KOU, Raphael (University of Sussex)

Co-author: LEWIS, Antony (University of Sussex)

Presenter: KOU, Raphael (University of Sussex)

Session Classification: Contributed talks

Track Classification: UK Cosmo

Contribution ID: **50** Type: **Talk**

Primordial Black Hole Formation for Scalar Field - Perfect Fluid Dominated Systems with Full General Relativity: The Case of a Scalar Field Dominated Universe

Tuesday 8 April 2025 10:00 (20 minutes)

In this work, we introduce a numerical code that solves the Misner-Sharp formalism for a spherically symmetric cosmological model containing both a scalar field and a perfect fluid. While the code is capable of exploring general scenarios involving an uncoupled scalar field and perfect fluid, our current research focuses on the regime where the scalar field dominates the dynamics. As an initial application, we investigate a post-inflationary scalar field-dominated scenario, in which the universe is governed by a rapidly oscillating scalar field for an extended period. We analyse the threshold for PBH formation under quadratic and quartic potentials, considering perturbations that are initially on superhorizon scales. Our results confirm that a quartic potential behaves analogously to a radiation-dominated universe, resulting in a PBH formation threshold close to the well-established value in radiation backgrounds. Conversely, in the quadratic potential case, we observe a significant deviation from dust-like behaviour, where wave-like effects counteract gravitational collapse. While numerical limitations prevent us from evolving a wide range of initial conditions to determine a precise threshold for PBH formation, our findings suggest that PBH formation may be suppressed in this scenario, potentially allowing the formation of stable solitonic structures instead. This study highlights the importance of properly accounting for wave dynamics in oscillating scalar fields when determining PBH formation criteria.

Author: MILLIGAN, Ethan (QMUL)

Co-authors: MULRYNE, David (Queen Mary University of London); Dr PADILLA, Luis (QMUL)

Presenter: MILLIGAN, Ethan (QMUL)

Session Classification: Contributed talks

Track Classification: UK Cosmo

Contribution ID: **52** Type: **Talk**

Thermal nucleation in perturbation theory

Tuesday 8 April 2025 11:50 (20 minutes)

Cosmological first-order phase transitions may have generated an observable gravitational wave background, offering a unique probe of beyond-Standard-Model physics. A crucial step in predicting this background is the reliable computation of bubble nucleation rates. In this talk, I will give an overview of recent advancements in perturbative high-temperature nucleation rate calculations. These include the application of effective field theory, which enhances our understanding of the equilibrium part of the computation, and the use of Boltzmann equations to account for the off-equilibrium effects of the primordial plasma onto nucleation. I will also discuss some open challenges that remain in perturbative approaches, paving the way for future developments.

Author: HIRVONEN, Joonas (University of Nottingham)

Presenter: HIRVONEN, Joonas (University of Nottingham)

Session Classification: Contributed talks

Track Classification: UK Cosmo

Contribution ID: **55** Type: **Talk**

Gravitational-wave signatures of gravito-electromagnetic couplings

Gravitational waves (GWs) can undoubtedly serve as a messenger from the early Universe and a novel probe of the underlying gravity theory. In this talk, motivated by one-loop vacuum-polarization effects on curved spacetime, we investigate a gravitational theory with non-minimal curvature-electromagnetic coupling terms of the form $\xi \frac{R}{M_p^2} F_{\mu\nu} F^{\mu\nu}$, where M_p is the reduced Planck mass, R is the scalar curvature and $F_{\mu\nu}$ the Faraday tensor, which can be responsible for the generation of primordial electromagnetic fields. We study then the GW phenomenology of such coupling terms by deriving for the first time to the best of our knowledge the modified tensor modes equation of motion. Notably, we find a universal infrared (IR) frequency scaling f^5 of the electromagnetically induced GW (EMIGW) signal, which, depending on the energy scale of inflation, the duration of inflation and reheating as well as the dynamical behavior of the coupling function ξ, can be well within the detection sensitivity bands of GW experiments such as SKA, LISA, ET and BBO, thus being potentially detectable in the future by GW observatories.

Authors: TZEREFOS, Charalampos (University of Athens); LAMBIASE, Gaetano (Università di Salerno & INFN); CAPOZZIELLO, Salvatore (INFN - National Institute for Nuclear Physics); PAPANIKOLAOU, Theodoros

Presenter: TZEREFOS, Charalampos (University of Athens)

Session Classification: Flash talks

Track Classification: UK Cosmo

Contribution ID: **56** Type: **Talk**

Synergies of LISA and ET

Tuesday 8 April 2025 11:30 (20 minutes)

LISA and ET will operate in different frequency ranges but with comparable integrated sensitivities to a stochastic GW background (SGWB). We explore their synergies in detecting cosmological SGWBs with large amplitudes and broad frequency spectra, arising from sources such as cosmological phase transitions, cosmic strings, and primordial inflation. By combining measurements from both detectors, we can more effectively characterize the GW spectrum across different frequency scales.

Author: MARRIOTT-BEST, Alisha (Swansea University)

Presenter: MARRIOTT-BEST, Alisha (Swansea University)

Session Classification: Contributed talks

Track Classification: UK Cosmo

Contribution ID: **57** Type: **Talk**

Outlook for the detection of higher gravitational wave memory effects

Wednesday 9 April 2025 16:52 (2 minutes)

Gravitational wave memory is a non-oscillatory feature of gravitational wave signals which both probes nonlinearities appearing in Einstein's equations and is connected to the asymptotic structure of isolated gravitating systems. In recent years, in addition to the usual "displacement" memory, which appears as a DC offset in the gravitational wave signal, other "higher" memory effects have been proposed, such as the spin and center-of-mass memories. While none of these effects are large enough to be confidently observed in single events with current ground-based detectors, evidence for these effects can be inferred in a population by combining data from multiple events. In this talk, we will review past forecasts of the detectability of displacement and spin memories, which were expected to be dominant, as well as discuss the detectability of the center-of-mass memory and two other higher memory effects.

Authors: GRANT, Alexander (University of Southampton); NICHOLS, David (University of Virginia); SIDDHANT, Siddhant (University of Virginia)

Presenter: GRANT, Alexander (University of Southampton)

Session Classification: Flash talks

Track Classification: Gravitational waves

Contribution ID: **58** Type: **Talk**

Deciphering Coupled Scalar Dark Sectors

Monday 7 April 2025 14:56 (8 minutes)

Coupled dark sector models have gained significant attention, motivated by recent advances in cosmology and the pressing need to address unresolved puzzles. In this talk, I will review recent work on coupled scalar dark sector models involving scalar couplings arising either from their kinetic terms, or from their scalar potential. Using a dynamical systems approach, I will show that certain kinetic and potential interactions may mimic one another or even cancel out, making them observationally indistinguishable. If such a distinction becomes possible through observational constraints, it could provide valuable insights into the underlying field space metric and its connection to fundamental physics.

Author: RAHIMY, Saba (Swansea University)

Presenter: RAHIMY, Saba (Swansea University)

Session Classification: Flash talks

Track Classification: UK Cosmo

Contribution ID: **59** Type: **Talk**

New understandings of black hole mergers

Wednesday 9 April 2025 11:30 (20 minutes)

Historically, studies of the merger stage of a black hole binary have centred on fully nonlinear numerical relativity simulations. However, nonlinear black hole perturbation theory provides powerful insights into the ringdown regime immediately following merger, and perturbative self-force theory has proved highly accurate in describing asymmetric binary inspirals even for mass ratios not too far from 1. Here I present a self-force framework for perturbatively modelling the full binary evolution through merger and ringdown, highlighting the synergies with ringdown calculations.

Authors: Prof. POUND, Adam (University of Southampton); Prof. COMPERE, Geoffrey (Université Libre de Bruxelles); Dr KUCHLER, Lorenzo (University of Southampton)

Presenter: Prof. POUND, Adam (University of Southampton)

Session Classification: Contributed talks

Track Classification: Gravitational waves

Contribution ID: **60** Type: **Talk**

Signatures from metastable oppositely-charged black hole binaries

Wednesday 9 April 2025 16:10 (20 minutes)

In this talk, I will present recent developments aimed at simulating black hole binaries beyond general relativity in Spectre, an open-source numerical relativity code by the SXS Collaboration. For concreteness, I will focus on scalar Gauss-Bonnet (sGB) gravity. I describe results derived from a parameter space exploration of a model of sGB gravity using initial data sequences of equal-mass black hole binaries in quasistationary equilibrium. Leveraging the strengths of two numerical relativity evolution codes, we find potential tell-tale signatures for such binaries near the scalarization threshold.

Author: LARA, Guillermo (Max Planck Institute for Gravitational Physics (Albert Einstein Institute))

Presenter: LARA, Guillermo (Max Planck Institute for Gravitational Physics (Albert Einstein Institute))

Session Classification: Contributed talks

Track Classification: Gravitational waves

Contribution ID: **62** Type: **Talk**

The search for modified gravity signatures within early and late time cosmological data

Monday 7 April 2025 14:40 (8 minutes)

In this talk I will review how modified gravity parametrisations can, in principle, be exploited to not only test general relativity, but also tackle the problematic tensions that riddle cosmology in its current state, considering these issues by the point of view of both background observables and perturbations. More precisely, I will aim to provide insight into questions such as: to which extent are modifications to the Hubble expansion rate, within f(R) and f(R,T) theories, valid and useful to resolve the Hubble tension, according to SNe and BAO data? Can phenomenological modifications in the growth of the large scale structure, introduced at the level of the linear perturbation equations in general relativity, be detected/detectable by data such as CMB lensing?

Author: SPECOGNA, Enrico (University of Sheffield)

Presenter: SPECOGNA, Enrico (University of Sheffield)

Session Classification: Flash talks

Track Classification: UK Cosmo

Contribution ID: **63** Type: **Talk**

Simulating neutron stars with dissipative hydrodynamics

Wednesday 9 April 2025 16:54 (2 minutes)

In this talk, I will discuss our work in modelling neutron stars using the recently developed formulation for relativistic dissipative hydrodynamics, known as the BDNK theory. By performing numerical simulations of neutron stars in spherically symmetric spacetimes, we will study how incorporating dissipation using the BDNK theory affects the physical predictions of the system.

Author: SHUM, Lik Hang Harry (University of Nottingham)

Presenter: SHUM, Lik Hang Harry (University of Nottingham)

Session Classification: Flash talks

Track Classification: Gravitational waves

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

Model Agnostic Tests of Gravity with Large Scale Structure

Stage IV large scale structure surveys are promising probes of gravity on cosmological scales. Due to the vast model-space in the modified gravity literature, model-independent parameterisations represent useful and scalable ways to test extensions of ΛCDM. In this talk, I will present recent work that shows how one can consistently parameterise and constrain modified gravity models with a redshift-binned clustering strength μ and a gravitational slip η. I will also discuss how one can expand this framework to account for additional complexity in the time and scale dependence of these bins when computing the 3x2pt data vector.

Author: SRINIVASAN, Sankarshana (Ludwig Maximilian University)

Presenter: SRINIVASAN, Sankarshana (Ludwig Maximilian University)

Session Classification: Flash talks

Track Classification: UK Cosmo

Contribution ID: **65** Type: **Talk**

Black hole ringdown beyond General Relativity

Wednesday 9 April 2025 16:30 (20 minutes)

Black hole quasi-normal modes (QNMs) provide a powerful probe of deviations from General Relativity. We analyze the relative contributions of shifts in the QNM spectrum of Kerr black holes and the presence of additional modes sourced by extra fields in a theory-agnostic framework. By exploring different regimes, we identify when each effect dominates and propose suitable ansätze for the corresponding waveforms.

Authors: D'ADDARIO, Giovanni (University of Nottingham); LESTINGI, Jacopo (University of Nottingham); SOTIRIOU, Thomas

Presenter: D'ADDARIO, Giovanni (University of Nottingham)

Session Classification: Contributed talks

Track Classification: Gravitational waves

Contribution ID: **66** Type: **Talk**

Constraining the interaction between dark matter and dark energy

Tuesday 8 April 2025 16:50 (20 minutes)

Although ΛCDM has been a successful cosmological model, there is a 5σ tension between H_0 values inferred from the cosmic microwave background (CMB) data by Planck and those measured directly by SH0ES. Apart from the Hubble tension, debates also extend to tensions on other cosmological parameters. Many alternative models are proposed to reconcile these tensions in cosmology. I will focus on a cosmological model featuring an interaction between dark matter and dark energy, where dark energy has a constant equation of state w=-1. Although the interaction remains minimal, it is favoured by a combined analysis of Planck CMB and DESI Baryon Acoustic Oscillation (BAO).

Authors: VAN DE BRUCK, Carsten (University of Sheffield); WILSON-EWING, Edward (University of New Brunswick); DI VALENTINO, Eleonora (University of Sheffield); DE CESARE, Marco (University of Naples "Federico II"); ZHAI, Yuejia (University of Sheffield)

Presenter: ZHAI, Yuejia (University of Sheffield)

Session Classification: Contributed talks

Track Classification: UK Cosmo

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

The Ins and Outs of Cosmological Correlators

Monday 7 April 2025 13:40 (1 hour)

By directly probing the initial conditions of our universe, cosmological surveys offer us a unique observational handle on quantum field theory in curved spacetime with dynamical gravity and might even allow us to glean information about a full theory of quantum gravity. Here I will report on recent progress in the study of the natural observables in the problem, namely cosmological correlators. To set the stage, I will review the four things that every physicist should know about cosmology. Then, I will review results from two different approaches. First, I will provide an executive summary of general properties that follow from symmetries, unitarity, causality and locality. I will describe how these properties can be leveraged to predict signals that might be hiding in cosmological surveys. Second I will present a new "in-out" formalism to compute cosmological correlators as an interesting alternative to the well-known in-in formalism and I will stress some of its advantages, such as a proposal for a de Sitter scattering matrix.

Presenter: Dr PAJER, Enrico (University of Cambridge)

Session Classification: Plenary talks

Track Classification: UK Cosmo

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

Gravity in the era of Stage IV Surveys

Monday 7 April 2025 09:20 (1 hour)

Stage IV Large Scale Structure Surveys are ushering in a new era of precision cosmology!
In this talk, I will explore the effort to test gravity on cosmological scales, highlighting the theoretical advancements aimed at constructing an optimal framework. I will also touch on the synergy with gravitational wave surveys. Additionally, I will provide a detailed review of recent findings based on currently available data and conclude with an outlook on the challenges and future prospects in this field.

Presenter: SILVESTRI, Alessandra

Session Classification: Plenary talks

Track Classification: UK Cosmo

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

How large are extra dimensions if they would exist?

Tuesday 8 April 2025 09:00 (1 hour)

Abstract: I discuss in a (hopefully) pedagogical manner the possibility of extra dimensions of space and the constraints on their sizes and detection. In particular we will distinguish between rigid and non-rigid extra dimensions, depending on how easily the extra dimensions can fluctuate. Without going to full-fledged string- or M-theory we can already deduce such properties using 1) entropy bounds, 2) energy conditions in relativity and 3) (more speculatively) the requirement that quantum gravity effects take place at black hole horizons. Throughout the talk I will highlight aspects of the so-called Swampland Program as a paradigm for addressing questions regarding the UV completion of quantum gravity.

Presenter: VAN RIET, Thomas (Leuven U.)

Session Classification: Plenary talks

Track Classification: UK Cosmo

Contribution ID: **70** Type: **Talk**

Deciphering Gravitational Wave Observations

Wednesday 9 April 2025 09:00 (1 hour)

Gravitational Waves emitted by colliding black holes were detected for the first time by LIGO in 2015. The subsequent observation of merging neutron stars in 2017, and its electromagnetic counterpart signal, attracted the attention of the astronomy community worldwide. Over two hundred gravitational wave signals have been observed to date by the LIGO-Virgo-KAGRA network, with several new observations per week.
The properties of a binary system, such as the masses and spins of each black hole, the system' s orientation and location, are all encoded in different, subtle ways into the emitted gravitational waveform. In this talk, I will present an intuitive explanation of how the observed waveform can be used to extract the physical parameters of the system. I will focus on less commonly observed phenomena, such as higher gravitational wave multipoles, spin-induced orbital precession and binary eccentricity. I will discuss how these features can be observed and the new insights they provide on the properties of the system and the formation and evolution of individual binaries and populations.

Presenter: FAIRHURST, Stephen

Session Classification: Plenary talks

Track Classification: Gravitational waves

Contribution ID: **71** Type: **Talk**

The non-linear side of gravity and imprints on gravitational waves

Thursday 10 April 2025 16:10 (1 hour)

The merger of compact objects offer the opportunity to explore and put General Relativity to test. This talk will discuss particular examples and connect them with broader aspects from observations to other research fronts in physics.

Presenter: LEHNER, Luis

Session Classification: Plenary talks

Track Classification: Gravitational waves

Contribution ID: **72** Type: **Talk**

Things that go bump in the night: the search for gravitational-wave bursts

Wednesday 9 April 2025 10:30 (1 hour)

Gravitational-wave bursts are a class of transient gravitational-wave signals which have unknown or very difficult to model signal morphologies. Likely progenitors of gravitational-wave bursts include core-collapse supernovae, cosmic string cusps, pulsar glitches, and black hole encounters. By definition, gravitaitonal-wave bursts cover a broad parameter space which poses a significant challenge to gravitational-wave burst detection techniques. This talk will present an overview of various gravitational-wave burst signal progenitors. Gravitational-wave burst search techniques, including recent machine learning applciations, will also be described. The impact of these searches on our understanding of the transient gravitational wave universe will be discussed.

Presenter: HENG, Siong (University of Glasgow)

Session Classification: Plenary talks

Track Classification: Gravitational waves

Contribution ID: **73** Type: **Talk**

When gravity waves

Wednesday 9 April 2025 13:40 (1 hour)

The recent gravitational wave observations of the collision of black holes and neutron stars have allowed us to pierce into the extreme gravity regime, where the gravitational interaction is simultaneously unfathomably large and wildly dynamical. These gravitational waves encode a trove of information about physics that is prime for the taking, including potential revelations about the validity of Einstein's theory and constraints of possible deviations. In this talk, I will describe some of the physics inferences we have made from gravitational wave observations, and the future inferences that will come next.

Presenter: Prof. YUNES, Nicolas

Session Classification: Plenary talks

Track Classification: Gravitational waves

Contribution ID: **74** Type: **Talk**

Axion phenomenology from string theory to the lab

Thursday 10 April 2025 10:50 (1 hour)

Axions are a hypothetical class of particle predicted in a variety of settings and of utility in solving many mysteries of theoretical physics, most notably as dark matter candidates and solving the strong CP problem. I will describe recent dramatic progress in understanding what string theory predicts about the properties of axions, and the door this opens to test quantum gravity. I will thus describe the cosmology of axions, how they differ from other dark matter candidates, and how we might discover evidence for them in astrophysics. I will then describe why, and by what technology, so many axion experiments are being built around the world. I will end by discussing the recent measurement, for the first time, of axion quasiparticles in magnetic topological insulators the laboratory.

Presenter: MARSH, David (King's College London)

Session Classification: Plenary talks

Track Classification: Fundamental physics

Contribution ID: **75** Type: **Talk**

Towards multi-messenger observations of supermassive black hole binaries

Wednesday 9 April 2025 14:40 (1 hour)

Supermassive black hole binaries (SMBHBs) are exceptional multi-messenger sources, since they emit bright electromagnetic (EM) radiation and low-frequency gravitational waves (GWs). On the EM side, SMBHB can be detected as quasars with periodic variability in time-domain surveys. Several promising candidates have already been identified and many more discoveries are expected with the Rubin Observatory, which will begin operations in the next months. On the GW side, binaries can be detected by pulsar timing arrays (PTAs). Recently, all major PTA collaborations have found evidence for the GW background, which likely consists of many unresolved binaries. The detection of individually resolved binaries on top of this background is expected soon. In this talk, I will discuss the status of observational searches of binaries and expectations for the Rubin era, the recent discovery of the GW background and its astrophysical interpretation. Finally, I will present prospects for detecting individual sources and combining PTA data with EM data to bring the first multi-messenger detection of a SMBHB within reach.

Presenter: CHARISI, Maria (Columbia University)

Session Classification: Plenary talks

Track Classification: Relativistic astrophysics

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

TBC

Thursday 10 April 2025 13:40 (1 hour)

Presenter: BONGA, Béatrice (Radboud University)

Session Classification: Plenary talks

Track Classification: Gravitational waves

Contribution ID: **77** Type: **Talk**

Observational signatures for extremal black holes

Thursday 10 April 2025 14:40 (1 hour)

We will discuss the black hole stability problem and discuss results on asymptotics of linear waves. We will present results for extremal and sub-extremal black holes.

Presenter: ARETAKIS, Stefanos (University of Toronto)

Session Classification: Plenary talks

Track Classification: Mathematics

Contribution ID: **78** Type: **Talk**

TBC

Thursday 10 April 2025 09:00 (1 hour)

Presenter: GREGORY, Ruth

Session Classification: Plenary talks

Track Classification: Experiments

Contribution ID: **79** Type: **Talk**

Quasinormal modes in semi-open systems

Wednesday 9 April 2025 17:06 (2 minutes)

Presenter: SOLIDORO, Leonardo (University of Nottingham)

Session Classification: Flash talks

Track Classification: Experiments

Contribution ID: **80** Type: **Talk**

Measuring the Universe with DESI

Tuesday 8 April 2025 13:40 (1 hour)

The Dark Energy Spectroscopic Instrument (DESI) is the first of a new generation of Dark Energy experiments, and probes evolution in the universe using galaxy clustering. Within the galaxy clustering signal, the projected location of the Baryon Acoustic Oscillations (BAO) acts as a standard ruler to map cosmic evolution. I will present the latest BAO results from the DESI Data Release 2 (DR2) sample, which contains 3 years of data, and their impact on our understanding of dark energy and neutrino masses. I will explain some of the difficulties in expanding this work to model the full clustering signal, and the work underway to provide more robust results. I will then review how we can extend this work using voids, regions in the universe containing very few galaxies, which act as a standard volume rather than a standard ruler. Finally, I will consider how the amplitude of the BAO signal can help us measure the Hubble constant, potentially helping to solve the Hubble tension.

Presenter: PERCIVAL, Will (University of Waterloo)

Session Classification: Plenary talks

Track Classification: UK Cosmo

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

Panel discussion on

Tuesday 8 April 2025 14:40 (40 minutes)

Panelists: Will Percival, Alessandra Silvestri, Ed Copeland, TBD
Chair: TBD

Session Classification: UK cosmo discussion