BOOK OF ABSTRACTS (By alphabetical order)

MADRID WINTER WORKSHOP

Abreu de Paula

Can regular black holes mimic standard ones?

One of the possibilities for obtaining regular black hole solutions is by coupling gravity and nonlinear electrodynamics models. Since the late 1990s, based on the nonlinear electrodynamics framework, several regular black hole solutions have been obtained within general relativity and beyond, and recently the study of the absorption and scattering properties of such solutions has been gaining attention. We investigate the possibility of regular black holes mimicking standard ones, from the perspective of the absorption and scattering of massless scalar fields. We show that Ayón-Beato-García and Reissner-Nordstrom black hole solutions can have very similar absorption and scattering properties for arbitrary values of the frequency and scattering angle of the massless scalar wave, as long as we consider low-to-moderate values of the electric charge.

Aguiar Gomes

Early evolution of fully convective stars in scalar-tensor gravity

In this work, the early evolution of low-mass fully convective stars is studied in the context of DHOST (degenerate higher order scalar-tensor) theories of gravity. Although it is known that the hydrostatic equilibrium equation is modified for scalar-tensor gravity, the consequent modifications to the early evolution phases of a star were not explored in this framework. With this in mind, we consider three evolutionary phases - contraction to the main sequence, lithium burning and entrance to the main sequence - and investigate how each of these phases is affected by the theory's parameter. Taking these effects into account, we are able to show, among other things, that the Hayashi tracks are shifted and the star's age is considerably modified.

Agullo

On entanglement in quantum field theory

It is believed that even the simplest states in the simplest quantum field theories are highly entangled. The main support for this statement comes from the Reeh-Schlieder theorem and calculations of entanglement entropy between a region of space and its complement. I will argue that these results do not provide much information about the entanglement between individual local degrees of freedom. I will then present a way of quantifying such entanglement and show that entanglement in field theory is significantly less ubiquitous than it is commonly believed.

Alonso-Serrano

Placing Unruh-DeWitt detectors in a time-machine geometry

We study the response of an Unruh-DeWitt detector interacting with a massless scalar field on a time-machine geometry and compare it with the response in the spacetime without time machine. What information can they provide to us?

Alvarez-Dominguez

TBA

Argañaraz

First use case: Double null coordinates in Kerr spacetime.

The possibility to generalize the previous knowledge gained for the Schwarzschild case to this axis-symmetric spacetime makes the calculation of null coordinates for Kerr geometry an interesting and necessary subject. However, it has also been remarkably elusive. It is an interesting question, since in its construction one can grasp the details of the geometry encoded in the Kerr metric. It is a necessary and useful construction for the discussion and calculation of characteristic problems in the Kerr geometry, from a theoretical and numerical point of view. It is elusive, since before this work, there were no presentations of complete, round, smooth null coordinates that enfold the horizons in a regular way

We present a definition for a pair of null coordinates that are naturally adapted to the horizons and future null infinity of Kerr spacetime, and that are generated by the center-of-mass sections at future null infinity. We compare our definition with other previous attempts in the literature, and we show that all of them have divergent behavior at the axis of symmetry. Thus, our construction presents the first double null coordinate system which makes possible computations over all the Kerr spacetime. As a first application, we have developed and implemented a numerical scheme and code that computes the evolution of the massless scalar field wave equation in Kerr spacetime, using double null coordinates. The results show a smooth behavior across the event horizon, making it possible to give initial data outside the event horizon, evolve the scalar field across the horizon, and keep the evolution even inside the black hole. This is the first time that a double null evolution is performed for a scalar field in Kerr spacetime. References:
https://doi.org/10.1103/PhysRevD.104.024049 https://doi.org/10.1103/PhysRevD.105.084012

Arrechea

The quantum nature of astrophysical black holes

Black holes have become the cornerstone prediction of Einstein's theory of general relativity. Inasmuch as they provide a laboratory for testing GR to astonishing precision through gravitational-wave observations, they cannot strictly correspond to the extremely dark and compact objects observed (astrophysical black holes or ABHs), if only because GR itself is doomed to break down in their innermost regions, where quantum-gravitational effects are expected to dominate. Nowadays, the most robust, well-established framework that addresses the interaction between the gravitational and quantum realms is quantum field theory in curved spacetimes, the theory behind the discovery of Hawking evaporation. While the relevance of Hawking's discovery remains undisputable, here we raise a question of a different nature: Can the quantum corrections responsible for Hawking evaporation also give rise to new kinds of stars nearly as compact as ABHs while lacking event horizons and/or spacetime singularities? For this purpose, we address the semiclassical backreaction problem, including the expectation value of a renormalized stress-energy tensor (RSET) as an extra source in the Einstein field equations. We explore different prescriptions for obtaining RSETs of massless scalar fields and prove that the backreaction of the RSET allows for the existence of novel exotic compact objects that can mimic the observational properties of ABHs.

Arzano

Getting hot without accelerating

The generators of radial conformal symmetries in Minkowski space-time can be put in correspondence with the generators of time evolution in conformal quantum mechanics. Within this correspondence I show that in conformal quantum mechanics the state corresponding to the inertial vacuum for a conformally invariant field in Minkowski spacetime has the structure of a thermofield double. The latter is built from a bipartite "vacuum state" corresponding to the ground state of the generators of hyperbolic time evolution. These can evolve states only within a portion of the time domain. When such generators correspond to conformal Killing vectors mapping a causal diamond in itself and generators of dilations, the temperature of the thermofield double reproduces, respectively, the diamond temperature and the Milne temperature. This result indicates that, for conformally invariant fields, the fundamental ingredient at the basis vacuum thermal effects in flat-space time is the non-eternal nature of the lifetime of observers rather than their acceleration.

Bak

Variational formulation of general relativity

Here, I present few results from my Master Thesis which are actually published in arxiv. I will focus on the equvalence between three variational principles (called ""pictures"") used in general relativity: the metric picture (the most popular case, where the metric is the fundamental object), the Palatni picture (here we control both the metric tensor and the connection) and the affine picture (the least known, where only the connection is controlled). Such construction shows quite an interesting fact: the matter could affect the character of the connection or, in other words, the non-metricity of the connection could be interpreted as a matter field. As an example of all this deliberations I will present the model of gravity with the cosmological constant and proposition of unification of the gravity and electromagnetism. Such a model embraces a few classical ideas:

1) Einstein's intuition that gravity is described by the symmetric part and electromagnetism by the skew-symmetric part of a certain geometric object (here: the Ricci tensor),

2) Weyl's concept of non-metric connection, where the measure of ""non-metricity"" is played by the electromagnetic potential,

3) Born-Infeled generalisation of electromagnetism, where the ""standard"" Maxwellian theory arises as its weak field approximation.

At the end of my talk I show how to use the equivalence between the three variational picures to describe some problems of the so called ""Weyl conformal gravity theories"" and quite interesting perturbation of the Proca theory."

Banerjee

Constraining modified gravity using tidal deformation of cataclysmic variables

When a star comes near a black hole or any other compact object, it experiences a tidal force due to the inhomogeneity of gravity. Tidal forces can be strong enough to disrupt a star and give rise to observable astrophysical phenomena. When the tidal force is equal to the self-gravity of the star at its surface, it is maximally deformed. It is known as the tidal disruption limit or the Roche limit. This critical limit is used to study various properties of the deformed star and the central object. In the talk, I shall begin with tidal effects on self-gravitating Newtonian stars in general relativistic spacetime background, namely the GR effects arising from the orbital properties. Thereafter, I'll talk about a novel methodology to find parametric constraints in beyond-Horndeski gravity using Roche lobe filling secondary stars in cataclysmic variables. We numerically model the Roche lobe filling secondary stars incorporating the modified fluid equations that appear in this theory. The numerical results are contrasted with existing observational data yielding the desired constraints in beyond-Horndeski theories. A similar method is used to constrain Eddington-inspired Born-Infeld gravity, which is an important modification of Einstein's general relativity and can give rise to non-singular cosmologies at the classical level, and avoid the end-stage singularity in a gravitational collapse process. By using our methodology, we are able to constrain these theories within 5 sigma confidence level.

Beltrán Jiménez

Linear responses of electrically K-mouflaged objects

Non-linear electromagnetism has been very extensively explored in the literature starting from the pioneering works of Born and Infeld in an attempt to regularise the self-energy of the electron. These theories naturally provide charges with a screening mechanism à la K-mouflage originating from the self-interactions. I will briefly review this mechanism and discuss some potential phenomenological consequences when dark matter interacts via a dark photon featuring K-mouflage. I will then proceed to discuss the linear response of screened objects with special emphasis in Born-Infeld and ModMax electromagnetisms. Remarkably, the polarisability and susceptibility of certain multipoles vanish in the case of Born-Infeld. I will show how to construct ladder operators for the perturbations and unveil the existence of two ladders that only exist for Born-Infeld, thus providing another characterisation that singles out this theory. Finally, I will show how the perturbations can be described as a supersymmetric quantum system.

Beltrán Palau

Static quantum-vacuum solutions of Einstein's equations

We explore static and spherically symmetric solutions of the 4-dimensional semiclassical Einstein's equations using the quantum vacuum polarization of a conformal field as a source. These solutions may be of interest for studying ECOs. The full backreaction problem is addressed by solving the semiclassical TOV equations making use of effective equations of state inspired from the trace anomaly and extra reasonable conditions expected for the vacuum state. We combine analytical and numerical techniques to solve the resulting differential equations, both perturbatively and non-perturbatively in \hbar. We also study the corrections that the quantum-vacuum polarization induces on the propagation of waves, and discuss the implications.

Bettoni

Quintessential inflation: a tale of emergent and broken symmetries

In this talk, I will first review the basics of quintessential inflation and how this paradigm can be embedded in a general scalar-tensor formulation and its relation to variable gravity scenarios. Particular emphasis will be placed on the role played by symmetries. In the second part of the talk, I will present some phenomenological aspects related to the breaking of symmetries triggered by the dynamics of the cosmon field and explore observational features of quintessential inflation.

Blixt

Hamilton's equations in teleparallel gravity

General relativity can be equivalently written in terms of torsion. This is called the teleparallel equivalent to general relativity (TEGR). Although the theories are equivalent there is an open question if TEGR has any advantage in numerical relativity, for instance. As a step towards answering this question we provide Hamilton's equations for TEGR in its covariant formulation without any gauge fixing. Apart from applications to numerical relativity the results can be applicable in the calculation of Poisson Brackets in teleparallel theories.

Bombacigno

What is new in metric-affine Chern-Simons gravity: black holes, cosmology and gravitational waves

We discuss the latest results in metric-affine Chern-Simons gravity, where projective invariance is recovered by supplementing the Pontryagin density with homothetic curvature terms. We present in different physical scenarios perturbative and non-perturbative solutions for the connection, showing how torsion and non-metricity can be related to the metric and to the pseudoscalar field ruling the Pontryagin term in the action. We review, in particular, how a non-trivial metric-affine geometry can affect quasinormal modes for Schwarzschild blackholes, Friedmann-Robertson-Walker solutions and the propagation of gravitational waves, both in vacuum and in matter.

Borislavov Vasilev

Future cosmological singularities in shift-symmetric Kinetic Gravity Braiding theories

Scalar field theories known as Kinetic Gravity Braiding models are acclaimed for the possibility of driving the expansion of the cosmos towards a future self-tuning de Sitter state when the corresponding Lagrangian is invariant under constant shifts in the scalar field. Nevertheless, this is not the only possible future phenomenology for these shift-symmetric models. In fact, I will argue that future cosmological singularities can also appear in this framework. As an example, I will present a simple model featuring a future big rip singularity.

Boyanov

Warp drive aerodynamics in the quantum vacuum

In this talk I will briefly introduce the geometry of the Alcubierre warp drive solution and discuss some of its causal properties. I will then present an analysis of the potential instabilities of this spacetime in the presence of quantum matter. Particularly, I will show how the instabilities found previously in 1+1 dimensional models are related to energy accumulation at points of infinite asymptotic blueshift, akin to points of a black hole inner horizon, and how this analysis can be extended to higher dimensions, where the instability may be tamed with appropriate shapes and trajectories for the warp bubble.

Brito

Resonant peaks on the power emitted by a source orbiting a small Schwarzschild–anti–de Sitter black hole

Using quantum field theory in curved spacetimes at tree level we calculate the power of scalar radiation emitted by a source moving along circular geodesics around Schwarzschild-anti-de Sitter black holes. For large black holes, the power exhibits an enhancement in the contribution of higher multipoles, as compared to the Schwarzschild case. For small black holes, the effective potential for the scalar field presents a local minimum giving rise to long-lived modes. These modes are almost trapped inside the potential well and produce sharp peaks in the total power emitted by the source. We also compare these results with the corresponding ones in the Schwarzschild-de Sitter spacetime.

Casado-Turrión

Pathological character of f(R)-exclusive constant-curvature solutions and the models which host them

Constant-curvature solutions lie at the very core of gravitational physics, with Schwarzschild and (anti)-de Sitter being two of the most paradigmatic examples. Although such kind of solutions are very well-known in General Relativity, that is not the case for theories of gravity beyond the Einsteinian paradigm. In this talk we provide a systematic overview on the constant-curvature solutions of f(R) theories. We conclude that, in general terms, the majority of f(R)-exclusive constant-curvature solutions and the f(R) models that harbour them suffer from several shortcomings, rendering their physical viability extremely limited, when not ruled out by physical evidence.

Castellano

The Emergence Proposal in Quantum Gravity

In the Emergence Proposal in Quantum Gravity it is conjectured that all light-particle kinetic terms are absent in the fundamental ultra-violet (UV) theory and are generated instead by quantum corrections in the infrared (IR). It has been argued that this proposal may provide for some microscopic understanding of some of the core ideas belonging to the so-called Swampland Program, whose aim is to elucidate the consistency conditions that low energy effective field theories (EFTs) have to satisfy in order to be consistent with Quantum Gravity in the UV. We will discuss with some detail how the phenomenom of emergence is realised in String Theory constructions, starting from 10d
maximal supergravity theories as well as lower dimensional realisations. We emphasize the crucial role the so-called species scale plays in any EFT weakly coupled to gravity, and discuss how our computations provide strong support for the idea that this physical cut-off may be the one beyond which purely quantum gravity effects are unavoidable, and local QFT may break down. "

Chowdhury

Analytical approach to slow stellar rotation in modified gravity

In this talk we are going to present the methodology to incorporate slow rotation in stellar objects analytically. Then we are going to introduce modified gravity in this particular formalism. This approach to deal with modified gravity theories in conjunction with slow rotation can yield us the analytic handle to the profiles of stellar parameters like pressure, density, mass and temperature. Usually the stellar structure codes that can deal with rotation needs to be made highly precise, in order to deal with slow rotation, which makes the analysis computationally expensive. On the other hand our aforementioned formalism should in principle help one easily understand the dynamics and interplay between the modified gravity theories and slow rotation, without any kind of computation.

de la Cruz-Dombriz

TBA

de Martino

Constraining cosmology with Einstein Telescope

We investigate the capability of Einstein Telescope to constrain the cosmological parameters of the non-flat ΛCDM cosmological model. Two types of mock datasets are considered depending on whether or not a short Gamma-Ray Burst is detected and associated with the gravitational wave event using the THESEUS satellite. Depending on the mock dataset, different statistical estimators are applied: one assumes that the redshift is known, and another one marginalizes over it assuming a specific prior distribution. We demonstrate that {\em (i)} using mock catalogs collecting gravitational wave events to which a short Gamma-Ray Burst has been associated, Einstein Telescope may achieve an accuracy on the cosmological parameters of $\sigma_{H_0}\approx 0.40$ km s^{-1} Mpc^{-1}, $\sigma_{\Omega_{k,0}}\approx 0.09$, and $\sigma_{\Omega_{\Lambda,0}}\approx 0.07$; while {\em (ii)} using mock catalogs collecting also gravitational wave events without a detected electromagnetic counterpart, Einstein Telescope may achieve an accuracy on the cosmological parameters of $\sigma_{H_0}\approx 0.04$ km s^{-1} Mpc^{-1}, $\sigma_{\Omega_{k,0}}\approx 0.01$, and $\sigma_{\Omega_{\Lambda,0}}\approx 0.01$. These results show an improvement of a factor 2-75 with respect to earlier results using complementary datasets.

Delgado Miravet

Generating baryons from metric perturbations

We make the observation that the gravitational leptogenesis mechanism can be implemented without invoking new axial couplings in the inflaton sector. We show that in the perturbed Robertson-Walker background emerging after inflation, the spacetime metric itself breaks parity symmetry and generates a non-vansihing Pontryagin density which can produce a matter-antimatter asymmetry.

Delhom

TBA

Della Monica

Shutting the allowed mass range of the ultralight bosons with the S2 star

We built mock catalogs mirroring the forthcoming astrometric and spectroscopic observations of S2, we used them to predict the accuracy down to which the mass of an ultralight boson may be bounded and we showed that, once complementary constraints are considered, this analysis will help to restrict the allowed range of the boson mass. It is well known that ultralight bosons form a solitonic dark matter core in the innermost part of the halo. The scale length of such a soliton depends on the inverse of the mass of the boson. On the other hand, the orbital motion of stars in the Galactic center depends on the distribution of matter whether be it baryonic or dark. Our analysis forecasts the bound on the mass of an ultralight boson to be $< 10^{-19}$ eV at the 95\% of confidence level.

Doneva

TBA

Duarte Lima Jr

Tidal forces in dirty black hole spacetimes

We study the tidal forces of spherically symmetric black holes in the presence of effective matter fields, dubbed as dirty black holes. These effective fields can generically represent usual or exotic matter associated to a variety of gravity theories. We show that this dirtiness leads to characteristic imprints in the tidal forces, which are absent in the case of a black hole surrounded by vacuum. We apply our results to particular cases, such as black holes coupled to linear and nonlinear electrodynamics theories and a Schwarzschild black hole surrounded by a spherical shell.

García-Moreno

Unimodular Gravity or General Relativity?

Unimodular Gravity is an alternative to General Relativity (GR) which, however, is so closely related to the latter that one can wonder to what extent they are different. The different behavior of the cosmological constant in the semiclassical regimes of both frameworks suggests the possible existence of additional contrasting features. UG and GR are based on two different gauge symmetries: UG is based on transverse diffeomorphisms and Weyl rescalings (WTDiff transformations), whereas GR is based on the full group of diffeomorphisms. This difference is related to the existence of a fiduciary background structure, a fixed volume form, in UG theories. In this work we present an overview as complete as possible of situations and regimes in which one might suspect that some differences between these two theories might arise. This overview contains analyses in the classical, semiclassical, and quantum regimes. When a particular situation is well known we make just a brief description of its status. For situations less analyzed in the literature we provide here more complete analyses. Whereas some of these analyses are sparse through the literature, many of them are new. Apart from the completely different treatment they provide for the cosmological constant problem, our results uncover no further differences between them. We conclude that, to the extent that the cosmological constant problem is considered to be a fundamental open issue in modern physics, UG is preferred over GR.

Guzman

Hamilton's equations for the teleparallel equivalent of general relativity

We compute Hamilton's equations for the teleparallel equivalent of general relativity (TEGR), which is a reformulation of general relativity based on a curvatureless, metric compatible, and torsionful connection. For this, we consider the Hamiltonian for TEGR expressed in the vector, antisymmetric, symmetric and trace-free, and trace decomposition of the phase space variables. We compare our results with Hamilton's equations of general relativity, and stress its importance for the formulation of the Cauchy problem in modifications based on this theory, as f(T) gravity, and its applicability in numerical relativity.

Herdeiro

On the fate of the LR instability

Ultracompact objects with light-rings (LRs) but without an event horizon could mimic black holes (BHs) in their strong gravity phenomenology. But are such objects dynamically viable? After reviewing some results about LRs and fundamental photon orbits of black holes, I will review a theorem establishing that stationary and axisymmetric ultracompact objects that can form from smooth, quasi-Minkowski, physical initial data must have at least one stable LR. Such LR has been argued to trigger a spacetime instability, but the development and fate of this instability has been unknown. Using ultracompact bosonic stars free of any other known instabilities as a testing ground for the instability, we will confirm the LRs triggered instability, identifying two possible fates: migration to non-ultracompact configurations or collapse to BHs. In concrete examples we show that typical migration/collapse time scales are not larger than a few thousands of light-crossing times, unless the stable LR potential well is very shallow. These results support that the LR instability is effective in destroying horizonless ultracompact objects that could be plausible BH imitators.

Hernández Rodríguez

First Law for Kerr Taub-NUT AdS Black Holes

The first law of black hole mechanics, which relates the change of energy to the change of entropy and other conserved charges, has been the main motivation for probing the thermodynamic properties of black holes. In this work, we investigate the thermodynamics of Kerr Taub-NUT AdS black holes. We present geometric Komar definitions for the black hole charges, that by construction satisfy the Smarr formula. Further, by a scaling argument based on Euler's theorem, we establish the first law for the Kerr Taub-NUT AdS black holes. The corresponding first law includes variations in the cosmological constant, NUT charges and angular momenta. The key new ingredient in the construction are the independent variations of both angular momenta, the black hole and Misner string angular momenta.

Employing the Brown-York quasilocal charge definitions we show that our expression for the mass and spin coincide with our generalized Komar expressions. We indicate the relevance of these results to the thermodynamics of rotating AdS black holes, including the proper choice of time-like Killing vector to produce the correct thermodynamic mass.

Huertas

Bubbles of Nothing: A Tunneling Potential Approach

Witten's Bubbles of Nothing (BoNs) are gravitational instantons, on whose surface spacetime ends, that describe the decay of spacetimes with compactified dimensions. BoNs can be understood as singular Coleman-de Luccia bounces in 4 dimensions and can be studied in the Tunneling Potential Formalism. This formalism offers a simple way to generalise BoNs beyond the flat space case and study them in cosmological scenarios with potentials, to obtain analytical results for their profiles and nucleation rates and to disprove that BoNs always dominate over other decay channels.

Izaurieta

Gravitational waves on Riemann-Cartan geometries

We offer a mathematical toolkit for the study of waves propagating on a background manifold with nonvanishing torsion. As an example, we briefly analyze the amplitude propagation of gravitational waves in an Einstein-Cartan-Sciamma-Kibble (ECSK) assuming a dark matter spin tensor sourcing for spacetime torsion at cosmological scales and assess whether a future detection by LISA is possible.

Järv

Spherical static configurations in symmetric teleparallel gravity

Symmetric teleparallel gravity is constructed with a nonzero nonmetricity tensor while both torsion and curvature are identically vanishing. The presentation will summarize progress in uncovering spherical static black hole configurations in these theories, and give examples of coincident gauge, i.e. a coordinate system whereby the connection vanishes globally and covariant derivatives reduce to partial derivatives. The talk is based on the recent papers arXiv: 2206.02725 and 2208.01872.

Jiménez Cano

Bootstrapping gravity: extension to the metric-affine framework

In this work we study diffeomorphism-invariant metric-affine theories of gravity from the point of view of self-interacting field theories on top of Minkowski spacetime. We revise how standard metric theories couple to their own energy-momentum tensor, and discuss the generalization of these ideas when torsion and nonmetricity are also present. We review the computation of the corresponding currents through Hilbert's and canonical prescriptions, emphasizing the potential ambiguities arising from both. We also provide the extension of this consistent self-coupling procedure to the vielbein formalism, so that fermions can be included in the matter sector. In addition, we clarify some subtle issues regarding previous discussions on the self-coupling problem for metric theories, both General Relativity and its higher derivative generalizations.

Karanasou

Thin-shell wormholes in Einstein and Einstein-Gauss-Bonnet theories of gravity

Wormholes are speculative spacetime tunnels that allow interstellar travels and they arise as solutions of gravity theories like black holes. The idea of this structure was first introduced by Einstein and Rosen in 1935 and later Morris and Thorne tried to classify their properties [1]. Two features that are universal for all classes of traversable wormholes in general relativity are the non-existence of an event horizon and the violation of the weak and the null energy conditions on the throat [2]. The last one implies the existence of not physically reasonable matter which we call “exotic matter"". We focus on thin-shell wormholes that were first introduced by Visser in 1989 [3]. These objects are not direct solutions of the field equations. We construct them by using the “thin-shell formalism” [4]. We study the construction and stability of spherically, planarly and hyperbolically symmetric thin-shell wormholes with Z2 symmetry made of negative tension branes in Einstein gravity and Einstein Gauss Bonnet gravity following the work of Kokubu, Maeda and Harada [5],[6],[7]. In Einstein gravity, the stability usually comes as a result of a proper choice of the electric charge and a negative cosmological constant. In EGB gravity, we consider only the solutions that admit the GR limit and we also investigate how the GB term affects the stability of wormholes. In both theories, we are able to find stable wormhole solutions and thus, this is promising for the future of wormhole physics.

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Klinkhamer

Taming the Big Bang

In this short talk, we present two results. First, we give a "regularized" big bang, while staying within GR but allowing for degenerate metrics. Second, we show how an emergent classical spacetime can be encoded in the IIB matrix model, a nonperturbative formulation of superstring theory.

Kozak

Metric-affine gravity effects on the internal structure of the Earth

In my talk, I would like to discuss the possibility of testing alternative gravity models using seismic data. The current Earth's interior model, called the Preliminary Reference Earth Model, is based on the assumption of Newtonian gravity; however, some theories modify the Newtonian limit of the theory, resulting in additional terms entering the Poisson equation for gravity. This opens up a possibility of constraining parameters of alternative gravity models, such as the Starobinsky theory in the Palatini approach, by comparing their predictions with the actual density profile, mass, and moment of inertia of the planet. I will show what the effects of modified gravity might look like and discuss how they might be tested in a way independent of the theory of gravity.

Liška

Emergence of Weyl transverse gravity from thermodynamics of spacetime

Weyl transverse gravity is an alternative gravitational theory with the same classical solutions as general relativity. However, rather than being fully diffeomorphism invariant, it is invariant under transverse diffeomorphisms and Weyl transformations. It turns out that this change in symmetry solves some of the cosmological constant problems which plague general relativity. In my talk, I will argue that further arguments in favour of Weyl transverse gravity come from thermodynamics. In particular, a derivation of the equations governing gravitational dynamics from thermodynamics of local causal horizons is more consistent with Weyl transverse gravity than with general relativity. This can be seen both from the way the cosmological constant and the local energy-momentum conservation are treated, and from the effect of conformal/Weyl transformations on thermodynamics.

Macedo

ECO-spotting: looking for extremely compact objects with bosonic fields

Black holes are thought to describe the geometry of massive, dark compact objects in the Universe. To further support and quantify this long-held belief requires knowledge of possible, if exotic alternatives. Here, we wish to understand how compact can self-gravitating solutions be. We discuss theories with a well-posed initial value problem, consisting in either a single self-interacting scalar, vector or both. We focus on spherically symmetric solutions, investigating the influence of self-interacting potentials into the compactness of the solutions, in particular those that allow for flat-spacetime solutions. We are able to connect such stars to hairy black hole solutions, which emerge as a zero-mass black hole. We show that such stars can have light rings, but their compactness is never parametrically close to that of black holes. The challenge of finding black hole mimickers to investigate full numerical-relativity binary setups remains open.

Magalhães

Scalar absorption by asymmetric wormholes in Palatini $f({\cal R})$ gravity

We investigate the absorption properties of reflection-asymmetric wormholes constructed via the thin-shell formalism in Palatini $f({\cal R})$ gravity. Such wormholes come from the matching of two Reissner-Nordström spacetimes at a time-like hypersurface (shell), which, according to the junction conditions in Palatini $f({\cal R})$ gravity, can have positive or negative energy density. Using numerical methods we investigate several configurations that satisfy the junction conditions, and analyze how the parameters of the system affect the absorption spectra."

Maldonado Torralba

Vector stability in metric-affine theories

In this talk I will show how studying the stability of the vector modes of quadratic metric-affine gravity, the parameter space of the theory reduces from 16 to 5 parameters. I will also explain how this analysis can be particularized to the Weyl-Cartan case.

Mangut

On the charged Zipoy–Voorhees metric

This study is focused on aspects of electrically charged Zipoy-Vorhees spacetimes. These spacetimes were obtained by applying Ernst formalism to Zipoy-Vorhees background with no source. From gravitational lensing evaluations to relevant astrophysical applications, these backgrounds are investigated with tools of general relativity. The relationship between the electric charge, distortion parameter and gravitational lensing angle is found via Gauss-Bonnet theorem and the associated results are compared with the uncharged case. Furthermore, the gravitational redshift is also calculated and results are presented.

Margalef

What is a degree of freedom in classical mechanics?

Degrees of freedom are one of the most important concepts learned on a first year course of classical mechanics. It later turns out essential on other areas such as statistical mechanics, condensed matter, field theories, or robotics. However, they are trickier than one might expect and some reflection can be done to gain a deeper knowledge and understanding. In this talk, through visual examples, I will show some ways to understand them and show some of their limitations.

Menéndez-Pidal

The problem of time in quantum cosmology

In this talk I will briefly present the results obtained in my PhD thesis. I will first introduce the problem of time in Quantum Gravity and outline its importance. Then, I will talk about the possible ways out of this issue and illustrate different clock choices in a cosmological model. Finally I will discuss how these different clock choices may affect singularity resolution.

Murcia Gil

Higher-derivative holography with a chemical potential

We carry out an extensive study of the holographic aspects of any-dimensional higher-derivative Einstein-Maxwell theories in a fully analytic and non-perturbative fashion. We achieve this by introducing the d-dimensional version of Electromagnetic Quasitopological gravities: higher-derivative theories of gravity and electromagnetism that propagate no additional degrees of freedom and that allow one to study charged black hole solutions analytically. These theories contain non-minimal couplings, that in the holographic context give rise to a modified <JJ> correlator as well as to a general <TJJ> structure whose coefficients we compute. We constrain the couplings of the theory by imposing CFT unitarity and positivity of energy (which we show to be equivalent to causality in the bulk) as well as positive-entropy bounds from the weak gravity conjecture. We also obtain the charged Rényi entropies and we observe that the chemical potential always increases the amount of entanglement and that the usual properties of Rényi entropies are preserved if the physical constraints are met. Finally, we compute the scaling dimension and magnetic response of twist operators and we provide a holographic derivation of the universal relations between the expansion of these quantities and the coefficients of <JJ> and <TJJ>.

Ortín

On the thermodynamics of Kaluza Klein black holes

Kaluza Klein black holes can have electric and magnetic charges in 4 dimensions and they satisfy a first law in which there are work terms associated to them. In 5 dimensions, though, they are Ricci-flat solutions whose only charges can be of purely geometrical nature. Our goal is to derive the 4-dimensional laws of thermodynamics including the electric and magnetic work terms from a 5-dimensional, purely geometrical, point of view.

Parra-López

Oscillations and vacuum choice in slow-roll sourced particle production

Particle production out of the vacuum due to a time-dependent geometry is a well-known feature of quantum field theories in curved spacetimes, and it has been proposed as a mechanism for explaining the observed abundance of dark matter. Gravitational production is especially important during the inflationary epoch as the universe rapidly expands. In this work, we study particle production for a spectator scalar field that is non-minimally coupled to gravity, considering the complete dynamics of spacetime during inflation and reheating. We analyze the importance of Ricci scalar oscillations in the resulting spectra, and we propose a prescription for the vacuum that allows to safely extrapolate the result to the present, given that the test field interacts only gravitationally.

Patra

Trans-IR flows to black hole singularities

Pedraza

Quantum backreaction in braneworld holography

Quantum backreaction in semi-classical gravity is a notoriously difficult task. In this talk I will explain how braneworld holography can help us to tackle this problem. As an application, I will show that the backreaction due to conformally coupled scalar fields in conical de Sitter space gives rise to quantum dS black holes in 3D, solutions that do not have a classical counterpart. The discussion will be mostly based on: arXiv:2207.03302.

Petrov

Lorentz symmetry breaking in gravity

The problem of constructing consistent Lorentz-CPT breaking extensions of various field theory models is actively discussed now. Within these studies, the problem of Lorentz-CPT symmetry breaking in gravity is of special importance. As it is well known, the main problems within this context are related in the fact that the group of general coordinate transformations playing the role of extension of the Lorentz group in a curved space-time, at the same time plays the role of the gauge group. As a result one faces the problem of breaking the gauge symmetry in a curved space-time. Another difficulty is related with the fact that while in the flat space the Lorentz symmetry breaking is introduced in terms of constant vectors (tensors), it is difficult to define such objects in a curved space-time.

All this implies that actually, there are three main directions in studying of Lorentz-breaking extensions of gravity: first, restricting to the case of weak (linearized) gravitational field where solving the problem of consistency of the Lorentz symmetry breaking with the gauge symmetry is easier, second, consideration of the four-dimensional gravitational Chern-Simons term which breaks parity, and, for special choice of the Chern-Simons coefficient, breaks also the Lorentz symmetry, third, using the mechanism of spontaneous Lorentz symmetry breaking. Within our talk, we rpesent the main results achieved by us within these approaches.

First, we discuss the four-dimensional gravitational Chern-Simons term, with the main attention will be paid to the problem of its perturbative generation within different approaches (both in linearized and full-fledged case), including the finite temperature. We emphasize the finiteness and ambiguity of this term. Within this consideration, we also briefly discuss the possibility for perturbative generation of other Lorentz-breaking terms in linearized gravity.

Second, we discuss the bumblebee gravity model allowing for spontaneous Lorentz symmetry breaking due to introducing an additional vector field, and discuss the consistency of some simple metrics, especially the Gödel metric within it.
Finally, we present some perspectives for studies of Lorentz-breaking extensions of gravity, including non-Riemannian gravity models.
Third, we review various Lorentz-breaking extension for linearized gravity and discuss corresponding dispersion relations.

Rosa

Recent developments on the observational imprints of bosonic stars

In the recent years, our understanding of the galactic centre has grown rapidly with the joint efforts of large international collaborations like the GRAVITY, who detected infrared flares close to the innermost stable circular orbit (ISCO) of the supermassive black-hole at the galactic centre, and the Event Horizon Telescope (EHT), which recently published the first picture of a black-hole shadow from Sgr A*. These observations are consistent with the predictions from General Relativity (GR) in black-hole spacetimes. However, due to the large experimental imprecisions, the data are not able to exclude the possibility of the central massive object in our galaxy not being a black-hole but instead some exotic compact object that mimicks the qualitative properties of black-hole exteriors. In this talk, we explore a particular example of such alternative compact objects: bosonic stars (Boson and Proca stars), and the possibility of these observations being consistent with with the presence of one of these exotic stars at the galactic centre.

Shabir

Spatially Control of Quantum Entropy in a Three-level Medium

In this study a quantum system of the three-level ladder type interacts with three electromagnetic fields which two of them are coherent and one of them is incoherent. We examine the atom-photon entanglement in the presence of quantum interference from spontaneous emission when two coherent fields become structural lights. We talked about the spatially dependent of the degree of entanglement (DEM) under various parametric conditions of quantum system. We discovered that when the quantum interference reaches a certain level, it is possible to regulate the position dependence of the DEM by altering the orbital angular momentum (OAM) of structure light. Furthermore, our findings demonstrate that one may determine the OAM number of the structure light by counting the regions of the DEM profile.

Silva

Symmetric teleparallel Bumblebee gravity

Bumblebee gravity is a Lorentz violating gravitational theory where the Lorentz symmetry is broken spontaneously by a vector field known as bumblebee field. In a Riemannian set up, non-minimal couplings between the bumblebee and the metric have been studied and modified gravitational solutions in black holes, cosmology and at the weak field limit have been found. Here, we investigate the dynamics of the bumblebee field coupled to the metric in a symmetric teleparallel formulation of general relativity. By considering terms constructing using the non-metricity tensor and the bumblebee field, we discuss how the bumblebee field modifies the gravitational dynamics at the weak field limit. Moreover, the modified Friedmann equations and their cosmological solutions are investigated.

Singh

On a novel relationship between shear and energy density at the bounce in non-singular Bianchi-I spacetimes

In classical Bianchi-I spacetimes, underlying conditions for what dictates the singularity structure - whether it is anisotropic shear or energy density, can be easily determined from the generalized Friedmann equation. However, in non-singular bouncing anisotropic models these insights are difficult to obtain in the quantum gravity regime where the singularity is resolved at a non-vanishing mean volume which can be large compared to the Planck volume, depending on the initial conditions. Such non-singular models may also lack a generalized Friedmann equation making the task even more difficult. We address this problem in an effective spacetime description of loop quantum cosmology (LQC) where energy density and anisotropic shear are universally bounded due to quantum geometry effects, but a generalized Friedmann equation has been difficult to derive due to the underlying complexity. Performing extensive numerical simulations of effective Hamiltonian dynamics, we bring to light a surprising, seemingly universal relationship between energy density and anisotropic shear at the bounce in LQC. For a variety of initial conditions for a massless scalar field, an inflationary potential, and two types of ekpyrotic potentials we find that the values of energy density and the anisotropic shear at the quantum bounce follow a novel parabolic relationship which reveals some surprising results about the anisotropic nature of the bounce, such as the maximum value of the anisotropic shear at the bounce is reached when the energy density reaches approximately half of its maximum allowed value. The relationship we find can prove very useful for developing our understanding of the degree of anisotropy of the bounce, isotropization of the post-bounce universe, and discovering the modified generalized Friedmann equation in Bianchi-I models with quantum gravity corrections.

Torrenti

Adiabatic regularization without infrared distorsions

Adiabatic regularization allows to identify and subtract the ultraviolet divergent terms of the two-point function of a scalar field in a FLRW spacetime. In the traditional formulation of the method, the terms are identified through a WKBlike expansion of the field modes, which significantly distorts the power spectrum at infrared scales and e.g. changes the standard results for de Sitter inflation. In my talk I will show how, by using the intrinsic ambiguities of the renormalization program in curved spacetime, we can build a new set of adiabatic subtraction terms that successfully removes the UV divergences, while leaving the IR part intact. I will discuss the implications of this result and future related work.

Velasco Aja

The Fate of Horizons under quantum corrections

In this paper, we study the physical effects of deforming the usual Einstein-Hilbert lagrangian with the Goroff-Sagnotti counterterm (the first which is nonvanishing on shell). The related facts that Schwarzschild's spacetime is not a solution to the corresponding equations of motion and Birkhoff's theorem is not valid anymore are analyzed and some consequences worked out.

Vicente-Becerril

Friedmann equations and cosmic bounce in a modified cosmological scenario

In this talk, I present a derivation of modified Raychaudhuri and Friedmann equations from a phenomenological model of quantum gravity based on the thermodynamics of spacetime. Starting from general gravitational equations of motion which encode low-energy quantum gravity effects, we found its particular solution for homogenous and isotropic universes with standard matter content, obtaining a modified Raychaudhuri equation. Then, we imposed local energy conservation and used a perturbative treatment to derive a modified Friedmann equation. The modified evolution in the early universe we obtained suggests a replacement of the Big Bang singularity by a regular bounce. Lastly, I also discuss here the range of validity of our perturbative treatment and the nonperturbative behaviour of our model in the regime of very strong gravity.

Vidal

Tolmann-Oppenheimer-Volkoff equation in scalar-tensor symmetric teleparallel gravity

Based on a generealized procedure on how to derive the Tolmann-Oppenheimer-Volkoff (TOV) equation for modified gravity theories, I will present it's implementation and results for scalar-tensor symmetric teleparallel gravity. Moreover, I will talk about further stellar processes that can be analised starting from this equation in modified gravity.

Wojnar

Matter and gravity

I will briefly present the recent works related to effects of modified gravity on stellar and substellar objects.

Xavier

Absorption by stringy black holes

We investigate the absorption of planar massless scalar waves by a charged rotating stringy black hole, namely a Kerr--Sen black hole. We compute numerically the absorption cross section and compare our results with those of the Kerr-Newman black hole, a classical general relativity solution. In order to better compare both charged black holes, we define the ratio of the black hole charge to the extreme charge as Q. We conclude that Kerr--Sen and Kerr-Newman black holes have a similar absorption cross section, with the difference increasing for higher values of Q.

Yousaf

Hyperbolically Symmetric Solutions

This study focuses on the impact of the cosmological constant on hyperbolically symmetric matter configurations in a static background. We describe the influences of such a repulsive character on a few realistic features of hyperbolical anisotropic fluids. After describing the Einstein-Λ equations of motion, we elaborate the corresponding mass function along with its conservation laws. Three families of solutions are found in the Λ-dominated epoch. Such a type of theoretical setup suggests its direct link to study a few particular quantum scenarios where negative behavior of energy density is noticed at the Λ-dominated regime.

Zumalacarregui

On the propagation of gravitational waves: diffraction, dispersion and birefringence

Just like light, gravitational waves (GWs) are deflected and magnified by the large-scale structure of the Universe, a phenomenon known as gravitational lensing. Their low frequency, phase coherence and capacity to propagate with no absorption makes GWs an ideal signal in which to observe wave-propagation phenomena. I will describe how GWs deflected by cosmic structures produce diffractive, wave-optics phenomena, whose measurement will allow us to infer the properties of galactic and dark matter halos. For GWs in strong gravitational fields, such as the vicinity of a massive black hole, their propagation depends on the frecuency (dispersion) and polarization (birefringence) through the gravitational spin-hall effect. I will describe how observations of sources near central black holes of galaxies may enable the observation of dispersive GWs. While birefringence might be too suppressed to observe in Einstein's general relativity, alternative theories predict that the two GW polarizations travel at different speeds near massive objects. Searches for this effect provide one of the most stringent tests of gravity so far.