Alternative Gravities and Fundamental Cosmology - ALTECOSMOFUN'21 [VIRTUAL]

Report of Contributions

https://indico.cern.ch/e/873762

Contribution ID: **1** Type: **Talk/seminar**

Existence of bulk viscous universe in $f(R,T)$ gravity and confrontation with observational data

Wednesday, 8 September 2021 15:10 (20 minutes)

In this paper we have investigated a bulk viscous universe in $f(R,T)$ gravity where R and T are the Ricci scalar and trace of energy momentum tensor respectively. We have obtained explicit solutions of field equations in modified gravity by considering the power law form of scale factor. The Hubble parameter and deceleration
parameter are derived in terms of cosmic time and redshift both. We have estimated the present values of these parameters with observational Hubble data and SN Ia data sets. At 1σ level, the estimated values of q_0 and m are obtained as $q_0 = -0.30 \pm 0.05$ \& $m = 0.70 \pm 0.02$ where q_0 is the present value of deceleration parameter and m is the model parameter. The energy conditions and Om(z) analysis for the anisotropic LRS Bianchi type I model are also discussed.

Primary author: Prof. SAHOO, Pradyumn Kumar (Birla Institute of Technology and Science-Pilani, Hyderabad Campus)

Presenter: Prof. SAHOO, Pradyumn Kumar (Birla Institute of Technology and Science-Pilani, Hyderabad Campus)

Session Classification: Regular Sessions

Contribution ID: **2** Type: **Talk/seminar**

Physics beyond the Standard Model with IceCube

Friday, 10 September 2021 10:00 (1 hour)

The IceCube neutrino observatory is a neutrino telescope situated near the South Pole in Antarctica. A cubic kilometer of ice is instrumented with optical modules sensitive to photons. When high energetic particles produce light in interactions with the ice, the signature can be recorded and used for reconstruction of the primary particle.

The design of IceCube not only facilitates the detection of astrophysical neutrinos up to PeV energies but also the direct and indirect probe of physics beyond the Standard Model with leading sensitivities. Exotic particles which can penetrate through the ice sheet or even the entire Earth can be measured directly, these include magnetic monopoles, Q-Balls, or partially charged particles. Dark matter is indirectly searched for by investigating its effect on neutrino spectra as well as arrival directions.

The discovery of astrophysical neutrinos enables the measurement of neutrino interactions at unprecedented energies where new physics might emerge such as Lorentz Invariance Violation. The recent achievements of IceCube in the search for beyond Standard Model physics will be presented.

Primary author: POLLMANN, Anna (University of Wuppertal)

Presenter: POLLMANN, Anna (University of Wuppertal)

Session Classification: Invited Plenary Session

Contribution ID: **4** Type: **Talk/seminar**

Modified gravity in light of cosmic tensions

Wednesday, 8 September 2021 12:30 (20 minutes)

The standard cosmological model, LCDM, is based on General relativity and assumes the Universe is made of a Dark energy component in the form of a cosmological constant (L). Although LCDM gives an astonishing description of the Universe, the model shows some shortcomings: the so-called cosmological constant problems.Furthermore, some mild observational tensions among different datasets emerge in this model, for instance, on the value of the Hubble constant and amplitude of the matter power spectrum at present time and scale of 8 h/Mpc. This picture summarizes the motivations at the basis of speculations on the validity of the LCDM model and the search for new physics beyond the standard model.
I will present the phenomenology and cosmological bounds on alternative cosmological models compatible with the stringent constraint on the speed of propagation of gravitational waves from GW170817 and GRB170817A and which either offer a better fit to data than LCDM or alleviate the cosmic tensions.

Primary author: FRUSCIANTE, Noemi (Instituto de Astrofísica e Ciências do Espaço)

Presenter: FRUSCIANTE, Noemi (Instituto de Astrofísica e Ciências do Espaço)

Session Classification: Regular Sessions

Contribution ID: **6** Type: **Poster**

Gravitational lensing by a black hole in Poincaré gauge theory

Thursday, 9 September 2021 18:30 (20 minutes)

One of the consequences of Einstein's general theory of relativity is bending of light as it passes through a gravitational field. Examining the path of light in a very strong gravitational field of a black hole can provide a huge amount of information about the geometry and characteristics of the surrounding space.
On the other hand, the path of light rays, extent, and shape of gravitational lensing, are directly related to the type of background geometry in which light is emitted. Since the theory of general relativity in very high energies and very strong gravitational fields is expected to be corrected, researchers have been looking at the phenomenon of gravitational lensing in the context of alternative theories for general relativity to find out the needed corrections for the results of general relativity and these corrections are likely to be more significant in a very strong gravitational field of a black hole.
Among the various theories that have been proposed for correcting the gravity in high energies, gauge theories of gravity have great importance. One of the important results of these theories is changing the geometry for the background in general relativity, Riemannian space-time, to a non-Riemannian geometry in which, in addition to curvature, there is also torsion. In these theories, the presence of torsion coupled to spin of a matter can affect the path of light rays and correct the results of gravitational lensing.
In this work, we want to study the effects of non-Riemannian geometry on the gravitational lensing of a black hole, and in particular the effects of torsion and spin in this context.

Primary author: ZAMANI, Saboura sadat (Golestan University, Iran)

Co-author: Dr AKHSHABI, Siamak (Golestan University,Iran)

Presenter: ZAMANI, Saboura sadat (Golestan University, Iran)

Session Classification: Regular Sessions

Contribution ID: **7** Type: **Talk/seminar**

Towards a $Lambda$CDM Universe in $f(R)$ gravity

Wednesday, 8 September 2021 13:30 (20 minutes)

ΛCDM model to date remains the best observationally fitting model for late time cosmology. However, this model suffers from the theoretical issue that the quantum vacuum energy, which is the only known candidate for Λ, gives from QFT calculation a value that mismatches with the observed value of Λ by orders of magnitude. This theoretical issue motivated the search for alternative late-time cosmological models. Among various alternative models, a broad class of models incorporate modified gravity, within which a significant subclass is f(R) gravity models. A very pertinent question to ask is whether there are some f(R) gravity models that can exactly mimic the ΛCDM evolution history. This question is of interest because if there are indeed such f(R) gravity models, then one need not worry about the theoretical issue on Λ. This problem can be approached with the reconstruction method of f(R) gravity, although the form is too complicated for further analytical consideration. We approach this problem with a new model-independent dynamical systems formulation of f(R) that we recently introduced in 2103.02274. We show that there is an inherent issue in trying to reproduce ΛCDM cosmology in f(R) gravity.

Primary authors: CHAKRABORTY, Saikat; Prof. DUNSBY, Peter (University of Cape Town); Ms MACDEVITTE, Kelly (University of Cape Town)

Presenter: CHAKRABORTY, Saikat

Session Classification: Regular Sessions

Contribution ID: **8** Type: **Talk/seminar**

Is asymptotically safe inflation eternal?

Thursday, 9 September 2021 15:10 (20 minutes)

Recently, based on swampland considerations in string theory, the (no) eternal inflation principle has been put forward. The natural question arises whether similar conditions hold in other approaches to quantum gravity. In this talk I will discuss the asymptotic safety hypothesis in the context of eternal inflation. As exemplary inflation- ary models the SU(N) Yang-Mills in the Veneziano limit and various RG-improvements of the gravitational action will be discussed. I will also discuss the finite action principle in the context of initial conditions for the Universe and (eternal) inflation.

Primary author: KWAPISZ, Jan

Presenter: KWAPISZ, Jan

Session Classification: Regular Sessions

Contribution ID: **9** Type: **Talk/seminar**

Freely-falling bodies in standing-wave spacetime

Friday, 10 September 2021 17:30 (20 minutes)

The phenomena of standing waves are mostly studied in the context of mechanical or electromagnetic waves. In the context of General Relativity, the issue of how to define standing gravitational waves was addressed by Bondi and later by Stefani. We investigate an expanding universe filled with standing gravitational waves. We study how freely falling particles in this spacetime behave, namely, we investigate the geodesic equation and the geodesic deviation equation. We show that antinodes attract freely falling particles and we trace the velocity memory effect.

Primary author: Mr SZYBKA, Sebastian (Astronomical Observatory, Jagiellonian University)

Co-author: UMAIR, Syed (Jagiellonian Universtiy)

Presenter: UMAIR, Syed (Jagiellonian Universtiy)

Session Classification: Regular Sessions

Contribution ID: **10** Type: **Talk/seminar**

Quantum black holes and resolution of the singularity

We present a simple quantum description of compact sources and black holes in which the General Relativistic exterior is reproduced by coherent states but the classical central singularity cannot be resolved because modes of arbitrarily short wavelength are not populated. Quantum corrections to the outer potential are also estimated, which could result in observable effects for the gravitational collapse of compact objects and both astrophysical and microscopic black holes.

Primary author: Prof. CASADIO, Roberto (Bologna University and INFN)

Presenter: Prof. CASADIO, Roberto (Bologna University and INFN)

Session Classification: Regular Sessions

Contribution ID: **11** Type: **Talk/seminar**

Thermodynamics of scalar-tensor gravity

Monday, 6 September 2021 12:50 (20 minutes)

In the 90s it was shown that the Einstein equation could be understood as an equation of state, general relativity as the equilibrium state of gravity, and f(R) gravity as a non-equilibrium one. In this presentation I discuss how the application of Eckart's first order thermodynamics to the effective dissipative fluid describing scalar-tensor gravity leads to a thermodynamics for the space of theories of gravity. Surprisingly, within this picture one obtains simple expressions for the effective heat flux, "temperature of gravity", shear and bulk viscosity, and entropy density, plus a generalized Fourier law in a consistent Eckart thermodynamical picture. Furthermore, a well-defined notion of the approach to equilibrium, missing in the current thermodynamics of spacetime scenarios, naturally emerges.

Primary author: GIUSTI, Andrea (ETH Zürich)

Co-author: Prof. FARAONI, Valerio (Bishop's University)

Presenter: GIUSTI, Andrea (ETH Zürich)

Session Classification: Regular Sessions

Contribution ID: **12** Type: **Talk/seminar**

Modified Teleparallel Gravity induced by quantum fluctuations in semi-classical approach

Monday, 6 September 2021 18:10 (20 minutes)

In the semi-classical regime, quantum fluctuations embedded in a Riemannian spacetime can be effectively recast as classical back reactions and manifest themselves in the form of non-minimal couplings between matter and curvature. In this work, we exhibit that this semi-classical description can also be applied within the Teleparallel formulation. In the Teleparallel description, quantum fluctuations generically lead to non-minimal matter-torsion couplings. Due to the equivalence between the (classical) Einstein gravity in the Riemannian description and that in the Teleparallel description, some effective models which were constructed using the Riemannian description can be recovered completely with the Teleparallel description. Besides, when the effective quantum correction term is proportional to the torsion scalar T, we obtain a subclass of novel f(T,B,T) gravity, where B is a boundary term, and T is the trace of the energy-momentum tensor. Next, we investigate the cosmological properties in this f(T,B,T) theory. In this work, the matter Lagrangian is solely constructed by a dynamical scalar field. We exhibit some interesting cosmological solutions, such as those with decelerating expansion followed by a late-time accelerating phase.

Primary author: KUNG, Yu-Hsien (National Taiwan University)

Co-author: CHEN, Che-Yu (Academia Sinica)

Presenter: KUNG, Yu-Hsien (National Taiwan University)

Session Classification: Regular Sessions

Contribution ID: **13** Type: **Talk/seminar**

Quasinormal frequencies and black hole shadow radius: an analytical correspondence

Thursday, 9 September 2021 17:50 (20 minutes)

We study the relation between quasinormal modes and geodesic quantities recently brought back due to the black hole shadow observation by Event Horizon Telescope. With the help of WKB method we found an analytical relation between the real part of quasinormal frequencies at the eikonal limit and shadow radius of the same black hole. Some examples fulfilling the correspondence are provided.

Primary author: CUADROS-MELGAR, Bertha (USP)

Co-authors: Prof. DE OLIVEIRA, Jeferson (Federal University of Mato Grosso); Prof. FONTANA, Rodrigo D.B. (Federal University of the Southern Border)

Presenter: CUADROS-MELGAR, Bertha (USP)

Session Classification: Regular Sessions

Contribution ID: **14** Type: **Talk/seminar**

Renormalization Group in Six-derivative Quantum Gravity

Tuesday, 7 September 2021 18:30 (20 minutes)

The exact one-loop beta functions for the four-derivative terms (Weyl tensor squared, Ricci scalar squared, and the Gauss-Bonnet) are derived for the minimal six-derivative quantum gravity (QG) theory in four spacetime dimensions. The calculation is performed by means of the Barvinsky and Vilkovisky generalized Schwinger-DeWitt technique. With this result we gain, for the first time, the
full set of the relevant beta functions in a super-renormalizable model of QG. The complete set of renormalization group (RG) equations, including also these for the Newton and the cosmological constant, is solved explicitly in the general case and for the six-derivative Lee-Wick (LW) quantum gravity proposed in a previous paper by two of the authors. In the ultraviolet regime, the minimal theory is shown to be asymptotically free and describes free gravitons in Minkowski or (anti-) de Sitter ((A)dS) backgrounds, depending on the initial conditions for the RG equations. The ghost-like
states appear in complex conjugate pairs at any energy scale consistently with the LW prescription. However, owing to the running, these ghosts may become tachyons. We argue that an extension of the theory that involves operators cubic in Riemann tensor may change the beta functions and hence be capable of overcoming this problem.

Primary authors: Prof. RACHWAŁ, Leslaw (UFJF, ICE); MODESTO, Leonardo (SUSTech); Prof. SHAPIRO, Ilya (UFJF); Prof. PINZUL, Aleksandr (UNB)

Presenter: Prof. RACHWAŁ, Leslaw (UFJF, ICE)

Session Classification: Regular Sessions

Contribution ID: **15** Type: **Talk/seminar**

Entanglement Entropy at Critical Points in the Multiverse

Monday, 6 September 2021 13:10 (20 minutes)

Recently the entanglement entropy between universes has been calculated, an entropy which somehow describes the quantumness of a homogeneous multiverse. The third quantization formalism of canonical quantum gravity is used here. Improvements of the results in a more general scenario will be shown, studying what happens at critical points of the evolution of a classical universe. Besides, we infer the relation of that entanglement entropy with the Hubble parameter of a single universes.

Primary author: Mr BARROSO BELLIDO, Samuel (University of Szczecin)

Presenter: Mr BARROSO BELLIDO, Samuel (University of Szczecin)

Session Classification: Regular Sessions

Contribution ID: **17** Type: **Talk/seminar**

Probing black holes without Z_2 symmetry: A theory-agnostic approach

Thursday, 9 September 2021 18:10 (20 minutes)

Testing strong gravity regimes such as the vicinity of black holes is likely to be attainable with the future developments of observing technology. In this talk, adopting a theory-agnostic approach, we first propose a class of Kerr-like rotating black holes, whose Z_2 symmetry is generically broken. We focus on the possibility that such a violation of Z_2 symmetry is induced by the spin of the black hole. This class of Kerr-like spacetimes could be a good approximation to general black hole solutions in effective low-energy theories of a fundamental quantum theory of gravity. In the model, the violation of the Z_2 symmetry can be parametrized by a single parameter. Then, we discuss how the Z_2 asymmetry in the spacetime could give interesting astrophysical consequences which may be observable.

Primary author: Dr CHEN, Che-Yu (Institute of Physics, Academia Sinica)

Presenter: Dr CHEN, Che-Yu (Institute of Physics, Academia Sinica)

Session Classification: Regular Sessions

Contribution ID: **19** Type: **Talk/seminar**

CGHS Moving Mirror

Tuesday, 7 September 2021 14:50 (20 minutes)

CGHS black holes have rightfully garnered much attention over the last few decades as the models are simplified (1+1)-dimensional versions of black hole evaporation. Their solubility has lead to tractable physical insights into the radiative process. Concurrently, moving mirrors are well-known simplified (1+1)-dimensional models for black hole evaporation. We synthesize the two by finding an exact correspondence between the CGHS black hole and exponentially accelerated moving mirror. The equivalence of these two models can be seen from several matching quantities such as trajectory of the moving mirror that, in turn, corresponds to the center of the black hole; spectrum of the particle radiation; the event horizon locations and the temperatures.
Furthermore, a novel derivation and understanding of the mirror power and self-force are applied to this particular moving mirror, CGHS mirror.

Primary authors: MYRZAKUL, Aizhan (Nazarbayev University); Dr XIONG, Chi (Xiamen University Malaysia); Dr GOOD, Michael (Nazarbayev University)

Presenter: MYRZAKUL, Aizhan (Nazarbayev University)

Session Classification: Regular Sessions

Contribution ID: **20** Type: **Talk/seminar**

Baryogenesis in f(P) Gravity

Monday, 6 September 2021 18:30 (20 minutes)

In this work, we investigate gravitational baryogenesis in the framework of f(P) gravity to understand the applicability of this class of modified gravity in addressing the baryon asymmetry of the Universe. For the analysis, we set f(P)=αP where α is the model parameter. We found that in f(P) gravity, the CP-violating interaction acquires a modification through the addition of the nontopological cubic term P in addition to the Ricci scalar R and the mathematical expression of the baryon-to-entropy ratio depends not only on the time derivative of R but also the time derivative of P. Additionally, we also investigate the consequences of a more complete and generalized CP-violating interaction proportional to f(P) instead of P in addressing the baryon asymmetry of the Universe. For this type of interaction, we report that the baryon-to-entropy ratio is proportional to $\dot{R}$, $\dot{P}$ and $f'(P)$. We report that for both of these cases, rational values of α and χ generate acceptable baryon-to-entropy ratios compatible with observations.
Reference: arXiv:2103.15312

Primary author: Mr BHATTACHARJEE, SNEHASISH

Presenter: Mr BHATTACHARJEE, SNEHASISH

Session Classification: Regular Sessions

Contribution ID: **22** Type: **Talk/seminar**

Can dark energy emerge from a varying G and spacetime geometry?

Monday, 6 September 2021 15:10 (20 minutes)

The accelerated expansion of the Universe implies the existence of an energy contribution known as dark energy. Associated with the cosmological constant in the standard model of cosmology, the nature of this dark energy is still unknown. In this talk I will discuss an alternative gravity model in which this dark energy contribution emerges naturally, as a result of allowing for a time-dependence on the gravitational constant, G, in Einstein Field Equations. With this modification, Bianchi identities require an additional tensor field to be introduced so that the usual conservation equation for matter and radiation is satisfied. The equation of state of this tensor field is obtained using additional constraints, coming from the assumption that this tensor field represents the space-time response to the variation of G. I will also present the predictions of this model for the late Universe data, and show that the energy contribution of this new tensor is able to explain the accelerated expansion of the Universe without the addition of a cosmological constant. Unlike many other alternative gravities with varying gravitational strength, the predicted G evolution is also consistent with local observations and therefore this model does not require screening. I will finish by discussing possible other implications this approach might have for cosmology and some future prospects.

Primary author: HANIMELI, Ekim Taylan (Universität Bremen)

Co-authors: Dr TUTUSAUS, Isaac (Institut d'Estudis Espacials de Catalunya (IEEC), Institute of Space Sciences (ICE, CSIC)); Prof. LAMINE, Brahim (Université de Toulouse, UPS-OMP, IRAP, CNRS); Prof. BLANCHARD, Alain (Université de Toulouse, UPS-OMP, IRAP, CNRS)

Presenter: HANIMELI, Ekim Taylan (Universität Bremen)

Session Classification: Regular Sessions

Contribution ID: **23** Type: **Talk/seminar**

Affine gravitational scenario for dark-matter decays

Thursday, 9 September 2021 16:50 (20 minutes)

I discuss in this talk a new formulation of dark-matter (DM) coupling to gravity. Unlike the Standard Model (SM) sector which couples to the metric, DM couples to the spacetime affine connection through a Z_2-symmetry breaking term. I will show that such a structure allows DM to be only scalar particles (unlike the other alternative gravities). I discuss the different decay modes of DM in this framework, and comment on bounds from observational data. Furthermore, I will discuss the possible signatures at present and future colliders with an emphasis on light DM masses, *i.e.* $m_\phi \simeq \mathcal{O}(10)$ GeV.

Primary author: Dr JUEID, Adil (Konkuk University)

Co-authors: Dr AZRI, Hemza (United Emirates University); Dr KARAHAN, Canan (Istanbul Technical University); Prof. NASRI, Salah (United Emirates University)

Presenter: Dr JUEID, Adil (Konkuk University)

Session Classification: Regular Sessions

Contribution ID: **24** Type: **Talk/seminar**

Polynomial Affine Gravity

Thursday, 9 September 2021 11:50 (20 minutes)

The polynomial affine gravity is an alternative model to describe gravitational interactions using the affine connection as the sole mediator. The action is built using a sort of dimensional analysis technique and preserving the invariance under diffeomorphisms. Interestingly, the coupling constants are dimensionless, which is desirable from a quantum field stand point. In $3+1$ dimensions the field equations in the torsion free sector contain Einstein's vacuum equations, moreover, it is possible interpret the symmetric part of the Ricci tensor or a special combination of the product of two torsion tensors as an emergent metric in this model. Similar analysis can be done in $2+1$ dimensions. Therefore, starting from a purely affine geometrical model, we can obtain a metric tensor, and consequently define physical quantities such as the redshift, classification of space-null-time like self-parallel curves, providing a way to differentiate trajectories of massive and massless particles.

Primary author: PERDIGUERO, Jose (Universidad Tecnica Federico Santa Maria)

Presenter: PERDIGUERO, Jose (Universidad Tecnica Federico Santa Maria)

Session Classification: Ph.D. Students Workshop

Contribution ID: **25** Type: **Talk/seminar**

Orbital precession of the S2 star in Scalar-Tensor-Vector-Gravity

Thursday, 9 September 2021 09:00 (20 minutes)

The GRAVITY Collaboration achieved the remarkable detection of the orbital precession of the S2 star around the Galactic Centre supermassive black hole, providing yet another proof of the validity of the General Relativity. The departure from the Schwarzschild precession is encoded in the parameter $f_{\rm SP}$ which multiplies the predicted general relativistic precession. Such a parameter results to be $f_{\rm SP} = 1.10 \pm 0.19$, which is consistent with General Relativity ($f_{\rm SP} = 1$) at 1σ level. Nevertheless, this parameter may also hide an effect of modified theories of gravity. We used the Schwarzschild-like metric of Scalar-Tensor-Vector-Gravity to predict the orbital motion of S2-star, and to compare it with the publicly available astrometric data, which include 145 measurements of the positions, 44 measurements of the radial velocities of the S2 star along its orbit, and the recent measurement of the orbital precession. We employed a Monte Carlo Markov Chain algorithm to explore the parameter space, and constrained the only one additional parameter of Scalar-Tensor-Vector-Gravity to $\alpha \leq 0.410$ at $99,7\%$ confidence level, where $\alpha = 0$ reduces this modified theory of gravity to General Relativity.

Primary authors: DELLA MONICA, Riccardo (Universidad de Salamanca); DE MARTINO, IVAN (Universidad de Salamanca); Prof. DE LAURENTIS, Mariafelicia (Università degli Studi di Napoli Federico II)

Presenter: DELLA MONICA, Riccardo (Universidad de Salamanca)

Session Classification: Ph.D. Students Workshop

Contribution ID: **26** Type: **Talk/seminar**

Quantum gravitational decoherence from minimal length

Friday, 10 September 2021 16:30 (20 minutes)

Schemes of gravitationally induced decoherence are being actively investigated as possible mechanisms for the quantum-to-classical transition. In this talk, I introduce a decoherence process attributable to quantum gravity effects. In particular, I assume a foamy quantum spacetime with a fluctuating minimal length coinciding on average with the Planck scale. Considering deformed canonical commutation relations with a fluctuating deformation parameter, it is possible to derive a Lindblad master equation that yields localization in energy space and decoherence times consistent with the currently available observational evidence. Compared to other schemes of gravitational decoherence, one can see that the decoherence rate predicted by this model is extremal, being minimal in the deep quantum regime below the Planck scale and maximal in the mesoscopic regime beyond it. Finally, I briefly discuss possible experimental tests of the model based on cavity optomechanics setups with ultracold massive molecular oscillators and provide preliminary estimates on the values of the physical parameters needed for actual laboratory implementations.

Primary author: Dr PETRUZZIELLO, Luciano (University of Salerno & INFN - National Institute for Nuclear Physics)

Co-author: Prof. ILLUMINATI, Fabrizio

Presenter: Dr PETRUZZIELLO, Luciano (University of Salerno & INFN - National Institute for Nuclear Physics)

Session Classification: Regular Sessions

Contribution ID: **28** Type: **Talk/seminar**

Modified gravity effects on non-compact spherical-symmetric objects

Tuesday, 7 September 2021 14:30 (20 minutes)

I will present an impact of alternative theories of gravity on low-mass (sub-)stellar objects' evolution and properties. I will also demonstrate how seismic data acquired from earthquakes and marsquakes could be use to test theories of gravity.

Primary author: Dr WOJNAR, Aneta (Tartu University)

Presenter: Dr WOJNAR, Aneta (Tartu University)

Session Classification: Regular Sessions

Contribution ID: **29** Type: **Talk/seminar**

A novel mechanism to probe Planck scale effects using wave-packet expansion experiments

Approaches to Quantum Gravity (QG) often propose a fundamental minimal length scale in Nature irrespective of our measurement precision. This scale is believed to be at or near the Planck length (10^{-35} m), which also makes it unlikely to be probed directly. In this talk, we put forward a mechanism, recently developed by us, which propose an indirect probe to measure some effects of the minimal length scale on the low energy physics. We shall show that the time resolved wave-packet expansion experiments are one of the best mechanisms available to experimentally verify the existence of such a length scale and thus could be useful for obtaining vital clues on QG.

Primary authors: Prof. DAS, Saurya (University of Lethbridge); MODAK, Sujoy (Universidad de Colima)

Presenter: MODAK, Sujoy (Universidad de Colima)

Session Classification: Regular Sessions

Contribution ID: **30** Type: **Talk/seminar**

Dark Matter from quantum Dark Energy

Thursday, 9 September 2021 17:30 (20 minutes)

We present a simple quantum description of the Universe in which the effective de Sitter spacetime geometry emerges from a coherent state of background gravitons. Once localised baryonic matter is added consistently, this quantum state is shown to contain the necessary components to describe MoND phenomenology at galactic scales and possibly explain the tension between values of the Hubble parameter measured from the CMB and supernovae data.

Primary authors: Dr GIUSTI, Andrea (ETH, Zurich); CASADIO, Roberto (Bologna University and INFN); Prof. HEISENBERG, Lavinia (ETH Zurich); Mrs BUFFA, Silvia (Bologna University)

Presenter: CASADIO, Roberto (Bologna University and INFN)

Session Classification: Regular Sessions

Contribution ID: **31** Type: **Talk/seminar**

Early universe cosmology in fundamentally motivated alternative theories of gravity and the principle of finite amplitudes

Monday, 6 September 2021 15:30 (20 minutes)

The principle of finite amplitudes postulates that semi-classical transition amplitudes from the early universe up to current field values should be well defined. We will show in this talk that the application of this simple principle has strong theoretical constraining power for fundamentally motivated alternative theories of gravity and their solutions for the very early universe. In particular, we will present universes that emerge from the big bang in quadratic gravity and show that only inflating backgrounds (both isotropic and anisotropic) are consistent with finite quantum amplitudes. We will also present the analysis for non-singular cosmologies from limiting curvature gravity and fully α'-corrected string cosmology, which are shown to be consistent with the principle of finite amplitudes.

Primary author: QUINTIN, Jerome (Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Potsdam)

Presenter: QUINTIN, Jerome (Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Potsdam)

Session Classification: Regular Sessions

Contribution ID: **32** Type: **Talk/seminar**

A resolution to Hubble tension

Wednesday, 8 September 2021 14:50 (20 minutes)

I will motivate how moving beyond the FLRW paradigm may be the only way to resolve Hubble tension.

Primary author: O COLGAIN, Eoin (Sogang University)

Presenter: O COLGAIN, Eoin (Sogang University)

Session Classification: Regular Sessions

Contribution ID: **35** Type: **Talk/seminar**

Gravitational Wave lensing beyond Einstein's General Relativity

Wednesday, 8 September 2021 17:10 (20 minutes)

Gravitational lensing of light is a well established test of gravity. However, little is known about how gravitational waves (GW) propagate beyond the simplest space-times in theories beyond Einstein's General Relativity (GR). I will present a framework for GW lensing beyond GR at leading order in frequency. The modified causal structure and kinetic mixing between metric and additional degrees of freedom leads to new phenomena, providing clear-cut tests that do not require an electromagnetic counterpart. I will present detailed predictions for static, spherically symmetric lenses in an quartic Horndeski theory in which novel GW lensing effects can provide tests far more stringent than the multi-messenger event GW170817. The next terms in the frequency expansion will further enrich the phenomenology of GW lensing and enable new precision tests of gravity.

Primary authors: EZQUIAGA, Jose Maria (University of Chicago); Dr ZUMALACARREGUI, Miguel (University of California at Berkeley)

Presenter: Dr ZUMALACARREGUI, Miguel (University of California at Berkeley)

Session Classification: Regular Sessions

Contribution ID: **36** Type: **Talk/seminar**

Modified bimetric-like gravity from spectral geometry.

Friday, 10 September 2021 16:50 (20 minutes)

The tools of spectral geometry lead to the derivation of the action functionals both for gauge theories and gravity. The simplest, mildly noncommutative models with a product geometry give the standard Yang-Mills-Higgs models and the General Relativity action with a cosmological constant. An interesting situation occurs when the geometry is not of the product type, thus allowing the metric to be dynamical in the discrete degrees of freedom. The resulting model resembles bimetric gravity, and demonstrates stability for a class of typical cosmological solutions. Based on a joint work with Arkadiusz Bochniak.

Primary authors: SITARZ, Andrzej (Jagiellonian University); Mr BOCHNIAK, Arkadiusz (Jagiellonian University)

Presenter: SITARZ, Andrzej (Jagiellonian University)

Session Classification: Regular Sessions

Contribution ID: **37** Type: **Talk/seminar**

Scalar Fields in CDT Quantum Gravity

Thursday, 9 September 2021 13:10 (20 minutes)

CDT is a numerical approach to quantum gravity which attempts to describe our Universe with the help of Regge Calculus and Path Integral formalism. The study of the past years revealed the rich phase-diagram of the model, which contains a physical de Sitter phase with higher order phase-transitions on its boarders. Recently we added scalar fields to the model. The classical fields were used as coordinates, which revealed the structure of the CDT Universes which resembled the cosmological voids and webs. When the dynamical / quantum fields were used they triggered a phase-transition which effectively changed the space-time topology. During my talk I will show the most recent results related to scalar-fields in the model of Causal Dynamical Triangulations.

Primary author: NÉMETH, Dániel (Németh Dániel)

Presenter: NÉMETH, Dániel (Németh Dániel)

Session Classification: Ph.D. Students Workshop

Contribution ID: **38** Type: **Talk/seminar**

Inflation From The MSSM. N=1 Supergravity Setup

Thursday, 9 September 2021 15:30 (20 minutes)

Taking the minimalistic approach, within MSSM, we propose the model of inflation in which the inflaton field is a scalar component of the MSSM state(s).
The proposed model turns out to be very predictive. The inflationary phase is fully governed by the MSSM Yukawa superpotential couplings. The values of the scalar spectral index and the tensor-to-scalar ratio are predicted to be ns⊠0.966 and r=0.00118. The post-inflation reheating of the Universe proceeds by the inflaton's decay with the reheating temperature around 10 thousands TeV.
Some phenomenological implication will be also outlined and discussed.

Primary author: TAVARTKILADZE, Zurab (Ilia State University)

Presenter: TAVARTKILADZE, Zurab (Ilia State University)

Session Classification: Regular Sessions

Contribution ID: **42** Type: **Talk/seminar**

Effective Quantum Black Hole Collapse via Surface Matching

Tuesday, 7 September 2021 15:50 (20 minutes)

The fate of matter forming a black hole is still an open problem, although models of quantum gravity corrected black holes are available. In loop quantum gravity (LQG) models were presented, which resolve the classical singularity in the centre of the black hole by means of a black-to-white hole transition, but neglect the collapse process. The situation is similar in other quantum gravity approaches, where eternal non-singular models are available. A strategy is presented to generalise eternal models to dynamical collapse models by surface matching. Assuming 1) the validity of a static quantum black hole spacetime outside the collapsing matter, 2) homogeneity of the collapsing matter, and 3) differentiability at the surface of the matter fixes the dynamics of the spacetime uniquely. It is argued that these assumptions resemble a collapse of pressure-less dust and thus generalises the Oppenheimer-Snyder-Datt model. The junction conditions and the spacetime dynamics are discussed generically for bouncing black hole spacetimes, as proposed by LQG, although the scheme is approach independent. A global spacetime picture of the collapse for a specific LQG inspired model is discussed.

Primary author: MÜNCH, Johannes (Aix-Marseille Université, Université de Toulon, CPT, CNRS)

Presenter: MÜNCH, Johannes (Aix-Marseille Université, Université de Toulon, CPT, CNRS)

Session Classification: Regular Sessions

Contribution ID: **43** Type: **Talk/seminar**

Covariant effective actions for bouncing cosmology in fourth-order gravity

Friday, 10 September 2021 13:10 (20 minutes)

Cyclic universes with bouncing solutions are candidates for solving the big bang initial singularity problem. Here I will look for bouncing solutions in the context of modified theories of gravity whose field equations contain up to fourth-order derivatives of the metric tensor. In finding such bouncing solutions I will resort to an order reduction technique that reduces the order of the differential equations of the theory to second-order and thus enables one to find solutions which are perturbatively close to general relativity. I will also build the covariant effective actions of the resulting order reduced theories.
Based on: arXiv:1904.00260, arXiv:1907.11732, arXiv:2107.07777.

Primary author: Dr VERNIERI, Daniele (University of Naples "Federico II")

Presenter: Dr VERNIERI, Daniele (University of Naples "Federico II")

Session Classification: Regular Sessions

Contribution ID: **44** Type: **Talk/seminar**

Observational constraints on cosmological solutions of f(Q) theories

Friday, 10 September 2021 12:30 (20 minutes)

Over the last years some interest has been gathered by f(Q) theories, which are new candidates to replace Einstein's prescription for gravity. The nonmetricity tensor Q allows to put forward the assumption of a free torsionless connection and, consequently, new degrees of freedom in the action are taken into account. This work focuses on a class of f(Q) theories, characterized by the presence of a general power-law term which adds up to the standard (linear in) Q term in the action, and on new cosmological scenarios arising from them. Using the Markov chain Monte Carlo method, we carry out statistical tests relying upon background data such as Type Ia supernovae luminosities and direct Hubble data (from cosmic clocks), along with cosmic microwave background shift and baryon acoustic oscillations data. This allows us to perform a multifaceted comparison between these new cosmologies and the (concordance) ΛCDM setup. We conclude that, at the current precision level, the best fits of our f(Q) models correspond to values of their specific parameters which make them hardly distinguishable from our general relativity "échantillon,"that is, ΛCDM.

Primary authors: AYUSO, Ismael (Instituto de Astrofísica e Ciências do Espaço); LAZKOZ, Ruth (University of the Basque Country); SALZANO, Vincenzo (University of Szczecin)

Presenter: LAZKOZ, Ruth (University of the Basque Country)

Session Classification: Regular Sessions

Contribution ID: **45** Type: **Talk/seminar**

Testing screening mechanisms with mass profiles of galaxy clusters

Friday, 10 September 2021 14:30 (20 minutes)

Galaxy clusters constitute a powerful tool to investigate modification of gravity at cosmological scales; in particular, with the combination of cluster's mass profiles derived with lensing and internal kinematic analyses, it is possible to constrain departures from General Relativity in a complementary way with respect to other cosmological and astrophysical probes. In this context, I will present MG-MAMPOSSt, a code to constrain modified gravity models by reconstructing the mass profile with the kinematics of cluster's member galaxies. I will focus in particular on recent results and forecasts on two classes of models characterized by different screening mechanisms, namely chameleon and Vainshtein screening. I will show the capability of the method when combined with lensing data as well as some criteria to control possible systematics in view of the application to the data of upcoming imaging and spectroscopic surveys.

Primary author: PIZZUTI, Lorenzo (FCF- Astronomical Observatory of the Autonomous Region of Aosta)

Co-authors: SALTAS, Ippocratis (Czech Academy of Sciences); AMENDOLA, Luca (University of Heidelberg)

Presenter: PIZZUTI, Lorenzo (FCF- Astronomical Observatory of the Autonomous Region of Aosta)

Session Classification: Regular Sessions

Contribution ID: **47** Type: **Talk/seminar**

Effects of a scalar field potential on primordial perturbations in Hybrid (Loop) Quantum Cosmology.

Tuesday, 7 September 2021 18:10 (20 minutes)

There is an increasing interest in cosmological models with scalar fields that present kinetically dominated phases in their evolution, since these may have played a relevant role in the very early stages of the Universe and lead to modifications in observable quantities, e.g. the cosmic microwave background. The departures of this scenario from standard slow-roll inflation prevent one for employing the approximate analytical formulas for the power spectrum that are valid in slow roll, complicating the calculations, that, in most cases, have to be done numerically. Moreover, the complexity of these calculations increases if the model takes into account the quantum behavior of the background, incorporating it by means of expectation values on the background geometry, as it happens in hybrid quantum cosmology. In this situation, an interesting possibility consists in approximating our description of the perturbations around the free evolution without potential, so that only the knowledge of the dynamics of this particular case is required in full detail. In order to consider the influence of the potential, it is necessary to include the corrections that its presence produces on this free dynamics. We analyze these corrections at dominant order. In principle, the analysis that we present can be extended to cover higher-order corrections as well. In particular, our results facilitate the study of the quantum geometry effects on the primordial perturbations, which, in models as those of LQC, occur in kinematically dominated regimes.

Primary author: JIMÉNEZ, Rafael

Co-author: Dr MENA MARUGÁN, Guillermo (IEM-CSIC)

Presenter: JIMÉNEZ, Rafael

Session Classification: Regular Sessions

Contribution ID: **48** Type: **Talk/seminar**

Modified gravity and dark energy from one point matter statistics

Thursday, 9 September 2021 09:20 (20 minutes)

The late universe contains a wealth of information about fundamental physics and gravity, wrapped up in non-Gaussian fields. To make use of as much information as possible it is necessary to go beyond power spectra. Rather than going to higher order N-point correlation functions, this talk will demonstrate that the probability distribution function (PDF) of spheres in the matter field (a 1-point function) already contains a large fraction of this non-Gaussian information. The matter PDF dissects different density environments which are lumped together in 2 point statistics, making it particularly useful for probing modifications of gravity or expansion history.

With an analytic model for the matter PDF we extend this formalism into cosmologies beyond ΛCDM, including $f(R)$ and DGP modified gravity and evolving dark energy. In all cases, the matter PDF provides an excellent complement to the matter power spectrum. Combining weakly non-linear power spectrum information with the matter PDF yields 5σ detections of both modified gravity theories, and increases the Figure of Merit for dark energy by a factor of 5 beyond power spectrum information alone.

Primary author: GOUGH, Alex (Newcastle University)

Presenter: GOUGH, Alex (Newcastle University)

Session Classification: Ph.D. Students Workshop

Contribution ID: **49** Type: **Talk/seminar**

Vector fields and gravitational wave propagation

Wednesday, 8 September 2021 17:30 (20 minutes)

We study the effects of cosmological vector fields on the propagation of gravitational waves (GWs). The so-called dark sector in Cosmology remains unexplained, even though it makes up most of the content of the Universe. This fact has led to the proposal of several models of dark matter, dark energy or dark radiation. Among them, we can find some based upon vector fields (such as ultralight vector fields, which contribute to the matter content). Vector fields generically contribute with a non-zero anisotropic stress, thus affecting GWs, which are becoming increasingly important in observational astrophysics and cosmology. In this talk we focus on the effect of vectors on GW propagation. We present some phenomenological features, which include suppression, anisotropy and linear polarization of GWs, and show results for some specific models.

Primary author: DELGADO MIRAVET, Alfredo (Universidad Complutense de Madrid)

Co-author: Prof. LÓPEZ MAROTO, Antonio (Universidad Complutense de Madrid)

Presenter: DELGADO MIRAVET, Alfredo (Universidad Complutense de Madrid)

Session Classification: Regular Sessions

Contribution ID: **50** Type: **Talk/seminar**

Scattering Amplitudes for Binary Systems beyond GR

Tuesday, 7 September 2021 16:10 (20 minutes)

Amplitude methods have shown to be a promising technique to perform Post-Minkowskian calculations used as inputs to construct gravitational waveforms. In this talk, I will show how to extend these methods beyond GR. As proof of principle, I will consider spinless particles conformally coupled to a gravitational helicity-0 mode. This setup leads to subtleties in the matching procedure used to construct the potential for conformally coupled matter. I will show how to tackle these subtleties when computing the potential and scattering angle for the binary system, and how the result involves a non-trivial dependence on the momentum of the scattered particles.

Primary author: CARRILLO GONZALEZ, Mariana (Imperial College London)

Presenter: CARRILLO GONZALEZ, Mariana (Imperial College London)

Session Classification: Regular Sessions

Contribution ID: **51** Type: **Talk/seminar**

Global portraits of nonminimal inflation

Monday, 6 September 2021 16:10 (20 minutes)

We reconsider the dynamical systems approach to analyze inflationary universe in the Jordan frame models of scalar field nonminimally coupled to curvature or torsion. The adopted set of variables allows us to clearly distinguish between different asymptotic states in the phase space, including the kinetic and inflationary regimes. Inflation is realized as a heteroclinic trajectory originating either at infinity from a nonhyperbolic asymptotic de Sitter point or from a regular saddle de Sitter point. We also present a comprehensive picture of possible initial conditions leading to sufficient inflationary expansion and show their extent on the phase diagrams. In addition we determine the correct slow roll conditions applicable in the Jordan frame and show how they approximate the leading inflationary "attractor solution". To seek the asymptotic fixed points we outline a heuristic method in terms of the "effective potential"and "effective mass", which can be applied for any nonminimally coupled theories.

Primary authors: Dr TOPORENSKY, Alexey (Lomonosov Moscow State University); Dr JÄRV, Laur (University of Tartu); Mr LEMBER, Joosep (University of Tartu)

Presenter: Dr JÄRV, Laur (University of Tartu)

Session Classification: Regular Sessions

Contribution ID: **52** Type: **Talk/seminar**

Distinguishing cores from cusps in the dark matter density profile using the proper motions measurements

Friday, 10 September 2021 14:50 (20 minutes)

We have shown the potential of next-generation astrometric satellites for distinguishing between a cusp and a core in the dark matter density profile. This goal can be achieved with the measure of the proper motions of at least 6000 stars within a nearby dwarf galaxy with an accuracy of 1 km˜s^{-1} at most. We have built mock star catalogues similar to those expected in future astrometric missions like Theia. Our mocks include celestial coordinates, radial velocity, and proper motion of the stars, while density and velocity fields of the stars are sampled from an extended Navarro-Frank-White (eNWF) spherical model. Employing a Monte Carlo Markov Chain algorithm, we have shown that the eNFW parameters with a relative uncertainty of 20\%, on average can be recovered, and thus we can distinguish between a core and a cusp at 3σ. Our result shows that the measure of the proper motions of stars can provide a fundamental contribution to understanding the nature and the properties of dark matter particles.

Primary author: DE MARTINO, IVAN (Universidad de Salamanca)

Presenter: DE MARTINO, IVAN (Universidad de Salamanca)

Session Classification: Regular Sessions

Contribution ID: **53** Type: **Talk/seminar**

New applications of unparticles: Inflation, dark energy, bouncing cosmologies, and the Hubble tension

Monday, 6 September 2021 12:30 (20 minutes)

Unparticles are a hypothetical new form of matter created from fermions in an SU(N) gauge theory. Unparticles provide a wide spectrum of new cosmological applications. In my talk (based on arxiv:2010.02998 and arxiv: 1912.10532), I will show that they can display a cosmological-constant-like behavior, and since then they can be used to generate cosmic inflation or dark energy. I will show realistic bouncing and cyclic Universes filled with unparticles and perfect fluid. I will also discuss constraints on unparticles energy density and their possible role in relaxing the Hubble tension

Primary author: Dr ARTYMOWSKI, Michal (Ariel University)

Presenter: Dr ARTYMOWSKI, Michal (Ariel University)

Session Classification: Regular Sessions

Contribution ID: **55** Type: **Talk/seminar**

Matter Bounce Scenario in f(Q,T) Gravity

Thursday, 9 September 2021 14:30 (20 minutes)

In the context of the late time cosmic acceleration phenomenon, many geometrically modified theories of gravity have been proposed in recent times. In this paper, we have investigated the role of a recently proposed extension of symmetric teleparallel gravity dubbed as f(Q,T) gravity in getting viable cosmological models, where Q and T respectively denote the non-metricity and the trace of energy momentum tensor. We stress upon the mathematical simplification of the formalism in the f(Q,T) gravity and derived the dynamical parameters in more general form in terms of the Hubble parameter. We considered two different cosmological models mimicking non-singular matter bounce scenario. Since energy conditions play a vital role in providing bouncing scenario, we have analyzed different possible energy conditions to show that strong energy condition and null energy condition be violated in this theory. The models considered in the work are validated through certain cosmographic tests and stability analysis.

Primary author: MISHRA, Bivudutta (BITS-Pilani, Hyderabad Campus)

Presenters: MISHRA, Bivudutta (BITS-Pilani, Hyderabad Campus); Prof. MISHRA, Bivudutta (BITS-Pilani, Hyderabad Campus)

Session Classification: Regular Sessions

Contribution ID: **56** Type: **Talk/seminar**

Progress within the Scale Invariant Vacuum (SIV) Paradigm

Thursday, 9 September 2021 17:10 (20 minutes)

We will review the Scale Invariant Vacuum idea as related to Weyl Integrable Geometry. Main results related to SIV and inflation 1, the growth of the density fluctuations 2, and application of the SIV to scale-invariant dynamics of Galaxies, MOND, Dark Matter, and the Dwarf Spheroidals 3 will be summarized. If time permits, a potential connection of the weak field SIV results to the un-proper time parametrization within the reparametrization paradigm, will be discussed as well 4.

1 Maeder, A., Gueorguiev, V. G., Scale invariance, horizons, and inflation. MNRAS 504, 4005 (2021). arXiv: 2104.09314 [gr-qc].

2 Maeder, A., Gueorguiev, V., G., The growth of the density fluctuations in the scale-invariant vacuum theory, Phys. Dark Univ. 25, 100315 (2019). arXiv: 1811.03495 [astro-ph.CO]

3 Maeder, A.; Gueorguiev, V.G. Scale-invariant dynamics of galaxies, MOND, dark matter, and the dwarf spheroidals, MNRAS 492, 2698 (2019). arXiv: 2001.04978 [gr-qc]

4 Gueorguiev, V. G., Maeder, A., Geometric Justification of the Fundamental Interaction Fields for the Classical Long-Range Forces. Symmetry 13, 379 (2021). arXiv: 1907.05248 [math-ph].

Primary authors: Prof. MAEDER, Andre (Geneva Observatory); Dr GUEORGUIEV, Vesselin (Institute for Advanced Physical Studies (IAPS), Sofia, Bulgaria)

Presenter: Dr GUEORGUIEV, Vesselin (Institute for Advanced Physical Studies (IAPS), Sofia, Bulgaria)

Session Classification: Regular Sessions

Contribution ID: **57** Type: **Talk/seminar**

Axionlike clouds in the vicinity of compact objects

Tuesday, 7 September 2021 15:10 (20 minutes)

It is an observationally established fact that dark matter forms large scale structures in the intergalactic space. However it is not fully known if any structures can emerge on the stellar scale and if so, what would they look like.
In this short talk I will discuss the possibilities of the emergence of axionlike particle (ALP) clouds around compact objects, such as black holes. Using Einstein-Maxwell-ALP theory I will present how the geometrical structure of the clouds depends on the kind of the hosting object and its parameters. By virtue of the system's free energy I will indicate the most probable scenarios for ALP clouds formation.

Primary author: KICZEK, Bartłomiej

Co-author: ROGATKO, Marek (Maria Curie Sklodowska University)

Presenter: KICZEK, Bartłomiej

Session Classification: Regular Sessions

Contribution ID: **58** Type: **Talk/seminar**

On the emergence of cosmic space and the first law of thermodynamics in a non-flat universe

Thursday, 9 September 2021 15:50 (20 minutes)

Based on connections between gravity and thermodynamics, interpreting the dynamics of the universe as a quest for achieving holographic equipartition is a novel concept proposed by Padmanabhan. However, the generalization of Padmanabhan's conjecture to the non-flat universe had resulted in uncertainty about the choice of volume. We have shown that the exact mathematical formulation of the conjecture is impossible with the proper invariant volume (Volume term derived from the FRW metric) for a non-flat universe. The deep connection between the first law of thermodynamics and the law of emergence motivated us to also explore the status of the first law in a non-flat universe when one uses proper invariant volume. We have shown that the first law of thermodynamics, $dE = TdS + WdV$, cannot be formulated properly for a non-flat universe using proper invariant volume. We can also show that the energy change within the horizon is not equivalent to the outward energy flux in the non-flat universe if one used the proper invariant volume. We further point out that the consistency between the above two forms of the first law will hold only with the use of areal volume, which hints us why our universe appears to be spatially flat.

Primary authors: THURUTHIPILLY, Hareesh (National Center for Nuclear Research, Poland); Dr P B , Krishna (Cochin University of Science and Technology, India); Prof. K. MATHEW, Titus (Cochin University of Science and Technology, India)

Presenter: THURUTHIPILLY, Hareesh (National Center for Nuclear Research, Poland)

Session Classification: Regular Sessions

Contribution ID: **59** Type: **Talk/seminar**

Phantom-like dark energy from quantum gravity

Wednesday, 8 September 2021 13:10 (20 minutes)

We analyse the emergent cosmological dynamics corresponding to the mean field hydrodynamics of quantum gravity condensates, in the tensorial group field theory formalism. We focus in particular on the cosmological effects of fundamental interactions, and on the contributions from different quantum geometric modes. The general consequence of such interactions is to produce an accelerated expansion of the universe, which can happen both at early times, after the quantum bounce predicted by the model, and at late times. Our main result is that, while this fails to give a compelling inflationary scenario in the early universe, it produces naturally a phantom-like dark energy dynamics at late times, compatible with cosmological observations. By recasting the emergent cosmological dynamics in terms of an effective equation of state, we show that it can generically cross the phantom divide, purely out of quantum gravity effects without the need of any additional phantom matter. Furthermore, we show that the dynamics avoids any Big Rip singularity, approaching instead a de Sitter universe asymptotically.

Primary authors: Dr ORITI, Daniele (LMU Munich); PANG, Xiankai (LMU Munich)

Presenter: PANG, Xiankai (LMU Munich)

Session Classification: Regular Sessions

Contribution ID: **60** Type: **Talk/seminar**

Simple-graduated dark energy and spatial curvature: Do the simplest negative energy densities alleviate the H0 tension?

Wednesday, 8 September 2021 14:30 (20 minutes)

In the first part of this talk, I will review the Hubble tension and then describe some theoretical efforts to alleviate it—as well as the discrepancy with the BAO Lyman-α data —via the dark energy models that yield negative density values in the past. I will then discuss a recent work with two minimal extensions of the ΛCDM model, together or separately, can realize such a scenario: (i) The spatial curvature, which, in the case of spatially closed universe, mimics a negative density source, (ii) Simple-graduated dark energy, which promotes the null inertial mass density of the usual vacuum energy to an arbitrary constant —if negative, the corresponding energy density decreases with redshift similar to the phantom models, but unlike them crosses below zero at a certain redshift. I will close the talk by presenting the results when these are constrained using the latest observational data.

Primary authors: Dr ACQUAVIVA, Giovanni; Dr VAZQUEZ , J. Alberto (Instituto de Ciencias Fisicas, Universidad Nacional Aut'onoma de M'exico); KATIRCI, Nihan (Doğuş University); Dr AKARSU, Özgür (İstanbul Technical University)

Presenter: KATIRCI, Nihan (Doğuş University)

Session Classification: Regular Sessions

Contribution ID: **61** Type: **Talk/seminar**

A data-driven reconstruction of Horndeski gravity using late-time Hubble data

Thursday, 9 September 2021 09:40 (20 minutes)

We reconstruct the Hubble function using late-time cosmological data sets and use it to draw out Horndeski theories that are fully anchored on the expansion history. We discuss various formalisms for the inversion of the modified Friedmann equations and complement this with the reconstructed Hubble data to obtain predictive constraints on the Horndeski potentials and the dark energy equation of state.

Primary authors: Prof. LEVI SAID, Jackson (University of Malta); Dr BERNARDO, Reginald Christian (University of the Philippines)

Presenter: Dr BERNARDO, Reginald Christian (University of the Philippines)

Session Classification: Ph.D. Students Workshop

Contribution ID: **62** Type: **Talk/seminar**

Neutron Stars in Palatini $f(R) = R + \alpha R^2$ and $f(R, Q) = R + \alpha R^2 + \beta Q$ Theories - Talk in Modified Gravity Phenomenology

Thursday, 9 September 2021 10:20 (20 minutes)

Adding corrections quadratic in the curvature, like R^2 or $Q = R_{\mu\nu}R^{\mu\nu}$, to the Gravity Lagrangian can make the theory perturbatively renormalizable as a quantum field theory or even produce early time inflation. Testing such modifications to gravity is challenging, but can be done by astrophysical observations. Based on our findings in 1, this talk will focus on observable traces of modifications to gravity in the mass-radius relation of neutron stars. Focusing on $f(R) = R+\alpha R^2$ and $f(R, Q) = R + \alpha R^2 + \beta Q$ theories in the Palatini formalism, where α and β control the strength of the modification, we show that the influence on the properties of a neutron star can be sizeable for certain combinations of α, β and some equations of state (EoS). Furthermore, we show that the main factors that influence the deviation from the GR result are, apart from α and β, the first and second derivative of the EoS, which go into the stellar structure equations. As a consequence, knowledge of the exact neutron star EoS is required to discriminate between GR and modified gravity theories. However, as soon as the neutron star EoS is known, observations of the mass and radius of neutron stars can be used to test modifications to GR of the Palatini $f(R)$ and $f(R, Q)$ type.

1 https://arxiv.org/abs/2102.05722

Primary authors: HERZOG, Georg; Dr SANCHIS-ALEPUZ, Helios

Presenter: HERZOG, Georg

Session Classification: Ph.D. Students Workshop

Contribution ID: **63** Type: **Talk/seminar**

Scalar Tensor Vector Gravity

Thursday, 9 September 2021 12:50 (20 minutes)

Scalar Tensor Vector Gravity (STVG) is a metric theory of gravity with dynamical scalar fields and a massive vector field introduced in addition to the metric tensor. In the weak field approximation STVG modifies the Newtonian acceleration with a Yukawa like repulsive term due to Maxwell-Proca type Lagrangian. This associates matter with a fifth force and a modified equation of motion.STVG has been successful in explaining galaxy rotation curves, gravitational lensing, cosmological observations and all other solar system observation without the need of dark matter. In this talk we present the key concepts of STVG theory. Then I will discuss existing observational bounds on STVG parameters.In particular I will present our original results obtained from X-COP sample of
galaxy clusters.

Primary author: Mr HARIKUMAR, Sreekanth (National Centre for Nuclear Research)

Presenter: Mr HARIKUMAR, Sreekanth (National Centre for Nuclear Research)

Session Classification: Ph.D. Students Workshop

Contribution ID: **64** Type: **Talk/seminar**

Viability of teleparallel theories of gravity

Thursday, 9 September 2021 11:30 (20 minutes)

General relativity has been very successful in describing gravity. However, cosmological observations such as the dark sector of the universe, the value of the cosmological constant, and the Hubble constant give indications to new physics. This might be explained by modified theories of gravity. What has often been overlooked is that general relativity has different equivalent descriptions. One of those is generally called teleparallel equivalent to general relativity, with an action formulation which only differs from the Einstein-Hilbert action by a boundary term. Starting from this action it is possible to formulate modified theories of gravity different from those based on the Einstein-Hilbert formulation. These theories are called teleparallel theories of gravity. I will present the present understanding of the viability of those theories based on the Hamiltonian analysis arxiv:2012.09180. I will also mention conclusions drawn from perturbation theory of teleparallel gravity in order to make stricter bounds on the viability.

Primary author: BLIXT, Daniel

Co-authors: HOHMANN, Manuel (University of Tartu); PFEIFER, Christian (University of Tartu); MARÍA-JOSÉ, Guzmán (University of Tartu)

Presenter: BLIXT, Daniel

Session Classification: Ph.D. Students Workshop

Contribution ID: **65** Type: **Talk/seminar**

Alternative Gravity and Gravastars

Tuesday, 7 September 2021 15:30 (20 minutes)

This work explores the effects of charge on a peculiar stellar object, recognized as gravastar, under the influence curvature-matter coupling gravity. The gravastar is also known as an alternative to a black hole and is expressed by three distinct domains named as (i) the interior domain, (ii) the intermediate shell and (iii) the exterior domain. We analyze these domains for a specific modified gravity model conceding the conformal Killing vectors. In the interior domain, we assume that pressure is equal to negative energy density which leads to the existence of repulsive force on the spherical shell. The intermediate shell consists of ultra-relativistic plasma and pressure which shows a direct relation with energy density and counterbalances the repulsive force applied by the interior domain. The exterior vacuum spherical domain is taken to be the de Sitter spacetime illustrated by the Reissner-Nordstrom metric.

Primary author: SHARIF, Muhammad (University of the Punjab)

Presenter: SHARIF, Muhammad (University of the Punjab)

Session Classification: Regular Sessions

Contribution ID: **66** Type: **Talk/seminar**

Nonparametric Techniques to Reconstructing Cosmological Data

Wednesday, 8 September 2021 15:30 (20 minutes)

Cosmological tensions in recent measurements of both Hubble expansion and the growth of structure in the Universe has led to a reconsideration of certain aspects of the concordance model of standard cosmology. One part of this comes from the growing tension between observations that are independent of cosmological models against others that are dependent on ΛCDM. To this end, the ability of reconstruction techniques to provide efficient and effective extractions of cosmological data has become ever more pressing. In this talk, some recent approaches to the problem are explored such as the use of Gaussian processes and the Locally weighted Scatterplot Smoothing together with Simulation and extrapolation method (LOESS-Simex) together with their advantages and disadvantages. The talk will also cover how genetic algorithmics may help improve the performance of these approaches. We close with a look at how deep learning may help improve the ability of these approaches to produce reconstructions of cosmic data

Primary authors: LEVI SAID, Jackson (University of Malta); MIFSUD, Jurgen (CERN); BERNARDO, Reginald Christian (University of the Philippines)

Presenter: LEVI SAID, Jackson (University of Malta)

Session Classification: Regular Sessions

Contribution ID: **67** Type: **Talk/seminar**

Graviton mass in the era of multi-messenger astronomy

Friday, 10 September 2021 17:10 (20 minutes)

The idea of massive graviton plays a fundamental role in modern physics as a landmark of most scenarios related to the modification of the theory of gravity. Limits on graviton mass can be obtained with capabilities of multi-messenger astronomy. In particular, non-zero graviton mass would modify estimates of the total cluster mass (Yukawa term influences Newtonian potential). This can be measured through the X-ray surface brightness of the intracluster medium combined with a characteristic distortion in the cosmic microwave bacground spectrum observed in the cluster direction, known as thermal Sunyaev-Zel'dovich (SZ) effect. Using X-COP galaxy cluster sample, where total masses up to certain radii were measured by using X-ray data from XMM-Newton telescope combined with SZ data from Planck satellite, we obtaned that m_g < (4.99 – 6.79) × 10ˆ(–29) eV (at 95% C.L.) which is one of the stringest available. On the other hand, modified relativistic dispersion relation of massive graviton may lead to changes in travel time of gravitational waves (GWs) emitted from a distant astrophysical objects. Strong gravitational lensing of signals emitted from a carefully selected class of extra-galactic sources like compact object binaries (in particular, binary neutron stars) is predicted to play an important role in this context. Particularly, comparing time delays between images of the lensed GW signal and its electromagnetic counterpart may be a new model-independent strategy, especially promising in the time of successful operating runs of LIGO/Virgo GW detectors (recently joined by KAGRA observatory) resulting in numerous records of GW signals from coalescing compact object binaries. In this talk I will discuss the above ideas in more details.

Primary author: PIÓRKOWSKA-KURPAS, Aleksandra (University of Silesia in Katowice)

Presenter: PIÓRKOWSKA-KURPAS, Aleksandra (University of Silesia in Katowice)

Session Classification: Regular Sessions

Contribution ID: **68** Type: **Talk/seminar**

The quasi-static approximation in Horndeski models

Friday, 10 September 2021 15:30 (20 minutes)

The quasi-static approximation (QSA) is a useful tool to get a quick and clear physical understanding of the phenomenology of modified gravity which is encoded in two functions (of scale and time): the effective gravitational constant (describing the modified evolution of matter perturbations) and the slip (parametrizing the relations between the two gravitational potentials). This approximation is often used to put constraints on cosmological models using phenomenological expressions. In this talk I will consider three different formulations based on the QSA for Horndeski models and assess their performance on some cosmological observables and assess the range of validity of this approximation. I will also highlight why different schemes lead to different expressions on very large scales and how we can improve them.

Primary author: PACE, Francesco (University of Bologna)

Presenter: PACE, Francesco (University of Bologna)

Session Classification: Regular Sessions

Contribution ID: **69** Type: **Talk/seminar**

Superfluid vacuum theory predictions for astrophysics

Monday, 6 September 2021 14:50 (20 minutes)

Using the logarithmic superfluid model, one can formulate quantum post-relativistic theory of superfluid vacuum, which contains special and general relativity in the "phononic"(low-momenta) limit, but differs at higher momenta. According to the theory, an effective gravitational potential is induced by the quantum wavefunction of physical vacuum in a stationary state, while the vacuum itself is viewed as the superfluid described by the logarithmic quantum wave equation. On a galactic scale, the model explains the non-Keplerian behaviour of galactic rotation curves, as well as why their profiles can vary depending on the galaxy. It also makes a number of predictions about the behaviour of gravity at larger galactic and extragalactic scales, which are expected to be seen in the outer regions of large spiral galaxies. We compare the non-flat asymptotics'prediction with the furthest data points available for a number of galaxies. Using a two-parameter fit, we do a preliminary estimate; which disregards the combined effect of gas and stellar disc, but is relatively simple and uses minimal assumptions for galactic luminous matter. The data strongly points out at the existence of a crossover transition from flat to non-flat regimes at galactic outskirts and beyond. Another range of applications of the "logarithmic"matter can be found in the astrophysics of cold dense stars. We demonstrate the existence of equilibria in self-gravitating logarithmic fluid, described by spherically symmetric nonsingular finite-mass asymptotically-flat solutions in general relativity. Unlike other boson star models known to date, equilibrium configurations of relativistic logarithmic fluids are shown not to have scale bounds for their gravitational mass or size. Therefore, they can describe large massive dense astronomical objects, such as bosonized superfluid stars or cores of neutron stars.

Primary author: Dr ZLOSHCHASTIEV, Konstantin (Durban University of Technology)

Presenter: Dr ZLOSHCHASTIEV, Konstantin (Durban University of Technology)

Session Classification: Regular Sessions

Contribution ID: **70** Type: **Talk/seminar**

Multi-component DHOST analysis in galaxy clusters

Thursday, 9 September 2021 10:00 (20 minutes)

Screening mechanisms in Extended Theories of Gravity (ETGs) are essential to make theories able to pass Solar System constraints and, at the same time, possibly driving the accelerated expansion of the Universe at large scales (thus behaving as dark energy). In our work, we have considered an ETG belonging to the family of Degenerate High-Order Scalar-Tensor theories (DHOST) and characterized by a partial breaking of such a screening mechanism. We test this theory on galaxy cluster scales, using strong and weak lensing data, X-ray observations, and a multi-component approach. We investigate the consistency of this model with data in two different scenarios: as a dark energy candidate; and, through the breaking of the screening mechanism, we assume and test the possibility it might even mimic dark matter. Final results show that the DHOST model, when acting as dark energy-only model, might be statistically preferred (by Bayesian evidence) in most of the cases with respect to General Relativity. Instead, when the DHOST is assumed to mimic also dark matter, it is generally disfavored.

Primary author: LAUDATO, Enrico (Szczecin University, Institute of Physics- Doctoral School)

Co-authors: SALZANO, Vincenzo (University of Szczecin); UMETSU, Keiichi (Academia Sinica)

Presenters: LAUDATO, Enrico (Szczecin University, Institute of Physics- Doctoral School); SALZANO, Vincenzo (University of Szczecin)

Session Classification: Ph.D. Students Workshop

Contribution ID: **71** Type: **Talk/seminar**

On the Viability of Chameleon Gravity in Galaxy Clusters and Cosmic Voids

Friday, 10 September 2021 15:10 (20 minutes)

In this talk I will review the recent results of a numerical study of chameleon gravity in the context of galaxy clusters and cosmic voids. In this study we solved the chameleon field equation for NFW halos and cosmic void density profiles for the currently observationally viable chameleon models. The obtained results shine light on the non-trivial relationship between the NFW halo parameters and the chameleon acceleration and have important implications for the future observational searches for the fifth force.

Primary author: TAMOSIUNAS, Andrius (University of Nottingham)

Co-authors: Mr BRIDDON, Chad (University of Nottingham); Prof. BURRAGE, Clare (University of Nottingham); Dr MOSS, Adam (University of Nottingham); Dr CUI, Weiguang (University of Edinburgh)

Presenter: TAMOSIUNAS, Andrius (University of Nottingham)

Session Classification: Regular Sessions

Contribution ID: **73** Type: **Talk/seminar**

Non-local extension of Starobinsky inflation and targets for future CMB data

The emergence of R^2 inflation which is the best fit framework for CMB observations to date comes from the attempts to attack the problem of quantization of gravity which in turn have resulted in the trace anomaly discovery. Further developments in trace anomaly and different frameworks aiming to construct quantum gravity indicate an inevitability of non-locality in fundamental physics at small time and length scales. A natural question would be to employ the R^2 inflation as a probe for signatures of non-locality in the early Universe physics. Recently R^2 inflation has been embedded in a string theory-inspired non-local gravity modification. We discuss the promising theoretical predictions of non-local R^2-like inflation with respect to the key observables such as tensor-to-scalar ratio, tensor tilt which tell us about the spectrum of primordial gravitational waves, and scalar Non-Gaussianities which tell us about the three-point correlations in the CMB fluctuations.

Primary author: KUMAR, Sravan (Tokyo Institute of Technology)

Presenter: KUMAR, Sravan (Tokyo Institute of Technology)

Session Classification: Regular Sessions

Contribution ID: **74** Type: **Talk/seminar**

The 3+1 Formalism in the Geometric Trinity of Gravity

Monday, 6 September 2021 17:50 (20 minutes)

Both a metric and a tetrad $3 + 1$ formulation for a general affine connection is developed while also assuming nonmetricity. By splitting the space-time metric and tetrad into their spatial and temporal parts as well as through finding the Gauss-like equations for any tensor through which gravity is expressed, a general foundation for the formalisms is set up. Based on this foundation the resulting general 3-tetrad and 3-metric evolution equations are derived. Finally, through the choice of the two respective connections, the metric $3 + 1$ formulation for General Relativity is reaffirmed and the tetrad 3+1 formulation of the Teleparallel Equivalent of General Relativity and the metric 3+1 formulation of Symmetric Teleparallel Gravity with the coincident gauge are derived up to the latest state of the research.

Primary author: Mr FINCH, Andrew (University of Malta)

Co-authors: Dr LEVI SAID, Jackson (University of Malta); Prof. CAPOZZIELLO, Salvatore (INFN - National Institute for Nuclear Physics); Dr MAGRO, Alessio (ISSA University of Malta)

Presenter: Mr FINCH, Andrew (University of Malta)

Session Classification: Regular Sessions

Contribution ID: **75** Type: **Talk/seminar**

Quantum Effects in Higher Order Theories of Gravity

Tuesday, 7 September 2021 17:50 (20 minutes)

Higher order extensions of Einstein gravity play important roles in various areas such as cosmology, the early universe or quantum gravity. In this talk, I will take a look into quantum properties of general higher order extensions of gravity provided that they depend on the Riemann tensor and the inverse metric. Using the functional renormalisation group, a flow equation for such theories is derived and its implications for a UV completion of gravity and gravitational fixed points are discussed.

Primary authors: LITIM, Daniel (University of Sussex); Mr KLUTH, Yannick (University of Sussex)

Presenter: Mr KLUTH, Yannick (University of Sussex)

Session Classification: Regular Sessions

Contribution ID: **76** Type: **Talk/seminar**

Nonlinear structure in general modified gravity models

Friday, 10 September 2021 15:50 (20 minutes)

With the advent of surveys such as the Legacy Survey of Space and Time (LSST), there will be opportunities in the near future to study nonlinear aspects of modified gravity (MG) theories through weak lensing and galaxy clustering measurements. These will be important in constraining the theory space for MG theories with screening effects, which are manifestly nonlinear. As the typical method for studying nonlinear effects, N-body simulation, is expensive computationally and temporally, an alternative method is desirable. In this talk, I will show our current progress in being able to solve the background equations of motion for any model in the reduced-Horndeski framework and produce its power spectrum, valid on mildly nonlinear scales, using the Co-moving Lagrangian Acceleration (COLA) numerical scheme.

Primary authors: SEN GUPTA, Ashim (Queen Mary University of London); BAKER, Tessa (Queen Mary University of London)

Presenter: SEN GUPTA, Ashim (Queen Mary University of London)

Session Classification: Regular Sessions

Contribution ID: **77** Type: **Talk/seminar**

Doubled FLRW models from the spectral geometry

Thursday, 9 September 2021 10:40 (20 minutes)

The non-product spectral geometry may lead to models that possess features characteristic to bimetric gravity theories. Starting from the pair of Friedmann–Lemaître–Robertson–Walker metrics on the product geometry and mildly modifying the Dirac operator we end up with a class of models that have a nontrivial interacting potential term, and their solutions are stable for several cosmological scenarios. The resulting doubled FLRW geometries can be thought of as the generalization of the family of bimetric models with non-polynomial potential. Based on a joint work with Andrzej Sitarz.

Primary authors: SITARZ, Andrzej (Jagiellonian University); BOCHNIAK, Arkadiusz (Jagiellonian University)

Presenter: BOCHNIAK, Arkadiusz (Jagiellonian University)

Session Classification: Ph.D. Students Workshop

Contribution ID: **78** Type: **Talk/seminar**

Quasi-normal Modes of near-extremal black holes in Generalized spherically symmetric spacetime and Strong Cosmic Censorship Conjecture

A number of near-extremal conditions are utilized to simplify the equation of motion of the neutral scalar perturbations in generalized spherically symmetric black hole background into a differential equation with the Pöschl-Teller potential. An analytic formula for quasinormal frequencies is obtained. The analytic formula is then used to investigate Strong Cosmic Censorship conjectures (SCC) of the generalized black hole spacetime for the smooth initial data. The Christodoulou version of the SCC is found to be violated for certain regions of the black hole parameter space including the black holes in General Relativity while the C^{1} version of the SCC is always valid.

Primary authors: WUTHICHARN, Taum (Chulalongkorn University); BURIKHAM, Piyabut; PONGLERTSAKUL, Supakchai

Presenter: WUTHICHARN, Taum (Chulalongkorn University)

Session Classification: Regular Sessions

Contribution ID: **80** Type: **Talk/seminar**

Impact of H_0 priors on $f(T)$ late time cosmology

Friday, 10 September 2021 12:50 (20 minutes)

We perform observational tests on the $f(T)$ gravity using the Cosmic Chronometer data, SNIa data and BAO data together with three different independent measurements of the current value of H_0. In this work, we investigate the impact of these priors on five core models in $f(T)$ gravity. In addition, we perform background studies on these models to better distinguish the impacts of the priors and $f(T)$ models. To do so, the Markov chain Monte Carlo (MCMC) technique was used in order to constrain the varying parameters of the models, including the Hubble constant H_0. These models, in turn, are compared to the ΛCDM model which allows us to investigate the H_0 tension.

Primary authors: BRIFFA, Rebecca (University of Malta); Dr LEVI SAID, Jackson (University of Malta); Dr MIFSUD, Jurgen (University of Malta); Prof. ESCAMILLA RIVERA, Celia (Universidad Nacional Autónoma de México); Mr PULLICINO, Nathan (University of Malta)

Presenter: BRIFFA, Rebecca (University of Malta)

Session Classification: Regular Sessions

Contribution ID: **81** Type: **Talk/seminar**

Linking the lithium problem and the H_0 tension: the gravitational constant at BBN

Monday, 6 September 2021 14:30 (20 minutes)

The primordial abundance of lithium is still a subject of controversy, given the disagreement between numerical results and observational estimates. We show how this discrepancy can be understood in the context of variation of fundamental constants at the epoch of Big Bang Nucleosynthesis. The variation of Newton's constant plays a crucial role. In particular, its interpretation in terms of additional relativistic degrees of freedom suggests an alleviation to the H_0 tension.

Primary authors: Mrs MOSQUERA, Mercedes (Universidad de La Plata); FRANCHINO-VIÑAS, Sebastián (Universidad Nacional de La Plata)

Presenter: FRANCHINO-VIÑAS, Sebastián (Universidad Nacional de La Plata)

Session Classification: Regular Sessions

Contribution ID: **82** Type: **Talk/seminar**

Classification of Teleparallel Horndeski Cosmology via Noether Symmetrie

Thursday, 9 September 2021 12:30 (20 minutes)

Abstract

After the recent detection of GW170817, the most interesting terms of Horndeski theory were severely
constrained. Nevertheless, the analog of Horndeski theory in the Teleparallel Gravity framework is far richer in structure since the extra term in the Lagrangian, Ltele emerges.
As a result, the terms that were eliminated in standard Horndeski theory could, in this case, survive through the Lagrangian contribution leading to a varied phenomenology.

In order to determine the unknown functions Gi(φ; x) of the Horndeski analog in the Teleparallel framework, we adopt Noether point symmetries as a classification criterion. The existence of such symmetry not only selects the form of the Gi(φ; x) but also could lead to valid cosmological models for future research
and study.

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Co-author: OIKONOMOPOULOU, ZINOVIA (UNIVERSITY OF MALTA)

Presenter: OIKONOMOPOULOU, ZINOVIA (UNIVERSITY OF MALTA)

Session Classification: Ph.D. Students Workshop

Contribution ID: **83** Type: **Talk/seminar**

Shadow cast by rotating black hole with a cosmological constant

Interpreting the cosmological constant (Λ) as the vacuum energy, and under a minimum amount of assumptions, leads to a deformation in the vicinity of a black hole and a new Kerr–de Sitter solution. The new Kerr–de Sitter solution is a more straightforward and has richer geometric structure than the original one. Interestingly, there exist minimum (M_{min}) and maximum (M_{min}) mass such that for $M_{min} < M < M_{min}$, we have an event horizon, two cosmological horizons and as well as the Cauchy horizon. For $M = M_{min}$, we have an extremal case where the event and cosmological horizons degenerate. Further, we investigate the black hole shadow and associated observables viz. the shadow radius R_s, area A, deformation δ_s and oblateness D. We also estimate the parameters Λ and a of the new Kerr de Sitter black hole from its astronomical shadow observables. The shadow observables of the new Kerr de Sitter black hole are found to significantly deviate from the corresponding observables of the Kerr de Sitter black hole over an appreciable range of the parameter space ($a/M - \Lambda/M^{-2}$). Also, the circularity deviation ΔC of the new Kerr de Sitter black hole is studied in the ($a/M - \Lambda/M^{-2}$) parameter space and is found to be affected by the distance of observer from the black hole.

Primary authors: AFRIN, MISBA (JAMIA MILLIA ISLAMIA); Prof. GHOSH, SUSHANT G. (JAMIA MILLIA ISLAMIA)

Presenter: AFRIN, MISBA (JAMIA MILLIA ISLAMIA)

Session Classification: Ph.D. Students Workshop

Contribution ID: **84** Type: **Talk/seminar**

Curvature for quantum gravity

Tuesday, 7 September 2021 17:30 (20 minutes)

In non-smooth and discrete metric spaces of some models of quantum gravity, e.g., those based on Ricci calculus, it is a nontrivial task to introduce a notion of curvature that works at any length scale down to the cutoff scale and in the continuum limit converges to a curvature defined in terms of the Riemann tensor. The recently introduced *quantum Ricci curvature* has those properties. In the talk I will present this quantity and the results of calculating it in discrete spaces of several kinds, including the newest results in the most physically relevant four-dimesional model of Causal Dynamical Triangulations with the toroidal spatial topology.

Primary author: DROGOSZ, Zbigniew (Jagiellonian University Krakow)

Presenter: DROGOSZ, Zbigniew (Jagiellonian University Krakow)

Session Classification: Regular Sessions

Contribution ID: **85** Type: **Talk/seminar**

Theoretical Constraints on Boostless Amplitudes and Cosmological Correlators

Thursday, 9 September 2021 14:50 (20 minutes)

Flat space theories of spinning particles must obey nontrivial consistency conditions that follow from locality, unitarity and gauge invariance. These conditions are especially powerful in the case of Lorentz invariant theories of massless particles, where they have been used to derive the gravitational equivalence principle, among other interesting results. In a recent paper, we have shown that even if we drop the assumption of boost invariance, as long as all particles are assumed to propagate at the speed of light, similar conclusions still apply and the gravitational interactions pass consistency tests only if they are Lorentz invariant. This result should be kept in mind when considering Lorentz violations in theories defined on the Minkowski background, and perhaps also in the study of the early universe, where boost invariance is broken by the expanding space.

Primary author: SUPEŁ, Jakub (University of Cambridge)

Co-authors: STEFANYSZYN, David (DAMTP); PAJER, Enrico (University of Cambridge); CABASS, Giovanni (Physics Department and INFN, La Sapienza University of Rome)

Presenter: SUPEŁ, Jakub (University of Cambridge)

Session Classification: Regular Sessions

Contribution ID: **86** Type: **Talk/seminar**

Application of the Broad Line Region radius-luminosity relation in cosmology

Wednesday, 8 September 2021 12:50 (20 minutes)

In the previous works, using the SALT measurements of three luminous quasars, we confirmed the presence of the Broad Line Region radius-luminosity relation for the ultraviolet line of MgII. Together with SDSS-RM as well as Oz-DES datasets, we studied the classical as well as extended versions of the radius-luminosity (RL) relation. Using 78 sources, we simultaneously fitted the parameters of the RL relation as well as the cosmological parameters of six cosmological models (both flat and spatially curved). We found that regardless of the cosmological model, the RL relation is consistent and robust with the scatter of ˜0.3 dex, which makes it possible to use MgII quasars as standardizable candles. The obtained cosmological constraints are consistent with the BAO+H(z) sample, favouring spatially flat ΛCDM model. However, the current dataset of MgII quasars, when used jointly with the BAO+H(z) sample, does not exclude cosmological models with mild dark energy and a little spatial curvature.

Primary author: ZAJACEK, Michal (Center for Theoretical Physics, Polish Academy of Sciences)

Co-authors: Prof. CZERNY, Bozena (CFT PAN); Dr MARTÍNEZ-ALDAMA, Mary Loli (CFT PAN Warsaw); Dr KHADKA, Narayan (Kansas State University); Prof. RATRA, Bharat (Kansas State University)

Presenter: ZAJACEK, Michal (Center for Theoretical Physics, Polish Academy of Sciences)

Session Classification: Regular Sessions

Contribution ID: **87** Type: **Talk/seminar**

Probing Fundamental Physics in Extreme Gravity with Gravitational Waves

Wednesday, 8 September 2021 16:10 (1 hour)

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

Primary author: Prof. YUNES, Nicolas (University of Illinois at Urbana-Champaign)

Presenter: Prof. YUNES, Nicolas (University of Illinois at Urbana-Champaign)

Session Classification: Invited Plenary Session

Contribution ID: **89** Type: **Talk/seminar**

Dynamical String Tension Theories: New possibilities for Gravity Cosmology, Thermodynamics and Brane world Scenarios.

Monday, 6 September 2021 15:50 (20 minutes)

If we are so eager to modify gravity, why can´t we modify string theory?, which in turn can give us even more modified gravity theories. For example the string tension does not have to be put in by hand, it can be dynamically
generated, as in the case when we formulate string theory in the modified measure formalism. For gravity theories, the modified measure formalism gives a dynamical cosmological constant. Then string tension appears, but as an additional
dynamical degree of freedom . It can be seen however that this string tension is not universal, but rather each string generates its own string tension, which can have a different value for each string. We also define a new Tension scalar background field which change locally the value of the string tension along the world sheets of the strings. When there are many strings with different string tensions this Tension field can be determined from the requirement of world sheet conformal invariance and for two types of string tensions depending on the relative sign of the tensions we obtain non singular cosmologies and warp space scenarios and when the two string tensions are positive, we obtain scenarios where the Hagedorn temperature is avoided in the early universe or in regions of warped space time where the string tensions
become very big. Bubbles and Braneworld scenarios where strings are constrained to be be between two surfaces where the string tension grows to infinity also appear naturally in this approach
……..
references
1. Light Like Segment Compactification and Braneworlds with Dynamical String Tension Eduardo Guendelman, e-Print: 2107.08005 [hep-th]
2. Escaping the Hagedorn Temperature in Cosmology and Warped Spaces with Dynamical Tension Strings E.I. Guendelman, e-Print: 2105.02279 [hep-th] 3. Cosmology and Warped Space Times in Dynamical String Tension Theories Eduardo Guendelman, e-Print: 2104.08875 [hep-th]

Primary author: Prof. GUENDELMAN, Eduardo (Ben Gurion University)

Presenter: Prof. GUENDELMAN, Eduardo (Ben Gurion University)

Session Classification: Regular Sessions

Contribution ID: **90** Type: **Talk/seminar**

Varying fine structure constant - Latest developments

Tuesday, 7 September 2021 10:00 (1 hour)

Abstract:
Recent observations carried out using all 4 VLTs simultaneously have provided new quasar spectra of unprecedented quality. I will describe the very recent analysis of such data, carried out using new AI methods and other statistical tools that permit fully automated and unbiased estimates of the fine structure constant at high redshift.

Primary author: WEBB, John (Cambridge University)

Presenter: WEBB, John (Cambridge University)

Session Classification: Invited Plenary Session

Contribution ID: **91** Type: **Talk/seminar**

Ricci Cosmology in light of astronomical data

Thursday, 9 September 2021 12:10 (20 minutes)

From the study of relativistic dynamics of fluids out of equilibrium in a curved background, a new cosmological framework, dubbed Ricci Cosmology, has emerged in which linear terms in Ricci scalar and Ricci tensor lead to modifications of the equilibrium pressure in the energy-momentum tensor in the fluids filling the Universe. The coefficients in front of such terms are called second order transport coefficients and parametrise the fluids response to the pressure terms arising from the spacetime curvature.
Under the assumption of constant coefficients, we find the simplest solution in which the presence of such terms causes a departure from the perfect fluid redshift scaling for matter components in the Universe. By using the second law of thermodynamics, theoretical bounds on the transport coefficients are imposed. In order to test the viability of this solution, we make four different ansätze on the transport coefficients, giving rise to four different cases of our model. The observational bounds on the second order transport coefficients obtained by testing each case against cosmological data are compatible with the thermodynamical bounds and indicate that Ricci Cosmology is compatible with ΛCDM cosmology for all the ansätze.

Primary author: CAROLI, Roberto (University of Szczecin)

Co-authors: Prof. DABROWSKI, Mariusz (University of Szczecin); Prof. SALZANO, Vincenzo (University of Szczecin)

Presenter: CAROLI, Roberto (University of Szczecin)

Session Classification: Ph.D. Students Workshop

Contribution ID: **92** Type: **Talk/seminar**

Modified gravity imprints in galaxy clusters

Extending General Relativity by adding extra degrees of freedom is a popular approach to explain the accelerated expansion of the universe and to build high energy completions of the theory of gravity. The presence of such new degrees of freedom is, however, tightly constrained from observations and experiments. The viability of a given modified theory of gravity therefore strongly depends on the existence of screening mechanisms that suppresses the extra degrees of freedom in certain scales and regimes. I describe how one can use nonlinear structure formation to probe extensions to General Relativity, and will present a set of astrophysical observables that could give smoking guns of screening mechanism at galaxy and cluster scales.

Primary author: MOTA, David F.

Presenter: MOTA, David F.

Session Classification: Invited Plenary Session

Contribution ID: **93** Type: **Talk/seminar**

Gravitational Wave Propagation and Polarizations in the Teleparallel analog of Horndeski Gravity

Wednesday, 8 September 2021 18:10 (20 minutes)

Gravitational waves (GWs) have opened a new window of fundamental physics in a number of important ways. The next generation of GW detectors may reveal more information about the polarization structure of GWs. Additionally, there is growing interest in theories of gravity beyond GR. One such theory which remains viable within the context of recent measurements of the speed of propagation of GWs is the teleparallel analogue of Horndeski gravity. In this work, we explore the polarization structure of this newly proposed formulation of Horndeski theory. In curvature-based gravity, Horndeski theory is almost synonymous with extensions to GR since it spans a large portion of these possible extensions. We perform this calculation by taking perturbations about a Minkowski background and consider which mode propagates. The result is that the polarization structure depends on the choice of model parameters in the teleparallel Horndeski Lagrangian with a maximum of seven propagating degrees of freedom. While the curvature-based Horndeski results follows as a particular limit within this setup, we find a much richer structure of both massive and massless cases which produce scalar–vector–tensor propagating degrees of freedom. We also find that the GW polarization that emerges from the teleparallel analogue of Horndeski gravity results in analogous massive and massless modes which take on at most four polarizations in the massless sector and two scalar ones in the massive sector. In none of the cases do we find vector polarizations.

Primary authors: Dr SARIDAKIS, Emmanuel N. (National Observatory of Athens / University of Science and Technology of China); LEVI SAID, Jackson (University of Malta); Prof. SULTANA, Joseph (University of Malta); Dr DIALEKTOPOULOS, Konstantinos F. (Yangzhou University); Dr HOHMANN, Manuel (University of Tartu); CARUANA, Maria (University of Malta); Dr BAHAMONDE, Sebastian (University of Tartu); Mr GAKIS, Viktor (University of Athens)

Presenter: CARUANA, Maria (University of Malta)

Session Classification: Regular Sessions

Contribution ID: **95** Type: **Talk/seminar**

Cosmological dynamics from LQG

Tuesday, 7 September 2021 16:50 (20 minutes)

During the last years many inspired Loop Quantum Gravity (LQG) models for homogeneous cosmology were carefully studied, however all these models required extra input to be self consistent. In this talk I will briefly present a gauge fixed version of LQG adapted to cosmological systems. The interesting feature of this model is the resulting cosmological dynamics: by using the full structure of LQG the usual bouncing scenario is replaced by the so called emergent bouncing universe.

Primary author: BOTTA, gioele (university of warsaw)

Presenter: BOTTA, gioele (university of warsaw)

Session Classification: Regular Sessions

Contribution ID: **96** Type: **Talk/seminar**

Aspects of traversable wormholes

Friday, 10 September 2021 11:30 (1 hour)

In recent years there have appeared several constructions of traversable wormholes, in four and other dimensions, which only involve physically acceptable, controllable ingredients. They connect in deep ways many aspects of gravity, quantum field theory, and quantum information. I will discuss several features of these constructions, with a focus on traversability, connectivity between multiple mouths, and the (im)possibility of time travel.

Primary author: EMPARAN, Roberto (University of Barcelona)

Presenter: EMPARAN, Roberto (University of Barcelona)

Session Classification: Invited Plenary Session

Contribution ID: **97** Type: **Talk/seminar**

Testing gravity and constraining dark energy with Euclid

Tuesday, 7 September 2021 09:00 (1 hour)

Euclid is an ESA medium class astronomy and astrophysics space mission. Euclid was selected by ESA in October 2011 and its launch is planned for 2022. Euclid will explore how the Universe evolved over the past 10 billion years to address questions related to fundamental physics and cosmology..

I will give a general overview of the Euclid satellite and its mission, and describe the main probes and how they observe the evolution of the Universe. Focusing particularly on dark energy and modified gravity models, I will then briefly review what we know now, and how the Euclid observations will help to improve our knowledge.

Primary authors: CONSORTIUM, Euclid; KUNZ, Martin (Universite de Geneve (CH))

Presenter: KUNZ, Martin (Universite de Geneve (CH))

Session Classification: Invited Plenary Session

Contribution ID: **98** Type: **Talk/seminar**

Inflationary universe in deformed phase spece Sáez–Ballester theory

Thursday, 9 September 2021 16:10 (20 minutes)

By proposing an appropriate dynamical deformation between the momenta associated with the scalar field (of the Sáez–Ballester theory) and scale factor of the spatially flat FLRW metric, we establish a modified cosmological model. Subsequently, for some particular cases, by focusing on the early epoch of the universe, we show that our model provides a more successful description for evolution of the universe with respect to the corresponding standard models.

Primary author: RASOULI, Seyed Meraj (Universidade da Beira Interior)

Presenter: RASOULI, Seyed Meraj (Universidade da Beira Interior)

Session Classification: Regular Sessions

Contribution ID: **99** Type: **Talk/seminar**

Is quantum TEGR equivalent to quantum GR?

Tuesday, 7 September 2021 17:10 (20 minutes)

We will review our previous work on precanonical quantization of GR and the recent work on precanonical quantization of the teleparallel equivalent of GR. Both approaches are based on Palatini formulations in vielbein variables and the analysis of constraints within the De Donder-Weyl Hamiltonian formulation which treats space and time variables on equal footing. In both theories, we obtain the generalized Dirac brackets of fundamental variables represented by differential forms. Their quantization leads to two different descriptions of quantum space-time: quantum connection dynamics in the case of GR and the quantum frames dynamics in the case of TEGR. In both cases, we present the corresponding covariant precanonical Schroedinger equations and briefly discuss the classical limit, the quantum-gravitational avoidance of singularities, the emergence of the cosmological constant, and compare the simplest quantum cosmological solutions and their potentially observable consequences.

Primary author: Dr KANATCHIKOV, Igor

Presenter: Dr KANATCHIKOV, Igor

Session Classification: Regular Sessions

Contribution ID: **104** Type: **Talk/seminar**

Shadow cast by rotating black hole with a cosmological constant

Wednesday, 8 September 2021 17:50 (20 minutes)

Presenter: AFRIN, MISBA (JAMIA MILLIA ISLAMIA)

Session Classification: Regular Sessions

Contribution ID: **106** Type: **Talk/seminar**

The Black Hole Universe: the perfect cosmological principle

Monday, 6 September 2021 10:15 (1 hour)

Most cosmologists today believed that our universe corresponds to a Big Bang homogeneous (FLRW) metric with an age which is only three times larger than the age of Earth. This seems in agreement with most observations and with the cosmological principle which states that space-time is homogeneous only in space, but not in time. Recent measurements indicate that our cosmic expansion is dominated by a repulsive cosmological constant $\Lambda > 0$. This indicates that we are inside a closed hypersphere, $r < r_\Lambda \equiv \sqrt{3/\Lambda}$, which corresponds to the interior of a Black Hole (BH) event horizon. Our universe expands inside this BH with asymptotic deSitter interior. In proper coordinates such universe becomes static. We call this the BH Universe (BHU). The BHU involves two nested FLRW metrics which we show here is an exact solution of classical General Relativity. Our BHU could be part of a much larger and older network of BHUs in a new version of the Steady State Cosmology. This results in an implementation of the perfect cosmological principle, where time and space are in the same footing, as required by the principle of relativity. We argue that observed BHs (or BHs making up the observed Dark Matter, DM) inside our universe could also be smaller BHUs themselves. In such case, BHs and BH mergers, rather than reheating at the end of inflation, could be the source of all matter-energy content in our universe, which resolves the coincidence problem (between the density of DM and Λ today).
We discuss other observational features of such a BHU cosmology, such as CMB anomalies and high energy BH ejection.

Primary author: GAZTANAGA, Enrique (ICE/CSIC)

Presenter: GAZTANAGA, Enrique (ICE/CSIC)

Session Classification: Invited Plenary Session

Contribution ID: **107** Type: **Talk/seminar**

Quantum Frequency Interferometry: with applications ranging from gravitational wave detection to dark matter searches

Tuesday, 7 September 2021 11:30 (1 hour)

We introduce a quantum interferometric scheme that uses states that are sharp in frequency and delocalized in position. The states are frequency modes of a quantum field that is trapped at all times in a finite volume potential, such as a small box potential. This allows for significant miniaturization of interferometric devices. We consider a concrete implementation using the ground state and two phononic modes of a trapped Bose-Einstein condensate. We apply this to show that frequency interferometry can improve the sensitivity of phononic gravitational waves detectors by several orders of magnitude, even in the case that squeezing is much smaller than assumed previously and that the system suffers from short phononic lifetimes. Other applications range from magnetometry, gravimetry and gradiometry to dark matter/energy searches.

Primary author: Prof. FUENTES, Ivette (University of Southampton)

Presenter: Prof. FUENTES, Ivette (University of Southampton)

Session Classification: Invited Plenary Session

Contribution ID: **108** Type: **Talk/seminar**

Mystery Noise in Gravitational Wave Detectors, as a probe of Fundamental Physics

Tuesday, 7 September 2021 12:30 (1 hour)

Where, I venture into how the noise in gravitational wave detectors could tell us about the physics beyond the standard model of particle physics, and the fundamental nature of quantum black holes.

Primary author: AFSHORDI, Niayesh (University of Waterloo)

Presenter: AFSHORDI, Niayesh (University of Waterloo)

Session Classification: Invited Plenary Session

Contribution ID: **111** Type: **Talk/seminar**

Cosmological tensions: hints for a new concordance model?

Wednesday, 8 September 2021 11:30 (1 hour)

The Cosmic Microwave Background temperature and polarization anisotropy measurements have provided strong confirmation of the LCDM model of structure formation. Even if this model can explain incredibly well the observations in a vast range of scales and epochs, with the increase of the experimental sensitivity, a few interesting tensions between the cosmological probes, and anomalies in the CMB data, have emerged with different statistical significance. While some portion of these discrepancies may be due to systematic errors, their persistence across probes strongly hints at cracks in the standard LCDM cosmological scenario. The most statistically significant are the Hubble constant puzzle, the S8 parameter tensions, the Alens anomaly and a curvature of the Universe. I will review these tensions, showing some interesting extended cosmological scenarios that can alleviate them.

Primary author: Dr DI VALENTINO, Eleonora (Durham University)

Presenter: Dr DI VALENTINO, Eleonora (Durham University)

Session Classification: Invited Plenary Session

Contribution ID: **112** Type: **Talk/seminar**

Compact Objects in Alternative Gravities

Monday, 6 September 2021 11:30 (1 hour)

Compact astrophysical objects like black holes and neutron stars are excellent tools to test the strong gravity regime of General Relativity and alternative gravity theories by comparing their theoretical predictions with current and future observations, since alternative gravity theories may feature distinctive signatures for these compact objects. While the analysis of the properties of black holes may yield direct insights for the gravity theories, an additional step is required in the case of neutron stars, whose properties depend also on their unknown equation of state. Thus universal relations should be obtained, to have (almost) equation of state independent predictions, that may, however, differ among the various gravity theories.

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Session Classification: Invited Plenary Session