Grav19

April 8th–12th, 2019, Córdoba, Argentina

	Monday	Tuesday	Wednesday	Thursday	Friday
9:00-9:50	J. Pullin	P. Ajith	8:45 F. Pretorius	D. Siegel	A. Pérez
10:00-10:30	COFFEE		†Live streaming EHT/ESO	COFFEE	
10:30-11:20	I. Agullo	J. R. Westernacher	11:00 Coffee/discussion	I. Rácz	J. Peraza
11:30-12:20	H. Friedrich	O. Sarbach	#12:00. S Liebling/L.Lehner	F. Beyer	F. Carrasco
12:20-14:00	**Reception Lunch**	LUNCH			
14:00-14:50	J. Frauendiener	A. Rogers		J. Jaramillo	O. Moreschi
14:50-15:10	R. Gleiser	B. Araneda		A. Aceña	C. del Pilar Quijada
15:10-15:30	T. Mädler	L. Combi		A. Giacomini	E. Eiroa
15:30-15:50	P. Rioseco	J. Badía	*enjoy*	I. Gentile	G. Figueroa Aguirre
15:50-16:10	COFFEE		*your*	COFFEE	
16:10-16:30	J. Oliva	F. Cánfora	*free*	M. Argañaraz	M. Ramirez
16:30-16:50	M. Rubio	A. Petrov	*afternoon*	F. Abalos	O. Fierro Mondaca
16:50-17:10	O. Baake	G. Crisnejo		P. Anglada	M. J. Guzmán
17:10-17:30	N. Mirón Granese	N. Poplawski			
18:30-20:00	**Wine and Cheese**	⋆⋆ 19:00hs. Jorge Pullin			

⋆Gabriela Gonzalez: Public Lecture (Charla Pública, libre y gratuita). Friday, April 5: 20.00 HS at Observatorio Astronómico de Córdoba: LAPRIDA 854, Auditorio MIRTA MOSCONI.

⋆⋆ Jorge Pullin: La telenovela de las ondas gravitacionales: desde Newton en 1666 hasta Estocolmo 2017, Martes 9, 19:00HS en el SUM de la Plaza Cielo Tierra (Bv. Chacabuco 1300).

† 10:00-1100. Live announcement from the Event Horizon Telescope/ESO collaboration.

Steve Liebling talk followed by the tlak of Luis Lehner.

Morning Talks

Monday 8

Loop quantum gravity overview and recent developments
J. Pullin
Louisiana State University.

We give a non technical summary of loop quantum gravity and discuss applications in cosmology and black holes.

Electromagnetic Duality Anomaly in Curved Spacetimes
Ivan Agullo
Louisiana State University, University of Valencia

It is well known that the source-free Maxwell equations are invariant under electric-magnetic duality rotations. This is true even in the presence of an arbitrary gravitational background field. I will discuss in this talk whether this symmetry is maintained when the electromagnetic field is quantized. The answer is in the affirmative in the absence of gravity, but not necessarily otherwise. As a consequence, the net polarization of the quantum electromagnetic field fails to be conserved in certain spacetimes, as for instance in presence of mergers of compact objects. I will discuss the analogy with the well-known chiral anomaly spin 1/2 fermions, and potential physical consequences.

Einstein-lambda-matter flows and asymptotic simplicity.
Helmut Friedrich
Max-Planck-Institut für Gravitationstheorie (AEI)

The recently observed accelerating expansion of our cosmos seems to be well modeled by solutions to the Einstein equations with cosmological constant in four space-time dimensions. In this talk I consider these equations coupled to various matter fields and discuss the behaviour of the solution at future time-like infinity in detail. It will be seen that there are massive matter fields that admit the construction of and an unimpeded evolution of the fields across a smooth conformal extensions at future time-like infinity. We also consider situations where the matter fields impose obstructions to a smooth conformal extensibility of the solution.

Probing strong gravity using gravitational wave observations
P. Ajith
International Centre for Theoretical Sciences, TIFR, Bangalore, India

Gravitational wave observations by LIGO and Virgo provide a unique laboratory to study gravity in a regime inaccessible to traditional astronomical observations and laboratory tests. These observations enable tests of the validity of general relativity, the existence of black hole horizons and the nature of compact objects. The large number of binary merger events expected in the near future, including some “golden” events, will significantly improve the precision of these tests. This talk will discuss the results from the recent observations and will give a flavor of the future prospects and challenges.

Expositor: J. R. Westernacher-Schneider
Multimessenger Seismology of Core-Collapse Supernovae
J. R. Westernacher-Schneider, E. O’Connor, E. O’Sullivan, I. Tamborra, M.-R. Wu
University of Arizona

Asteroseismology of the inner core of a core-collapse supernova is possible with gravitational waves and neutrinos. We show that the excitation of a linear mode of the core can imprint itself on the neutrino luminosity, provided the mode amplitude is large enough in the vicinity of the neutrinosphere. This can occur with sufficient rotation. Thus, neutrinos carry information about the mode excitation at a radius of 60-70 km, whereas gravitational waves probe deeper.

Well-posed Cauchy formulation for Einstein-aether theory
Olivier Sarbach
Universidad Michoacana de San Nicolás de Hidalgo, México.

We discuss the well-posedness of the Cauchy problem of vacuum Einstein-aether theory. The latter is a Lorentz-violating gravitational theory consisting of General Relativity with a dynamical timelike “aether” vector field, which selects a preferred time direction at each spacetime event. The Einstein-aether action is quadratic in the gradient of the aether, and thus yields second-order field equations for the metric and the aether. However, in general the structure of these equations is rather complicated, and this makes it difficult to formulate a well-posed Cauchy problem away from the simple case of linearized perturbations over flat spacetime. In this talk we employ a first-order formulation of Einstein-aether theory in terms of projections on a tetrad frame and show that under suitable conditions on the coupling constants of the theory, the resulting evolution equations can be cast into strongly or even symmetric hyperbolic form, and therefore they define a well-posed Cauchy problem.

Testing General Relativity with Black Hole Mergers
F. Pretorius
Princeton University, USA

Testing the predictions of general relativity in the dynamical strong-field regime, in particular black holes and their dynamics, has only recently become possible with LIGO/Virgo observations of black hole mergers. I will review some of the tests that have been performed to date. However, one obstacle to extracting the most stringent constraints possible from the data are the lack of predictions of what the coalescence phase of black hole mergers should like in gravitational wave emission within modified gravity theories (or theories that claim exotic alternatives to black holes). To make things worse, there are doubts to how well-posed many modified gravity theories, than in principle might offer interesting merger dynamics, are. One such theory is Einstein-dilaton-Gauss-Bonnet (EdGB) gravity. I will describe early results beginning to address the well-posedness of EdGB gravity within the dynamical strong-field regime. We restrict attention to gravitational collapse in spherical symmetry, and show for sufficiently strong coupling EdGB gravity is not well-posed from the perspective of the Cauchy initial value problem.

Press Conference on First Result from the Event Horizon Telescope

The European Commission, European Research Council, and the Event Horizon Telescope (EHT) project will hold a press conference to present a groundbreaking result from the EHT.

Extensions to GR, challenges and possible resolutions
L. Lehner
Perimeter Institute for Theoretical Physics, Canada.

Theories that are extensions to GR often involve severe problems which can stand in the way of understanding them or interpret lessons drawn at the linear level on the original theory. This talk will discuss some examples and options to either constrain viable options or, alleviate their possible pathologies.

Alternatives to Binary Black Hole Mergers in GR
Steven L. Liebling
Long Island University.

The mergers of many binary black holes (BBH) have already been observed by LIGO, with many more expected when LIGO comes back online soon. Such observations serve to constrain and test our theory of gravity, and, as such, it makes sense to study alternatives to the general theory of relativity (GR). I will discuss BBH mergers within two models that move beyond GR. The first is Einstein-Maxwell-dilaton which adds a vector and a scalar field to the gravitational degrees of freedom. the flatspace sector, Maxwell-dilaton, represents a simpler, yet still nonlinear, model which also has interesting dynamics. The second is an ad-hoc model that considers possible fluctuations near the black hole horizons that might arise from a quantum theory of gravity.

Multimessenger astrophysics and cosmic nucleosynthesis
Daniel M. Siegel
Columbia University, USA

The recent detection of the binary neutron star merger GW170817 by advanced LIGO and Virgo and its fireworks of electromagnetic counterparts across the entire electromagnetic spectrum marked the beginning of multi-messenger astronomy and astrophysics with gravitational waves. Such detections combined with observations of other prime targets of transient astronomy hold the premise to understand the cosmic origin of most elements in the periodic table after decades of speculation. In this talk, I will review current advances in both observations and the theoretical modeling of neutron star mergers and core-collapse supernovae in the context of heavy element nucleosynthesis, and discuss challenges and opportunities for the coming years.

On the use of evolutionary methods in spaces of Euclidean signature
István Rácz
University of Warsaw and Wigner RCP, Budapest

Two examples of physical interest will be presented. Both, contrary to the folklore, demonstrate that evolutionary methods may also play significant role in spaces of Euclidean signature. First, the propagation of the constraints is considered. It is shown that once a clear separation of the evolutionary and constraint equations is done, the subsidiary equations satisfied by the constraint expressions form a first order symmetric hyperbolic system regardless whether the ambient Einsteinian space is of Lorentzian or Euclidean signature. Second, the constrains of Einstein's theory of gravity are considered. Since the seminal observations of Lichnerowicz and York these equations are usually referred to as a semilinear elliptic system. It will be shown that–according to the choice of the dependent variables–the constraints may have different characters. In particular, they may take the form of either a parabolic-hyperbolic or a strongly hyperbolic system. Some of the recent developments related to these alternative choices will also be discussed.

Big bang dynamics and velocity term dominance
Florian Beyer
University of Otago, New Zealand

In this talk I discuss recent results regarding the singular dynamics of the early universe governed by the (purely classical) Einstein's field equations.

Discreteness in quantum gravity and possible implications
Alejandro Pérez
Centre de Physique Theorique, Aix-Marseille University, France.

Different approaches and ideas about quantum gravity suggest that the smooth metric and smooth matter fields of classical physics should be replaced by a more fundamental description in terms of discrete structures at the Planck scale. Independently of the precise nature of these underlying physics one is led to the expectation of diffusive effects. In an effective description, and with some simple assumptions about the nature of the underlying discrete structures (motivated by observed Lorentz invariance of 'low energy' physics) one can quantify the amount of diffusion experienced by test particles. The effect is tiny in general but, in the context of cosmology, it can pile up at early stages after the big-bang, and manifests itself today as an effective cosmological constant. Quantitative estimates agree with observations in order of magnitude.

Expositor: Javier Peraza
A complete classification of S1-symmetric static vacuum black holes.
Javier Peraza and Martin Reiris
Centro de Matemática, Udelar, Montevideo, Uruguay.

In a seminal paper of 1917, H. Weyl presented a remarkable reduction of the static axisymmetric vacuum Einstein equations, serving as a relatively straighforward technique to generate and explore new solutions. Weyl's reduction was used by Myers in 1987, and independently by Korotkin-Nicolai in 1994, to construct a new family of static and axisymmetric solutions with compact non-empty horizon, however with non-trivial topology and asymptotically Kasner. This family, together with the Schwarzschild and the Boost families, remained until now as the only known S1-symmetric static black hole solutions, namely, (metrically complete) S1-symmetric static vacuum solutions with compact and non-emtpy horizon. In this talk we explain how, indeed, these three families exhaust all the examples of S1-symmetric static vacuum black holes.

Expositor: Federico Carrasco
Force-free magnetospheres of black holes and neutron stars.
F. Carrasco[1], O. Reula, C. Palenzuela, R. Cayuso, D. Viganò, J. Pons
[1]Universitat de les Illes Balears

Force-free electrodynamics describes a particular regime of magnetically dominated relativistic plasmas, which arises on several astrophysical scenarios of interest such as pulsars or active galactic nuclei. In this talk, I will present results from GR3D force-free simulations on a variety of astrophysical settings: (i) energy extraction from spinning black holes (AGNs) and neutron stars (pulsars); (ii) jets from compact objects moving through a magnetized plasma; (iii) outburst activity from twisted magnetic footprints in magnetars.

AFTERNOON TALKS

MONDAY 8

Numerical gluing of relativistic initial data sets.
Jörg Frauendiener
DEPARTMENT OF MATHEMATICS AND STATISTICS, UNIVERSITY OF OTAGO, PO BOX 56, DUNEDIN 9010, NEW ZEALAND

Almost 20 years ago, Corvino and Schoen presented a new way to solve the constraint equations of General Relativity. They used this method to glue two initial data sets together along an overlap region and showed that an asymptotically flat initial data set can be deformed outside a compact set into an initial data set which is identical to Schwarzschild data. In this talk we describe a numerical method implementing the Corvino-Schoen procedure and we present numerical results on the deformation of asymptotically flat initial data sets. We discuss some of the new numerical tools that we used in the implementation. Finally, we mention possible further directions of research.

On the linear stability of the Linet - Tian solutions with positive cosmological constant.
R. J. Gleiser
IFEG, FAMAF, Universidad Nacional de Córdoba, Argentina

The Linet - Tian metrics are solutions of the Einstein equations with a cosmological constant, Λ, that can be positive or negative. The gravitational instability of the Linet - Tian solutions with $\Lambda < 0$, was recently established. The purpose of this paper is to extend those results to the case $\Lambda > 0$. A fundamental difference with the case $\Lambda < 0$, already known in the literature, is that, rather than the natural cylindrical geometry of the metrics with $\Lambda < 0$, we have for $\Lambda > 0$ a "toroidal" geometry, with two orthogonal axis, along which the metric is singular. In attempting to solve the linearized perturbation equations we are confronted with the problem of a gauge ambiguity that leads to the introduction of a gauge invariant function, W_1, that is shown to be also a *master function*, that satisfies a second order ODE, and in terms of which one can express all the perturbation functions. Unfortunately, the equation satisfied by W_1 contains singular coefficients, and, although one can show that *all* its solutions are regular, because of the presence of these singularities one cannot, as in the case of negative Λ, set up an associated self adjoint problem that provides a complete set of solutions for W_1. We are thus restricted to solving numerically the perturbation equations, and using those solutions for constructing W_1, for particular values of the parameters. In all the cases analyzed we find unstable modes, which strongly suggests that all the Linet - Tian space times with $\Lambda > 0$ are linearly unstable under gravitational perturbations. The problem of determining the time evolution of arbitrary initial data in terms of the W_1, or something equivalent, remains open.

Expositor: Thomas Mädler
Radiation memory and boosted black holes.
Thomas Mädler[1] and Jeffrey Winicour
[1]Universidad Diego Portales, Santiago, Chile

Gravitational wave memory is the permanent displacement of test particles after the passage of the wave. This radiation effect can be separated into an 'ordinary' memory effect and a null memory effect. For the former no energy is lost to null infinity due to gravitational waves while the latter is a nonlinear effect solely depending on the asymptotic properties of the radiation field of zero rest mass fields like gravitational waves, Maxwell fields or neutrinos. An important class of the ordinary memory is the memory due to the ejection of a particle, a.k.a the boost memory effect. Here I discuss the gravitational memory effect resulting from a transition of a stationary to

boosted Schwarzschild/Kerr exterior spacetime. I sketch some of the notational difficulties and consequences in asymptotic analysis of Kerr-Schild black holes in defining a boost. It turns out that both the Kerr-Schild version of the Kerr metric and the Kerr-Schild version of the Schwarzschild metric have two intrinsically-distinct 'Minkowski backgrounds' to define a boost. Indeed, only the Minkowski background with respect to their ingoing principal null direction yields the correct result of the boost memory at future null infinity agreeing with the linearised result of the retarded Green function.

Expositor: Paola Rioseco
Relativistic Kinetic Theory with Applications in Astrophysics.
Paola Rioseco and Olivier Sarbach
UMSNH, México

I will show a summary about relativistic kinetic theory, applied to two phenomena, the first is accretion of matter in a Schwarzschild hole where the accretion rate is obtained and secondly I will also talk about the dynamics of the kinetic gas for a disk in the equatorial plane of Kerr, in this case the so-called mixing phenomenon appears, which causes that the gas configuration relaxes to stationary axisymmetric state through the mixing phenomenon.

Expositor: Julio Oliva
Four-dimensional Traversable Wormholes in Vacuum
Andres Anabalon[1], Julio Oliva[2]
[1] Universidad Adolfo Ibáñez, Viña del Mar, Chile [2] Universidad de Concepción, Concepción, Chile

In this talk we point out the existence of solutions to General Relativity with a negative cosmological constant in four dimensions, which contain solitons as well as traversable wormholes. The latter connect two asymptotically locally AdS4 spacetimes. At every constant value of the radial coordinate the spacetime is a spacelike warped AdS3. We compute the dual energy momentum tensor at each boundary showing that it yields different results. We also show that these vacuum wormholes can have more than one throat and that they are indeed traversable by computing the time it takes for a light signal to go from one boundary to the other, as seen by a geodesic observer.

Expositor: Marcelo Rubio
Recent advances on hyperbolic theories for ultrarelativistic Hydrodynamics.
Oscar Reula and Marcelo Rubio
IFEG - CONICET; FAMAF - UNC, Córdoba, Argentina.

Much effort has been devoted in order to develop a theory that describes dissipative fluid dynamics in the context of General Relativity. It is well known that much of the equations that describe those effects are of parabolic type, and thus the information propagates at infinite speed. This fact goes against the causality principles of Einstein's theory, that postulates that nothing can travel faster than speed of light. This problem makes the issue of describing dissipative fluids in the context of General Relativity a highly non-trivial task. In this talk I will present a novel theroy for utrarelativistic fluids, that are invariant under conformal transformations. We show that such a theory is symmetric-hyperbolic near equilibrium states, which implies that it has a well posed initial value problem, and study causality and stability of equillibrium states (solutions that admit Killing vector fields). Finally, we comment on a original way for numerically evolve this class of theories, focusing on the difficulties that appear during

evolution, and show some preliminary simulations at short times.

Expositor: Olaf Baake

Superradiance of a charged scalar field coupled to the Einstein-Maxwell equations

Olaf Baake[1] and Oliver Rinne[2]
[1] University of Talca, Centro de Estudios Científicos [2] Albert Einstein Institute

We consider the Einstein-Maxwell-Klein-Gordon equations for a spherically symmetric scalar field scattering off a Reissner-Nordström black hole in asymptotically flat spacetime. The equations are solved numerically using a hyperboloidal evolution scheme. For suitable frequencies of the initial data, superradiance is observed, leading to a substantial decrease of mass and charge of the black hole. We also investigate the late-time decay of the scalar field.

Expositor: N. Miron Granese

Non-linear dynamics of tensor modes in fluctuating real relativistic fluids

N. Miron Granese[1], A. Kandus[2] and E. Calzetta[3]
[1]Departamento de Física, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires; [2]Departamento de Ciencias Exatas e Tecnologicas, Universidade Estadual de Santa Cruz; [3]Departamento de Física, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires e Insitituo de Física de Buenos Aires (IFIBA) CONICET - Universidad de Buenos Aires

When describing real relativistic fluids is usual to use Second Order Theories (SOT), in which the non-ideal properties are described by a new set of dynamical tensor variables. In this work we explore the non-linear dynamics of those modes in a conformal fluid. Among all possible SOTs, we choose to work with the Divergence Type Theories (DTT) formalism, which ensures that the second law of thermodynamics is satisfied non-perturbatively. In considering a perturbative scheme within this formalism, at next to leading order a set of Maxwell- Cattaneo relaxation equations is obtained.

New perspectives on astrophysical lensing
Adam Rogers
Brandon University, Canada

Gravitational lensing is a well-known phenomenon predicted by General Relativity, and famously provided the first observational test of the theory. Despite its cornerstone role in verifying Einstein's view of gravitation, it was not generally believed that lensing effects would be observed for any object other than the Sun. Today, gravitational lensing is well-established and has been observed on diverse scales from individual stars to entire galaxy clusters acting as lenses. Meanwhile, theorists have been exploring the ramifications of so-called exotic lens models which act like diverging lenses, counter to the usual (converging) gravitational lens behaviour. Surprisingly, observational signatures very similar to the predictions of these exotic lenses have been seen since the early 1980s in a much different context: the frequency-dependent lensing of background radio sources due to electron density inhomogeneities in the interstellar medium. These Extreme Scattering Events provide an observational probe of AU-scale structures in the plasma medium between the stars. In this talk, I will discuss the connection between plasma lenses and the formation of images by exotic lens models from GR, which unexpectedly share many similar characteristics.

Twistor structures and massless fields on curved spacetimes
Bernardo Araneda
FAMAF, Universidad Nacional de Córdoba, Argentina

We show that the geometry underlying the Teukolsky equations (the leading approach for analyzing black hole linear stability) can be understood by using conformal and complex structures in Petrov type D spaces. Then we show that there are natural relations between this geometry and Twistor Theory.

Expositor: Luciano Combi
First pulsar observations in South America and gravitational wave science
Luciano Combi, Michael Lam, Carlos Lousto, Guillermo Gancio, Jorge Combi, Santiago del Palacio, Federico Lopez Armengol, Federico García, Ana Mueller, Paula Kornecki, Hugo Command
Instituto Argentino de Radioastronomía, West Virginia University, Rochester Institute of Technology

The PuMA collaboration (Pulsar Monitoring in Argentina) is a team of scientist and technicians based at the Argentine Institute of Radioastronomy with the main goal of using and upgrading the IAR's radio antennas for pulsar observations. In this work, we show the latest developments of the collaboration since 2018, including studies of glitching pulsars, magnetars, and the daily observation campaign of the millisecond pulsar J0437-4715 that is relevant for gravitational wave science. These results mark the first pulsar observations in South America and the beginning of pulsar science in Argentina.

Expositor: Javier Badía
Determining properties of a rotating black hole from its shadow
Javier Badia and Ernesto F. Eiroa

Instituto de Astronomía y Física del Espacio (IAFE, CONICET-UBA)

Massive objects deflect the trajectories of light rays in their vicinity, as a consequence of the space-time curvature. If the object is a black hole, this creates an optical effect in which part of the trajectories of photons coming from the region behind it are trapped, forming a dark zone called the shadow. For a static black hole the shadow has a circular shape, but for a rotating one it is deformed in an asymmetric manner, depending on the angle of observation and the spin of the black hole. We review the usual method for analytically obtaining the contour of the shadow of a black hole via the Hamilton-Jacobi equation, together with its application to the Kerr geometry of General Relativity and other solutions of interest taken from alternative theories. We also discuss recent developments proposing that black hole properties can be extracted from the observation of the shadow, allowing for a determination of physical quantities and parametrizing possible deviations from the Kerr solution. We briefly discuss observational aspects regarding the supermassive black hole located at the galactic center.

Gravitating Skyrmions

F. Canfora
CECs, Valdivia, Chile

In this talk I will present the first examples of analytic gravitating Skyrmions: namely exact and topologically non-trivial solutions of the coupled Einstein-Skyrme system in (3+1)-dimensions. The geometries corresponding to these gravitating solitons are regular, while the ansatz for the SU(2)-valued matter fields belongs to a sector with non-vanishing Baryon charge. Taking a suitable flat limit of these gravitating solutions it is possible to construct the first explicit examples of Skyrmions living within a finite volume in flat space-times.

Lorentz symmetry breaking in gravity

A. Yu. Petrov
Universidade Federal da Paraiba, Joao Pessoa, Brazil

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 with 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 Einstein gravity with the additive 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 present the main results achieved by us within these approaches.

First, we consider 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 cases), including the finite temperature. We demonstrate 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.

The talk is based on papers: 0708.3348, 0805.4409, 1407.5985, 1805.11049.

Expositor: Gabriel Crisnejo

Weak lensing in a plasma medium using the Gauss-Bonnet theorem

Gabriel Crisnejo[1], Emanuel Gallo[1,2] and Adam Rogers[3]
[1] FaMAF, Universidad Nacional de Córdoba, Córdoba, Argentina
[2] Instituto de Física Enrique Gaviola, Conicet, Argentina
[3] Department of Physics and Astronomy, Brandon University, Canada.

We apply the Gauss-Bonnet theorem to the study of light rays in a plasma medium in a static and spherically symmetric gravitational field and also to the study of timelike geodesics followed for test massive particles in a spacetime with the same symmetries. The possibility of using the theorem follows from a correspondence between timelike curves followed by light rays in a plasma medium and spatial geodesics in an associated Riemannian optical metric. A similar correspondence follows for massive particles. Finite distance corrections to the bending angle are also discussed.

Big Bounce and inflation from spin and torsion

N. Poplawski
University of New Haven, West Haven, CT, USA

The conservation law for the total (orbital plus spin) angular momentum of a Dirac particle in the presence of gravity requires that spacetime is not only curved, but also has a nonzero torsion. The coupling between the spin and torsion in the Einstein–Cartan theory of gravity generates gravitational repulsion at extremely high densities, which prevents a singularity in a black hole and may create there a new, closed, baby universe undergoing one or more nonsingular bounces. We show that quantum particle production caused by an extremely high curvature near a bounce creates enormous amounts of matter and can generate a finite period of inflation. Our scenario has only one parameter, does not depend significantly on the initial conditions, does not involve hypothetical scalar fields, avoids eternal inflation, and predicts plateau-like inflation that is supported by the Planck observations of the cosmic microwave background. This scenario suggests that our Universe may have originated from a nonsingular bounce in a black hole existing in another universe.

Spectral problems from black hole spacetime boundaries: when 'non-normal' is generic
José Luis Jaramillo
Institut de Mathématiques de Bourgogne (IMB), Dijon, France

Black hole spacetimes often pose problems where 'inner' and/or 'outer' boundaries play a key role. Here we focus on problems that can be formulated in terms of the spectral properties of a given elliptic operator. The interest of such an approach strongly relies on the capability to keep the corresponding spectral problem under 'good' control. For self-adjoint (and more generally 'normal') operators this is guaranteed by the 'spectral theorem', underlying the familiar notion of 'normal mode'. The situation changes qualitatively when the operator is non-normal, and issues such as spectral (in)stability or available spectral expansions become more subtle. We argue here that this situation is generic. We illustrate this with two examples. The first one concerns the MOTS-stability operator controlling the dynamics of apparent horizon worldtubes. In particular, it is shown that such an operator is non-normal whenever the (Hajicek) form controlling rotation is not Killing. The resulting potential spectral instability may impact recent eigenvalue analyses of "apparent horizon jumps" in binary black hole mergers. The second problem concerns the study of quasi-normal modes in the asymptotically flat case. Specifically, this problem is cast for a (spherically symmetric) black hole in terms of a (proper) non-selfadjoint operator, by compactifying along hyperboloidal slices to implement outgoing boundary conditions. As shown by Warnick in the asymptotically AdS case, this type of formulation offers a rich avenue to the problem. At the same time, potential 'non normal' issues may suggest the need of new tools and concepts.

Expositor: Andrés Aceña
Sobolev spaces for multi-black hole initial data
María Eugenia Gabach Clément[1] and Andrés Aceña[2]
[1] Facultad de Matemática, Astronomía y Física, Universidad Nacional de Córdoba, Instituto de Física Enrique Gaviola, CONICET, Córdoba, Argentina. [2] Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Cuyo, CONICET, Mendoza, Argentina.

Initial data for the Einstein field equations representing isolated multiple black hole systems are known to exist under certain conditions. One example of particular importance is the Majumdar-Papapetrou solution, describing many extremal, charged black holes in equilibrium. Sobolev spaces arise naturally when studying the elliptic equations coming from the Einstein constraints. Moreover, weighted Sobolev spaces are very useful for studying extremal black hole initial data. The case of many black holes has been treated in the literature using alternative approaches, which rely mainly in partitions of the initial 3-manifold and subsequent limiting procedures. In this talk we present weighted Sobolev spaces that are best suited to treat initial data for multiple black hole systems. We extend general results for elliptic operators to these spaces and give a simple proof of existence of a class of initial data describing many extremal black holes.

Expositor: Alex Giacomini
Black branes in four-dimensional conformal equivalent theories
Nikolaos Dimakis, Alex Giacomini, Andronikos Paliathanasis
Universidad Austral de Chile

The physical properties of static analytic solutions which describe black brane geometries are discussed. In particular we study the similarities and differences of analytic black brane/string solutions in the Einstein and Jordan frames. The comparison is made between vacuum power law f(R) gravity solutions and their conformal equivalents in the Einstein frame. In our analysis we examine how the geometrical and physical properties of these analytic

axisymmetric solutions - such as singularities, the temperature and the entropy - are affected as we pass from one frame to the other

Expositor: Ivan Gentile de Austria
Stability of Spherical Bonnor Solutions
Andrés Aceña and Ivan Gentile de Austria
FCEN, UNCUYO, Argentina

In this talk we discuss the stability of spherical electrically charged dust under radial gravitational perturbation. We take into account the perturbation on the geometry as well as the electric field and matter, obtaining a complete system of equations for the evolution of the perturbations, whose analysis would yield conditions for stability or instability.

Expositor: Marcos A. Argañaraz
Kerr center of mas null system
Marcos A. Argañaraz and Osvaldo M. Moreschi
Universidad Nacional de Córdoba, Instituto de Física Enrique Gaviola (IFEG), CONICET. Córdoba, Argentina.

While the Kerr metric has deservedly been one of the most studied exact solutions, there appears to be a peculiar lack of natural null coordinates to describe a dual-null foliation of the space-time, meaning two families of null hypersurfaces intersecting in a two-parameter family of transverse spatial surfaces, such that the horizons are two of the hypersurfaces. We present a new definition for null coordinates, that we call $\mathbf{u}$ (out-going) and $\mathbf{v}$ (in-going), which are naturally adapted to the horizons. Our definition involves a differential equation which we solve numerically. In our construction there naturally appears a family of spheres that are parameterized by r_s, which are the intersections of the null coordinates $\mathbf{u}$ and $\mathbf{v}$. They can also be characterized in a coordinate independent way, by the intrinsic and extrinsic GHP curvature, given by $K_{Gaussian} = \bar{Q}_{GHP} + Q_{GHP}$ and $K_{Extrinsic} = i\left(\bar{Q}_{GHP} - Q_{GHP}\right)$, with $Q = \sigma\sigma' - \rho\rho' - \Psi_2$ given in terms of the spin coefficients of the GHP formalism.

Our work improves several attempts that can be found in the literature, and gives a useful new insight in the study of Kerr solution and the Kerr stability open problem. We plan to use them, in further works of Kerr perturbations.

Expositor: Fernando Abalos
On necessary and sufficient conditions for strong hyperbolicity
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In this work we study constant-coefficient first order systems of partial differential equations and give necessary and sufficient conditions for those systems to have a well posed Cauchy Problem. In many physical applications, due to the presence of constraints, the number of equations in the PDE system is larger than the number of unknowns, thus the standard Kreiss conditions can not be directly applied to check whether the system admits a well posed initial value formulation. In this work we find necessary and sufficient conditions such that there exists a reduced set of equations, of the same dimensionality as the set of unknowns, which satisfy Kreiss conditions and so are well

defined and properly behaved evolution equations. We do that by decomposing the systems using the Kronecker decomposition of matrix pencils and, once the conditions are met, finding specific families of reductions. We show the power of the theory in an example, the Klein Gordon equations written as a first order system, and study its Kronecker decomposition and its reductions.

Comments on Penrose inequality with angular momentum for general horizons.

Pablo Anglada
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In axially symmetric space-times it is expected that the Penrose inequality can be strengthened to include angular momentum. In a previous work we have proved a version of this inequality for minimal surfaces, and in this talk we will present a recent work in which we have extended and improved that previous result to compact and connected general horizons. More precisely, we have obtained a lower bound for the ADM mass in terms of the area, the angular momentum and a particular measure of the size of the general horizon. We consider an axially symmetric and asymptotically flat initial data, and have used the monotonicity of Hawking quasi-local energy on 2-surfaces along the inverse mean curvature flow.

New measure for a common signal in two detectors and its application to the GW150914 event

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We have presented previously a different pre-processing filtering technique, than the one widely used in GW publications based on whitening. With this, we were able to notice that the astrophysical signal in the GW150914 event extends at least up to 0.5 seconds previous to the event time; instead of the published 0.1s. We can also show that the resulting strains have the expected phase behavior. One of the most striking observations is the concomitance in the behavior of both strains and the respective matched templates. Making use of the similarity of the respective matched templates we present a new measure for the search of a common signal in two gravitational wave detectors and report new findings that arise with this technique when applied to the GW150914 event.

Expositor: Constanza Quijada

Vector perturbation in the Einstein-dilaton-Maxwell theory

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In this work we study the stability of static solutions of the Einstein-dilaton-Maxwell system in four dimensions, with an arbitrary self-interaction, under a generic vector perturbation. We obtain that the system is reduced to two second order differential equations. If certain differential conditions are satisfied by the background, it is possible to decouple the equations in terms of master variables that are proportional to the gauge field perturbation and combinations of first integrals and derivatives of the metric perturbations. Consequently, Gibbons-Maeda black hole, naturally emerges from this analysis. We therefore obtain two Schroedinger-like equations that control the dynamics of the perturbations and we use the effective potentials to analyze the stability of this system.

Expositor: Ernesto F. Eiroa

Pure double layers in quadratic F(R) theories

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One of the most popular modified gravity theories is obtained by adopting a lagrangian which is a function F(R) of the scalar curvature R. Here we present the construction of spherically symmetric bubbles, by matching a vacuum solution with an exterior one having a non null mass, within the framework of quadratic F(R) theories. Each of these regions have a constant value of the curvature scalar, different from one another, that can be interpreted as different cosmological constants. We use the junction formalism in F(R) for the construction, which in the quadratic case results in a hypersurface that gathers both the characteristics of a thin shell and a gravitational double layer. We show that for a particular set of values of the parameters, it is possible to obtain a pure double layer, so that the surface energy density and the pressure are both null at the shell. This is the first explicit example of a pure double layer in a gravitational theory.

Expositor: Griselda Figueroa Aguirre
Thin shells with spherical symmetry in F(R) theories
Ernesto F. Eiroa, Griselda Figueroa Aguirre
Instituto de Astronomía y Física del Espacio (IAFE, CONICET-UBA)

In order to provide alternatives to unsolved problems in modern cosmology, several theories that modify General Relativity were proposed, among them the F(R) theories of gravity. In these theories, the Einstein-Hilbert lagrangian is replaced by a function F(R) of the curvature scalar R. The junction formalism, recently extended to F(R) gravity, allows the study of the behavior of thin shells of matter by matching different solutions across a hypersurface. We present the construction of a broad class of spherical thin shells within F(R) gravity with a constant curvature scalar, and the corresponding stability analysis under perturbations preserving the symmetry. We show that the equation of state which relates the energy density with the pressure at the shell is forced by the junction conditions. We introduce some interesting examples in which stable configurations are possible for suitable values of the parameters.

Expositor: Marcos A. Ramirez
Evolution of thin shells in spacetimes of arbitrary dimension
Marcos A. Ramirez, Daniel Aparicio
INENCO, CONICET - Universidad Nacional de Salta

This talk is based on arXiv:1806.07867, where we consider singular timelike spherical hypersurfaces embedded in a D-dimensional spherically symmetric bulk spacetime which is an electrovacuum solution of Einstein equations with cosmological constant. We study the dynamics according to Einstein equations for arbitrary matter satisfying the dominant energy condition. In particular, we thoroughly analyse the asymptotic dynamics for both the small and large-shell-radius limits. We also study the main qualitative aspects of the dynamics of shells made of linear barotropic fluids that satisfy the dominant energy condition. Finally, we prove weak cosmic censorship for this class of solutions.

Expositor: Octavio Fierro Mondaca
Scalar qnms on asymptotically locally flat rotating black holes in three dimensions
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The pure quadratic term of New Massive Gravity in three dimensions admits asymptotically locally flat, rotating black holes. These black holes are characterized by their mass and angular momentum, as well as by a hair of gravitational origin. As in the Myers-Perry solution in dimensions greater than five, there is no upper bound on the angular momentum. We show that, remarkably, the equation for a massless scalar field on this background can be solved in an analytic manner and that the quasinormal frequencies can be found in a closed form. The spectrum is obtained requiring ingoing boundary conditions at the horizon and an asymptotic behavior at spatial infinity that provides a well-defined action principle for the scalar probe.

Expositor: Maria José Guzman
Degrees of freedom and Hamiltonian formalism of modified teleparallel gravity
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Modified teleparallel theories of gravity have attracted a lot of attention in the last years, due to its versatility to predict new physics both in high and low energy regimes. A source of intense debate lies on its Lorentz-breaking character and the nature of its degrees of freedom. The former aspect can be regarded as the theory selecting preferential tetrads that parallelize spacetime, or can be tackled by covariant versions of the theory. For the physical understanding of the degrees of freedom of this kind of theories, the Dirac-Bergmann algorithm for constrained Hamiltonian systems proves to be a powerful tool. Recent progress has been made on the Hamiltonian formulation of the teleparallel equivalent of general relativity and its simplest generalization, f(T) gravity. A detailed analysis shows that contrary to previous claims, f(T) gravity has only one extra degree of freedom for arbitrary dimension. In order to understand this outcome, it will be helpful the comparison with the f(R) gravity case and the analysis of the trace of the equations of motion of both theories. Finally, we briefly discuss the possible role of the extra degree of freedom in a FLRW background and cosmological perturbations.