Copernicus Webinar and Colloquium Series

Report of Contributions

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

Relieving the Hubble tension with primordial magnetic fields

Thursday, July 9, 2020 3:00 PM (1 hour)

The standard cosmological model determined from the accurate cosmic microwave background measurements made by the Planck satellite implies a value of the Hubble constant H0 that is 4.2 standard deviations lower than the one determined from Type Ia supernovae. The Planck best fit model also predicts lower values of the matter density fraction Om and clustering amplitude S8 compared to those obtained from the Dark Energy Survey Year 1 data. We show that accounting for the
additional inhomogeneities in the baryon density induced by primordial magnetic fields present in the plasma prior to recombination can help to solve both the H0 and the S8-Om tensions. The required field strength is just what is needed to explain the existence of galactic, cluster, and extra-galactic magnetic fields without relying on dynamo amplification. Our results show clear evidence for this effect and motivate further detailed studies of primordial magnetic fields, setting several well-defined targets for future observations.

Presenter: POGOSIAN, Levon (Simon Fraser U.)

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

informal discussion/coffee time

Thursday, July 9, 2020 4:00 PM (1 hour)

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

High frequency gravitational waves

Wednesday, July 29, 2020 3:00 PM (1 hour)

Gravitational waves in the MHz to GHz range are window to the very early Universe, and thus provide a unique way to probe physics around the energy scale of grand unification. The detection of such relic gravitational waves is however extremely challenging. In this talk, I will highlight the fundamental processes generating such high frequency gravitational waves and discuss recent progress in searching for these primordial messengers. I will focus in particular on a natural cosmological gravitational wave detector, based on the conversion of gravitational waves into photons in the presence of cosmic magnetic fields. I demonstrate that this conversion leads to a distortion of the cosmic microwave background (CMB). The measurements of the radio telescopes EDGES and ARCADE can be cast as a bound on the gravitational wave amplitude. For the strongest magnetic fields allowed by astrophysical constraints, these constraints exceed current laboratory constraints by about seven orders of magnitude. Future advances in 21cm astronomy may conceivably push these bounds below the sensitivity of cosmological constraints on the total energy density of gravitational waves.

Presenter: DOMCKE , Valerie

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

informal discussion/coffee break

Wednesday, July 29, 2020 4:00 PM (1 hour)

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

Physical Implications of a Fundamental Period of Time

Wednesday, July 15, 2020 3:00 PM (1 hour)

If time is described by a fundamental process rather than a coordinate, it interacts with any physical system that evolves in time. The resulting dynamics has recently been shown to be consistent provided the fundamental period of the time system is sufficiently small. A strong upper bound $T_C < 10^{-33}$s of the fundamental period of time, several orders of magnitude below any direct time measurement, can be obtained from bounds on dynamical variations of the period of a lab system evolving in time. Possible cosmological implications will be discussed.

Presenter: BOJOWALD, Martin

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

informal discussion/coffee time

Wednesday, July 15, 2020 4:00 PM (1 hour)

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

The Cosmic Microwave Background

Friday, July 17, 2020 3:00 PM (1 hour)

Precision measurements of the Cosmic Microwave Background (CMB) have the potential to provide information about the birth and evolution of our universe. I will review how we extract cosmological parameters from the CMB from both temperature and polarization maps. The Atacama Cosmology Telescope (ACT) has been making measurements of the CMB since 2006. I will discuss the recent results from ACT and their implications. I will also provide a glimpse of the instrumentation being developed for the upcoming Simons Observatory.

Presenter: DEVLIN, Mark (University of Pennsylvania)

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

informal discussion/coffee time

Friday, July 17, 2020 4:00 PM (1 hour)

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

Two-body dynamics and gravitational waves in general relativity

Monday, September 28, 2020 9:00 AM (1 hour)

The monumental discovery of gravitational waves by the LIGO-Virgo detectors confirms the sophisticated predictions from general relativity and emphasizes the importance of theoretical works (both analytical and numerical) on the compact binary dynamics: two black holes or neutron stars initially detected in close inward spiralling orbits will merge to form a single massive black hole, producing a burst of gravitational waves. In this talk, after motivating remarks on the properties of gravitational waves and the new gravitational astronomy, we shall describe the analytic two-body problem in general relativity, and the post-Newtonian (PN) approximation which allows an accurate description of the inspiralling phase of compact binaries, and plays a crucial role in the definition of the gravitational wave templates used in the data analysis of the detectors. We shall also mention some recent developments where the PN approximation is computed using the effective field theory and a diagrammatic expansion in the classical limit of general relativity.

Presenter: BLANCHET, Luc (IAP)

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

Constraining Early Dark Energy with Large Scale Structure

Thursday, July 23, 2020 3:00 PM (1 hour)

The Hubble tension is conventionally viewed as that between the cosmic microwave background (CMB) and the SH0ES measurement. A prominent proposal for a resolution of this discrepancy is to introduce a new component in the early universe, which initially acts as "early dark energy" (EDE), thus decreasing the physical size of the sound horizon imprinted in the CMB and increasing the inferred H_0, bringing it into near agreement with SH0ES. However, this impacts cosmological observables beyond the CMB – in particular, the large scale structure (LSS) of the universe across a range of redshift. The H_0 tension resolving EDE cosmologies produce scale-dependent changes to the matter power spectrum, including 10% more power at k=1 h/Mpc. Motivated by this, I will present the results of two analyses of LSS constraints on the EDE scenario. Weak lensing and galaxy clustering data (from, e.g., the Dark Energy Survey) significantly constrain the EDE model, and the resulting H_0 is in significant tension with SH0ES. Complementary to this, including data from the Baryon Oscillation Spectroscopic Survey (BOSS), analyzed using the effective field theory (EFT) of LSS, yields an EDE H_0 value that is in significant (3.6\sigma) tension with SH0ES. These results indicate that current LSS data preclude the EDE model as a resolution of the Hubble tension, and, more generally, that the EDE model fails to restore cosmological concordance. A sensitivity forecast for EUCLID suggests that future LSS surveys can close the remaining parameter space of the model.

Presenter: Dr MCDONOUGH, Evan (MIT)

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

informal discussion/coffee time

Thursday, July 23, 2020 4:00 PM (1 hour)

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

Primordial black holes as the solution of many cosmological conundra

Wednesday, August 26, 2020 3:00 PM (1 hour)

Studies of primordial black holes (PBHs) usually focus on constraints on their abundance, since this has interesting implications for cosmology even if they never formed. However, recently attention has turned to the possibility that they may actually exist and solve various cosmological conundra. The most exciting possibility is that they provide the dark matter, although this is only feasible in a few mass windows. In particular, if they form at the QCD phase transition, the tiny collapse fraction required might naturally explain the cosmic photon-to-baryon ratio and the comparability of the PBH and baryon densities. Even if PBHs provide only a small fraction of the dark matter, they might still explain some of the OGLE and quasar microlensing events, the LIGO/Virgo gravitational wave events, the spatial coherence in the fluctuations of the source-subtracted cosmic infrared and soft X-ray backgrounds, some anomalies associated with Ultra Faint Dwarf galaxies, and the supermassive black holes in galactic nuclei. With a suitable extended mass spectrum, they might even explain all these anomalies. So an exciting new era in PBH research has began, with various forthcoming observations able to probe this proposal.

Presenter: Prof. CARR, Bernard

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

informal discussion/coffee time

Wednesday, August 26, 2020 4:00 PM (1 hour)

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

Origin of matter and gravitational wave

Thursday, August 6, 2020 3:00 PM (1 hour)

We exist today thanks to the asymmetry between matter and anti-matter. Its origin, however, has been one of the major mysteries in cosmology and particle physics. Arguably the leading theory called leptogenesis is that the asymmetry is generated by the decay of heavy neutrinos at the temperature above 10ˆ9 GeV. I review this theory and point out that the gravitational wave will be an important test. If time permits, I will also discuss a different origin of the asymmetry which is also tied to the origin of dark matter, again with a gravitational wave signature.

Presenter: Prof. MURAYAMA, Hitoshi

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

informal discussion/Coffee time

Thursday, August 6, 2020 4:00 PM (1 hour)

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

The Noise of Gravitons

Tuesday, August 11, 2020 3:30 PM (1 hour)

For the purpose of describing observed phenomena, it has thus far been sufficient to regard gravity as a classical field obeying Einstein's equations. Here we treat the gravitational field as a quantum field and consider the implications for gravitational wave detectors. We present a formalism to obtain the quantum effects of gravity based on the Feynman-Vernon influence functional. We find that the separation of free-falling particles is subject to random fluctuations ("noise"), with the classical geodesic deviation equation being replaced by a stochastic equation. The statistical characteristics of the noise depend on the quantum state of the gravitational field; for certain classes of quantum states, the noise can be greatly enhanced. Detection of this fundamental noise would constitute direct evidence for the quantization of gravity and the existence of gravitons.

Presenter: PARIKH, Maulik

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

informal discussion/coffee time

Tuesday, August 11, 2020 4:30 PM (30 minutes)

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

Firewalls in General Relativity

Tuesday, September 1, 2020 2:00 PM (1 hour)

We present spherically symmetric solutions to Einstein's equations, which are equivalent to canonical Schwarzschild and Reissner-Nordstrom black holes on the exterior, but with singular (Planck-density) shells at their respective event and inner horizons. The locally measured mass of the shell and the singularity are much larger than the asymptotic Arnowitt-Deser-Misner mass. The area of the shell is equal to that of the corresponding canonical black hole, but the physical distance from the shell to the singularity is a Planck length, suggesting a natural explanation for the scaling of the black hole entropy with area. The existence of such singular shells enables solutions to the black hole information problem of Schwarzschild black holes and the Cauchy horizon problem of Reissner-Nordstrom black holes. While we cannot rigorously address the formation of these solutions, we suggest plausibility arguments for how "normal"black hole solutions may evolve into such states. We also discuss the stability of these structures.

Presenters: MCMANUS, Ryan; RAJENDRAN, Surjeet

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

alpha'-Cosmological tale: String Cosmology backgrounds from Classical String Geometry

Thursday, August 20, 2020 3:00 PM (1 hour)

In this talk, I intend to give a pedagogical, nonetheless biased, introduction to String Cosmology. After briefly reviewing the Lambda-CDM model and motivating inflation, we will remind ourselves that early universe cosmology remains singular and waiting for alternatives. That will be our cue to consider string theory to define our gravity sector and string thermodynamics to define our matter sector. We will learn how that doesn't work, unless we consider more string corrections (in fact, infinity of them!). Once we are stringy enough, we will be able to build a full cosmological model that is non-singular and already poses itself as an alternative to inflation at the background level.

Presenter: FRANZMANN, Guilherme

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

informal discussion/coffee time

Thursday, August 20, 2020 4:00 PM (1 hour)

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

Cosmic Bell Tests: Using Quasars to Test Quantum Theory

Monday, September 21, 2020 3:00 PM (1 hour)

For decades, physicists have conducted experimental tests of quantum entanglement, a phenomenon that Albert Einstein once dismissed as "spooky action at a distance." Despite Einstein's misgivings, the experiments have consistently found results compatible with quantum theory. Yet every experiment has been subject to one or more "loopholes," which would still allow for an explanation without the need for quantum mechanics. Arguably the most subtle and stubborn loophole is known as "freedom of choice," and concerns whether any unknown mechanism could have affected both the selection of measurements to be performed on the entangled particles and the outcomes of those measurements. To address this loophole, one should obtain random numbers that can be expected to be uncorrelated with any aspect of the entanglement experiment. In recent "Cosmic Bell"experiments, we used real-time astronomical observations of distant quasars as a classical source of binary numbers, to determine which measurements to perform on pairs of entangled particles. We found clear violations of Bell's inequality, providing even more compelling evidence that quantum entanglement is a robust feature of our world. These experiments push back to at least 7.8 Gyr ago the most recent time by which any (non-quantum-mechanical) local-realist mechanism could have exploited the freedom-of-choice loophole to engineer the observed Bell violation, excluding any such mechanism from 96% of the spacetime volume of the past light cone of our experiment, extending from the big bang to today.

Presenter: Prof. KAISER, David (MIT)

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

informal discussion/coffee time

Monday, September 21, 2020 4:00 PM (1 hour)

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

Signals of a Quantum Universe

Wednesday, September 16, 2020 6:00 PM (1 hour)

The idea that structure in the universe was created from quantum mechanical vacuum fluctuations during inflation is very compelling, but unproven. Testing this proposal is challenging because the universe we observe is effectively classical. I will explain the origin of this challenge and how it can be circumvented if we observe equilateral primordial non-Gaussianity. In particular, we will see that the absence of an accompanying folded non-Gaussian signal is only possible (assuming locality) with quantum vacuum fluctuations.

Presenter: Prof. GREEN, Daniel

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

informal discussion/coffee time

Wednesday, September 16, 2020 7:00 PM (1 hour)

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

The status of cosmological tensions after Planck

Wednesday, October 28, 2020 3:00 PM (1 hour)

The results of the ESA Planck satellite have enabled extrordinary progress in our understanding of the universe in the past few years. Furthermore, its (sub)-percent measurement of cosmological parameters allowed us to discover a few inconsistencies with other astrophysical probes, which might point towards a crisis of the current standard model of cosmology. In this talk, I will review some of these inconsistencies and highlight the prospects for the future.

Presenter: Prof. GALLI, Silvia (IAP)

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

informal discussion

Wednesday, October 28, 2020 4:00 PM (1 hour)

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

Exploring the early universe with the stochastic background of induced gravitational waves

Tuesday, November 17, 2020 3:00 PM (1 hour)

I will discuss the current status of the secondary gravitational waves induced by the curvature perturbation and why they might be an important source of the cosmological stochastic gravitational wave background. As a practical example, I will use the latest NANOGrav results on the stochastic background of nanohertz gravitational waves to constrain the equation of state parameter of the early universe and the mass of the associated primordial black holes.

Presenter: Dr DOMENECH, Guillem (Padova)

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

Probing extremely small-scale primordial perturbations by gravitational waves

Thursday, October 8, 2020 10:00 AM (1 hour)

According to the theory of inflation, the primordial perturbations existed over a wide range of length scales from meter size at the smallest scale up to at least the Hubble horizon on the largest scale. Stochastic gravitational waves have been attracting a lot of interest recently as a new powerful probe of the primordial perturbations on very small scales. In this talk, I will give a brief overview in this field and present a recent search for such gravitational waves by using LIGO O2 data and its implications.

Presenter: Prof. TERUAKI, Suyama

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

Detecting the thermal effect of acceleration in an Analog system.

Thursday, October 15, 2020 8:00 PM (1 hour)

Given the intimate connection of gravity and its dependence on the changing flow of time from place to place, it is surprizing that General Relativistic effects can be modeled in other systems. In 1981 I showed that even the Hawking effect has analogies in other systems, which has spawned an active experimental effort in the past few decades. A harder case has turned out to to model the thermal effect that an accelerated detector in the vacuum. Following Bell and Leinaas in 1983, we showed that a circularly accelerated detector can also show a themal effect. This talks will present a way of implimenting a broad band detector of the quantum fluctuations in a BEC which may also be just realisable with an interferometric detector by borrowing techniques from LIGO, with the interferometer in frequency space rather than in real space.

Presenter: Prof. UNRUH, Bill

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

Observational Signatures of Multifield Inflation

Friday, September 11, 2020 3:00 PM (1 hour)

Slow-roll single-field inflation constitutes the main paradigm of the Early Universe. But this model suffers from a number of conceptual issues that naturally lead to the consideration of multifield models of inflation with curved field space, which have recently been under scrutiny as realistic realisations of high-energy physics in the Early Universe. I will show that the non-trivial internal geometry reshuffles observational predictions from inflation, at the level of the background (geometrical destabilisation of inflation), of linear fluctuations (spectral index, tensor-to-scalar ratio) and can lead to exotic type of non-Gaussianities (bispectrum, higher-order correlation functions). This last fact in particular motivates the thorough analysis of non-Gaussianities in this large class of models. For that, we revisit Maldacena's calculation of the bispectrum in a 2-field context. As a byproduct, we also derive the effective single-field theory including interactions, when the fluctuation perpendicular to the trajectory (isocurvature mode) can be integrated out, and explicitly show the effect of the curvature of the field space on the bispectrum. Time permitting I will also mention other projects that might interest the audience, such as multifield stochastic inflation and multifield/multi-fluid reheating after inflation.

Presenter: Dr PINOL, Lucas (IAP)

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

Pulsar Timing Arrays: The Next Window to Open on the Gravitational-Wave Universe

Thursday, October 22, 2020 7:00 PM (1 hour)

Galaxy mergers are a standard aspect of galaxy formation and evolution, and most (likely all) large galaxies contain supermassive black holes. As part of the merging process, the supermassive black holes should in-spiral together and eventually merge, generating a background of gravitational radiation in the nanohertz to microhertz regime. An array of precisely timed pulsars spread across the sky can form a galactic-scale gravitational wave detector in the nanohertz band. I describe the current efforts to develop and extend the pulsar timing array concept, together with recent limits which have emerged from international efforts to constrain astrophysical phenomena at the heart of supermassive black hole mergers.

Presenter: MINGARELLI, Chiara

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

Einstein-Cartan gravity: Electroweak Symmetry Breaking, Inflation and Dark Matter

Thursday, November 5, 2020 4:00 PM (1 hour)

It is well-known since the works of Utiyama and Kibble that the gravitational force can be obtained by gauging the Lorentz group, which puts gravity on the same footing as the Standard Model fields. The resulting theory - Einstein-Cartan gravity - happens to be very interesting. First, it may generate the electroweak symmetry breaking by a non-perturbative gravitational effect. In this way, it does not only address the hierarchy problem but opens up the possibility to calculate the Higgs mass. Second, the model incorporates inflation at energies below the onset of the strong-coupling of the theory. Finally, it inevitably contains a four-fermion interaction that originates from torsion associated with spin degrees of freedom. This interaction leads to a novel universal mechanism for producing singlet fermions in the Early Universe. These fermions can play the role of dark matter particles. The mechanism is operative in a large range of dark matter particle masses: from a few keV up to ~10^8 GeV.

Presenter: Prof. SHAPOSHNIKOV, Mikhail

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

Causality with Gravity

Thursday, December 3, 2020 2:00 PM (1 hour)

In standard effective field theories, the notion of causality is intrinsically linked with that of subluminality and with a set of positivity constraints to be imposed on the low-energy scattering amplitudes. I will highlight how the presence of gravity leads to a more subtle relation between causality, (sub)luminality and positivity bounds. I will clarify why a mild level of superluminality is not in contradiction with causality, analyticity or Lorentz invariance and show how consistent gravitational low energy effective theories can self-protect by ensuring that any time advance and superluminality calculated within the regime of validity of the effective theory is necessarily unresolvable for such theories. These considerations are particularly relevant for putting constraints on cosmological and gravitational effective field theories and I will provide explicit criteria to be satisfied so as to ensure causality and a standard high energy completion in gravitational effective field theories.

Presenter: Prof. CLAUDIA, de Rham

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

New Physics and the Black Hole Mass Gap

Monday, November 23, 2020 4:00 PM (1 hour)

In this talk I will demonstrate the potential of the black hole mass gap to probe new physics. The mass gap, in which no black holes can be formed, is a standard prediction of stellar structure theory. I will show that new physics that couples to the Standard Model can act as an additional source of energy loss in the cores of heavy stars, dramatically altering their evolution, resulting in large shifts of the gap. I will also discuss how new contributions may modify the stellar equation of state. The gravitational wave observations by the LIGO/Virgo collaboration will bring the edges of the black hole mass gap in sight in the coming years, making this a promising novel probe of new physics.

Presenter: CROON, Djuna (TRIUMF)

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

Quantum fluctuations and new instantons

Tuesday, January 12, 2021 1:00 PM (1 hour)

I will discuss how quantum fluctuations modify the Coleman theory of the decay of false vacuum

Presenter: Prof. MUKHANOV, Viatcheslav (LMU)

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

Hunting for Parity-violating Physics in Polarisation of the Cosmic Microwave Background

Tuesday, January 26, 2021 2:00 PM (1 hour)

Polarised light of the cosmic microwave background, the remnant light of the Big Bang, is sensitive to parity-violating physics. In this presentation we report on a new measurement of parity violation from polarisation data of the European Space Agency (ESA)'s Planck satellite. The statistical significance of the measured signal is 2.4 sigma. If confirmed with higher statistical significance in future, it would have important implications for the elusive nature of dark matter and dark energy.

Presenter: Prof. KOMATSU, Eiichiro (Max-Planck-Institute for Astrophysics)

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

[Colloquium] Are there any fundamental problems with quantum gravity?

Tuesday, February 2, 2021 3:00 PM (1 hour)

I plan to informally discuss several issues that have traditionally been raised in various approaches to quantizing gravity. They are invariably related to the concepts that are thought to be fundamental in one of the two theories (quantum and GR) but are (allegedly) at odds with the other one. I will discuss some of the key issues in my talk, such as Bell non-locality and the equivalence principle, only to conclude that they are, in my view, not fundamentally an obstacle. Lack of experiments, on the other hand, is a real obstacle, but, even here, we are closer than ever to being able to test the quantum nature of gravity in the lab. I will describe how.

Presenter: Prof. VEDRAL, Vlatko (Oxford)

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

Cosmological Genesis: Approaches and Problems.

Thursday, January 28, 2021 11:00 AM (2 hours)

Cosmological Genesis is a scenario without initial singularity,
in which the Universe starts off from nearly Minkowski state with nearly vanishing energy density, then the energy density increases, the expansion rate grows; at some later epoch the energy density is converted into heat, and the conventional hot epoch begins (variant: at some later epoch energy density stops increasing and inflationary epoch begins).
Clearly, this scenario requires exotic form of matter, which violates energy conditions, and/or exotic modification of gravity. This talk will concentrate on scalar-tensor theories of Horndeski type, and generalizations thereof. Despie initial high expectations, there are problems with stable and subluminal Genesis in these theories. These problems, and attempts to solve them, will be the main focus.

Presenter: Prof. RUBAKOV, Valery (INR Moscow)

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

The Topology of Data: from String Theory to Cosmology to Phases of Matter

Thursday, February 4, 2021 4:00 PM (1 hour)

We are faced with an explosion of data in many areas of physics, but very so often, it is not the size but the complexity of the data that makes extracting physics from big datasets challenging. As I will discuss in this talk, data has shape and the shape of data encodes the underlying physics. Persistent homology is a tool in computational topology developed for quantifying the shape of data. I will discuss three applications of topological data analysis: 1) identifying structure of the string landscape, 2) constraining cosmological parameters from CMB measurements and large scale structures data, and 3) detecting and classifying phases of matter. Persistent homology condenses these datasets into their most relevant (and interpretable) features, so that simple statistical pipelines are sufficient in these contexts. This suggests that TDA can be used in conjunction with machine learning algorithms and improves their architecture.

Presenter: Prof. SHIU, Gary (University of Wisconsin-Madison)

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

New physics on the horizon? Testing the nature of dark compact objects

Tuesday, March 2, 2021 2:00 PM (1 hour)

Gravitational-wave astronomy and new electromagnetic facilities allows us for unprecedented tests of the nature of dark compact objects and provide a novel way to search for new physics. I will give an overview of the many recent result in this area including, shadows, constraints on the multipolar structure, ringdown tests, gravitational-wave echoes, and tidal effects in binaries.

Presenter: Prof. PANI, Paolo (Sapienza University of Rome)

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

[Colloquium] Emergence of electromagnetic wave and gravitational wave from quantum information (qubit ocean)

Thursday, March 4, 2021 2:00 PM (1 hour)

From quantum theory, we know that all elementary particles are waves. For example, photons are waves that satisfy Maxwell equation. Here we discuss the possibility that our space is a qubit ocean. We show that, if the qubits that form the space are properly entangled, the deformation of the qubit ocean corresponds to wave that satisfy Maxwell equation. This is an emergence of electromagnetic wave from quantum information. We then discuss attempts to have an emergence of gravitational wave from qubit ocean, that is only half successful.

Presenter: Prof. WEN, Xiao-Gang (MIT)

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

Gravitational waves from first-order phase transition during inflation

Tuesday, February 23, 2021 2:00 PM (1 hour)

I will talk about the properties of the gravitational wave (GW) signals produced by first-order phase transitions during the inflation era. I will show that the power spectrum of the GW oscillates with its wave number. This oscillatory feature corresponds to the instantaneous nature of the first-order phase transition. I will also show that we can get information about how the universe evolves during and after inflation from the slopes of different parts of the spectrum. I will also present simple models that first-order phase transition can happen and finish during inflation. I will also show that this signal can be observed directly by future terrestrial and spatial GW detectors and through the B-mode spectrum in CMB.

Presenter: Prof. HAIPENG AN (Tsinghua University)

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

Quantum gravity predictions for cosmology: from the beginning to dynamical dark energy.

Tuesday, February 9, 2021 3:00 PM (1 hour)

Presenter: Prof. CHRISTOF WETTERICH (Universitat Heidelberg)

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

Axions, Dark Matter, and the Primordial Density Perturbation

Thursday, February 18, 2021 10:00 AM (1 hour)

I will present new ideas about how the QCD axion or axion-like particles can make up the dark matter of our universe, and/or explain the origin of the primordial density perturbation. For axion dark matter, I will introduce a novel production mechanism that invokes a kinetic mixing between the axion and the inflaton. I will show that this mechanism opens up new windows in the axion parameter space, where conventional scenarios such as vacuum misalignment cannot work. The impact of primordial electromagnetic fields on the axion window will also be discussed. For the density perturbation, I will demonstrate that an axion-like particle coupled to a new confining gauge group is a perfect candidate of a curvaton, and that the resulting density perturbation has distinct signatures that are testable in upcoming experiments.

Presenter: Prof. TAKESHI KOBAYASHI (Nagoya University)

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

A look at axion inflation in string theory

Friday, December 11, 2020 10:00 AM (1 hour)

We will take a look at axion inflation in string theory, taking a somewhat eclectic approach guided by some mechanism classes and (semi-)explicit examples. Looking at models with either 1 or 2 axions, we will argue that (up to manifestly tuning for small-field models) inflation can arise from 2 different mechanisms - either monodromy, or hybrid inflation. Cautiously incorporating both known limits of top-down theory knowledge as well as bottom-up 'effective quantum gravity'conjectural constraints, should lead to a 'theory error blob'of CMB observable predictions describing the 'mechanism equivalence class'. We outline this using harmonic hybrid inflation as a representative of 2-axion hybrid inflation, and then describe a systematic method of propagating the 'theory error'to observable predictions using machine learning and information geometry

Presenter: Prof. WESTPHAL , Alexander (DESY)

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

Black Holes Are Finally in Vogue

Monday, December 14, 2020 3:00 PM (1 hour)

With black holes, what you see is not what you get. They are extreme structures of spacetime that represent the ultimate prison, from where even light cannot escape. After decades of being a subject of mathematical interest, recently black holes became a topic of direct observational studies, for which two Nobel prizes were awarded over the past three years. I will describe some of the most exciting frontiers in current multi-messenger studies of astrophysical black holes.

Presenter: Prof. LOEB , Abraham (Avi) (Harvard University)

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

Cosmology from the CMB frequency spectrum

Thursday, March 11, 2021 3:00 PM (1 hour)

The frequency spectrum of the CMB was last measured in the nineties by the FIRAS instrument onboard COBE. It was found to be consistent with a perfect blackbody spectrum, up to <1e-4 relative deviations. Today, there is growing interest in re-exploring in more depth this aspect of the CMB, which is complementary to the well-studied CMB anisotropies. In this talk I will briefly review the physics of CMB spectral distortions, and what signals are guaranteed in the standard cosmological model. Beyond this, I will show how CMB spectral distortions can probe dark matter interactions with standard particles, and could thus help shed light on its nature. Lastly, I will discuss the interplay between the CMB monopole temperature T0 and cosmological parameters (in particular the Hubble constant H0) inferred from CMB anisotropies.

Presenter: Prof. ALI-HAIMOUD, Yacine (NYU)

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

Gravitational Collider Physics

Tuesday, March 16, 2021 2:00 PM (1 hour)

Gravitational wave astronomy will transform astrophysics in many ways; can it do the same for particle physics? In this talk, I will describe how the gravitational waves emitted by binary black holes offer a new window onto physics beyond the Standard Model. I will focus on probes of ultralight bosons such as axion-like particles and dark photons, which can spontaneously form bound states around rotating black holes. Remarkably, these bound states resemble the proton-electron structure of the hydrogen atom and are therefore often called the “gravitational atoms”. In addition, the dynamics of these atoms in binary systems can be formulated as scattering events which are quantified by a S-matrix. These dynamics would significantly backreact on the orbit, thereby affecting the gravitational waves emitted by the binary system. These gravitational wave signatures would also carry imprints of the masses and intrinsic spins of the ultralight bosons, making binary black holes novel detectors of these putative new fields and effectively “gravitational colliders”.

Presenter: Prof. CHIA, Horng Sheng (IAS)

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

Decoding and bootstrapping cosmological fluctuations

Thursday, March 25, 2021 2:00 PM (1 hour)

I will review our current understanding of the initial conditions of the universe, and describe what information is available from current and future measurements of cosmological correlation functions. Then I will describe a new method to compute and constrain the possible shapes of those correlation functions, assuming they were generated during inflation. This "cosmological bootstrap"draws inspiration from the modern scattering amplitudes program in flat space, as well as the conformal bootstrap of phase transitions. After discussing primordial scalar fluctuations, I will also explain how the consistent propagation of gravitational waves imposes further constraints on the structure of spinning primordial correlators.

Presenter: Prof. PIMENTEL, Guilherme L. (Leiden U.)

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

An order-unity correction to Hawking radiation

Tuesday, March 30, 2021 3:00 PM (1 hour)

When a black hole first forms, the properties of the emitted radiation as measured by observers near future null infinity are very close to the 1974 prediction of Hawking. However, deviations grow with time, and become of order unity after a time $t \sim M_i^{7/3}$, where M_i is the initial mass in Planck units. After an evaporation time the corrections are large: the angular distribution of the emitted radiation is no longer dominated by low multipoles, with an exponential falloff at high multipoles. Instead, the radiation is redistributed as a power law spectrum over a broad range of angular scales, all the way down to the scale $\Delta\theta \sim 1/M_i$, beyond which there is exponential falloff. This effect is is a quantum gravitational effect, whose origin is the spreading of the wavefunction of the black hole's center of mass location caused by the kicks of the individual outgoing quanta, discovered by Page in 1980. The modified angular distribution of the Hawking radiation has an important consequence: the number of soft hair modes that can effectively interact with outgoing Hawking quanta increases from the handful of modes at low multipoles l, to a large number of modes, of order $\sim M_i^2$. We argue that this change removes on of the primary objections to the Hawking-Perry-Strominger proposed mechanism for purifying the Hawking radiation.

Presenter: Prof. FLANAGAN, Eanna (Cornell University)

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

What the Hubble tension really is and how (not) to solve it

Tuesday, April 13, 2021 3:00 PM (1 hour)

Despite being arguably one of the hottest topics in the recent literature, there are several widely spread misconceptions concerning what the Hubble tension really is. Moreover, leaving these misconceptions aside, no compelling model to solve the Hubble tension has been found so far, despite a huge number of attempts (and false alarms). I will begin by explaining what the Hubble tension really is, presenting three different interpretations in order of increasing "correctness". I will then discuss why so many proposed models have failed so far, and what in my opinion is the way forward towards constructing a realistic solution to the tension. I will close by presenting the "10 commandments" which I believe every "Hubble hunter" should abide by.

Presenter: Dr VAGNOZZI, Sunny (Cambridge University)

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

New Probes of Large-Scale Structure

Tuesday, April 20, 2021 3:00 PM (1 hour)

Progress in cosmology over the past few decades has been quantified by the extent to which we can accurately measure "two-point functions"such as the power spectrum of galaxies; the shear-shear- correlation function; galaxy-galaxy lensing; and most famously the C_l's of the anisotropies in the cosmic microwave background. New statistics are emerging though that offer potential to infer even more information about the universe. I will open by asking your opinions about what information is most important that is not listed above. Then, I will give my opinion and share some proposals for extending this relatively new class of statistics to learn about the large-scale structure of the universe.

Presenter: Prof. DODELSON, Scott (Carnegie Mellon U.)

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

Fundamental Physics from Gravitational Waves

Thursday, April 29, 2021 3:00 PM (1 hour)

Following the direct discovery of gravitational waves (GWs) by LIGO and Virgo, there are many opportunities to probe fundamental physics using GWs. These include using GWs from astrophysical sources to constrain the graviton mass and search for Lorentz violation, as well as searching for GWs from dark matter in merging neutron stars, from first-order phase transitions in the early Universe, and from loops of cosmic strings, as may be hinted by recent data from the NANOGrav pulsar timing array. The roles that could be played by atom interferometers measuring GWs in the mid-frequency band between LIGO/Virgo and LISA will be highlighted.

Presenter: Prof. ELLIS, John (King's College London)

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

[Colloquium] Black Hole Information

Thursday, April 8, 2021 3:00 PM (1 hour)

Black hole information is one of the greatest puzzles of theoretical physics from the 20th century that has persisted into the 21st century. After Stephen Hawking discovered black hole evaporation in 1974, in 1976 he predicted that black hole formation and evaporation would cause a pure quantum state to change into a mixed state, effectively losing information from the universe. In 1979 I questioned this conclusion, as many years later did many others, and in 2004 Hawking conceded that black hole evaporation does not lose information. However, a minority of gravitational theorists have not accepted Hawking's concession. There do remain many puzzles about black hole information, such as how it gets out (if it indeed does), and whether there are firewalls at the surfaces of old black holes that would immediately destroy anything falling in.

Presenter: Prof. PAGE, Don (University of Alberta)

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

Black Holes, Unscripted

Tuesday, May 4, 2021 3:00 PM (1 hour)

Black Holes occupy a special place in the fascination of astronomers and physicists. From the most speculative mathematical physicist to the most sensible radio astronomer, everyone has their own narrative of what lies within a black hole, based on their own preconceptions. This is in contrast to the more empirical and agnostic approach that we take in studying (almost) everything else in physics. As an alternative, I will outline what I consider to be a physical roadmap to unravelling what lies within black holes.

Presenter: Prof. AFSHORDI, Niayesh (Perimeter Institute)

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

Symmetries of Black Hole Perturbation Theory

Tuesday, May 11, 2021 3:00 PM (1 hour)

We present novel symmetries of perturbation theory around rotating and non-rotating black holes in general relativity, and discuss their origins and implications for gravitational-wave astronomy. This is motivated by two special aspects of black hole perturbations in four dimensions: isospectrality of quasinormal modes and the vanishing of tidal Love numbers. There turn out to be off-shell symmetries underlying both of these phenomena. One is a duality, which on shell reproduces the famous Chandrasekhar duality and therefore underlies isospectrality, and can be thought of as an extension of electric-magnetic duality to black hole backgrounds. The other is an infinite set of "ladder symmetries" relating modes of different angular momentum or spin, which imply the vanishing of Love numbers. We further discuss the geometric origins of these symmetries.

Presenter: Prof. SOLOMON, Adam (Carnegie Mellon U.)

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

Black hole existence and intrinsic angular momentum in general relativity

Thursday, May 13, 2021 3:00 PM (1 hour)

In this talk , I shall report on how black hole is formed and how classical conserved quantities are defined in general relativity . These are joint works with Schoen , Mu Tao Wang , Poning Chen , and Ye Kai Wang .

Presenter: Prof. YAU, Shing-Tung (Harvard University & Tsinghua University)

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

Quantum collapse models and cosmic inflation

Tuesday, May 18, 2021 3:00 PM (1 hour)

Attempts to apply quantum collapse theories to Cosmology and cosmic inflation are reviewed. These attempts are motivated by the fact that the theory of cosmological perturbations of quantum-mechanical origin suffers from the single outcome problem, which is a modern incarnation of the quantum measurement problem, and that collapse models can provide a solution to these issues. Since inflationary predictions can be very accurately tested by cosmological data, this also leads to constraints on collapse models. These constraints are derived in the case of Continuous Spontaneous Localization (CSL) and are shown to be of unprecedented efficiency.

Presenter: Prof. MARTIN, Jerome (IAP)

Contribution ID: **59** Type: **not specified**

Minimalism in modified gravity

Tuesday, May 25, 2021 2:00 PM (1 hour)

It is generally believed that modification of general relativity inevitably introduces extra physical degree(s) of freedom. In this talk I argue that this is not the case by constructing modified gravity theories with two local physical degrees of freedom. After classifying such theories into two types, I show explicit examples and discuss their cosmology and phenomenology, such as possible amelioration of the H0 tension and stable massive gravity/bigravity cosmology.

Presenter: Prof. MUKOHYAMA, Shinji (YITP)

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

Probing high-scale new physics with modulated reheating

Tuesday, June 1, 2021 3:00 PM (1 hour)

Scalar fields with spatially varying background could modulate the reheating process, thereby leaving their imprints in the density perturbations. In this talk we discuss two scenarios using this mechanism to probe physics at very high scales. First, we introduce a "cosmological Higgs collider"where the SM-Higgs-modulated reheating allows us to discover heavy particles and to measure their Higgs couplings in the squeezed primordial bispectrum. Second, we explain that the modulated reheating can act as a "cosmic microscope"that enlarges the small-scale preheating dynamics to CMB scales, providing us a chance to learn non-perturbative dynamics of the preheating.

Presenter: Prof. XIANYU, Zhong-Zhi (Tsinghua University)

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

[Colloquium] Black Hole Thermodynamics, Then and Now

Thursday, June 17, 2021 3:00 PM (1 hour)

Presenter: Prof. WITTEN, Edward (IAS)

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

Dark Matter via inverse phase transition

Tuesday, April 6, 2021 3:00 PM (1 hour)

I will discuss a novel mechanism of Dark Matter production through an inverse phase transition. I will focus on a simple Z_2-symmetric model of Dark Matter composed of a scalar singlet. Due to couplings to other matter fields, Z_2-symmetry is spontaneously broken at very early times, and the Dark Matter field is offset from zero. As the Universe expands, Z_2-symmetry is restored, and the Dark Matter field starts oscillating around zero contributing to the pressureless fluid of the Universe. This simple picture of Dark Matter production admits multiple realisations depending on the nature of symmetry breaking couplings: purely gravitational, magnetic, or due to the interaction with the thermal bath. I will discuss phenomenological consequences in each of these cases.

Presenter: Prof. RAMAZANOV, Sabir (Prague, Inst. Phys.)

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

Indirect detection of gravitons through quantum entanglement

Tuesday, June 8, 2021 3:00 PM (1 hour)

We propose an experiment that the entanglement between two macroscopic mirrors suspended at the end of an equal-arm interferometer is destroyed by the noise of gravitons through bremsstrahlung. By calculating the correlation function of the noise, we obtain the decoherence time from the decoherence functional. We estimate that the decoherence time induced by the noise of gravitons in squeezed states stemming from inflation is approximately 20 seconds for 40 km long arms and 40 kg mirrors. Our analysis shows that observation of the decoherence time of quantum entanglement has the potential to detect gravitons indirectly. This indirect detection of gravitons would give strong evidence of quantum gravity.

Presenter: Prof. KANNO, Sugumi (Kyushu University)

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

A stringy perspective on the coincidence problem

Tuesday, June 15, 2021 3:00 PM (1 hour)

The cosmological coincidence problem is the question of why now? Why do we live at the dawn of dark energy domination, when the energy density of dark matter and dark energy are roughly comparable? In this talk, I will describe how the problem is significantly alleviated, if not entirely solved, in generic string theory models of dark energy.

Presenter: Prof. PADILLA, Antonio (Nottingham University)

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

Self-Organised Localisation

Tuesday, June 22, 2021 3:00 PM (1 hour)

We describe a new phenomenon in quantum cosmology: self-organised localisation. When the fundamental parameters of a theory are functions of a scalar field subject to large fluctuations during inflation, quantum phase transitions can act as dynamical attractors. As a result, the theory parameters are probabilistically localised around the critical value and the Universe finds itself at the edge of a phase transition. We illustrate how self-organised localisation could account for the observed near-criticality of the Higgs self-coupling, the naturalness of the Higgs mass, or the smallness of the cosmological constant.

Presenter: Prof. YOU, Tevong (CERN)

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

Probing particle physics and cosmology with cosmic strings and gravitational waves

Tuesday, June 29, 2021 3:00 PM (1 hour)

In this seminar I will present the latest research and results on cosmic strings, which are line-like defects which may be formed in spontaneous symmetry breaking phase transitions in the early universe. Such phase transitions may have occurred at grand unification energy scales, and more generally at lower scales. Through their different observational consequences —which I will discuss here —cosmic strings can therefore probe particle physics, and also cosmology, beyond the standard models, and at energy scales much above those of particle accelerators. Being highly relativistic, cosmic strings are sources of gravitational waves (GWs), and a network of cosmic strings formed in the early universe emits GWs throughout its history generating a stochastic gravitational wave background (SGWB). We discuss the shape of this spectrum, depending on the properties of the string network and also the expansion history of the universe, and the constraints which are (and will be) placed by GW detectors. Additionally, cosmic strings produce short bursts of GWs that can be searched for individually in LIGO-Virgo data, and we present the latest results from the O3 run. Finally, we discuss some other advanced and open topics, including how cosmic strings can be a possible component of dark matter.

Presenter: Prof. STEER , Daniele (APC, Paris)

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

A higher dimensional view on quantum cosmology

Tuesday, July 6, 2021 3:00 PM (1 hour)

Fundamental questions in cosmology, such as understanding the Big Bang, the cosmic hierarchy problem and boundary conditions for the wave function of the universe, should be possible to address explicitly in (toy?) models that are UV complete. Inspired from string theory I will discuss the role of extra dimensions in all these issues and show that indeed with some varying degree of precision the physics of extra dimensions provides answers. For instance; in a very natural suggestion by Banerjee et al to realise a de Sitter cosmology from string theory, I will explain how Vilenkin's tunneling wave function is selected as the unique boundary condition for the wave function of the universe.

Presenter: VAN RIET, Thomas

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

Clustered PBHs and Stellar Bubbles from the Primordial Universe

Tuesday, July 13, 2021 3:00 PM (1 hour)

We explore the possibility of strongly clustered primordial black holes (PBHs). Such clustered PBHs may be produced by multi-stream inflation. Those PBH bubbles may produce gravitational waves possibly detectable by LISA, or themselves shine with optical signals like stars. Similar clustering mechanisms may be used to study bubbles with other exotic matter such as unstable particles, domain walls, cosmic strings or monopoles.

Presenter: Prof. WANG, Yi (HKUST)

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

[Colloquium] Is Nature Natural? The Electroweak Hierarchy Problem Circa 2021

Thursday, July 15, 2021 3:00 PM (1 hour)

The discovery of the Higgs boson at the LHC marks the culmination of a decades-long quest for the final piece of the Standard Model. But the discovery of the Higgs also adds new urgency to the hierarchy problem, namely the question of why the Higgs boson is so light despite its unique quantum sensitivity to much higher energy scales. This puzzle is made all the more challenging by the lack of evidence for conventional approaches to the hierarchy problem at the LHC and other experiments. In this talk I'll discuss the essential features of the hierarchy problem and its many possible solutions —ranging from the familiar to the highly speculative —with a particular focus on recently-developed approaches that connect the hierarchy problem to cosmology in diverse ways.

Presenter: Prof. CRAIG, Nathaniel (UC, Santa Barbara)

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

Testing the expansion rate with the cosmological recombination lines and exotic physics

Tuesday, July 27, 2021 3:00 PM (1 hour)

Current measurements of the CMB anisotropies have given us unprecedented precision surrounding the standard ΛCDM model of cosmology and the parameters that make up this model. The data accrued by collaborations like Planck have even allowed us to test additional models of fundamental physics. These models have grown more recently in the context of diluting the tension between low-redshift and high-redshift measurements of the Hubble constant. With the exquisite data, we required a deeper understanding of recombination physics, particularly focused on the relationship between the electrons and the photons. Consequently, we can now calculate the distortions to the CMB black body from such an interaction. In this talk, I am going to demonstrate how we could measure these distortions in future experiments (e.g., Voyage 2050) and discuss the impact on the recombination radiation when we add exotic physics such as early dark energy or fundamental constant variations.

Presenter: Prof. HART, Luke (University of Manchester)

Contribution ID: **71** Type: **not specified**

Primordial features and non-Gaussianities as probes of fundamental physics

Tuesday, July 20, 2021 3:00 PM (1h 20m)

During the primordial universe such as the inflationary epoch, all particles with mass up to the Hubble parameter or higher are excited quantum-mechanically or classically. These particles left their imprints in the primordial density perturbations, as primordial features and non-Gaussianities, which may be probed by astrophysical observations of the large-scale structure of the universe today. These informations include the particle mass and spin spectra, and the scale factor evolutionary history a(t) of the primordial universe. The latter would provide a direct evidence for the inflation or an alternative scenario. As an example, we present an inflationary primordial feature model that can explain both the large and small-scale feature anomalies in the currently measured CMB anisotropy spectra, revealing a clip of adventurous history of the Universe during its primordial epoch and realizing some of the properties outlined above. We show how to further test such models in future experiments.

Presenter: Prof. CHEN, Xingang (Harvard, CfA)

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

[Colloquium] GW astrophysics with LIGO/VIRGO data

Thursday, September 23, 2021 3:00 PM (1 hour)

I will describe our recent work re-analyzing the GW data made public by the LIGO collaboration. More broadly I will discuss some of the outstanding questions related to binary black hole mergers, what the data might be saying and what we might expect in the near future. I will focus on what can be inferred from the spin measurements.

Presenter: Prof. ZALDARRIAGA, Matias (IAS)

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

Chemical-Potential-Assisted Particle Production in FRW Spacetimes; Uncalibrated cosmic standards (UCS) and Early-Universe-Physics Insensitive determinations of the Hubble Constant

Tuesday, September 21, 2021 3:00 PM (2 hours)

We analyze gravitational particle production assisted by chemical potential. By utilizing the uniformly smoothed Stokes-line method and Borel summation, we gain insight into the fine-grained history of enhanced particle production. Analytic/semi-analytic formulae describing the production amount, time and width are obtained for both spin-1 and spin-1/2 particles in various FRW spacetimes. Our work also serves as a concrete demonstration of the uniformly smoothed Stokes-line method applied to cosmology.

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To further investigate whether pre-recombination physics alone can resolve the Hubble tension, we explore H0 determinations that are insensitive to early-universe physics. The similarity between the two sound horizons at recombination and at the drag epoch is insensitive to early-universe physics. This allows us to relate the two horizons and treat them as free parameters. Together with Type Ia supernovae, these uncalibrated cosmic standards (UCS) robustly constrain the matter density fraction. Combining with other non-local observations, we obtain several constraints on H0 with significantly reduced sensitivity to early-universe physics, which are consistent with Planck. These results suggest that pre-recombination physics cannot fully resolve the Hubble tension.

Presenter: ., Xi Tong and Weikang Lin (Hong Kong University of Science and Technology; Tsung-Dao Lee Institute, Shanghai Jiao Tong University)

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

Probing dark energy and inflation with gravitational waves

Tuesday, September 14, 2021 3:00 PM (2 hours)

In this talk, I will summarize several recent results about gravitational wave cosmology in the context of dark energy and inflation. In the first part of the talk, I will concentrate on astrophysical gravitational waves and will argue that the spatial clustering of gravitational wave sources provides a wealth of invaluable information concerning the propagation law of gravitational waves. I will demonstrate its importance for constraining deviations from General Relativity on cosmological scales. In the second part of the talk, I will discuss gravitational waves produced during inflation and will revisit the implications of their possible near-future detection for inflationary models. I will particularly present our proposal of resonant gravitational wave production during inflation due to non-linear effects and will discuss the implications for the well-known Lyth bound. I will also present related ideas for producing induced gravitational waves and primordial black holes on small scales.

Presenter: VARDANYAN, Valeri (Kavli IPMU, University of Tokyo)

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

Understanding Cosmic Acceleration: A Question of Life, the Universe and Everything?

Tuesday, September 7, 2021 3:00 PM (1h 20m)

The cosmological constant provides a simple explanation for the observed late-time accelerated expansion of our Universe. Our lack of understanding of it, however, motivates the exploration of alternative explanations such as a modification of General Relativity at cosmological scales. I will first discuss how gravitational wave observations have severely challenged that concept. I will then present a new self-tuning mechanism that provides a simple toy model to simultaneously solve both the old and new aspects of the cosmological constant problem. A possible signature of this mechanism is the variation of fundamental constants across different spacetime regions. I will briefly present new tools that can be used with forthcoming nonlinear cosmological data in the search for New Physics. Finally, I will explore the Emergence of Life across a potential multiverse as an approach to a deeper understanding of the fundamental parameters and laws of our own observable Universe.

Presenter: LOMBRISER, Lucas (University of Geneva)

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

Small scale signatures of non-trivial inflationary and post-inflationary dynamics

Tuesday, August 31, 2021 3:00 PM (1h 20m)

The primordial scalar power spectrum is well constrained over large scales, essentially by the observations of the anisotropies in the cosmic microwave background. However, the current bounds on the scalar power spectrum over small scales are considerably weaker. During the last few years, there has been an interest in examining scenarios which generate enhanced scalar power on small scales and lead to significant production of primordial black holes as well as induce secondary gravitational waves (GWs) of possibly detectable amplitudes. In this talk, I shall first outline some of the inflationary scenarios we have examined in this context. Thereafter, I shall describe the scalar bispectrum arising in such scenarios in single field models of inflation and discuss the corresponding imprints on the spectral density of secondary GWs. I shall then illustrate the difficulty in generating enhanced power on small scales from squeezed initial states. Lastly, I shall highlight the manner in which non-trivial post-inflationary dynamics can leave telltale imprints on the spectral density of primary GWs at small scales.

Presenter: SRIRAMKUMAR, Lakshmanan (Indian Inst. of Tech., Madras)

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

Beyond the WIMP paradigm

Tuesday, April 12, 2022 3:00 PM (1h 20m)

Weakly-interacting massive particle (WIMP) has been the leading paradigm of dark matter for decades. Still, experimental searches for non-gravitational signatures of WIMPs have not found any positive evidence yet. It motivates us to think about new search strategies and novel dark matter models.
My talk consists of the two directions looking beyond WIMP. First, I will introduce an effective field theory of superfluid helium. Developing the effective field theory is the first step of a project to build a dark matter direct detection detector using superfluid helium to search for sub-GeV mass dark matter. Then, in the other part of my talk, I will outline a new paradigm, where dark matter is made up of a novel form of matter, called "gapped continuum", rather than an ordinary particle.

Presenter: XUE, Wei (Florida U.)

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

Testing the cosmological principle

Tuesday, January 18, 2022 3:00 PM (1h 20m)

Our local Universe is anisotropic. On the contrary the CMB indicates that the early Universe was isotropic. A convergence between the two is expected in the standard model of cosmology. In this talk, I explore various observational probes to search for the cross-over between these two domains.

Presenter: MOHAYAEE, Roya (Paris, Inst. Astrophys.)

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

Influence Through Mixing: Hotspots as Benchmarks for Black Hole Behaviour

Tuesday, August 10, 2021 3:00 PM (1h 20m)

Effective theories are being developed for quantum fields outside black holes, often with an unusual open system feel due to the influence of large number of degrees of freedom lying out of reach beyond the horizon. The absence of comparisons to simpler systems that share these features complicates the interpretation of what is found. This talk describes a simple model aimed to help remedy this, that involves a single external scalar field that mixes in a limited region of space with a large number of hot internal degrees of freedom. Since the model is at heart gaussian it can be solved explicitly, and correlation functions computed for the external field once the others are traced out. The results can be compared with various approximations, such as perturbative and resummed open-system calculations, to test their efficacy, and predictions can be made for the response of external qubit probes and for the evolution and decoherence of the external field itself.

Presenter: Prof. BURGESS, Cliff (McMaster University, Perimeter Institute)

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

On the assumptions leading to the information loss paradox

Tuesday, August 3, 2021 3:00 PM (1h 20m)

The information loss paradox is usually stated as an incompatibility between general relativity and quantum mechanics. However, the assumptions leading to the problem are often overlooked and, in fact, a careful inspection of the main hypothesises suggests a radical reformulation of the problem. Indeed, I will present a thought experiment that shows the existence of an incompatibility between (i) the validity of the laws of general relativity to describe infalling matter far from the Planckian regime, and (ii) the so-called central dogma which states that as seen from an outside observer a black hole behaves like a quantum system whose number of degrees of freedom is proportional to the horizon area. We critically revise the standard arguments in support of the central dogma, and argue that they cannot hold true unless some new physics is invoked even before reaching Planck scales. This leads to the counterintuitive result that the information loss problem, in its current formulation, is not necessarily related to any loss of information or lack of unitarity. Semiclassical general relativity and quantum mechanics can be perfectly compatible before reaching the final stage of the black hole evaporation where, instead, a consistent theory of quantum gravity is needed to make any prediction.

Presenter: Prof. DI FILIPPO, Francesco (YITP, Kyoto)

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

[Colloquium] Determining the Universe's Initial Conditions

Thursday, February 24, 2022 4:00 PM (1h 20m)

Observations of the cosmic microwave background and measurements of the large-scale structure of the universe have revealed the initial fluctuations that grew to form galaxies. I will review measurements showing that these fluctuations were Gaussian random phase and that the basic properties of the universe appear to be described by the Lambda Cold Dark Matter model. I will report recent results from the Atacama Cosmology Telescope that probe not only the initial conditions but also map the integrated matter density, integrated pressure and integrated electron monentum through gravitational lensing and the Sunyaev-Zel'dovich Effects. I will then discuss the use of machine learning techniques to enable rapid forward modeling of the universe and discuss how these can be used in the coming years to recover the initial conditions from observations of large-scale structure.

Presenter: SPERGEL, David (Flatiron Institute & Princeton University)

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

[colloquium] Cosmology from the Moon: two concepts to explore

Thursday, December 2, 2021 2:00 PM (1h 20m)

I will review the prospects for future progress in cosmology. I will give examples of two futuristic experiments. One can obtain the dark ages signature via low frequency radio astronomy on the lunar far side. Attainable angular resolution potentially opens up huge numbers of modes to provide a new and robust probe of inflationary cosmology. A second direction involves a far infrared telescope to search for the elusive deviations from the blackbody spectrum of the cosmic microwave background. This could provide an unprecedented probe of the Universe in its first hundred thousand years. Both concepts could be implemented in future decades via lunar observatories.

Presenter: SILK, Joseph (IAP / JHU / BIPAC, Oxford)

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

Unlocking Dark Matter Physics out of Astrophysical Data Sets

Tuesday, October 12, 2021 3:00 PM (1h 20m)

Cosmological observations and galaxy dynamics seem to imply that 84% of all matter in the universe is composed of dark matter, which is not accounted for by the Standard Model of particles. The particle nature of dark matter is one of the most intriguing puzzles of our time.
The wealth of knowledge which is and will soon be available from astrophysical surveys will reveal new information about our universe. I will discuss how we can use new and complementary data sets to improve our understanding of the particle nature of dark matter both at large and small scales.

Presenter: DVORKIN, Cora (Harvard University)

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

Solving the dark matter problem with new gravitational degrees of freedom

Tuesday, January 25, 2022 3:00 PM (1h 20m)

In this talk, I will discuss how a newly proposed gravitational theory (arXiv: 2007:00082) could lead to a solution for the dark matter problem by reducing to Milgrom's Modified Newtonian Dynamics at the scale of galaxies and to the LambdaCDM model on cosmological scales. I will show that it (i) leads to correct gravitational lensing on galactic scales, (ii) propagates tensor modes at the speed of light, and (iii) gives excellent fits to the Cosmic Microwave Background anisotropies and the large-scale structure power spectrum.

Presenter: SKORDIS, Constantinos (CEICO, Institute of Physics of the Czech Academy of Sciences)

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

Testing the equivalence principle on cosmological scales

Tuesday, December 7, 2021 3:00 PM (1h 20m)

The weak equivalence principle is one of the cornerstones of general relativity. Its validity has been tested with impressive precision in the Solar System, with experiments involving baryonic matter and light. However, on cosmological scales and when dark matter is concerned, the validity of this principle is still unknown. In this talk I will show how relativistic effects in the large-scale structure can be used to test whether dark matter obeys the weak equivalence principle. I will present forecasts for this new test of gravity for future surveys like the SKA.

Presenter: BONVIN, Camille (Geneva U.)

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

A New Era of Precision Cosmology using Multi-Messenger Observations

Tuesday, November 30, 2021 3:00 PM (1h 20m)

The discovery of astrophysical gravitational waves has opened a new avenue to explore the cosmos. I will discuss a few new frontiers in the field of physical cosmology and fundamental physics that can be explored using the LIGO-Virgo-KAGRA network of gravitational wave detectors. I will elucidate how the synergies between electromagnetic probes and gravitational wave probes will play a key role in developing a data-driven model of cosmology in the near future.

Presenter: MUKHERJEE, Suvodip (Perimeter Inst. Theor. Phys.)

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

Dark matter, pulsars, and the Galactic Center Gamma-Ray Excess

Thursday, November 18, 2021 3:00 PM (1h 20m)

A bright and statistically significant flux of GeV-scale gamma rays has been detected from the region surrounding the Galactic Center. While the spectrum, angular distribution, and intensity of this signal is consistent with the predictions of annihilating dark matter matter particles, it has also been suggested that these gamma rays could potentially be produced by a large population of millisecond pulsars. In this talk, I'll review the arguments for each of these interpretations, and discuss the current status of the hunt for dark matter particles using gamma-ray telescopes.

Presenter: HOOPER, Dan (Fermi Lab & U. of Chicago)

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

Testing gravity on all scales

Tuesday, November 16, 2021 3:00 PM (1h 20m)

Recent years have seen great progress in probing gravitational physics on a vast range of scales, from the very largest cosmological scales to the microscopic ones associated with high energy particle physics. In this talk I will focus on how we can use these different systems synoptically to learn more about dark energy. Specifically, I will discuss the interplay of dark energy constraints from the following systems: gravitational waves emitted by binary systems, the cosmic microwave background, large scale structure, and (theoretical) bounds on the behaviour of gravity on scales inaccessible to current experiments.

Presenter: NOLLER, Johannes (University of Portsmouth & University of Cambridge)

Contribution ID: **91** Type: **not specified**

Ultra-light dark matter: the light and fuzzy side of dark matter

Among the many possible candidates for the nature of dark matter, one of the most well-motivated class of models and leading candidate is the ultra-light dark matter. This class represents the lightest possible dark matter candidates, and exhibits a wave-like behavior on galactic scales. This leads to a rich phenomenology on small scales that can potentially not only reconcile the CDM picture with the small scale behavior of dark matter, but offer us the unique possibility to probe their distinctive predictions, and imprints that can reveal clues about the internal properties of dark matter. In this talk, I will review this class of models, describing and classifying the different constructions and their phenomenology. I will give special attention to the fuzzy dark matter, which is the simplest and most studied of these models. Given their vast cosmological and astrophysical effects on observables, I will describe the ongoing advances in constraining these models using current gravitational tests, and highlight the strong constraining power of small scale astrophysical observations. I will show the latest constraints and how with this we are narrowing down the mass range available for these models.

Presenter: FERREIRA, Elisa (Max Planck Institute for Astrophysics)

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

A new test of the Cosmological Principle: measuring our peculiar velocity and the large-scale anisotropy independently

Tuesday, November 2, 2021 2:00 PM (1h 20m)

I shall present a novel approach to disentangle two key contributions to the largest-scale anisotropy of the galaxy distribution: (i) the intrinsic dipole due to clustering and anisotropic geometry, and (ii) the kinematic dipole due to our peculiar velocity. Including the redshift or angular size of galaxies, in addition to their fluxes and positions allows us to measure both the direction and amplitude of our velocity independently of the intrinsic dipole of the source distribution. This method enables two simultaneous tests of the Cosmological Principle: comparing the observations of our peculiar velocity with the CMB dipole, and testing for a significant intrinsic anisotropy on large scales which indicates effects beyond the standard cosmological model. I shall discuss the prospects of this new method for future galaxy surveys like LSST and Euclid (with galaxy redshifts) or SKA (with galaxy sizes).

Presenter: DURRER, Ruth (Université de Genève)

Contribution ID: **94** Type: **not specified**

Some Ideas about Cosmic Structure on the Smallest Scales

Tuesday, October 19, 2021 3:00 PM (1h 20m)

The present day distribution of dark matter on scales smaller than the mass scale of dwarf galaxies contain a wealth of information on the early history of the early universe as well as the nature of dark matter. This distribution is not reflected in the distribution of gas and stars because the amplitude of dark matter inhomogeneities on these scales are constrained to have little effect on these baryonic tracers. Yet the remnants of the smallest scale dark matter structure surround us, perhaps in the form of dark matter "microhalos". This talk will focus on two ideas related to the smallest scale dark matter structures:
1) what are the remnants of the gravitationally bound structures which may have existed during an early phase of matter domination
2) detecting the inevitable small inhomogeneities in ultra-light dark matter required by the uncertainty principle

Presenter: STEBBINS, Albert (University of Chicago)

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

Tension in the Hubble Constant: Is There a Crisis in Cosmology?

Thursday, October 28, 2021 3:00 PM (1h 20m)

An important and unresolved question in cosmology today is whether there is new physics that is missing from our current standard Lambda Cold Dark Matter (LCDM) model. Recent measurements of the Hubble constant, Ho – based on Cepheids and Type Ia supernovae (SNe) – are discrepant at the 4-5-sigma level with values of Ho inferred from measurements of fluctuations in the cosmic microwave background (CMB). The latter assumes LCDM, and the former assumes that systematics have been fully accounted for. If real, the current discrepancy could be signaling a new physical property of the universe. I will present new results based on an independent calibration of SNe Ho based on measurements of the Tip of the Red Giant Branch (TRGB). The TRGB marks the luminosity at which the core helium flash in low-mass stars occurs and provides an excellent standard candle. Moreover, the TRGB method is less susceptible to extinction by dust, to metallicity effects, and to crowding/blending effects than Cepheid variable stars. I will address the current uncertainties in both the TRGB and Cepheid distance scales, as well as discuss the current tension in Ho and whether there is need for additional physics beyond the standard LCDM model.

Presenter: FREEDMAN, Wendy (The University of Chicago)

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

Emergent Cosmology from the BFSS Matrix Model

Friday, October 1, 2021 3:00 PM (1h 20m)

The BFSS matrix model is a proposed non-perturbative definition of M-theory in which space is emergent. In this talk, I shall present a new paradigm of early-universe cosmology in the context of the BFSS theory. Specifically, I will show that matrix theory leads to an emergent non-singular cosmology which, at late times, can be described by an expanding phase of Standard Big Bang cosmology. Crucially, the thermal fluctuations in the emergent phase source an approximately scale-invariant spectrum of scalar perturbations and a scale-invariant spectrum of gravitational waves. Hence, this model leads to a successful scenario for the origin of perturbations responsible for the currently observed structure in the universe while providing a consistent UV-complete description.

Presenter: BRAHMA, Suddhasattwa (U. Edinburgh)

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

Gauge invariant formulation of the induced gravitational waves

Friday, October 8, 2021 3:00 PM (1h 40m)

The gauge dependence of the second order induced gravitational waves are widely recognized issue since GWs should be physical observable. While there have been several studies about the gauge dependence, I will talk about a new idea to solve the issue. I revisited the definition of nonlinear tensor modes and their gauge transformation from a covariant perspective and find a way to properly define the gauge invariant energy density of the induced GWs.

Presenter: OTA, Atsuhisa (Hong Kong University of Science and Technology)

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

Coupled Early Dark Energy

Wednesday, February 23, 2022 3:00 PM (1h 20m)

I will describe how some of the fine-tuning problems of the early dark energy solution to the Hubble tension can be addressed using couplings to other fields already present in cosmology. I will discuss the formulation, the cosmology, and the constraints on such models, arising from both observational and theoretical considerations.

Presenter: TRODDEN, Mark (University of Pennsylvania)

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

Covariant formulation of non-equilibrium thermodynamics in General Relativity: Cosmic Acceleration from First Principles

Tuesday, February 15, 2022 3:00 PM (1h 20m)

Presenter: GARCIA-BELLIDO, Juan

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

The Hubble tension and new physics at the eV scale: The path to New Early Dark Energy

Tuesday, March 1, 2022 3:00 PM (1h 20m)

I will discuss the possibility that the Hubble tension is the signature of a fast triggered phase transition in the dark sector. Such a phase transition is called New Early Dark Energy (NEDE) and must have taken place just before recombination at the eV scale to resolve the tension fully. After discussing the cosmological NEDE phase transition, I will discuss the details of possible particle physics realizations.

Presenter: SLOTH, Martin (CP3, University of Southern Denmark)

Contribution ID: **103** Type: **not specified**

Wave dark matter

Thursday, January 27, 2022 3:00 PM (1h 20m)

We will discuss the possibility that dark matter is composed of sufficiently light particles that it effectively behaves as a collection of waves. We will review the particle physics motivations and the rich wave phenomenology, and discuss the implications for astronomical observations and experimental detection.

Presenter: HUI, Lam (Columbia University)

Contribution ID: **104** Type: **not specified**

Aspects of Light Scalar Dark Matter

Wednesday, February 2, 2022 3:00 PM (1h 20m)

I discuss various aspects of very light scalar dark matter, including axions. I begin by reviewing the properties of light scalar dark matter in superfluid condensates, and the relation to classical field theory. I review how such condensates are spatially localized clumps, which may be present in the galaxy. I then discuss the interesting possibility of parametric resonance of scalar axion clumps into electromagnetic waves, after mergers, which may leave an astrophysical signature. I also critically examine whether ultra-light scalars can resolve the core-cusp problem at the center of galaxies. I discuss the rate of decoherence of dark matter scalars that are in non-trivial quantum states. Finally, I examine the theoretical consistency of scalar dark matter models with non-standard interactions that address novel galactic features.

Presenter: HERTZBERG, Mark (Tufts University)

Contribution ID: **105** Type: **not specified**

Primordial gravitational waves boosted by the axion

Tuesday, February 8, 2022 3:00 PM (1h 20m)

I will discuss how early dynamics of the axion can naturally induce a matter-kination era inside the standard radiation era. The matter-kination era imprints a smoking-gun gravitational-wave peak on the irreducible inflationary GW background as well as on the local/global cosmic-string gravitational-wave background, whose position depends on kination's energy scale and duration. Remarkably, the viable parameter space allows for a kination era at the MeV-EeV scale and generates a gravitational-wave peak which lies inside LISA, as well as ET, and CE sensitivity windows. Future GW observatories will thus offer a new window on axion models.

Presenter: SERVANT, Geraldine (DESY & Universität Hamburg)

Contribution ID: **106** Type: **not specified**

Probing the Early Universe with Gravitational Waves

Tuesday, March 8, 2022 3:00 PM (1h 20m)

Presenter: FASIELLO, Matteo (Madrid, IFT & ICG, Portsmouth)

Contribution ID: **107** Type: **not specified**

Ghosts without Runaway

Tuesday, March 15, 2022 2:00 PM (1h 20m)

I will discuss our recent work Phys.Rev.Lett. 128 (2022) 4, 041301 in which we present a simple class of mechanical models where a canonical degree freedom interacts with another one with a negative kinetic term, i.e., with a ghost. We prove analytically that the classical motion of the system is completely stable for all initial conditions, notwithstanding that the conserved Hamiltonian is unbounded from below and above. Numerical computations fully supported this. Systems with negative kinetic terms often appear in modern cosmology, quantum gravity, and high energy physics and are usually deemed as unstable. Our result demonstrates that for mechanical systems this common lore can be too naïve and that living with ghosts can be stable.

Presenter: VIKMAN, Alexander (CEICO, Institute of Physics of the Czech Academy of Sciences)

Contribution ID: **108** Type: **not specified**

[colloquium] The Route from Black-Hole Singularities to a Cyclic Cosmology

Thursday, March 17, 2022 2:00 PM (1h 20m)

The "singularity theorems"of the 1960s, demonstrated that large enough celestial bodies, or collections of such bodies, would, collapse gravitationally, to singularities, where the equations and usual assumptions of Einstein's classical theory of general relativity cannot be mathematically continued. These singularities are normally expected to lie deep within what are now referred to as black holes, and would, themselves, not be observable from the outside. Nevertheless, their presence is fundamentally problematic for classical physics and it is normally argued that a quantum theory of gravity would be needed to resolve the issue.

Similar arguments (developed largely by Stephen Hawking) apply to the "Big-Bang"picture of the origin of the universe, showing, again, the inevitability of a singularity in the universe's initial state. However, a puzzling yet fundamental distinction between these two types of singularity is found, deeply connected with the 2nd law of thermodynamics. Accordingly, it is hard to see how any ordinary procedures of "quantization"of the gravitational field can resolve this fundamental problem. A possible route to addressing this issue, namely to "gravitize"quantum mechanics, aimed at providing an objective theory of wave-function collapse, will be briefly discussed.

Nevertheless, a deeper understanding of the special nature of the Big Bang can be illuminated by examining it from the perspective of conformal geometry, according to which the Big-Bang singularity becomes non-singular, this being quite different from the situation arising from the singularities in black holes. In conformal geometry, big and small become equivalent, which can only hold for a singularity of the type we seem to find at the Big Bang. This situation is also relevant in relating the extremely hot and dense Big Bang to the extremely cold and rarefied remote future of a previous "cosmic aeon", leading to the picture of conformal cyclic cosmology (CCC) according to which our Big Bang is viewed as the conformally continued remote future of a previous cosmic aeon. It turns out that there are now certain strong observational signals, providing some remarkable support for this highly non-intuitive but mathematically consistent CCC picture.

Presenter: PENROSE, Sir Roger (University of Oxford)

Contribution ID: **109** Type: **not specified**

Null Surface Thermodynamics

Tuesday, March 22, 2022 2:00 PM (1h 20m)

We study D dimensional pure Einstein gravity theory in a region of spacetime bounded by a generic null boundary. We show besides the graviton modes propagating in the bulk, the system is described by boundary degrees of freedom labeled by D surface charges associated with nontrivial diffeomorphisms at the boundary. We establish that the system admits a natural thermodynamical description. Using standard surface charge analysis and covariant phase space method, we formulate laws of null surface thermodynamics which are local equations over an arbitrary null surface. This thermodynamical system is generally an open system and can be closed only when there is no flux of gravitons through the null surface. Our analysis extends the usual black hole thermodynamics to a universal feature of any area element on a generic null surface in a generic diffeomorphism invariant theory of gravity.

Presenter: JABBARI, Shahin Sheikh (IPM, Iran)

Contribution ID: **110** Type: **not specified**

The enigma of the largest cosmic structures: mapping the CMB Cold Spot region with the Dark Energy Survey

Tuesday, March 29, 2022 3:00 PM (1h 20m)

The Cold Spot is a puzzling large-scale feature in the Cosmic Microwave Background temperature maps and its origin has been subject to active debate. As an important foreground structure at low redshift, the Eridanus supervoid was recently detected, but it was subsequently determined that, assuming the standard LCDM model, only about 10-20% of the observed temperature depression can be accounted for via its Integrated Sachs-Wolfe imprint. However, R > 100 Mpc/h supervoids elsewhere in the sky have shown ISW imprints about 5 times stronger than expected from LCDM, which warrants further inspection. Using the Year-3 redMaGiC catalogue of luminous red galaxies from the Dark Energy Survey, our new analysis confirmed the detection of the Eridanus supervoid as a significant under-density in the Cold Spot's direction at z < 0.2. The DES Year-3 data also revealed, with S/N > 5 significance, that the Eridanus supervoid appears as the most prominent large-scale under-density in the dark matter mass maps reconstructed from gravitational lensing data. While we report no significant anomalies, an interesting aspect is that the amplitude of the lensing signal from the Eridanus supervoid at the Cold Spot centre is about 30% lower than expected from similar peaks found in N-body simulations based on the standard LCDM model. Overall, the new DES Y3 results confirm the causal relation between these individually rare structures in the cosmic web and in the CMB. Yet, the observed dimensions of the Eridanus supervoid cannot fully account for the Cold Spot's deep temperature depression if the standard model of dark energy is assumed in the calculations; the full explanation would require an even stronger dark energy component to cause faster expansion and a less clumpy Universe at late times. In this talk, I will also describe how the ISW analysis of supervoids in the more distant Universe, probed by eBOSS quasars, may also help to understand the core of this long-standing problem in cosmology.

Presenter: KOVÁCS, Andras (IAC & La Laguna)

Contribution ID: **111** Type: **not specified**

Detection of Cosmological 21 cm Emission with CHIME

Tuesday, April 5, 2022 3:00 PM (1h 20m)

Intensity mapping of the 21 cm emission line from neutral hydrogen (HI) is a promising method to efficiently map the large-scale structure of the Universe out to high redshift. The Canadian Hydrogen Intensity Mapping Experiment (CHIME) is a radio interferometer specifically designed for this purpose. CHIME recently reported the detection of 21 cm emission from large-scale structure between redshifts 0.8 and 1.4. This was achieved by stacking maps of the radio sky, constructed from 102 nights of CHIME data, on the angular and spectral locations of luminous red galaxies, emission line galaxies, and quasars from the eBOSS clustering catalogs. In this talk, I will introduce the experiment and provide an overview of the detection. I will describe key aspects of the both the data processing pipeline and the simulation pipeline used to model the stacked signal. I will discuss the implications of the detection. Finally, I will evaluate the prospects for using CHIME to measure the power spectrum of 21 cm emission, identify the signature of baryon acoustic oscillations, and constrain dark energy.

Presenter: SIEGEL, Seth (McGill U.)

Contribution ID: **113** Type: **not specified**

Going beyond linear perturbations in Cosmology

Tuesday, April 19, 2022 3:00 PM (1h 20m)

The standard approach to cosmological observables involves a homogeneous and isotropic background model on top of which small linear perturbations are considered. While the need to go beyond this first-order approach is universally recognized when dealing with cosmic structures, there are several other consequences of “going beyond linearity” which have become an important tool in cosmological analyses during the last 20-30 years and others which are still poorly explored. In this talk, I will review several examples of deviations from linearity, such as: production of primordial non-Gaussian signals, production of gravitational waves and magnetic fields out of scalar density fluctuations, production of density perturbations out of gravitational waves, as well as non-vanishing cross-correlations among seemingly independent observables.

Presenter: MATARRESE, Sabino (University of Padua)

Contribution ID: **114** Type: **not specified**

Binary systems as gravitational wave detectors

Tuesday, April 26, 2022 3:00 PM (1h 20m)

The passage of gravitational waves (GWs) through a binary perturbs the trajectories of the two bodies, potentially causing observable changes to their orbital parameters. In the presence of a stochastic GW background (SGWB) these changes accumulate over time, causing the binary orbit to execute a random walk through parameter space. In this talk I will present a new formalism for calculating the full statistical evolution of a generic binary system in the presence of a SGWB, capturing all six of the binary's orbital parameters. I will show how this formalism can be applied to timing of binary pulsars and lunar laser ranging, thereby setting novel upper limits on the SGWB spectrum in a frequency band that is currently inaccessible to all other GW experiments.

Presenter: BLAS, Diego (UAB-IFAE)

Contribution ID: **115** Type: **not specified**

Cosmological tensions

Tuesday, May 3, 2022 3:00 PM (1h 20m)

After introducing the standard model of cosmology and its parameters, I will discuss two important tensions between early and late-time measurements, namely the H0 tension and the sigma8 tension. Considering a small late-time deviation of the standard model, I will drive fully analytical conditions that any late-time dark energy model has to satisfy in order to solve both tensions simultaneously (see arxiv:2201.11623).

Presenter: HEISENBERG, Lavinia (Zurich, ETH and U. Heidelberg, ITP)

Contribution ID: **116** Type: **not specified**

[colloquium] "Observational Signatures of Quantum Gravity?"

Thursday, April 21, 2022 3:00 PM (1h 20m)

Utilizing toy models from AdS/CFT to fluid gravity, we consider whether non-perturbative effects in near-horizon states of quantum gravity could give rise to effects in the infrared, that are possibly observable in terrestrial experiments.

Presenter: ZUREK, Kathryn (Caltech)

Contribution ID: **117** Type: **not specified**

Isotropisation in the approach to a singularity

Monday, October 25, 2021 3:00 PM (1h 20m)

In the approach to a singularity in general relativity, spacetime often becomes largely shear dominated and highly anisotropic. Any speculative cosmological scenario with a contracting phase prior to a Big Bounce must therefore address the issue of large anisotropies. In this talk, I will review this anisotropy problem and the status of isotropisation mechanisms in this context, which involve, e.g., modified gravity or non-perfect fluids. An emphasis will be given on the latter, in light of the recent work arXiv:2109.11701 [gr-qc].

Presenter: QUINTIN, Jerome (Albert Einstein Institute)

Contribution ID: **118** Type: **not specified**

Ultra-light dark matter: the light and fuzzy side of dark matter

Friday, November 12, 2021 2:00 PM (1h 20m)

Among the many possible candidates for the nature of dark matter, one of the most well-motivated class of models and leading candidate is the ultra-light dark matter. This class represents the lightest possible dark matter candidates, and exhibits a wave-like behavior on galactic scales. This leads to a rich phenomenology on small scales that can potentially not only reconcile the CDM picture with the small scale behavior of dark matter, but offer us the unique possibility to probe their distinctive predictions, and imprints that can reveal clues about the internal properties of dark matter. In this talk, I will review this class of models, describing and classifying the different constructions and their phenomenology. I will give special attention to the fuzzy dark matter, which is the simplest and most studied of these models. Given their vast cosmological and astrophysical effects on observables, I will describe the ongoing advances in constraining these models using current gravitational tests, and highlight the strong constraining power of small scale astrophysical observations. I will show the latest constraints and how with this we are narrowing down the mass range available for these models.

Presenter: FERREIRA, Elisa (Max Planck Institute for Astrophysics)

Contribution ID: **119** Type: **not specified**

Consistency conditions and primordial black holes in single field inflation

Friday, November 26, 2021 3:00 PM (1h 20m)

In single field inflationary models that are capable of generating primordial black hole (PBH) populations, the power spectrum of curvature perturbation has interesting universal features such as the presence of a pronounced dip, occurring at scales much larger than the peak responsible for PBH formation. Focusing on the analytic framework of gradient expansion formalism, I will first discuss the soft-limits of three and four point function of the curvature perturbation around the dip feature to show that they satisfy consistency conditions, connecting their amplitudes and scale dependence to the global enhancement in the power spectrum and to its slope, respectively. Utilizing these robust consistency relations, I will then discuss how the scale dependence of the non-Gaussianities leads to characteristic features in mu distortions anisotropies, providing a distinctive window of PBH forming inflationary scenarios that can be tested using well understood CMB physics.

Presenter: OZSOY, Ogan (CEICO @ Institute of Physics, Czech Academy of Sciences)

Contribution ID: **122** Type: **not specified**

Testing inflation with small-scale anisotropies

Thursday, December 16, 2021 3:15 PM (1h 20m)

Inflation predicts a stochastic background of gravitational waves. In this talk I will discuss how anisotropies in the gravitational wave energy density can be a powerful tool in characterizing the inflationary gravitational wave background and potentially distinguishing it from backgrounds due to other sources.

Presenter: DIMASTROGIOVANNI, Ema (Groningen U. and New South Wales U.)

Contribution ID: **123** Type: **not specified**

Euclidean path integral, entanglement entropy, and information loss paradox; Cutting Rule for Cosmological collider Signals: A Bulk Evolution Perspective

Thursday, January 13, 2022 2:00 PM (1h 20m)

In this presentation, we discuss the information loss paradox of black holes in the light of the Euclidean path integral approach. This provides an interesting idea to understand the entanglement entropy and the Page curve. In order to make the discussion better, perhaps we further need to provide some quantum boundary conditions for the singularity. Finally, we compare our results to the recent developments in the string community.

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We show that the evolution of interacting massive particles in the de Sitter bulk can be understood at leading order as a series of resonant decay and production events. From this perspective, we classify the cosmological collider signals into local and nonlocal categories with drastically different physical origins. This further allows us to derive a cutting rule for efficiently extracting these cosmological collider signals in an analytical fashion. Our cutting rule is a practical way for extracting cosmological collider signals in model building, and can be readily implemented as symbolic computational packages in the future.

Presenter: ., Dong-han Yeom; Yuhang Zhu (Pusan National University; Hong Kong University and Technology)

Contribution ID: **124** Type: **not specified**

Pulsar hints for nanohertz gravitational waves?

Thursday, February 10, 2022 2:00 PM (1h 20m)

All major pulsar timing array (PTA) collaborations—NANOGrav, PPTA, EPTA, and IPTA—are now seeing indications of a new stochastic process in their latest data sets. If confirmed in the future, this new signal may turn out to be the first glimpse of a stochastic gravitational-wave background (GWB) at nanohertz frequencies. In this talk, I will review how PTAs search for gravitational waves and outline the properties of the newly detected signal. In particular, I will discuss why we cannot yet claim the detection of a GWB and which future steps will be necessary in order to finally reach this goal. In addition, I will highlight various possible interpretations of the signal, including supermassive black-hole binaries on the astrophysical side as well as various new-physics scenarios on the cosmological side, such as cosmological phase transitions and cosmic strings. Finally, I will conclude with a brief outlook on the future of the field, which is set to see some amazing progress in the coming years.

Presenter: SCHMITZ, Kai (CERN)

Contribution ID: **125** Type: **not specified**

[Colloquium]

Presenter: BRANDENBERGER, Robert

Contribution ID: **126** Type: **not specified**

Primordial Black Holes in the era of Gravitational Wave Astronomy

Tuesday, May 10, 2022 3:00 PM (1h 20m)

We will discuss the state of the art of primordial black holes in view of the gravitational wave current and future measurements.

Presenter: RIOTTO, Antonio (University of Geneva)

Contribution ID: **127** Type: **not specified**

On the kinematic cosmic dipole tension

Tuesday, May 17, 2022 3:00 PM (1h 20m)

Our motion through the Universe generates a dipole in the temperature anisotropies of the Cosmic Microwave Background (CMB) and also in the angular distribution of sources. If the cosmological principle is valid, these two dipoles are directly linked, such that the amplitude of one determines that of the other. However, it is a longstanding problem that number counts of radio sources and of quasars at low and intermediate redshifts exhibit a dipole that is well aligned with that of the CMB but with about twice the expected amplitude, leading to a tension reaching up to 4.9sigma. In this talk, I revisit the theoretical derivation of the dipole in the sources number counts, explicitly accounting for the redshift evolution of the population of sources. I will argue that if the spectral index and magnification bias of the sources vary with redshift, the standard theoretical description of the dipole may be inaccurate. I will provide an alternative expression which does not depend on the spectral index, but instead on the time evolution of the population of sources. I then determine the values that this evolution rate should have in order to remove the tension with the CMB dipole.

Presenter: DALANG, Charles (University of Geneva)

Contribution ID: **128** Type: **not specified**

The Effective Theory of Gravity and Dynamical Vacuum Energy

Tuesday, May 24, 2022 5:00 PM (1h 20m)

Gravity and general relativity are considered as an Effective Field Theory (EFT) at low energies and macroscopic distance scales. The effective action of the conformal trace anomaly of light or massless quantum fields has significant effects on macroscopic scales, owing to its describing light cone singularities not captured by an expansion in local curvature invariants. A compact local form for the Wess-Zumino effective action of the conformal anomaly and stress tensor is given, involving the introduction of a new light scalar, which it is argued should be included in the low energy effective action for gravity. This scalar conformalon couples to the conformal part of the spacetime metric and allows the effective value of the vacuum energy, described as a condensate of a 4-form abelian gauge field, to change in space and time. The EFT of vacuum energy thereby replaces the fixed constant Lambda of the classical theory with a dynamical condensate whose natural ground state value in empty flat space is Lambda_eff = 0 identically. In addition to the conformal anomaly, the principal physical inputs to the EFT are a topological vacuum susceptibility characterizing the coupling of the 4-form condensate to the anomaly current, in analogy to the chiral susceptibility of QCD, and the extension of the fermion anomaly to a general Einstein-Cartan space including torsion. By allowing Lambda_eff to vary rapidly near a black hole horizon, the EFT of dynamical vacuum energy provides an effective Lagrangian framework for gravitational condenstate stars, as the final state of complete gravitational collapse consistent with quantum theory. Possible consequences of dynamical vacuum dark energy in cosmology, the cosmic coincidence problem, and the role of conformal invariance for other fine tuning issues in the Standard Model will be discussed if time allows.

Presenter: MOTTOLA, Emil (Univ. of New Mexico)

Contribution ID: **129** Type: **not specified**

Cosmological constant problem on the horizon

Tuesday, May 31, 2022 4:00 PM (1h 20m)

We revisit the quantum cosmological constant problem and highlight the important roles played by the dS horizon of zero-point energy. We argue that fields which are light enough to have dS horizons of zero-point energy comparable to the FLRW Hubble radius are the main contributors to dark energy. On the other hand, the zero-point energy of heavy fields develop strong nonlinearities on sub-Hubble scales and can not contribute to dark energy. We speculate how this proposal can solve the old and new cosmological constant problems. We further speculate if the zero-point energy of heavy fields can provide the seeds of dark matter.

Presenter: FIROUZJAHI , Hassan (IPM, Tehran)

Contribution ID: **130** Type: **not specified**

Adventures in gravitational-wave astronomy: Testing for hair, memory, and eccentricity

Tuesday, June 7, 2022 2:00 PM (1h 20m)

Since the first gravitational-wave detection of a binary black hole merger in 2015, the LIGO-Virgo-KAGRA collaboration have observed gravitational waves from almost 100 merging systems. That number is expected to increase significantly over the coming years as these experiments become even more sensitive. The increased number of detections, and the improved sensitivity of these instruments, allows us to probe the ultra-strong regime of gravity, as well as the formation history of these systems. I will discuss ongoing efforts to test general relativity in the ultra strong-field regime, including tests of the no-hair theorem and searches for gravitational-wave memory – a permanent deformation of spacetime following the passage of a gravitational wave. I will also discuss efforts to detect orbital eccentricity in these systems, which has led to potentially the first observation of a second-generation black hole merger.

Presenter: LASKY, Paul (Monash U. & OzGrav)

Contribution ID: **131** Type: **not specified**

[colloquium] Physics of A Naturally Small Cosmological Constant

Thursday, June 16, 2022 3:00 PM (1h 20m)

After discussing the necessary condition for a naturally small cosmological constant, I present a string theory motivated supergravity model that satisfies this condition. This leads to the axi-Higgs model that offers a resolution to the Hubble tension, the Lithium puzzle in big bang nucleosynthesis and the isotropic cosmic birefringence, with predictions to be tested in the near future. For the sake of completeness, the model is extended to achieve an explicit realization of a naturally small cosmological constant, where the electroweak scale (˜ 100 GeV) emerges automatically.

Presenter: TYE, Henry (The Hong Kong University of Science and Technology & Cornell University)

Contribution ID: **132** Type: **not specified**

Positivity constraints on EFT's with spontaneously broken Lorentz invariance

Tuesday, June 14, 2022 2:00 PM (1h 20m)

The coefficients of the operators of an effective field theory (EFT) are constrained to satisfy certain inequalities, under the (mild) assumption that the UV completion satisfies general requirements of causality and unitarity. These "positivity" constraints have been the subject of intense investigation in the last 15 years, since they prove rigorously that some low energy theories cannot be UV completed. I will discuss the extension of these ideas to theories where the Lorentz symmetry is spontaneously broken, as it happens in cosmology and condensed matter physics. As a starting point I will focus on a conformal field theory at finite charge. The low energy excitations of this system are described by an EFT for the Goldstone of the spontaneously broken charge: a conformal superfluid. I will show that the coefficients of this EFT are constrained since, in analogy with what happens in the Lorentz invariant case, one can run a dispersive argument for the 2-point function of the conserved current and of the stress-energy tensor.

Presenter: CREMINELLI, Paolo (ICTP)

Contribution ID: **133** Type: **not specified**

Search for new physics through primordial gravitational waves

Tuesday, June 21, 2022 3:00 PM (1h 20m)

We are currently witnessing the dawn of a new era in astrophysics and cosmology, started by the LIGO/Virgo observations of gravitational waves. These signals also open a new window into processes taking place in the first moments of our Universe. This is due to the fact that GWs propagate freely from the moment of their production unlike like photon based signals which can only propagate freely since the Universe became transparent due to recombination.I will discuss prospects for GW detection with the next generation of experiments. Including the problems connected with observation of a primordial signal in the presence of a foreground produced much more recently by astrophysical objects. The specific early Universe sources I will focus on are cosmological first order phase transitions and cosmic string networks. I will also discuss to what extent we can probe the expansion of the Universe using these primordial GW signals.

Presenter: LEWICKI, Marek

Contribution ID: **134** Type: **not specified**

Dark matter, black holes, and gravitational waves

Tuesday, June 28, 2022 3:00 PM (1h 20m)

The interplay between dark matter and black holes remains largely unexplored. Dark matter can in principle be *made of* black holes, as long as these are primordial, i.e. they are formed in the very early universe. Dark matter can also *accumulate around* black holes, and modify the rich phenomenology exhibited by these objects. After an overview of the status of dark matter searches, I will discuss the prospects for detecting primordial black holes or robustly ruling them out as dark matter candidates. I will then discuss the prospects for characterizing and identifying dark matter using gravitational waves, covering a wide range of dark matter candidate types and signals.

Presenter: BERTONE, Gianfranco (Amsterdam U.)

Contribution ID: **135** Type: **not specified**

Primordial black holes: Searching in lots of places

Tuesday, July 5, 2022 2:00 PM (1h 20m)

Although black holes can be the remnants of dead stars, it is also possible that some predate stars. Such primordial black holes (PBHs) are a special (non-particle) dark matter candidate, and they could also explain some of the unexpected properties of the black hole mergers that LIGO-Virgo-KAGRA have detected. I will summarise the evidence and challenges behind this claim, linking PBH formation to inflation. There is an interesting coincidence of scales between the black hole merger events, the Chandrasekhar limit, the horizon mass during the QCD transition in the early universe, and the wavelength of gravitational waves on which NANOGrav may (potentially) have detected a stochastic gravitational wave background.

Presenter: BYRNES, Christian (Sussex U.)

Contribution ID: **136** Type: **not specified**

[colloquium] How do black holes shine? – multiwavelength emission in the high-energy Universe

Thursday, July 7, 2022 2:00 PM (1h 20m)

Astrophysical black holes are surrounded by accretion disks, jets, and coronae consisting of magnetized, (near)-collision-less relativistic plasma. They produce observable high-energy radiation, and it is currently unclear where and how this emission is exactly produced. The radiation typically has a non-thermal component, implying a power-law distribution of emitting relativistic electrons. Magnetic reconnection and plasma turbulence are viable mechanisms to tap the large reservoir of magnetic energy in these systems and accelerate electrons to extreme energies. The accelerated electrons can then emit high-energy photons that themselves may strongly interact with the plasma, rendering a highly nonlinear system. Modeling these systems necessitates a combination of magnetohydrodynamic models to capture the global dynamics of the formation of dissipation regions, and a kinetic treatment of plasma processes that are responsible for particle acceleration, pair creation and annihilation, and radiation. I will present novel studies of accreting black holes and how they radiate in regions close to black hole event horizon, using both first-principles general relativistic kinetic particle-in-cell simulations and global large-scale three-dimensional magnetohydrodynamics models. I will answer the question of how well fluid-type models like magnetohydrodynamics can capture collision-less plasma physics. With a combination of models, I determine where and how dissipation of magnetic energy occurs, and what kind of emission signatures are typically produced. In the end, I will outline how an approach of global magnetohydrodynamics, and kinetic models will enable quantitative comparisons with observations of multiwavelength observations of radio, X-ray, and TeV emission from accreting black holes and potentially study the structure of spacetime.

Presenter: RIPPERDA, Bart (Flatiron Institute & Princeton University)

Contribution ID: **137** Type: **not specified**

Quantum gravity here and now, and at the end of the world

Tuesday, November 15, 2022 3:00 PM (1h 20m)

I review a recent approach to connecting quantum gravity and the real world by deconstantizing the constants of nature, and using their conjugate as a time variable. This is nothing but a generalization of unimodular gravity. The wave functions are then packets of plane waves moving in a space that generalizes the Chern-Simons functional. For appropriate states they link up with classical cosmology in the appropriate limit. There are however deviations, namely during the matter to Lambda transition, raising the possibility that quantum gravity could be in action here and now. At the other extreme I show how this approach can be used to resolve the cosmological singularity, clarify the no-boundary proposal, and shed new light on the cosmological constant problem.

Presenter: MAGUEIJO, João (Imperial College London)

Contribution ID: **138** Type: **not specified**

A Quantum-Mechanical Mechanism for Reducing the Cosmological Constant

Thursday, July 14, 2022 2:00 PM (1h 20m)

We exhibit a mechanism which dynamically adjusts cosmological constant toward 0+. The adjustment is quantum-mechanical, discharging cosmological constant in random discrete steps. It renders de Sitter space unstable, and triggers its decay toward Minkowski. Since the instability dynamically stops at vanishing cosmological constant, the evolution favors the terminal Minkowski space without a need for anthropics. The mechanism works for any QFT coupled to gravity.

Presenter: KALOPER, Nemanja (UC Davis)

Contribution ID: **139** Type: **not specified**

Towards a Dark Sector Model from String Theory

Tuesday, July 19, 2022 3:00 PM (1h 20m)

I will describe a proposal for a unified dark sector model in heterotic string theory with the following features: The model-independent axion descending from the Kalb-Ramond 2-form field is identified with the dark-matter field, and the real part of a Kahler modulus field associated with the radius of one of the extra spatial dimension accounts for dark energy. The expectation value of the dilaton field is stabilized by a gaugino condensation mechanism. A dark-energy potential corresponding to a realistic low-energy scale results from some gentle tuning of the stabilized expectation value of the dilaton.

Presenter: BERNARDO, Heliudson (McGill U.)

Contribution ID: **140** Type: **not specified**

An introduction to the TianQin Project

Tuesday, July 26, 2022 3:00 PM (1h 20m)

The TianQin Project plans to deploy around 2035 three satellites to form an equilateral triangle constellation, TianQin, in an orbit centered on the Earth with an altitude of about 105 kilometers, to detect gravitational waves in space. TianQin is expected to open the gravitational wave detection window in the frequency band of 10-4 Hz ˜ 1 Hz, opening our eyes towards the nature of gravity, the origin of black holes and the history of the universe. The ultimate scientific detection capability of TianQin depends on the level of breakthroughs that can be achieved with various key technologies, such as high-precision space inertial refence and long baseline laser interferometry, etc., which are all being researched. In this talk, I will make a brief introduction to the TianQin project.

Presenter: MEI, JianWei (Sun Yat-sen University)

Contribution ID: **141** Type: **not specified**

[colloquium] Prospects for understanding the physics of the Universe

Thursday, November 17, 2022 3:00 PM (1h 20m)

The remarkable progress in cosmology over the last decades has been driven by the close interplay between theory and observations. Observational discoveries have led to a standard model of cosmology with ingredients that are not present in the standard model of particle physics – dark matter, dark energy, and a primordial origin for cosmic structure. Their physical nature remains a mystery, motivating a new generation of ambitious sky surveys. However, it has become clear that formidable modelling and analysis challenges stand in the way of establishing how these ingredients fit into fundamental physics. I will discuss progress in harnessing advanced machine-learning techniques to address these challenges, giving some illustrative examples. I will highlight the particular relevance of interpretability and explainability in this field.

Presenter: PEIRIS, Hiranya (University College London & Stockholm University)

Contribution ID: **142** Type: **not specified**

Signatures of Primordial Gravitational Waves on the Large-Scale Structure of the Universe

Tuesday, November 1, 2022 2:00 PM (1h 20m)

Primordial scalar perturbations are always considered as a source in the study of large-scale structures. Being the dominant ones at first order in perturbation theory, they have also encouraged the study of generation of second order gravitational waves from them. We seek to investigate the opposite effect, i.e. if gravitational waves can have an observable contribution on the matter power spectrum in the second order. For this, we consider gravitational waves with broken scale-invariance, which happens in some models of inflation. Our results are positive about having a significant effect, and we notice a crucial characteristic of this new effect, unlike the standard matter perturbation, it does not exist outside the horizon scales, although on smaller scales it can be said that it mimics the linear one.

Presenter: BARI, Pritha (Padua University)

Contribution ID: **143** Type: **not specified**

Probing Leptogenesis with the Cosmological Collider

Wednesday, November 9, 2022 7:00 PM (1h 20m)

In this talk I will first review the recent development and opportunities addressing the profound puzzle of matter-antimatter asymmetry in our Universe, as a general motivation. Then I will introduce a cosmological probe for a compelling solution to the puzzle, leptogenesis, which is generally challenging to directly test due to the very high energy scales involved. In particular, we propose a new probe for leptogenesis with cosmological collider physics. With the example of a cosmological Higgs collider, we demonstrate that during inflation leptogenesis models can produce detectable primordial non-Gaussianity with distinctive oscillatory patterns that encode information about the lepton-number violating couplings, the Majorana right-hand neutrino masses, and the CP phases, which are essential to leptogenesis. The detection prospect with upcoming astrophysical observations will also be discussed.

Presenter: CUI, Yanou (University of California, Riverside)

Contribution ID: **144** Type: **not specified**

How much entanglement is carried out by Hawking radiation?

Tuesday, September 20, 2022 3:00 PM (1h 20m)

That event horizons generate quantum correlations via the Hawking effect is well known. In this talk, I will argue that the creation of entanglement in Hawking's process very much depends on the environment surrounding the horizon. In fact, I'll show that such entanglement can be modulated as desired, by appropriately illuminating the horizon. I will further apply these ideas to analog event horizons concocted in the laboratory and insist that the ability to tune the generation of entanglement offers a promising route towards detecting quantum signatures of the elusive Hawking effect.

Presenter: AGULLO, Ivan (Louisiana State University)

Contribution ID: **145** Type: **not specified**

Non-Gaussianities from primordial quantum diffusion

Tuesday, September 27, 2022 2:00 PM (1h 20m)

I will show that primordial quantum diffusion unavoidably generates non-Gaussian, exponential tails in the distribution of inflationary perturbations. This type of non-Gaussianity cannot be captured by the usual perturbative parametrisations, and it leaves specific imprints on the statistics of cosmic structures that I will discuss.

Presenter: VENNIN, Vincent (LPENS, Paris & APC, Paris)

Contribution ID: **146** Type: **not specified**

[colloquium] Testing the No-Hair Theorem and the Area Theorem with LIGO

Thursday, September 15, 2022 3:00 PM (1h 20m)

One of the key results of general relativity is that an astrophysical black hole in equilibrium is uniquely described by just two parameters, its mass and spin. This is called the No-Hair Theorem, a result that is not true in alternative theories of gravity. For many years, people have speculated about testing the theorem using gravitational waves from merging black holes. However, the consensus has been that this test will require the sensitivity of next-generation detectors. I will show that this consensus is wrong for a surprising reason, and report a test with data from GW150914, the first LIGO gravitational wave detection. An extension of the test confirms Hawking's Area Theorem at the 97% limit.

Presenter: TEUKOLSKY, Saul

Contribution ID: **147** Type: **not specified**

Modified Gravity and Observational Constraints

Tuesday, October 4, 2022 3:00 PM (1h 20m)

There has been a lot of interest in theories that modified Einstein gravity but which reduce to general relativity in certain limits. Such modified gravity theories predict the existence of a fifth force. There are severe constraints on fifth forces from solar system observations. However there has been a recent resurgence of interest in modified gravity theories with the advent of sophisticated screening mechanism whereby the fifth force is suppressed in the solar system but not necessarily beyond. I will review some models of modified gravity and display the screening mechanism. I will then discuss how such models can be tested and constrained using laboratory experiments.

Presenter: DAVIS, Anne-Christine (DAMTP, University of Cambridge)

Contribution ID: **148** Type: **not specified**

[colloquium]tba

Presenter: NICOLIS, Alberto

Contribution ID: **149** Type: **not specified**

A cautionary case of casual causality & UV graviton scattering from IR singularities

Tuesday, October 11, 2022 3:00 PM (1h 20m)

In recent years, causality has become a popular criterion to distinguish between EFTs arising from physical and unphysical high-energy theories. A direct way to ensure a given EFT is causal is to demand a lower bound on scattering time delays, which essentially bounds the propagation speed averaged over the entire trajectory. In flat space, this is unambiguously dictated by the Minkowski light cones, but the situation is much more subtle on curved backgrounds. I will make the case that the relevant notion is the so-called infrared causality. I will then apply this notion of causality to the EFT of gravity on spherically symmetric black hole backgrounds. Careful consideration of the regime of validity shows that time delays are never resolvable (in the geometric optics sense), and therefore there is never any observable violation of infrared causality.

This talk is based on arXiv:2112.05031 in collaboration with C. de Rham, A. Margalit, and A. Tolley.

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Scattering amplitudes mediated by graviton exchange display IR singularities in the forward limit. This obstructs standard application of positivity bounds based on twice subtracted dispersion relations. Such divergences can be cancelled only if the UV limit of the scattering amplitude behaves in a specific way, which implies a very non-trivial connection between the UV and IR behaviors of the amplitude. We show that this relation can be expressed in terms of an integral transform, obtaining analytic results when t log s ->0. Carefully applying this limit to dispersion relations, we find that infinite arc integrals, which are usually taken to vanish, can give a non-trivial contribution in the presence of gravity, unlike in the case of finite negative t. This implies that gravitational positivity bounds cannot be trusted unless the size of this contribution is estimated in some way, which implies assumptions on the UV completion of gravitational interactions. We discuss the relevance of these findings in the particular case of QED coupled to gravity.

Presenter: CALVIN CHEN & ANNA TOKAREVA (Imperial College, London)

Contribution ID: **150** Type: **not specified**

Gravitational-wave lensing as a probe of dark matter halos & Decoherence of Cosmological Perturbations from Boundary Terms and the Non-Classicality of Gravity

Tuesday, October 18, 2022 2:00 PM (1h 20m)

Gravitational waves can probe cosmic structures via gravitational lensing in ways that are highly complementary to electromagnetic signals: 1) their low frequency and phase coherence makes them sensitive to wave-optics diffraction and frequency-dependent effects, 2) weak interactions with matter allow them to probe dense regions, such as the cores of galactic halos and 3) accurate waveform models provide an additional handle to pinpoint lensing effects.

In this talk I will describe how these features can be used to probe features of matter halos, such as the radial slope of the density and the existence of a central core. These unique signatures will enable novel probes of fundamental physics and astrophysics in galactic centres.

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The quantum-to-classical transition of inflationary cosmological perturbation is necessary to explain today's classical observations originating from primordial vacuum fluctuation. In the literature, such a transition is the decoherence obtained by tracing out the unobserved modes from a state having couplings between long and short modes by bulk interactions. We note that the decoherence of inflationary curvature perturbation is dominated by a boundary term of the gravity action. Although this boundary term cannot affect normal cosmological correlators, it induces much faster decoherence than the previous calculations based on bulk interactions. We also point out that the gravitational origin of inflationary decoherence may shed light on the quantum nature of gravity. By comparing with a Schrödinger-Newton semi-classical gravity, we show that gravity theories of classical or quantum origins can be distinguished by comparing their different decoherence rates of cosmological perturbation. Our result also suggests that density fluctuation better preserves quantum information than curvature perturbation for the purpose of constructing cosmological Bell-like experiments.

The talk is based on arXiv:2207.04435.

Presenter: GIOVANNI TAMBALO & CHON MAN SOU (Albert Einstein Institute & Hong Kong University of Science and Technology)

Contribution ID: **151** Type: **not specified**

Hearts of Darkness: Theory and Phenomenology of quantum gravity regularised black holes

Tuesday, October 25, 2022 3:00 PM (1h 20m)

Black holes are the purest expression of gravity and at the same time the places where our best theory of gravitation, Einstein General Relativity, meets its demise in the form of singularities. We know, however, that any successful theory of quantum gravity should be able to resolve these uncharted regions, but can it do so without showing any modification outside the event horizon? can real black holes be undistinguishable from the one predicted by general relativity? The recent direct observation of these tantalising objects represents an unprecedented possibility to answer these questions. In this talk, I shall explore on general grounds what alternative objects we can expect from a quantum gravity induced regularisation of singularities and discuss what observations can or might tell us about their nature.

Presenter: LIBERATI, Stefano (SISSA)

Contribution ID: **152** Type: **not specified**

[colloquium] Trans-Planckian Censorship, Breakdown of Effective Field Theory and Emergent Cosmology

Thursday, May 12, 2022 3:00 PM (1h 20m)

I will argue that effective point particle field theory will inevitably break down in a rapidly expanding universe. Hence, a non-perturbative formalism is required to understand the very early universe. A new approach based on matrix theory (a proposed non-perturbative definition of string theory(will be discussed, which yields an “emergent” cosmology.

Presenter: BRANDENBERGER, Robert (McGill University)

Contribution ID: **153** Type: **not specified**

Inflation, Origin of Matter Asymmetry, and GW Background

Tuesday, November 22, 2022 3:00 PM (1h 20m)

Modern cosmology has been remarkably successful in describing the Universe from a second after the Big Bang until today. However, our current understanding of the cosmos before that time is less precise. Moreover, cosmology profoundly involves particle theory beyond the Standard Model to explain its long-standing puzzles: the origin of the observed matter asymmetry, particle nature of dark matter, and cosmic inflation. In this talk, I will explain that relic axion-gauge fields in fractions of a second after the Big Bang can relate and explain these seemingly unrelated puzzles in early and late cosmology. This new particle physics for inflation breaks matter-antimatter symmetry in inflation and does not require CP violation in the neutrino sector. As a smoking gun, such relics would provide a new window into the early Universe through primordial gravitational waves. Therefore, they are testable by future probes of GWs across 21 decades in frequency.

Presenter: MALEKNEJAD, Azadeh (CERN)

Contribution ID: **154** Type: **not specified**

Semi-discrete Optimal Transport for Cosmological Reconstruction

Tuesday, November 29, 2022 3:00 PM (1h 20m)

Optimal Transport Theory is a field of Mathematics that describes the cost-effective transfer of probability distributions, and provides connections between probability theory, geometry, partial differential equations, and of course optimisation. Over more than two centuries active research this field has fuelled great advances, and more recently has led to understanding relations with other research fields, such as Computer Science and Physics. In this seminar, I will give an introduction to the main concepts in Optimal Transport, beginning with its original formulation and ending with modern examples of computational tools that allow for the construction efficient algorithms. I will then focus on a particular application in cosmology, the reconstruction of the linear density field from observations of the non-linearly evolved universe. In particular, I present results that show the efficient and accurate reconstruction of Baryonic Acoustic Oscillations from the late-time distribution of matter.

Presenter: VON HAUSEGGER, Sebastian (University of Oxford)

Contribution ID: **155** Type: **not specified**

Is our Universe geometrical after all?

Tuesday, December 6, 2022 3:00 PM (1h 20m)

After decades, we still lack a proper understanding of the quantum nature of gravity. Nonetheless, we have already seen many theoretical hints that gravity does not easily fit in the quantum mechanical framework. In this talk, I will discuss the issues associated with gravitating vacuum energy and take that as empirical evidence of the breakdown of QFT in the presence of gravity. Then, I will argue for a radical alternative where space(-time) is completely emergent from quantum mechanics alone, defined for finite-dimensional Hilbert spaces. After briefly reviewing how spacetime can be emergent, I will sketch a new research program that establishes experimental signatures to test the emergent nature of spacetime.

Presenter: FRANZMANN, Guilherme (Nordita)

Contribution ID: **157** Type: **not specified**

[colloquium] A new theory of the universe

Thursday, December 8, 2022 3:00 PM (1h 20m)

Observations of the universe have revealed a surprising economy in its basic laws and structure. In this light, Latham Boyle and I have reconsidered cosmology's central puzzles, aiming to find simpler, more principled and more predictive solutions. From an improved understanding of the big bang singularity, we were able to explain the dark matter as consisting of a stable, massive RH neutrino. Forthcoming large scale galaxy surveys including EUCLID and LSST will closely test this hypothesis. The baryon asymmetry can likewise accounted for by the standard model including RH neutrinos (leptogenesis). By calculating the gravitational entropy for realistic cosmologies, we have found a new explanation for the large scale geometry of the cosmos which does not require inflation. These thermodynamic arguments address the arrow of time and provide a clue to the role of the cosmological constant. We recently found a new cure for the leading order divergences of the standard model coupled to gravity, requiring no new particles or forces and explaining why there are three generations of standard model fermions (including RH neutrinos). As a byproduct of this change in the properties in the quantum vacuum of the standard model, we show how approximately scale-invariant, primordial curvature perturbations, responsible for the formation of galaxies and large scale structure, are generated. The perturbation amplitude, statistical properties and character are predicted in terms of standard model parameters. If time allows, I'll discuss a new and potentially observable signature on very large scales.

Presenter: TUROK, Neil (University of Edinburgh)

Contribution ID: **158** Type: **not specified**

Lattice simulations of axion inflation

Tuesday, May 30, 2023 3:00 PM (1h 20m)

If gauge fields are coupled to an axion field during inflation, they can lead to unique observational signatures. However, this system often shows strong backreaction effects, invalidating the standard perturbation theory approach. I will present the first nonlinear lattice simulation of an axion-U(1) system during inflation. The simulation is used to fully characterize the statistics of the primordial curvature perturbation ζ. We find high-order statistics to be essential in describing non-Gaussianity of ζ in the linear regime of the theory. On the contrary, non-Gaussianity is suppressed when the dynamics becomes nonlinear. This relaxes bounds from overproduction of primordial black holes, allowing for an observable gravitational waves signal at interferometer scales.

Presenter: CARAVANO, Angelo (LMU, Munich)

Contribution ID: **160** Type: **not specified**

Questions on calculation of primordial power spectrum with large spikes: the resonance model case

Tuesday, January 17, 2023 3:00 PM (1h 20m)

Inflationary models predicting a scale-dependent large amplification of the density perturbations have recently attracted a lot of attention because the amplified perturbations can seed a sizable amount of primordial black holes (PBHs) and stochastic background of gravitational waves (GWs). While the power spectra in these models are computed based on the linear equation of motion, it is not obvious whether loop corrections are negligible when such a large amplification occurs during inflation. In this talk, I will discuss our recent paper, arXiv:2211.02586, in which we use the in-in formalism and calculate the one-loop scalar power spectrum numerically and analytically in an illustrative model where the density perturbations are resonantly amplified due to oscillatory features in the inflaton potential. Our calculation is technically new in that the amplified perturbations are numerically taken into account in the in-in formalism for the first time. With the calculation results, I will show that, for the typical parameter space leading to the O(10ˆ7) amplification of the power spectrum for a sufficient PBH production in the oscillatory feature models, the one-loop power spectrum dominates over the tree-level one, indicating the breakdown of the perturbation theory.

Presenter: INOMATA, Keisuke (The University of Chicago)

Contribution ID: **161** Type: **not specified**

Hints of Cosmological Parity Violation

Tuesday, January 24, 2023 3:00 PM (1h 20m)

Observations of the Cosmic Microwave Background (CMB) have cemented the notion that the large-scale Universe is both statistically homogeneous and isotropic. But is it invariant also under mirror reflections? Recently, observations of CMB polarization (through birefringence) and the distribution of galaxies (through four-point functions, or trispectra) have challenged this notion, and give tentative evidence for new parity-violating processes at work in the early or late Universe. In this talk, I will discuss these measurements, focusing primarily on the parity-violating signature seen in the BOSS galaxy sample. I will present an overview of how the measurements are made and interpreted before commenting on possible explanations for the signal, both in terms of new physics (from inflation or modified gravity) and systematics (in the observations or analysis). I will further outline the possibilities for solving this cosmic controversy with new data in the coming years.

Presenter: PHILCOX, Oliver (Columbia University)

Contribution ID: **162** Type: **not specified**

Mapping the anisotropic stochastic gravitational-wave background

Tuesday, January 31, 2023 3:00 PM (1h 20m)

As of today, the Advanced LIGO and Virgo gravitational-wave (GW) detectors have cataloged nearly 100 GW detections from various compact object mergers. These discoveries began the endeavors to search for other kinds of GW sources. Among these, the Stochastic Gravitational-Wave Background (SGWB), because of the superposition of individually undetectable cosmological and/or astrophysical sources, is one of the potential sources to observe with the network of ground-based GW observatories in the coming years. A cosmologically produced SGWB would carry unique signatures from the earliest epochs in the evolution of the Universe. Likewise, an astrophysical background would provide information about the astrophysical sources that generated it. To a first approximation, the SGWB is assumed to be isotropic; one could determine its statistical properties by observing any part of the sky. However, these backgrounds can be anisotropic as well. We have developed techniques based on data folding to search for such anisotropies in the SGWB efficiently. With these techniques, we could even perform an extremely efficient search in all directions and frequencies. This led to the first creation of the atlas of SGWB. In this talk, I will explain how one can map the SGWB anisotropy and the new directions one can explore with these tools.

Presenter: SURESH, Jishnu (Louvain U., CP3)

Contribution ID: **163** Type: **not specified**

Wave-optics limit of the stochastic gravitational-wave background

Tuesday, February 7, 2023 3:00 PM (1h 20m)

The stochastic gravitational waves background is a rich resource of cosmological information, encoded both in its source statistics and its anisotropies induced by propagation effects. During their journey, the gravitational waves constituting the stochastic background encounter cosmic structures, which are able to modify the observed signal. According to the ratio between the wavelength of the wave, and the matter overdensities typical length-scale, interference and diffraction effects may arise, possibly boosting the signal's amplitude or inducing a non-trivial polarization pattern. In this talk I will present my results about the wave-optics limit of the stochastic gravitational wave background, and describe how we can use them to gain information about the matter content of the Universe.

Presenter: GAROFFOLO, Alice (Leiden University)

Contribution ID: **165** Type: **not specified**

Where my DAEMON hides – Power-law mass density models from fundamental principles

Tuesday, February 14, 2023 3:00 PM (1h 20m)

Mass density profiles are key ingredients of many astrophysical and cosmological data evaluations, for instance mapping the mass distribution in galaxies or galaxy clusters using strong gravitational lensing or kinematical information from spectroscopically inferred velocity dispersions. Yet, how accurate and precise are interpretations of such observations if their mass models are based on heuristically inferred functions fitted to simulated structures? More than 30 years have passed since the first N-body simulations were set up. But it is still unknown why almost universal fitting functions like the Navarro-Frenk-White mass density profile model the shape of dark matter halos over a large range of sizes so well.

In this talk I will introduce my idea to resolve this mystery and explain the mass density profiles of (broken) power-law type. The approach is called DAEMON (DArk Emergent Matter halO explanatioN) and can be applied to any ensemble of entities whose interactions are dominated by gravity. It employs the entities as sampling points in the continuous mass density to be reconstructed and only uses the prerequisite that Newtonian gravity is the dominant interaction between the entities. As one important result, the Navarro-Frenk-White profile can be derived from fundamental principles without encountering the issues commonly faced when trying to derive it from conventional ensemble theory in statistical mechanics.

Based on:
J. Wagner. Cosmic structures from a mathematical perspective 1: dark
matter halo mass density profiles. General Relativity and Gravitation,
52(6), 2020
J. Wagner. Self-gravitating dark matter gets in shape. International
Journal of Modern Physics D, 29(14), 2020

Presenter: WAGNER, Jenny (Bahamas Advanced Study Institute & Conferences)

Contribution ID: **166** Type: **not specified**

UV Physics and Hawking radiation

Tuesday, February 21, 2023 3:00 PM (1h 20m)

Although Hawking radiation was derived from an effective-theory calculation, many believe that it is robust, and insensitive to UV physics. We analyze Hawking radiation in more detail, paying attention to its time dependence, and find that it is in fact sensitive to UV physical effects. We conclude that the effective-theory prediction is not reliable. We will also comment on the applications of this analysis to other related problems.

Presenter: HO, Pei-Ming (National Taiwan University)

Contribution ID: **167** Type: **not specified**

Fuzzy Fields for Cosmic Conundrums

Friday, March 3, 2023 3:00 PM (1h 20m)

High-energy particle theory motivates that a very light (m«10^{-12} eV) field may exist, in addition to the usual standard model spectrum. If so, such a field could contribute to the dark matter and dark energy of the universe at a broad range of epochs. In this talk, I will explore the impact of such a field as a dark matter component (though its impact on CMB anisotropies), as a contributor to late-time acceleration or early dark energy components, and as a field driving evolution in the fundamental constants of nature. I will connect theory to observations, and perhaps preview the promise of future CMB and other cosmological experiments.

Presenter: GRIN, Daniel (Haverford college)

Contribution ID: **168** Type: **not specified**

Primordial non-Gaussianity beyond the bispectrum

Tuesday, March 7, 2023 3:00 PM (1h 20m)

I will review recent progress to address the generation of primordial non-Gaussianity during cosmic inflation. I will focus my attention on the origin of non-Gaussian signals that are poorly parametrized by the bispectrum (the three-point function). I will show that there are various types of non-Gaussianities that can arise during inflation that, to be understood, require taking into account a large set of n-point functions both, via perturbative or non-perturbative techniques. Such classes of non-Gaussianity may be crucial to understand the generation of primordial black holes.

Presenter: PALMA, Gonzalo (Universidad de Chile)

Contribution ID: **169** Type: **not specified**

Is H0 a constant in Lambda-CDM cosmology?

Tuesday, March 14, 2023 3:00 PM (1h 20m)

There are persistent tensions in flat LCDM cosmology, most notably H0 and S8 tension. Modifications of the flat LCDM model designed to alleviate one tension typically exacerbate the other. Returning to basics, I will argue why evolution of cosmological parameters with effective redshift is expected in LCDM cosmology. I will review observations supporting this claim.

Presenter: Ó COLGÁIN, Eoin (Atlantic Technological University)

Contribution ID: **170** Type: **not specified**

Cosmology via holography

Tuesday, March 21, 2023 4:30 PM (1h 30m)

We describe how the standard tools of holography might be used to define microscopic models of big-bang cosmology. We consider models where a bubble of the cosmological spacetime is embedded in an asymptotically AdS spacetime, and models where an asymptotically AdS Euclidean spacetime obtained by analytically continuing the cosmological spacetime is described via a Euclidean CFT construction. While the effective field theories we consider have negative cosmological constant, they can describe realistic accelerating cosmologies via the positive potential energy of time-dependent scalar fields.

Presenter: VAN RAAMSDONK, Mark (University of British Columbia)

Contribution ID: **171** Type: **not specified**

[colloquium] Scalar-tensor theories of modified gravity in cosmology and in strong-gravity objects

Thursday, March 23, 2023 3:00 PM (1h 20m)

This talk will present theories of modified gravity that contain a single scalar degree of freedom, in particular the very general framework of Degenerate Higher-Order Scalar-Tensor (DHOST) theories, which includes and extends Horndeski and Beyond Horndeski theories. I will then discuss cosmological aspects of these theories, notably the dynamics of cosmological perturbations. I will also present some results on non-rotating black holes and their perturbations in the context of DHOST theories.

Presenter: LANGLOIS, David (Universite Paris Cite, CNRS, AstroParticule et Cosmologie)

Contribution ID: **172** Type: **not specified**

Universal Nature of Black Hole Ringdown: Overtone Excitation and Graybody Factors

Tuesday, March 28, 2023 3:00 PM (1h 20m)

A gravitational wave from a binary black hole merger is an important probe to test gravity. Especially, the observation of ringdown may allow us to perform a robust test of gravity as it is a superposition of excited quasi-normal (QN) modes of a Kerr black hole. The excitation factor is an important quantity that quantifies the excitability of QN modes and is independent of the initial data of black hole mergers.

In this talk, I will show which QN modes can be important (i.e., have higher excitation factors) and will discuss how we can determine the start time of ringdown to maximally enhance the detectability of the QN modes.

Also, I will introduce my recent conjecture on the modeling of ringdown waveform: the thermal ringdown model in which the ringdown spectrum of a small mass ratio merger involving a massive and rapidly spinning black hole can be modeled by the graybody factor of the black hole, which is similar to the thermal Fermi-Dirac distribution.

Presenter: OSHITA, Naritaka (RIKEN, iTHEMS)

Contribution ID: **173** Type: **not specified**

Towards Precision Measurements of Dark Matter

Tuesday, April 4, 2023 3:30 PM (1h 20m)

For more than a century now, our inference of the mass distributions (including dark matter) in galaxies have been based on modeling the positions and velocities of stars, i.e., using kinematic analyses, which assume equilibrium. These kinematic estimates can be inaccurate for a time-dependent potential, and there are now many lines of observational evidence that show that our Galaxy has had a highly dynamic history. Technological advances now make it possible for us to carry out extreme-precision time-series measurements of the acceleration of stars that live within the gravitational potential of our Galaxy. I will talk about several different methods of direct acceleration measurements that we have developed, including our recent analysis of compiled pulsar timing data from which we were able to measure the Galactic acceleration for the first time. Given the measured acceleration, we can straightforwardly use the Poisson equation to determine the total density, and the local dark matter density (given an accounting of the stellar density). There are testable differences between popular models of dark matter on small scales, i.e., in their sub-structure. I will discuss the potential for measuring dark matter sub-structure in the Milky Way with pulsar timing and eclipse timing, and for constraining theories of gravity by combining constraints from pulsar timing and extreme precision radial velocity measurements. I will end by discussing our recent work in developing an "acceleration ladder"by calibrating kinematic estimates of the acceleration to direct acceleration measurements.

Presenter: CHAKRABARTI, Sukanya (Rochester Institute of Technology)

Contribution ID: **174** Type: **not specified**

More General Relativity

Tuesday, April 11, 2023 3:00 PM (1h 20m)

I will show that the quantum field theory that reproduces classical general relativity, has a slight but nontrivial generalization. The Hilbert space allows for states that violate some of Einstein‘s equations without creating additional degrees of freedom. This amounts to a “classical background “which is non-dynamical, but effectively redshifts like dark matter. I will go over a toy example, as well as the electromagnetic analog, which includes the violations of Gauss’s law. Then I will produce the modified GR equations with a source term. Finally, I will discuss some preliminary thoughts of the provocative phenomenology.

Presenter: KAPLAN, David (Johns Hopkins U.)

Contribution ID: **175** Type: **not specified**

Mapping the baryonic Universe: a new window into the cosmos

Tuesday, April 18, 2023 3:00 PM (1h 20m)

The evolution of the baryonic (normal) matter in the Universe is an excellent probe of the formation of cosmic structures and the evolution of galaxies. Over the last decade, considerable effort has gone into investigating the nature of baryonic material, theoretically and observationally. The technique of intensity mapping (IM), which measures the integrated emission from sources over a broad range of frequencies, is a promising probe of cosmological baryons. A particular advantage of IM is that it provides a tomographic, or three-dimensional picture of the Universe, unlocking significantly more information than available from traditional galaxy surveys. Astrophysical uncertainties, however, constitute an important systematic in our attempts to constrain cosmology with IM. I describe an innovative approach which allows us to fully utilize our current knowledge of astrophysics in order to develop cosmological forecasts from IM. Extensions of this model pave the way towards a comprehensive understanding of molecular gas evolution, allowing us to interpret results from upcoming surveys. This opens up the exciting potential of constraining physics beyond the LCDM model from future IM observations.

Presenter: PADMANABHAN, Hamsa (Université de Genève)

Contribution ID: **176** Type: **not specified**

[colloquium] Large density perturbations from stochastic inflation

Thursday, April 20, 2023 3:00 PM (1h 20m)

There has been renewed interest recently in the possibility of producing primordial black holes from large density perturbations after a period of inflation in the very early universe. Such large fluctuations would be the result of very rare, extreme excursions in the fields driving inflation which may not be well described by standard perturbation theory techniques. I will discuss a non-perturbative approach using the stochastic approach to study inflationary dynamics. I will present recent analytical and numerical work to reconstruct the non-Gaussian tail of the probability distribution function of density fluctuations from inflation, and discuss its application to the abundance of primordial black holes.

Presenter: WANDS, David (ICG, University of Portsmouth)

Contribution ID: **177** Type: **not specified**

Ultralight dark matter searches with laser interferometry

Tuesday, April 25, 2023 3:00 PM (1h 20m)

Despite overwhelming observational evidence for the existence of dark matter, its identity and properties remain a mystery. Recently, bosonic ultralight fields with masses below 1 eV are gaining a lot of attention, as they are well motivated by cosmology. Laser interferometers are sensitive to oscillations from such fields that change the interference fringe. Recently, we have proposed to search for axion dark matter by measuring the birefringence effect using a bow-tie optical ring cavity [PRL 121, 161301 (2018)] and gravitational wave detectors [PRL 123, 111301 (2019)]. We have also proposed to search for vector dark matter by searching for non-standard force acting on mirrors [PRD 102, 102001 (2020)]. In this talk, I will present some of the first results from a table-top experiment, Dark matter Axion search with riNg Cavity Experiment (DANCE) [arXiv:2303.035947], and the status of axion and vector dark matter searches using gravitational wave detectors.

Presenter: MICHIMURA, Yuta (LIGO Laboratory, Caltech & University of Tokyo)

Contribution ID: **178** Type: **not specified**

Can we detect gravitons or HFGWs?

Tuesday, July 4, 2023 10:00 AM (1h 20m)

Detecting gravitons is a big challenge. In this talk, we discuss possible experiments for the graviton detection. We consider macroscopic quantum phenomena and its relation to gravity. First of all, we will discuss quantum noise of gravitons in a detector. Then, we will explain how the decoherence due to noise of gravitons can be used for the graviton search. We also argue that high frequency gravitational wave detection is also related to the graviton search. Then, we propose a magnon detector for probing HFGWs.

Presenter: SODA, Jiro (Kobe University & KEK)

Contribution ID: **179** Type: **not specified**

A large |η| approach to single field inflation

Tuesday, June 27, 2023 3:00 PM (1h 20m)

Single field models of inflation capable to produce primordial black holes usually require a significant departure from the standard, perturbative slow-roll regime. In fact, in many of these scenarios, the size of the slow-roll parameter $|\eta|$ becomes larger than one during a short phase of inflationary evolution. In order to develop an analytical control on these systems, I explore the limit of $|\eta|$ large, and promote $1/|\eta|$ to a small quantity to be used for perturbative expansions. Formulas simplify, and analytic expressions for the two- and three-point functions of curvature fluctuations are obtained. I will then discuss the behavior of loop corrections to inflationary observables in this framework.

Presenter: TASINATO, Gianmassimo (Universita di Bologna & Swansea University)

Contribution ID: **180** Type: **not specified**

[colloquium] Effective field theories for phases of matter and cosmology

Thursday, October 27, 2022 3:00 PM (1h 20m)

I will review some modern applications of effective field theories outside their traditional particle physics domain. In particular, I will focus on spontaneous symmetry breaking for spacetime symmetries. The effective theories for the associated Goldstone excitations capture the low-energy/long-distance dynamics of a number of physical systems, from ordinary macroscopic media (solids, fluids, superfluids, supersolids) to more exotic cosmological ones.

Presenter: NICOLIS, Alberto (Columbia University)

Contribution ID: **181** Type: **not specified**

Dissipative Inflation via Scalar Production

Tuesday, July 25, 2023 3:00 PM (1h 20m)

We describe a new mechanism that gives rise to dissipation during cosmic inflation. In the simplest implementation, the mechanism requires the presence of a massive scalar field with a softly-broken global U(1) symmetry, along with the inflaton field. Particle production in this scenario takes place on parametrically sub-horizon scales. Consequently, the backreaction of the produced particles on the inflationary dynamics can be treated in a local manner, allowing us to compute their effects analytically. We determine the parametric dependence of the power spectrum which deviates from the usual slow-roll expression. Non-Gaussianities are always sizeable whenever perturbations are generated by the noise induced by dissipation.

Presenter: SALEHIAN, Borna

Contribution ID: **182** Type: **not specified**

On the cosmological constant appearing as an initial condition for inflationary models

Tuesday, July 11, 2023 3:00 PM (1h 20m)

It's known that some FLRW inflationary models admit spacetime extensions through the big bang. For k = -1 FLRW spacetimes, they are known as "Milne-like spacetimes." For k = 0 FLRW spacetimes, they are known as "past-asymptotically de Sitter" spacetimes. In both cases, a new set of coordinates shows that the big bang is a coordinate singularity for these spacetimes, and, in both cases, the cosmological constant appears as an initial condition, i.e. the equation of state for the energy density and pressure takes the form of a cosmological constant precisely at the big bang for these models. In this talk, we generalize this fact to nonhomogeneous versions of these spacetimes by exploring the geometry of the big bang in the spacetime extension. This has applications to inflationary theory for nonhomogeneous FLRW models. This is joint work with Ghazal Geshnizjani and Jerome Quintin.

Presenter: LING, Eric (University of Copenhagen & University of Toronto)

Contribution ID: **183** Type: **not specified**

The pi-axion and pi-axiverse of dark QCD

Tuesday, May 23, 2023 3:00 PM (1h 20m)

Axions and axion-like particles (ALPs) are a prominent dark matter candidate, drawing motivation in part from the axiverse of string theory. However, the string axiverse is not the only game in town: In this talk I will discuss axion-like particles that emerge as pions of a QCD-like dark sector. In a dark Standard Model (SM) wherein all 6 quark flavors are light while the photon is massive —one finds a rich low-energy spectrum of stable ultralight particles, in the form of neutral and charged dark pions, and complex neutral scalars analogous to the SM kaon, with mass splittings determined by the mass and charge of the dark quarks. Dark matter can be a mixture of all these ultralight bosonic degrees of freedom, and exhibit both parity-even and parity-odd interactions, making the theory testable at a wide variety of experiments. In context of dark QCD with Nf flavours of light quarks, this scenario predicts Nf ˆ2 −1 ultralight axion-like particles —effectively an axiverse from dark QCD. This axiverse is consistent with but makes no recourse to string theory. Accounting for the full spectrum of the theory, it can also include a superheavy ("WIMPzilla") dark matter component, whose mass is connected to the axiverse by the confinement scale of the dark QCD.

Presenter: MCDONOUGH, Evan (University of Winnipeg)

Contribution ID: **184** Type: **not specified**

Pulsar Polarization Arrays

Tuesday, May 9, 2023 3:00 PM (1h 20m)

Pulsar timing arrays (PTAs) consisting of widely distributed and well-timed millisecond pulsars can serve as a galactic interferometer to detect gravitational waves. With the same data acquired for PTAs, we have proposed Ref. [2] to develop pulsar polarization arrays (PPAs), to explore astrophysics and fundamental physics. As in the case of PTAs, PPAs are best suited to reveal temporal and spatial correlations at large scales that are hard to mimic by local noises.

As one scientific case for the PPAs, we consider the detection of axion-like wave dark matter (WDM). Because of its tiny mass, the axion-like WDM can be generated as a Bose-Einstein condensate, characterized by a strong wave nature. It can also affect the polarization of pulsar light via its Chern-Simons coupling, yielding an effect of "birefringence". We will particularly address in this context: (1) the excellent capability of the PPAs; and (2) their complementarity with the PTAs. The relevant sensitivities will be demonstrated.

Refs:
(1) https://journals.aps.org/prd/abstract/10.1103/PhysRevD.101.063012
(2) https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.130.121401
(3) https://arxiv.org/abs/2304.04735

Presenter: LIU, Tao (The Hong Kong University of Science and Technology)

Contribution ID: **185** Type: **not specified**

New avenues to the Cosmological Gravitational Wave Background

Tuesday, May 16, 2023 3:00 PM (20 minutes)

The Stochastic Gravitational Wave Background is one of the main targets of present and future detectors. Characterising its properties is crucial to pin down its origin and distinguish among the various possible sources. In this talk I will mainly consider the Cosmological Gravitational Wave Background (CGWB) and discuss a variety of new observables that can help reaching such a characterization. In particular I will focus on angular anisotropies of the CGWB and their cross-correlations with CMB. They do indeed retain crucial information about the primordial mechanisms that source the CGWB and about the evolution and the particle content of the universe. Therefore, they can provide a new testbed of various aspects of cosmology, from Early Universe physics (e.g., inflation, primordial black holes and primordial non-Gaussianity) to a new way to constrain cosmological parameters and test General Relativity. I will discuss the physics of CGWB anisotropies and their cross-correlations with CMB, and a few examples of future applications.

Presenter: BARTOLO, Nicola (Padua U. and INFN, Padua and Padua Observ.)

Contribution ID: **186** Type: **not specified**

Some directions for the future of primordial non-Gaussianities

Tuesday, June 13, 2023 3:00 PM (1h 20m)

The field of primordial non-Gaussianities is twenty years old. During that time, cosmologists have built a dictionary between the physics active during inflation and higher-order correlation functions of primordial density fluctuations. I will argue that this dictionary is far from complete, with theoretical predictions available only in restricted classes of theories.
To fill in this gap, I will present the cosmological flow, a complete and systematic approach to compute inflationary correlators for all inflationary theories. This enables to assist our theoretical understanding and to generate theoretical data for an unbiased interpretation of upcoming cosmological observations.
I will show that the cosmological collider signal, lying in soft limits of correlators, often described as a robust probe of the field content of inflation, is as robust as its assumptions are restrictive, and I will show its properties in theories involving multiple degrees of freedom, with strong mixing, in the presence of features.
Eventually, I will explain that if equilateral non-Gaussianities are detected, there exists a natural next observational target, the low-speed collider signal, manifesting as a peculiar resonance in mildly-soft kinematical configurations.

Presenter: RENAUX-PETEL, Sébastien (Paris, Inst. Astrophys.)

Contribution ID: **187** Type: **not specified**

New horizons in black hole physics

Tuesday, June 20, 2023 3:00 PM (1h 20m)

One of consequences of General Relativity is that vacuum black holes are remarkably simple macroscopic objects. They are thus ideal laboratories to test the underlying theory and to search for new degrees of freedom. I will discuss recent progress in black hole spectroscopy and in our understanding of black hole environments using gravitational-wave observations.

Presenter: CARDOSO, Vitor (Niels Bohr Institute and Lisbon, IST)

Contribution ID: **188** Type: **not specified**

Searching for Cosmological Concordance with New Physics in the Dark Sector: Hints and Challenges

Tuesday, June 6, 2023 4:00 PM (1 hour)

I will discuss recent and ongoing work focused on attempts to restore concordance amongst cosmological data sets, motivated by discrepancies between some measurements of the cosmic expansion rate (H_0) and the matter clustering amplitude (S_8). Particular attention will be paid to scenarios invoking new physics in the high-redshift universe, including models featuring interactions between the dark matter and an early dark energy (EDE) scalar field, as well as decaying particle scenarios that could lead to non-trivial evolution of the radiation density. I will discuss constraints on these models derived using CMB measurements from the Planck satellite and the Atacama Cosmology Telescope (ACT), amongst other data sets. I will also present new constraints on canonical axion-like EDE models derived from the Lyman-alpha forest, which pose a major challenge for this scenario to resolve the Hubble tension. Finally, I will conclude with a look ahead to the unprecedented constraining power of upcoming CMB analyses with ACT Data Release 6.

Presenter: COLIN HILL, James (Columbia University & Flatiron Insitute)

Contribution ID: **189** Type: **not specified**

Probing New Physics at the Pulsar Timing Array Frontier

Tuesday, October 10, 2023 11:00 AM (1h 20m)

Pulsar Timing Array (PTA) collaborations around the globe recently announced compelling evidence for a gravitational-wave background (GWB) at nanohertz frequencies. This breakthrough achievement has important implications for astrophysics, as the GWB signal, if genuine, is likely to originate from a cosmic population of supermassive black holes orbiting each other at the centers of galaxies. As I will illustrate in this talk, the new PTA data is, however, also of great interest to the high-energy physics community, as it allows to probe a broad range of particle physics models of the early Universe that predict the generation of a cosmological GWB in the Big Bang. In this sense, the PTA data opens a new window onto the very early Universe and enables particle physicists to constrain scenarios of new physics beyond the Standard Model at extremely high energies. In my talk, I will give an overview of these searches for new physics at the PTA frontier and highlight several cosmological scenarios that underline the relevance of PTA observations for fundamental problems such as dark matter, neutrino masses, and the matter-antimatter asymmetry of the Universe. Finally, I will conclude with a brief outlook on future measurements that may help in discriminating between a GWB signal of astrophysical origin and a GWB signal from the Big Bang. This talk is based on 2306.16219.

Presenter: SCHMITZ, Kai (Munster U., ITP)

Contribution ID: **190** Type: **not specified**

Does inflation always start with a Bang?

Tuesday, July 18, 2023 3:00 PM (1h 20m)

Inflationary spacetimes have been argued to be past geodesically incomplete in many situations. However, whether the geodesic incompleteness implies the existence of an initial spacetime curvature singularity or whether the spacetime may be extended (potentially into another phase of the universe) is generally unknown. Both questions have important physical implications. In this talk, we will take a closer look at the geometrical structure of inflationary spacetimes and investigate these very questions.

Presenter: QUINTIN, Jerome (U. Waterloo & Perimeter Inst. Theor. Phys.)

Contribution ID: **192** Type: **not specified**

An effective coda for loops in single clock inflation

Tuesday, November 21, 2023 3:00 PM (1h 20m)

In this talk, I will discuss an upcoming paper that shows how knowledge of the ultra-violet asymptotics of the effective action can offer a shortcut for the computation of certain processes in the effective theory of single clock inflation that involve loops of particles of arbitrary spin, in particular, with respect to the logarithmic running of correlation functions. In doing so, this work offers a coda to the question of the nature of the logarithmic running of inflationary correlators, confirming and generalizing the results of previous explicit in-in computations. Some implications for various applications of topical interest will be discussed.

Presenter: PATIL, Subodh (Leiden University)

Contribution ID: **193** Type: **not specified**

Phantom fluid cosmology: constraints and direct detection

Tuesday, September 26, 2023 3:00 PM (1h 20m)

Phantom fields have been widely invoked as a source of dark energy in cosmology, but rarely taken seriously as quantum theories. The vacuum is automatically unstable to production of negative-energy ghost particles plus normal particles, requiring such theories to be effective only, below some UV cutoff. I will present recent cosmological constraints arising from the vacuum instability, both at the level of the homogeneous background, and the density perturbations. We find that the fluid of particles produced from vacuum decay can ameliorate but not solve the notorious Hubble tension problem, and cannot fully replace the cosmological constant as a source of dark energy. The vacuum decay can be a source of boosted dark radiation, which might be detectable if it interacts with ordinary matter. I will show that this could fit recent excess events reported by the DAMIC experiment at SNOLAB.

Presenter: CLINE, James (McGill University)

Contribution ID: **194** Type: **not specified**

New inflationary probes of axion dark matter

Tuesday, November 7, 2023 3:00 PM (1h 20m)

The QCD axion, serving as a classical dark matter candidate, has a close intriguing interplay with cosmic inflation, a leading paradigm to understand the origin of our universe. In this talk, I will discuss two novel effects of interaction between the inflaton and the Peccei-Quinn (PQ) scalar field (the phase becomes the axion after symmetry breaking). First, the inclusion of the leading high-dimensional operator between the two fields could modify the conventional boundary between inflationary and post-inflationary axions drastically. In particular, a new window could be opened up for the post-inflationary axion, which does not suffer from the axion isocurvature problem. Second, in the feasible inflationary axion scenario, these operators could lead to a whole new suite of cosmological observables for axion isocurvature. They include correlated clock signals in the curvature and isocurvature spectra, and mixed cosmological-collider non-Gaussianities involving both curvature and isocurvature fluctuations with shapes and running unconstrained by the current data.

Presenter: FAN, JiJI (Brown University)

Contribution ID: **195** Type: **not specified**

Detecting single gravitons with quantum sensing

Tuesday, October 3, 2023 9:00 AM (1h 20m)

The quantization of gravity is widely believed to result in gravitons – particles of discrete energy that form gravitational waves. But their detection has so far been considered impossible. Here [1] we show that signatures of single gravitons can be observed in laboratory experiments. We show that stimulated and spontaneous single-graviton processes can become relevant for massive quantum acoustic resonators and that stimulated absorption can be resolved through continuous sensing of quantum jumps. We analyze the feasibility of observing the exchange of single energy quanta between matter and gravitational waves. Our results show that single graviton signatures are within reach of experiments. In analogy to the discovery of the photo-electric effect for photons, such signatures can provide the first experimental clue of the quantization of gravity.

Presenter: PIKOVSKI, Igor (Stockholm University & Stevens Institute of Technology)

Contribution ID: **205** Type: **not specified**

Cosmic birefringence: searching for parity-violating physics with the CMB polarization

Tuesday, October 24, 2023 3:00 PM (1h 20m)

The cross-correlation between the cosmic microwave background (CMB) E- and B-mode polarization can be used to probe parity-violating physics in the Universe. Parity-violating processes such as a Chern-Simons coupling to axion-like particles or the Faraday rotation induced by primordial magnetic fields are expected to rotate the plane of linear polarization and produce a non-null EB correlation. We commonly refer to that rotation as cosmic birefringence.
Past attempts at measuring isotropic cosmic birefringence tended to be dominated by systematic uncertainties and the limited precision of polarization angle calibration. Recently, a novel methodology has overcome the limitation imposed by the insufficient knowledge of instrument calibration by calibrating against Galactic foreground emission. When applied to Planck and WMAP data, this technique hints at the existence of an isotropic $\beta \approx 0.34^\circ \pm 0.09^\circ$ birefringence angle. Although it is still under scrutiny for its dependence on the modeling of Galactic dust emission, these results currently exclude $\beta = 0$ with a statistical significance of 3.6σ.
In this talk, I will review the current state of birefringence measurements from CMB polarization data, commenting on the impact of instrumental systematics and Galactic dust on the analysis. As the significance of the measurement continues to increase, I will also discuss the potential physical origin of the signal, focusing on axion-like particles as the most likely candidate.

Presenter: DIEGO PALAZUELOS, Patricia (Cantabria Inst. of Phys. and Cantabria U., Santander)

Contribution ID: **223** Type: **not specified**

Cosmic expansion versus motion: Probing the difference

Thursday, June 15, 2023 3:00 PM (1h 20m)

General inhomogeneous cosmologies give rise to differential cosmic expansion which differs from that of Friedmann-Lemaitre-Robertson-Walker (FLRW) models. Even models with an average isotropic homogeneous isotropic expansion law on > 100/h Mpc scales will generically have expansion laws which differ from FLRW plus local Lorentz boosts. That is, they differ from the conventional "kinematic interpretation". Strong evidence (˜ 5.1 sigma) against the kinematic interpretation has been provided by Secrest et al (2022), combining the Ellis-Baldwin test on 1.36 million distant quasars with similar studies of radio galaxies. There is a correlation with CMB anomalies.

Such signatures are a generic expectation in models which differ from FLRW, exhibiting backreaction, including the timescape cosmology. The particular features of nonkinematic differential expansion, regardless of the backreaction scheme, can be isolated by constructing toy Lambda-Szekeres models which asymptote to FLRW/Lamda CDM on > 100/h Mpc scales but exhibit nonkinematic differential expansion on smaller scales.

In this talk I will discuss ongoing work with the goal of constraining such toy models by local peculiar velocity data, and then using such models to probe the Ellis-Baldwin test, which in itself challenges the standard cosmology.

Presenter: WILTSHIRE, David (University of Canterbury)

Contribution ID: **224** Type: **not specified**

Graviton detection and the quantization of gravity

Tuesday, December 5, 2023 4:00 PM (1h 20m)

We revisit a question asked by Dyson: "Is a graviton detectable?" We demonstrate that in both Dyson's original sense and in a more modern measurement-theoretic sense, it is possible to construct a detector sensitive to single gravitons, and in fact a variety of existing and near-term gravitational wave detectors can achieve this. However, while such a signal would be consistent with the quantization of the gravitational field, we draw on results from quantum optics to show how the same signal could just as well be explained via classical gravitational waves. We outline the kind of measurements that would be needed to demonstrate quantization of gravitational radiation and explain why these are substantially more difficult than simply counting graviton clicks or observing gravitational noise in an interferometer, and likely impossible to perform in practice.

Presenter: RODD, Nicholas (CERN)

Contribution ID: **248** Type: **not specified**

Evolution in Dipole Lambda CDM Cosmology, from Big Bang to Now

Tuesday, August 1, 2023 3:00 PM (1h 20m)

Dipole cosmology is the maximally Copernican generalization of the FLRW paradigm that can incorporate bulk flows in the cosmic fluid. In this talk, I first discuss how multiple fluid components with independent flows can be realized in this set up. This is the necessary step to promote "tilted" Bianchi cosmologies to a viable framework for cosmological model building involving fluid mixtures (as in FLRW). I present a dipole Lambda CDM model which has radiation and matter with independent flows, with (or without) a positive cosmological constant. We follow evolution of the model from Big Bang and discuss the singularity around the Big Bang. A remarkable feature of dipole Lambda CDM model is that the relative flow between radiation and matter can increase at late times, which can contribute to eg., the CMB dipole. This can happen generically in the space of initial conditions. We discuss the significance of this observation for late time cosmic tensions.

Presenter: SHEIKH JABBARI, Shahin (IPM, Iran)

Contribution ID: **249** Type: **not specified**

Second quantization of noncommutative spaces: emergence of the Standard Model minimally coupled to gravity

Tuesday, November 14, 2023 1:30 PM (1 hour)

We start with a gentle introduction to the spectral approach to (noncommutative) geometry. We insist on the presence of fermions, so that a central role is played by a Dirac operator, acting on a one-particle Hilbert space. The combination with a coordinate algebra then allows for a full reconstruction of the spacetime geometry from the spectral data. Moreover, when allowing for noncommutative spaces described by an algebra of matrix-valued coordinates, the Dirac operator gets minimally coupled to a gauge field, as well as to the Higgs field.

The dynamics of all of these fields will emerge from the second quantization of the system. After a careful exposition of the latter procedure in the present context, we will analyze the information theoretic von Neumann entropy of the unique equilibrium state. We show that this entropy is given by the spectral action for a specific universal function. In the case of a curved spacetime manifold one finds that there is an asymptotic expansion of this entropy yielding the Einstein-Hilbert action, plus higher-order gravitational terms. Finally, in the presence of gauge and Higgs fields, the very same procedure yields additionally the Yang-Mills action functional and the scalar terms describing a Higgs mechanism.

Based on joint work with Ali Chamseddine and Alain Connes.

Presenter: VAN SUIJLEKOM, Walter (Radboud University Nijmegen)

Contribution ID: **251** Type: **not specified**

Termination of Superradiance from a Binary Companion

Tuesday, January 16, 2024 3:00 PM (1h 20m)

We study the impact of a binary companion on black hole superradiance at orbital frequencies away from the gravitational-collider-physics (GCP) resonance bands. A superradiant state can couple to a strongly absorptive state via the tidal perturbation of the companion, thereby acquiring a suppressed superradiance rate. Below a critical binary separation, this superradiance rate becomes negative, and the boson cloud gets absorbed by the black hole. This critical binary separation leads to tight constraints on GCP. Especially, a companion with mass ratio q > 10^{−3} invalidates all GCP fine structure transitions, as well as almost all Bohr transitions except those from the |ψ211> state. Meanwhile, the backreaction on the companion manifests itself as a torque acting on the binary, producing floating/sinking orbits that can be verified via pulsar timing. In addition, the possible termination of cloud growth may help to alleviate the current bounds on the ultralight boson mass from various null detections.

Presenter: ZHU, Hui-Yu (Hong Kong U. Sci. Tech.)

Contribution ID: **252** Type: **not specified**

tba

Friday, January 31, 2025 11:20 AM (20 minutes)

Contribution ID: **253** Type: **not specified**

Primordial Black Holes Are True Vacuum Nurseries

Tuesday, December 12, 2023 3:00 PM (1h 20m)

The Hawking evaporation of primordial black holes (PBH) reheats the Universe locally, forming hot spots that survive throughout their lifetime. We propose to use the temperature profile of such hot spots for light PBHs to calculate the decay rate of metastable vacua in cosmology, avoiding inconsistencies inherent to the Hartle-Hawking or Unruh vacuum and thermal loop correction which suppress the decay rate. We apply our formalism to the case of the purported electroweak (Higgs) vacuum stability and find that a PBH energy fraction $\beta > 7 \times 10^{-80}(M/g)^{3/2}$ is ruled out for black holes with masses $0.8g < M < 10^{15}g$.

Presenter: HAMAIDE, Louis (UCL, London)

Contribution ID: **254** Type: **not specified**

Instability and gravitational waves in axion inflation with strong backreaction from gauge modes

Tuesday, January 23, 2024 3:00 PM (1 hour)

I will talk about a model in which an inflaton, through an axionic coupling to a U(1) gauge field, causes an amplification of the gauge field modes that strongly backreact on its dynamics. In particular, I will discuss, using analytical formulae, an instability of the system that emerges when one considers the evolution of the gauge field modes coupled to the inflaton zero mode, treating perturbatively the deviation of the inflaton velocity from its mean-field value. This analysis confirms previous numerical results. I will also discuss two different numerical studies of the system in the same regime, showing how this behavior can generate peculiar observable features in the spectrum of gravitational waves produced by the modes of the gauge field.

Presenter: SORBO, Lorenzo (University of Massachusetts)

Contribution ID: **255** Type: **not specified**

The separate-universe approach and sudden transitions during inflation

Tuesday, January 30, 2024 3:00 PM (1 hour)

The separate-universe approach gives an intuitive way to understand the evolution of cosmological perturbations in the long-wavelength limit. It uses solutions of the spatially-homogeneous equations of motion to model the evolution of the inhomogeneous universe on large scales. We show that the separate-universe approach fails on a finite range of super-Hubble scales at a sudden transition from slow roll to ultra-slow roll during inflation in the very early universe. Such transitions are a feature of inflation models giving a large enhancement in the primordial power spectrum on small scales, necessary to produce primordial black holes after inflation. We show that the separate-universe approach still works in a piece-wise fashion, before and after the transition, but spatial gradients on finite scales require a discontinuity in the homogeneous solution at the transition. We discuss the implications for the delta-N formalism and stochastic inflation, which employ the separate-universe approximation.

Presenter: JACKSON, Joseph (Portsmouth U., ICG)

Contribution ID: **256** Type: **not specified**

Back-reaction in the early universe

Tuesday, April 23, 2024 3:00 PM (1 hour)

Both single- and multi-field models of inflation might lead to enhanced scalar fluctuations on scales much smaller than those seeding the large-scale structure formation. In these scenarios, it is possible that the spike of power at high wavenumber might induce large corrections to the scalar power spectrum, e.g. in the form of loop corrections, potentially endangering the perturbativity of the underlying models. In this talk we discuss recent developments in the calculation of the 1-loop correction.

Presenter: IACCONI, Laura (Queen Mary University of London & University of Portsmouth)

Contribution ID: **257** Type: **not specified**

Eternal Inflation and a Geodesically Complete Multiverse

Tuesday, April 9, 2024 5:00 PM (1 hour)

I will discuss the possibility of an eternal universe, a universe with no first moment and no end. The talk will focus on eternal inflation and the key role that inflation plays in resolving cosmological singularities. I will describe how proposed no-go theorems, such as the famous theorem of Borde, Guth and Vilenkin (BGV) are circumvented or obviated. Our exploration encompasses eternal inflating, loitering, and bouncing models, shedding light on the critical aspects that underpin geodesic completeness and the constraints energy conditions in General Relativity impose on such spacetimes. Ignoring the intractable subtleties introduced by quantum considerations, such as rare tunneling events and Boltzmann brains, we will argue that the universe need not have a beginning or an end.

Presenter: EASSON, Damien (Arizona State University)

Contribution ID: **258** Type: **not specified**

Multi-messenger probes of parity symmetry

Tuesday, May 28, 2024 3:00 PM (1 hour)

Gravitational waves (GWs) are an ideal observable to probe the properties of gravity, from the strong to the weak-field regimes. In particular, by studying their cosmological propagation, we can test the fundamenal properties of gravity on large scales, such as parity symmetry. In this talk, I will discuss the signatures that parity violation would leave on gravitational waves from coalescing binaries, showing how the GW polarization can change from emission to detection. I will then argue that the observation of GWs from binary neutron stars and their EM counterparts provide a unique opportunity to probe polarization changes, and hence constrain parity violation in the future.

Presenter: LAGOS, Macarena (Andres Bello Natl. U.)

Contribution ID: **259** Type: **not specified**

Parity violation as a probe for dark matter and theories beyond General Relativity

Tuesday, May 7, 2024 3:00 PM (1h 20m)

Next generation gravitational wave (GW) observatories will have sensitivities capable of obtaining polarization data of the GWs, which is one way to constrain parity violating models beyond General Relativity. Interestingly, this can also serve as a novel way to probe dark matter physics, in particular models which include nonminimal couplings between the metric and dark matter. In this talk, we will outline a model independent parameterization of the gravitational waveforms which captures effects of this type. Then, we will present a specific example of a dimension-four operator coupling the dual Riemann tensor to the Kalb-Ramond two-form, which has recently gained attention as a dark matter candidate.

Presenter: MANTON, Tucker (Brown University)

Contribution ID: **260** Type: **not specified**

(Runaway) Gravitational Production of Dark Photons

Tuesday, May 14, 2024 3:00 PM (1 hour)

Gravitational particle production is the process by which particles are created due to the expansion of spacetime during inflation. In this talk we will discuss aspects of gravitational particle production of dark photons, a popular dark matter candidate, with a particular focus on dark photons with nonminimal couplings to gravity. I will first show that the inclusion of nonminimal couplings can lead to instabilities in the theory, namely ghosts and "runaway"production, and that the parameter space for the couplings is limited in order to avoid such instabilities. Lastly, within the allowable non-ghost and non-runaway region of parameter space, I will show that dark photons can be produced in the correct abundance to account for all of the dark matter today.

Presenter: JENKS, Leah (KICP, University of Chicago)

Contribution ID: **261** Type: **not specified**

Primordial Black Holes: From formation to detection

Tuesday, May 21, 2024 3:00 PM (1 hour)

I will present recent work on the formation of primordial black hole dark matter and the resultant gravitational wave (GW) signal, in which my collaborators and I performed an MCMC analysis of a simple—yet generic—multifield inflation model characterized by two scalar fields coupled to each other and non-minimally coupled to gravity. The model was fit to the Planck 2018 CMB data. In particular, model parameters are constrained by data on the amplitude of the primordial power spectrum of scalar curvature perturbations on CMB scales ⊠⊠, the spectral index ⊠⊠, and the ratio of power in tensor to scalar modes ⊠, with a prior that the primordial power spectrum should also lead to primordial black hole (PBH) production sufficient to account for the observed dark matter (DM) abundance.⊠⊠, the spectral index ⊠⊠, and the ratio of power in tensor to scalar modes ⊠, with a prior that the primordial power spectrum should also lead to primordial black hole (PBH) production sufficient to account for the observed dark matter (DM) abundance.

I will discuss why such a class of multifield models is well-motivated and derives from natural high-energy ingredients, and what the parameter space can teach us about the genericness PBH formation from inflation.

I will then transition to the natural follow-up question: how might we detect such PBHs, if they do indeed constitute an O(1) fraction of the DM? I will show that, if PBHs lie within this mass range and make up most or all of the dark matter, the PBH abundance would be large enough for at least one object to cross through the inner Solar System per decade. Since Solar System ephemerides are modeled and measured to extremely high precision, such close encounters could produce detectable perturbations to orbital trajectories with characteristic features. Using a suite of simple Solar System simulations, I will make the case that the abundance of asteroid-mass PBHs can be probed by existing and near-term data, potentially furnishing us with a new direct probe of PBH dark matter.

Presenter: GELLER, Sarah (Santa Cruz Institute for Particle Physics, UC)

Contribution ID: **262** Type: **not specified**

Who ordered the disformal coupling for the Proca field?

Tuesday, April 30, 2024 10:00 AM (1 hour)

In this talk, we will study the massless limits of two cases of Proca theory – in the presence of self-interactions, and with non-minimal coupling to gravity. In contrast to its massless counterpart, this theory propagates an additional longitudinal mode in flat spacetime. Due to this, conventional methods indicate that the perturbative series is singular in mass. In the presence of self-interactions, we will confirm that the longitudinal mode becomes strongly coupled at the Vainshtein scale, and decouples from the remaining transverse modes beyond it, which in turn remain weakly coupled. In the case of non-minimal coupling to gravity, however, the longitudinal mode will cause the strong coupling of the tensor modes, leading to a surprising inconsistency. We will show that this can be solved by the introduction of the disformal couplings, and discuss further implications to the cosmological backgrounds.

Presenter: HELL, Anamaria (Kavli IPMU, the University of Tokyo)

Contribution ID: **263** Type: **not specified**

Cosmic birefringence and its implications

Tuesday, June 11, 2024 10:00 AM (1 hour)

Cosmic birefringence is a parity-violating phenomenon that rotates the plane of linear polarization of the CMB photons. Recently, a nonzero isotropic cosmic birefringence (ICB), its overall rotation angle from the last scattering surface to the present, with a statistical significance of 3.6 sigma has been reported for the latest joint analysis of Planck/WMAP data. In this talk, we will present some theoretical implications of ICB for new physics beyond the Standard Model, such as axions. Or, we will show why new physics is necessary to explain the measured ICB angle.

Presenter: OBATA, Ippei (Kavli IPMU, Tokyo University)

Contribution ID: **264** Type: **not specified**

Induced gravitational waves from inflaton oscillons and solitons

Tuesday, June 4, 2024 10:00 AM (1 hour)

We present a new way to study cosmic inflation with gravitational waves (GWs). The gravitational signal is generated thanks to nonlinear structures in the inflaton field, called oscillons. This novel probe allows us to test models of inflation which are challenging to constrain with CMB experiments. We also present a novel induced-GW signature, called Universal GWs, associated with all early-Universe scenarios involving the formation of non-inflaton solitons. Universal GWs provide a new avenue for testing the physics of primordial solitons, such as their formation and interactions, and also an explanation of the Pulsar Timing Array data.

Presenter: LOZANOV, Kaloian (Kavli IPMU, Tokyo University)

Contribution ID: **265** Type: **not specified**

Particle Production by Gravitational Fields and Black Hole Evaporation

Tuesday, October 31, 2023 4:00 PM (1h 20m)

based on Phys. Rev. Lett. 130 (2023) 221502 (arXiv:2305.18521 [gr-qc])

This talk presents a new avenue to black hole evaporation using a heat-kernel approach in the context of effective field theory analogous to deriving the Schwinger effect. Applying this method to an uncharged massless scalar field in a Schwarzschild spacetime, we show that spacetime curvature takes a similar role as the electric field strength in the Schwinger effect. We interpret our results as local pair production in a gravitational field and derive a radial production profile. The resulting emission peaks near the unstable photon orbit. Comparing the particle number and energy flux to the Hawking case, we find both effects to be of similar order. However, our pair production mechanism itself does not explicitly make use of the presence of a black hole event horizon and might have cosmological implications.

Author: FLORIAN WONDRAK, Michael (Radboud University)

Presenter: FLORIAN WONDRAK, Michael (Radboud University)

Contribution ID: **266** Type: **not specified**

Ultralight dark matter, review and future extensions

Tuesday, July 9, 2024 10:00 AM (1 hour)

The cosmological evidence supporting the existence of dark matter is extremely compelling. And while we have known how dark matter fits into the standard model of cosmology, Lambda CDM, direct observation still eludes us despite a global experimental effort ruling out large regions of once promising parameter space. This has motivated study of alternative dark matter models. One such model is Ultralight dark matter, where the particle mass is so light that wavelike phenomena impact large scale structure. This model was originally proposed to address small scale structure discrepancy between Lambda CDM and dark-matter only simulations. The mass associated with that purpose has long been ruled out. However, observations of small-scale structure continue to allow us to place a lower bound on the dark matter mass, ruling out decades of mass parameter space relying only on the dark matter's gravitational coupling. In this talk I review the field of ultralight dark matter. I will discuss the model itself and its related phenomenology and constraints. Finally, I will discuss the current direction of the field into extensions of the vanilla ultra light dark matter model and the implications of this work for constraints and pheno.

Presenter: EBERHARDT, Andrew (Kavli IPMU, the University of Tokyo)

Contribution ID: **267** Type: **not specified**

Upper bounds on the mass of fields from vacuum zero point energy fluctuations during inflation

Tuesday, July 16, 2024 3:00 PM (1h 20m)

We study the fluctuations in the vacuum zero point energy associated to quantum fields and their statistical distributions during inflation. We show that the perturbations in the vacuum zero point energy have large amplitudes and are highly non-Gaussian. The effects of vacuum zero point fluctuations can be interpreted as the loop corrections in primordial power spectrum and bispectrum. Requiring that the primordial curvature perturbation to remain nearly scale-invariant and Gaussian imposes strong upper bounds on the mass of fundamental fields during inflation. We show that the fundamental fields can not be much heavier than the Hubble scale during inflation, otherwise their vacuum zero point fluctuations induce large non-Gaussianities and scale-dependence in primordial perturbations. Imposing the observational upper bound on tensor to scalar ratio, we conclude that all fundamental fields are lighter than 10^{14} GeV.

Presenter: FIROUZJAHI, Hassan (Institute for Research in Fundamental Sciences)

Contribution ID: **268** Type: **not specified**

Gravitational Wave-Induced Freeze-In of Fermionic Dark Matter

Tuesday, June 25, 2024 3:00 PM (1h 20m)

The minimal coupling of massless fermions to gravity does not allow for their gravitational production solely based on the expansion of the Universe. In this talk I will explain that changes in the presence of realistic and potentially detectable stochastic gravitational wave backgrounds. Next, I will discuss the resulting energy density of Weyl fermions at 1-loop. If the initially massless fermions eventually acquire mass, this mechanism can explain the dark matter abundance in the Universe. Remarkably, it may be more efficient than conventional gravitational production of superheavy fermions.

Presenter: MALEKNEJAD, Azadeh (King's College London)

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Wednesday, December 25, 2024 4:00 PM (20 minutes)

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Dynamical systems and analytic cosmological bounds

Tuesday, June 18, 2024 3:00 PM (1 hour)

Any scalar FLRW-cosmology with multi-field multi-exponential potentials exhibits a universal late-time bound on cosmic acceleration, which we prove analytically. We discuss the conditions under which scaling solutions are inevitable late-time attractors for this class of theories. Without the need to find explicit solutions to the cosmological equations, we are also able to identify bounds in the additional presence of fields with exponential kinetic couplings. We can further see how the contraction rate of cosmologies with negative potentials can be bounded by similar methods as those for cosmic acceleration. These results endow us with strong analytic tools to discuss cosmological backgrounds that appear, for instance, in some asymptotic corners of string compactifications.

Presenter: TONIONI, Flavio (KU Leuven)

Contribution ID: **285** Type: **not specified**

Relic gravitons, single gravitons and high-frequency detectors

Tuesday, March 19, 2024 3:00 PM (1 hour)

The gravitons produced during the early stages of the evolution of the space-time curvature represent an ideal triple point where theoretical physics, high-energy physics and cosmology meet for different purposes. After a general introduction, I will focus on some recent results and argue that relic gravitons will represent, in the years to come, the sole direct probe of the the post-inflationary expansion history prior to big-bang nucleosynthesis. Along this perspective I will swiftly discuss the pulsar timing arrays and the audio band where wide-band detectors are currently operating. I will then suggest that the high-frequency gravitons in the MHz and GHz regions can be detected by using microwave cavities and electromechanical detectors as firstly propounded over thirty years ago. The sensitivities in the chirp amplitude should however improve by, at least, 10 or 15 orders of magnitude in comparison with the ones currently achievable in the audio band (i.e. between few Hz and few kHz). I will then analyze the high-frequency detectors in the framework of Hanbury-Brown Twiss interferometry and argue that they are actually more essential than the ones operating at lower frequencies if we want to investigate the quantumness of the relic gravitons and their associated second-order correlations. In particular the statistical properties of thermal and non-thermal gravitons can be distinguished by studying the corresponding Bose-Einstein interference effects.

Presenter: GIOVANNINI, Massimo (CERN Physics Department and INFN Milan-Bicocca)

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Friday, December 27, 2024 10:00 AM (20 minutes)

Contribution ID: **304** Type: **not specified**

Baryogenesis and baryon isocurvature perturbation from primordial magnetic fields

Tuesday, February 27, 2024 3:00 PM (1 hour)

Gamma-ray observations of blazars suggest the existence of the intergalactic magnetic fields and their origin is interest for both astro physicsts and cosmologists. Among several proposals, magnetogenesis in the early Universe is an interesting option since it might also be a probe for the physics beyond the Standard Model of particle physics. Recently, it has also been proven that the baryon asymmetry of the Universe can be also generated if the magnetic fields are produced before the electroweak symmetry breaking with helicity without imposing any new physics. However, baryon isocurvature perturbations are also generated at the scale of the magnetic field coherence length in the mean time, which is constrained by the inhomogeneous Big Bang Nucleosynthesis. Note that this is an inevitable consequence of the Standard Model of particle physics. In this talk, I give generic constraints of the hypermagnetic field properties generated before the electroweak symmetry breaking. Noting that the baryon isocurvature perturbations are generated even from non-helical magnetic fields, I show that with reasonable parameter sets for the Standard Model of particle physics and magnetic field evolution laws, the intergalactic magnetic fields suggested by the blazar observations are hardly explained solely by the hypermagnetic fields generated before the electroweak symmetry breaking. Helical hypermagnetic fields can still be the origin of the present baryon asymmetry of the Unvierse, but we need an additional magnetogenesis or an unknown magnetic field amplification mechanism.

Presenter: KAMADA, Kohei (University of Chinese Academy of Science)

Contribution ID: **305** Type: **not specified**

Effective Cuscuton Theory

Tuesday, February 13, 2024 3:00 PM (1 hour)

Non-propagating fields have a wide presence in the literature, from non-propagating form fields in quantum hall systems to non-propagating 4-form fields in supersymmetric theories. Among these, the cuscuton field theory stands out as an extension of general relativity that avoids introducing additional propagating degrees of freedom, making it highly applicable in cosmology. Its simplicity provides a more accessible route to understanding how non-propagating fields may lose their dynamics. In this discussion, I will explore the construction of a general geometric description of the cuscuton field theory. This involves introducing curvature corrections to both the volume (potential) and the surface (kinetic) terms in the original cuscuton action. This geometric approach involves a stack of spacelike branes, separated by 4-dimensional bulks. We conjecture that the cuscuton, initially a discrete field, becomes continuous in the limit, there are many such transitions. Finally, I will show some examples.

Presenter: MYLOVA, Maria (IPMU, the University of Tokyo)

Contribution ID: **306** Type: **not specified**

Lingering Before Inflation

Tuesday, February 20, 2024 3:00 PM (1 hour)

In this talk, we revisit motivation from String Theory for new phases of cosmology –prior to inflation. Cosmic inflation offers a causal way to predict initial conditions for the growth of structure and density fluctuations in the cosmic microwave background and large-scale structure formation. However, asymptotic de Sitter space possesses a past cosmological (physical) singularity implying the theory cannot be complete. In this talk, I will discuss how investigations into QCD led to an idea that could prevent the past singularity, or at least give a way to calculate predictions in real time on curved space-time backgrounds. This paradigm would lead to cosmologies that do not begin (Big Bang) or repeat (Ekpyrotic / Cyclic scenario) but instead begin from sitting around –a period of "lingering", as first considered by Lemaître.

Presenter: WATSON, Scott (Syracuse University)

Contribution ID: **307** Type: **not specified**

Universal black hole microstates

Tuesday, March 12, 2024 1:30 PM (1 hour)

All the existing derivations of the black hole entropy formula S=A/4G have something unsatisfactory to them, and this dissatisfaction has stimulated much investigation into the structure of spacetime. In this talk I will describe a very broad statistical interpretation of this formula. Together with Ana Climent, Javier Magan, Martin Sasieta, and Alejandro Vilar Lopez, we have refined and extended a recent construction of sets of black hole microstates with semiclassical interiors that span a Hilbert space of dimension exp(S), where S is the black hole entropy. I will argue that there is a limit in which the construction acquires universal validity, applicable to rotating and charged black holes, extremal and near-extremal solutions, with or without supersymmetry, and possibly including general quantum corrections.

Presenter: EMPARAN, Roberto (Universitat de Barcelona)

Contribution ID: **308** Type: **not specified**

Impact of primordial magnetic fields on matter power spectrum

Tuesday, March 5, 2024 3:00 PM (1 hour)

Primordial magnetic fields (PMFs) offer a simple explanation for the origin of galactic magnetic fields as well as of the purportedly detected magnetic fields in cosmic voids. In the talk, I discuss how PMFs' influence on structure formation can offer a complementary method to test for their existence. Specifically, I discuss how PMFs enhance the matter power spectrum on small scales, <Mpc. On scales relevant to galaxies and black holes, I show that PMFs can significantly enhance the baryon fraction in halos as well as the abundance of halos. Next, I show that on scales below the baryon Jeans scales, PMFs can enhance dark matter power spectrum purely by gravitational influence. I conclude by arguing how search for dark matter minihalos can potentially provide the most sensitive probe for PMFs.

Presenter: RALEGANKAR, Pranjal (SISSA)

Contribution ID: **320** Type: **not specified**

Entanglement generation by superradiance and its impact in Hawking radiation

Tuesday, March 26, 2024 3:00 PM (1 hour)

We recently showed that superradiance generates entanglement in generic situations. On the other hand, the entanglement generated during Hawking evaporation is a crucial aspect of the Hawking effect, and is influenced by rotational superradiance induced by the black hole ergoregion. In this talk, we will leverage Gaussian quantum information techniques to describe the Hawking process for a rotating black hole in a simple yet powerful manner. This formalism allows to quantify the entanglement generated during the Hawking process in presence of an external thermal bath — CMB radiation —. We will then discuss the entanglement structure of Hawking radiation, detailing the role of superradiance and its interaction with pair creation at the horizon, which leads to a distinctive signature in the quantum correlations of Hawking radiation. We will finish by briefly discussing laboratory analogues where these findings can be tested.

Presenter: DELHOM, Adrià (Louisiana State U.)

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Friday, January 31, 2025 11:15 AM (1 minute)