Program of the Conference

Grav24

"Celebrating the 65th birthday of Oscar Reula, Osvaldo Moreschi and Carlos Kozameh"

April 8th–12th, 2024, Córdoba, Argentina

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
9:00-9:50	Registration	M. Reiris	A. Pérez	M. Shibata	D. G. Lambas
10:00-10:30	COFFEE				
10:30-11:20	J. L. Jaramillo	A. L. García P.	S. Carneiro	O. Moreschi	J. H. Yoon
11:30-12:20	T. Mädler	L. Lehner	T. Sotiriou	M. Bezares	E. González
12:20-14:00	LUNCH				
14:00-14:50	M. Zilhão	P. LeFloch		K. Kiuchi	S. Landau
14:50-15:15	E. Eiroa	G. Dotti		P. H. Bessa	M. Domínguez
15:15-15:40	F. Mena	J. Fabris		M. Aguayo U.	J. Pelle
15:40-16:20	COFFEE		*Enjoy*	COFFEE	
16:20-16:45	A. Aceña	M. Richarte	*your*	E. Gutiérrez	J. R. Claros M.
16:45-17:10	G. F. Aguirre	C. L. de Oliveira	*free*	F. Venturi	F. Toscano
17:10-17:35		L. F. Demétrio	*afternoon*	F. Cerino	V. V. Kizakke C.
17:35-18:00				M. A. Ramírez	

Notice: All morning talks and the first talk in the afternoon are 45 minute talks plus 5 minutes for questions. The rest of the talks are 20 minute talks plus 5 minutes for questions.

Black Hole Quasi-Normal Mode instabilities: Pseudospectrum, asymptotics and resonant expansions

José Luis Jaramillo
Institut de Mathématiques de Bourgogne (IMB), France

Can we measure the 'effective regularity' of spacetime from the instabilities of black hole quasi-normal mode (QNM) overtones? Assessing the structural stability of QNM frequencies of self-gravitating compact objects is an important open problem in gravitational physics, given the fundamental role that QNMs play in diverse areas of gravity theory. A particular avenue to this problem is provided by Kato's perturbation theory of linear operators. However, such an approach requires first to cast QNMs in terms of a proper eigenvalue problem, in particular with proper (finite norm) QNM eigenfunctions in a Hilbert space. The hyperboloidal approach to black hole perturbations provides a geometric framework to such a characterization of QNMs in terms of the spectrum of a non-selfadjoint operator. In this talk we discuss some of the concepts and tools imported from the spectral theory of non-selfadjoint operators. Focus will be placed on the notion of pseudospectrum, paying special attention to QNM resonant expansions of a scattered field and, time allowing, possible connections to spacetime asymptotic symmetries. Black hole QNM instability is a classical general relativity low-regularity phenomenon, agnostic to possible detailed descriptions of gravity at higher-energies and potentially observationally accessible.

Developments in the characteristic formulation in General Relativity

Thomas Mädler
Institute of Astrophysical Studies/ Universidad Diego Portales, Chile

The characteristic formulation of General Relativity is associated with numerous discoveries and breakthroughs in gravitational physics such as gravitational waves, dynamic black hole space times and symmetry groups. I will discuss some recent developments in numerical applications and analytic investigations.

Hyperbolicity of General Relativity in Bondi-like gauges

Miguel Zilhão
Universidade de Aveiro, Portugal

We discuss the well-posedness of the Einstein field equations in Bondi-like gauges and present numerical tests demonstrating shortcomings for the corresponding characteristic initial boundary value problem.

Black hole shadows: analytical calculations and future observational prospects

Ernesto Fabian Eiroa
Instituto de Astronomia y Fisica del Espacio (IAFE, CONICET-UBA), Argentina

In recent years, the Event Horizon Telescope (EHT) Collaboration published the images of two supermassive black holes, located at the centers of the galaxies M87 and the Milky Way. These images show a dark region, known as the shadow, surrounded by a bright ring. A black hole strongly deflects the trajectories of light rays in its vicinity and part of photons coming from the region behind it are trapped, resulting in the presence of the shadow in the observer sky. For a static black hole the shadow is circular, while for a rotating one is deformed in an asymmetric form that depends on the angle of observation and the spin of the compact object. The standard analytical method for obtaining the contour of the shadow is based on the separation of variables in the Hamilton-Jacobi equation, which was introduced for the Kerr geometry many years ago. This method has then been extended to a large class of spacetimes; in particular, it was done for rotating black holes obtained by using the modified Newman-Janis algorithm. Recently, the formalism has been also adopted for black holes surrounded by a plasma satisfying a certain separability condition. The observation of the shadow is a useful tool to obtain the physical properties of supermassive black holes and to parametrize possible deviations from the Kerr solution in the strong field scenario. However, this kind of detailed studies exceed the current capabilities of the EHT. The next-generation Event Horizon Telescope (ngEHT) will greatly improve the existing EHT array, thus allowing to open new avenues of research. This talk presents a review of the analytical research and the prospects of the ngEHT.

Global solutions to the spherically symmetric Einstein-scalar field system

Filipe Mena
Instituto Superior Técnico, University of Lisbon, Portugal

The Einstein-scalar field system has applications in models of compact objects in astrophysics and in cosmology, being an important framework for numerical relativity. In this talk we consider a characteristic initial value problem, with initial data given on a future null cone, for the Einstein massless scalar field system with a positive cosmological constant. We will outline the prove that, for small data, this system has a unique global classical solution which is causally geodesically complete to the future and decays polynomially in radius and exponentially in time, approaching the de Sitter solution. We will then make some remarks about the case with a massive scalar field and large data as well as generalisations to higher order theories of gravity.

Thermodynamics sheds light on the nature of dark matter galactic halos

Andrés Aceña
ICB-CONICET, Argentina

Today it is understood that our universe would not be the same without dark matter, which apparently has given rise to the formation of galaxies, stars and planets. Its existence is inferred mainly from the gravitational effect on the rotation curves of stars in spiral galaxies. The nature of dark matter remains unknown. Here we show that the dark matter halo is in a state of Bose-Einstein condensation, or at least the central region is. By using fittings of observational data, we can put an upper bound on the dark matter particle mass in the order of $12\ eV/c^2$. We present the temperature profiles of galactic dark matter halos by considering that dark matter can be treated as a classical ideal gas, as an ideal Fermi gas, or as an ideal Bose gas. The only free parameter in the matter model is the mass of the dark matter particle. We obtain the temperature profiles by using the rotational velocity profile proposed by Persic, Salucci, and Stel (1996) and assuming that the dark matter halo is a self-gravitating stand-alone structure. From the temperature profiles, we conclude that the classical ideal gas and the ideal Fermi gas are not viable explanations for dark matter, while the ideal Bose gas is if the mass of the particle is low enough. If we take into account the relationship presented by Kormendy and Freeman (2004, 2016), Donato et al. (2009) and Gentile et al. (2009) between central density and core radius then we conclude that the central temperature of dark matter in all galaxies is the same. Remarkably, our results imply that basics thermodynamics principles could shed light on the mysterious nature of dark matter and if this is the case, those principles have to been taken into account in its description.

F(R) gravity in N-dimensions: stability of thin-shell wormholes

Griselda Figueroa Aguirre
Instituto de Astronomiia y Fisica del Espacio (IAFE, CONICET-UBA), Argentina

In this talk we present the construction of spherically symmetric thin-shell wormholes with a conformally invariant Maxwell field for N-dimensional F(R) gravity and constant scalar curvature R. We show two different classes of wormholes built by the cut-and-paste process of two manifolds: one symmetric across the throat and the other asymmetric with different scalar curvatures across the throat. We analyze the stability of these constructions with exotic matter at the throat under radial perturbations, and we find that unstable and stable solutions are both possible for suitable sets of the parameter values. There exist stable solutions only for a short range of values over the critical charge.

Vacuum static solutions that cannot be put into rotation

Martín Reiris
CMAT, FCien-UdelaR, Uruguay

Using techniques in comparison geometry, we will show that there are vacuum static 3+1 black hole solutions, metrically complete but with a non-standard spatial topology, that cannot be put into rotation, that is, there are no non-static stationary metrics close to them. To our knowledge, this is the first result of the kind in the literature.

Transport properties of relativistic gases: the first order kinetic theory approach

Ana Laura García Perciante
Universidad Autónoma Metropolitana, Mexico

Relativistic hydrodynamics is a relevant and interesting topic, both from the theoretical and experimental / observational points of view. Its applications range from processes in astrophysics and cosmology, to extreme systems created in devices such as particle colliders. However, the formal description of these systems is still an open problem and a physically sound formalism is currently a subject of intense research and debate. In this sense, the kinetic theory provides a powerful tool to describe the macroscopic behavior of gases, based on the known dynamics of individual particles through the Boltzmann equation. In this talk, the foundations and relevant results in this field, together with recent advances in the first order scenario, will be presented and discussed. The corresponding transport equations and dissipative flux-force relations, obtained within the Chapman-Enskog procedure, will be shown and analyzed both in the flat and curved space-time cases, including the effects of relativistic molecular velocities. Emphasis will be made on the relevance and pertinence of the linear approach and the importance of the flux-force couplings in the constitutive equations.

Fluid-gravity correspondence, multiple angles and intriguing consequences

Luis Lehner
Perimeter Institute, Canada

The fluid-gravity correspondence links the behavior of gravity and hydrodynamics with surprising consequences both on formal and practical fronts. This talk will cover particularly relevant aspects of what such connection can hint on the non-linear behavior of perturbed black hole horizons, as well as re-formulations of hydrodynamics.

Optimal shielding for Einstein gravity

Philippe G. LeFloch
Sorbonne University and CNRS, France

I will present recent advances on the analysis of asymptotically Euclidean, initial data sets for Einstein's field equations. In collaboration with Bruno Le Floch (Sorbonne University) I proved that solutions to the Einstein constraints can be glued together along possibly nested conical domains. The constructed solutions may have arbitrarily low decay at infinity, while enjoying (super-)harmonic estimates within possibly narrow cones at infinity. Importantly, our localized seed-to-solution method, as we call it, leads to a proof of a conjecture by Alessandro Carlotto and Rick Schoen on the localization problem at infinity, and generalize P. LeFloch and Nguyen's theorem on the asymptotic localization problem. This lecture will be based on https://arxiv.org/abs/2312.17706 and https://arxiv.org/abs/2402.17598 Blog: philippelefloch.org

Black hole regions containing no trapped surfaces

Gustavo Dotti
FaMAF - Universidad Nacional de Córdoba, Argentina

A simple criterion is given to rule out the existence of closed trapped surfaces in large open regions inside black holes. The presence of higher co-dimension trapped submanifolds in these regions is considered.

On unimodular gravity

Júlio Fabris
Universidade Federal do Espírito Santo, Brazil

Unimodular gravity (UG) was proposed soon after the formulation of General Relativity. It is based on a restricted class of diffeomorphims, the transverse diffeomorphism (TD). If the conservation of the energy-momentum tensor is imposed, UG is, in principle, equivalent to GR in presence of a cosmological constant. However, this equivalence may be not complete at classical and quantum level. At quantum level, the time problem that appear in quantum cosmology may acquire new features, and at classical level the non imposition of conservation of the energy-momentum tensor may be mapped in interacting models related, for example, to the vacuum decay configurations. In this context, we discuss in particular some cosmological and static, spherically symmetric configurations in UG. The status. of the cosmological constant problem in UG is also considered.

Stability of black hole in EMdilaton theory

Martín Richarte
Universidade Federal do Espírito Santo, Brazil

In this talk, I will present a complete analysis of black hole stability in the linear-dilaton scenario within the Einstein-Maxwell-Scalar theory. I start from the background metric and apply a gauge-invariant formalism to perturbations that preserve the symmetries of the base manifold. I expand the Lagrangian to the second order in the perturbed variables and remove the spurious variables. I then show that the master field equations for odd and even perturbations can be separated into several wave-like equations with a non-zero source. As a proof of concept, I demonstrate that the spectrum of the associated Schroedinger operator lies on the positive real half-line, rending the black hole solution into stable ones. I conclude with the numerical analysis of the modified wave equations and their comparison with the RN case.

Bayesian Analysis of Cluster Weak Lensing

Caio Lima de Oliveira
Universidade Estadual de Londrina, Brazil

Cluster weak gravitational lensing offers a powerful tool for probing the distribution of mass in galaxy clusters, shedding light on the underlying cosmological parameters. In this work, we delve into the application of Bayesian analysis techniques to the study of cluster weak lensing. By harnessing the flexibility and robustness of Bayesian inference, we aim to extract more accurate and reliable constraints on cluster mass estimates and cosmological parameters. Our approach leverages the Bayesian framework to incorporate prior knowledge, observational data, and model uncertainties seamlessly. Through the integration of prior information from various sources, including theoretical predictions and previous observations, we construct a comprehensive understanding of the parameter space governing cluster weak lensing phenomena. Furthermore, we employ sophisticated statistical methodologies, such as Markov Chain Monte Carlo (MCMC) simulations, to efficiently explore the high-dimensional parameter space and derive posterior distributions. The Bayesian analysis of cluster weak lensing not only provides precise estimates of cluster masses but also enables robust uncertainty quantification, crucial for making informed decisions in cosmological inference.

Two Fluid Quantum Bouncing Cosmology: an observation-consistent non-singular cosmological model
Luiz Felipe Demétrio
Universidade Estadual de Londrina (UEL), Brazil

In this seminar, we discuss a quantum cosmological model within the framework of Canonical Quantum Gravity, where the matter sector is characterized by dark matter and radiation. It is shown that, at background level, this model removes the primordial singularity and alleviates the well known initial conditition problems of the Λ-CDM model. At perturbative level, perturbations are coupled and demand a special quantization technique: the Hamiltonian Tensor Diagonalization. The model then predicts an almost scale invariant, red tilted primordial power spectrum for density perturbations on scales influencing the Cosmic Microwave Background (CMB). Remarkably, this model is the first to apply such new technique to the quantization of interacting field theories on curved spacetimes, while also providing predictions that may fit the CMB spectrum for some regions of parameter space, without making any use of exotic matter whatsoever.

WEDNESDAY 10

Is Planckian discreteness observable in cosmology?
Alejandro Pérez
Aix-Marseille University, France

A Planck scale inflationary era—in a quantum gravity theory predicting discreteness of quantum geometry at the fundamental scale—produces the scale invariant spectrum of inhomogeneities with very small tensor to scalar ratio of perturbations without the necessity of the quantum-to-classical transition of the standard inflationary paradigm and a hot big bang leading to a natural dark matter genesis scenario.

Remnant loop quantum black holes
Saulo Carneiro
Universidade Federal da Bahia, Brazil

Polymer models inspired by Loop Quantum Gravity (LQG) have been used to describe non-singular quantum black holes with spherical symmetry, with the classical singularity replaced by a transition from a black hole to a white hole. A recent model, with a single polymerisation parameter, leads to an asymptotically flat exterior metric, with same horizon area as in the classical theory. We can fix the radius of the transition surface by identifying its area with the area gap of LQG, which allows to extend the model to Planck scale black holes. In this talk we will extend this analysis to charged black holes, showing the existence of limiting states with zero surface gravity and Planck scale masses. We will also argue that primordial extremal black holes of Planck masses can be formed by particle scattering at the inflation reheating, with an abundance that allows their interpretation as forming the presently observed dark matter component.

Black holes with scalar hair: from no-hair theorems to non-linear dynamics
Thomas Sotiriou
University of Nottingham, UK

According to General Relativity, astrophysical black holes are remarkably simple and their properties are determined by just two quantities, their mass and their angular moment. Gravitational waves and other strong gravity observations promise to probe the nature of black holes more precisely that ever before. Any observed deviation from the simple description General Relativity provides can reveal the existence of new fundamental fields, which would signal a paradigm shift in theoretical physics, astrophysics, and cosmology. I will use the well-studied case of an additional new scalar field, coming from either an extension of the Standard Model or of General Relativity itself, as a case study to discuss 3 questions: Can new physics leave an imprint on black holes? If yes, which observations are more sensitive to this new physics? And, are all black holes the same?

THURSDAY 11

Exploring collapsar scenarios in numerical relativity

Masaru Shibata
Max Planck Institute for Gravitational Physics, Germany

By performing longterm magneto/viscous hydrodynamics simulations in general relativity for the collapse of rapidly rotating massive stars, we explore the collapsar scenarios. We will show how jets are launced and stellar explosion is accompanied with the jets.

Localization of a GW source from two observatories and the direct measurement of the gravitational polarization modes

Osvaldo M. Moreschi
FaMAF/CONICET, Argentina

We present a model independent method that can be used to determine the sky location of the source of a gravitational wave, using the spin-2 nature of the strains recorded in two detectors. To show the basics of the method we apply it to the GW170104 event, and found that this method gives locations very close to the sky delay ring, and it also agrees with the LIGO/Virgo team estimates.

As a sub-product, we present the first model independent reconstruction of the two gravitational-wave polarization modes, for different polarization angles. We also show that the GW signals can be completely reconstructed in terms of the estimated spin-2 polarization modes using two different procedures.

We thus provide the first direct measurement of the spin-2 polarization modes of a detected gravitational wave, in a model independent way using only the data of two detectors.

Numerical Relativity beyond General Relativity

Miguel Bezares
University of Nottingham, UK

We will explore the long path from Einstein's equations to computational simulations. I will discuss how Numerical Relativity can serve as a tool to study nonlinear dynamics in alternative theories of gravity. In this talk, I will consider two subclasses of the broader Horndeski theory of alternative theories of gravity: k-essence and scalar-Gauss-Bonnet gravity. In particular, I will discuss the rich phenomenology we can learn, the challenges that must be overcome to extend Numerical Relativity and the future of relativistic numerical simulations in these theories.

Numerical modeling of compact binary mergers in the multimessenger era

Kenta Kiuchi
Max Planck Institute for Gravitational Physics, Germany

After GW170817, a binary neutron star merger became a major player in the multimessenger era. Numerical relativity is the chosen way to construct accurate and reliable binary neutron star merger models. In this talk, I will present the recent progress of the numerical modeling of binary neutron star mergers in the AEI-CRA division and discuss its application to multimessenger observation.

Redshift Drift fluctuations: Theory and Simulations

Pedro Henrique Bessa
Universidade Federal do Espírito Santo, Brazil

With the advent of new facilities and surveys such as SKAO and the ELT, the redshift drift effect, which measures the real-time evolution of the redshift from distant sources, will be observable in the next few decades. In order to properly model this observation, one needs to understand possible errors and fluctuations arising from inhomogeneities and cosmological effects beyond the background level. In this work, we present first results in the prediction of the redshift drift fluctuations and its power spectra in a realistic Universe, and the validation of the theoretical predictions through Einstein-Boltzmann codes and cosmological simulations, providing a solid mathematical and numerical framework for when data on the redshift drift is first gathered.

(Quasi-)normal modes of asymptotically AdS spacetimes

Monserrat Aguayo Uribe
Universidad de Concepción, Chile

In this talk, we will study the gravitational perturbations of AdS spaces in 4 and 5 dimensions. First, we adopt Chandrasekhar' methodology and extend it to AdS spacetimes to compute the (quasi-)normal modes of asymptotically AdS black holes and solitons. Subsequently, we will examine the corresponding Klein-Gordon equations to contrast the outcomes obtained through both techniques. Finally, we will use the information gathered in the previous calculations to compute the normal modes of a recently discovered charged AdS soliton.

High-energy multimessenger radiation from jet-ejecta interaction in binary neutron star mergers

Eduardo Gutiérrez
The Pennsylvania State University, USA

Neutron star (NS) mergers are amongst the most promising multimessenger sources in the Universe, as demonstrated by the coincident detection of gravitational waves (GWs) and multi-wavelength electromagnetic (EM) radiation in the GW170817 event. Moreover, they have been proposed as potential sources of ultra-high-energy cosmic rays and high-energy neutrinos. Short-duration gamma-ray bursts (sGRBs) are thought to originate from relativistic jets launched by NS merger remnants, but there are still uncertainties about the exact nature of such a remnant: it may be a promptly formed black hole (BH), a hypermassive NS that later collapses to a BH, or even a stable NS. The jet launching mechanism and its properties may differ for each scenario, and so do the observable phenomena. In this work, we study jet propagation in realistic merger ejecta obtained from numerical simulations with the General-Relativistic Hydrodynamic (GRHD) code THC_M1. We investigate the role of the progenitor and the post-merger remnant properties on jet propagation, its interplay with the merger ejecta, and the cocoon formed by such an interaction. We examine the conditions for which the jet and cocoon successfully breaks out to calculate high-energy EM and neutrino signatures.

Fully-constrained formulation of General Relativity for numerical evolution of compact binaries

Fabrizio Venturi
Universitat de València, Spain

Numerical relativity has been fundamental to address elemental questions in relativistic astrophysics dealing with strong-field gravitation and, in particular, the detection of Gravitational waves signals from compact binary mergers reported by the LIGO-Virgo-KAGRA collaboration. The Einstein Equations can be solved numerically using either the so-called free evolution, where one solves the constraints equations once to provide the initial data and monitor them during the evolution, or the fully-constrained evolution, where the constraints are evolved along the evolution. In this talk, we will discuss our efforts to use the latest to perform 3D compact binary merger evolutions.

Surrogate models for gravitational waves, parameter estimation, electromagnetic counterparts, and software design

Franco Cerino
CONICET, FAMAF, Argentina

Obtaining a single gravitational waveform using numerical relativity (NR) to solve the full Einstein equations can cost months using supercomputers. Furthermore, there are studies such as parameter estimation which can require millions of sequential evaluations, dominating the computational expense of the problem. Over the last years, these problems have been addressed by building surrogate models from high-fidelity NR simulations, taking advantage of the redundancy of the solutions, which can build solutions in real time with no loss of accuracy. These models are indistinguishable within numerical precision from NR simulations but can be evaluated in less than a second on a laptop. They consist of three sequential steps: i) build a reduced basis, ii) apply the empirical interpolation method and iii) utilize a regression algorithm to create a predictive model. We present an implementation for all the stages of surrogate models following design principles from scikit-learn, the standard machine learning library for Python, which focuses on building models in an easy way for the user. Our approach allows for an automated adaptive domain-decomposition to build reduced basis through hp-greedy refinement. The approach constructs local reduced bases of lower dimensionality than global ones, with the same or higher accuracy. We introduce in the context of gravitational wave science, a study with hp-greedy, where local bases imply both faster evaluations when predicting new waveforms and faster data analysis. This work might allow for fast enough parameter estimation studies for followup of electromagnetic counterparts to gravitational waves.

Junction conditions for higher order gravity theories

Marcos A. Ramírez
IATE, CONICET - Universidad Nacional de Córdoba, Argentina

In this talk we briefly review different (and non-equivalent) methods considered in the literature to derive junction conditions for general quadratic and f(R) gravity theories. We distinguish two different approaches to the subject: studying the conditions under which certain distributional solutions to the field equations make sense or modifying the action of the theory by supplementing a boundary action that makes the variational problem well-defined. In the context of the latter approach, we study the problem of generalizing the Gibbons-Hawking-York boundary action for general quadratic theories of gravity and develop a new method to obtain them. From these terms we derive the junction conditions for a subset of this family of theories that includes Gauss-Bonnet (GB) gravity. We re-obtain the well-known results for GB theory, generalize them to other quadratic theories and compare the resulting junction conditions with the ones already derived in the literature using other methods.

A new CMB extragalactic foreground: explaining the cold spot anomaly and other possible cosmological issues

Diego Garcia Lambas
IATE, CONICET-UNC, Argentina

In this talk I will resume new results on the discovery of extragalactic foregrounds in the cosmic microwave foreground associated to spiral galaxy environments. Although their precise physical origin is still unknown, they provide a new explanation for cmb anomalies such as the Cold Spot. Other cosmological implications will also be briefly discussed.

Hamiltonian reduction of general relativity without isometries

Jong Hyuk Yoon
Konkuk University, S. Korea

A mathematical prescription of Hamiltonian reduction using (2+2) formalism of Einstein's gravity without isometry is presented. The area of a cross-section of an out-going null hypersurface is chosen as the privileged time coordinate, and the privileged spatial coordinates are chosen to be suitable functions of gravational phase space on the constant area time. In the privileged coordinates, all the constraints are solved completely, and gravitational Hamiltonian and momentum densities are expressed as local functions of physical degrees of freedom only. The logarithm of the four volume element of spacetime in the privileged coordinates turns out to be a superpotential, whose gradient is the energy-momentum four vector of physical Hamiltonian and momentum densities. The Hamilton's equations of motion obtained through Hamiltonian reduction agree with Einstein's equations in the privileged coordinates. This work is a generalization of Hamitonian reduction of Einstein's theory with two Killing vector fields by K. Kuchar to spacetimes without isometry.

Populating a dark Universe

Elizabeth González
PIC-IFAE, Spain

Over the past decades, the statistical inferences from observational cosmology suggest that the Universe can be described with a flat Λ cold dark matter (ΛCDM) model with only a handful of parameters. In this scenario the resultant large scale structure mainly traced by the galaxies, galaxy groups and clusters, can be described as a filamentary network. This complex structure is the result of the gravitational collapse of matter driven by the initial density fluctuations, leading to matter overdensities called halos in which the galaxy formation takes place. The galaxy-halo connection is one of the fundamental topics for understanding the structure formation and to improve the precision of the cosmological parameter estimates, crucial for the next generation of cosmological surveys. In this context, galaxy simulations emerge as a powerful tool, both in the planning and analyzing the galaxy surveys since they, in essence, are the most relevant proxy used to trace and infer the dark-matter content. In this presentation, I overview the main goals and characteristics of some of the upcoming surveys and how galaxy simulations can be use to plan the observational strategies and evaluate and validate the applied techniques in order to obtain the constrains for the cosmological model. In particular, I will describe the Flagship simulation and the improvements that are being inplementing in order to increase its feasibility.

Applications of the neural network bundle method to the cosmological scenario
Susana Landau
IFIBA-CONICET-UBA, Argentina

In the last few years, the application of the field of machine learning to analyze data and physical models has increased significantly. Among the various methods that have been developed, there is one that allows one to obtain a bundle of solutions of differential systems without the need of using traditional numerical solvers. On the other hand, the study of alternative cosmological models is motivated by several problems of the standard cosmological model. Furthermore, the computational times required for the inference of cosmological parameters in these kind of models are significantly larger than in the standard cosmological model. In this talk, I will describe the NN bundle method and its application to the cosmological scenario. The great advantage of this method is that, once the neural networks have been trained, the solution can be used indefinitely without having to carry out the integration process again, as is the case with numerical methods. As a consequence, the computational times of the inference process are reduced significantly using the NN based solutions.

A determination of the LMC dark matter subhalo mass using the MW halo stars in its gravitational wake
Mariano Domínguez
IATE-OAC-UNC, Argentina

Our goal is to study the gravitational effects caused by the passage of the Large Magellanic Cloud (LMC) in its orbit on the stellar halo of the Milky Way (MW). We employed the Gaia Data Release 3 to construct a halo tracers data set consisting of K-Giant stars and RR-Lyrae variables. Additionally, we have compared the data with a theoretical model to estimate the DM subhalo mass. We have improved the characterisation of the local wake and the collective response due to the LMC orbit. On the other hand, we have estimated for the first time the dark subhalo mass of the Large Magellanic Cloud, of the order of 2×10^{11} $M_{\odot}$, comparable to previously reported values in the literature. We present preliminar constraints about dark matter particle nature computed using our measurements.

Relativistic force-free models of thermal X-ray emission from millisecond pulsars
Joaquin Pelle
FAMAF, Universidad Nacional de Cordoba, Argentina

I will present our work on modeling thermal X-ray signals from millisecond pulsars (MSPs). We compare our modeled signals with a set of highly accurate NICER observations of four target MSPs, finding good simultaneous fits for both light curves and spectra. Our model comprehends from the numerical solution of the relativistic force-free magnetosphere to the transport of emitted radiation. In this model, the emission regions (ERs) are determined by space-like currents that reach the stellar surface. In curved spacetime, this leads to non-standard ERs within the closed line zone, in addition to standard ERs within the polar caps. The combined signals from both types of ER allow us to fit non-trivial interpulses in the light curves of all four targets; in particular, these results offer an alternative to interpretations that require magnetic quadrupoles.

Accurate analytical modeling of light rays in spherically symmetric spacetimes: Applications in the study of black hole accretion disks
Jonathan Raul Claros Martínez
IFEG - CONICET, FaMAF - UNC, Argentina

We present new, simple analytical formulas to accurately describe light rays in spherically symmetric static spacetimes. These formulas extend those introduced by Beloborodov and refined by Poutanen for the Schwarzschild metric. Our enhanced formulas are designed to be applicable to a broader range of spacetimes, making them particularly valuable for describing phenomena around compact objects like neutron stars and black holes. As an illustration of their application, we present analytical studies of images of thin accretion disks surrounding black holes and explore their associated polarimetry.

A CMB lensing analysis of the extended mass distribution of clusters

Facundo Toscano
IATE - CONICET, Argentina

This study focuses on investigating the anisotropic weak lensing signal associated with the mass distribution of massive galaxy clusters. To do so, we analyze the Cosmic Microwave Background (CMB) data obtained from the Planck Collaboration CMB lensing convergence map (2018). Specifically, we examine patches of it centered on SDSS DR8 redMaPPer clusters within the redshift range [0.4, 0.5]. Using mean radial profiles, we detect a statistically significant signal up to 40 Mpc/h for the κ convergence parameter. Furthermore, by aligning the clusters along their major axis, determined by the distribution of galaxy members, we observe a notable distinction between parallel and perpendicular convergence profiles. On the other hand, by employing a model that implies an anisotropic surface mass density, we obtain results that agree with the mass and ellipticities of the clusters derived by weak lensing shear estimates. These findings provide strong evidence for a correlation between the distribution of galaxy cluster membership and the large-scale mass distribution.

Latest results of the Pierre Auger Observatory

Varada Varma Kizakke Covilakam
Instituto de Tecnologías en Detección y Astropartículas, Argentina

The Pierre Auger Observatory, located in the province of Mendoza, Argentina, is the largest facility in the world capable of detecting ultra-high-energy cosmic rays (UHECR). This hybrid observatory registers extensive air showers using complementary detection techniques and has been taking data for almost 20 years. In this contribution, the most important results of measurements of the UHECR spectrum, primary mass composition, and arrival direction anisotropy are presented. The sensitivity of the Observatory to photons and neutrinos above 10^{17} eV is useful when searching for multi-messenger signals. The latest results pertaining to physics beyond the standard model and multi-messenger studies are outlined in this presentation.