Grav15
April 13th–17th, 2015, La Falda, Argentina

Schedule (as of April 6th, 2015)

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
9:00-9:50	Registration	G. Romero	L. Lehner	D. Correa	J. Oliva
10:00-10:30	COFFEE				
10:30-11:20	H. Friedrich	G. Dotti	S. Dain	A. Giacomini	E. Nungesser
11:30-12:20	M. E. Gabach C.	O. Moreschi	E. Eiroa	R. Gleiser	J. Pullin
12:20-14:00	LUNCH				
14:00-14:30	I. Sánchez G.	E. Gallo	*enjoy*	M. Ramírez	P. Martínez
14:35-15:05	P. Anglada	D. C.-Lombardo	*your*	C. Sendra	J. F. Abalos
15:05-15:45	COFFEE		*free*	COFFEE	
15:45-16:15	M. J. Guzmán M.	B. Araneda		F. López A.	E. Boero
16:20-16:50	M. Rubio	J. Fernandez T.	*afternoon*	M. Chocan	I. Gentile de A.
16:55-17:25	P. Denaro				

MOORNING TALKS

MONDAY 13

Geometric Asymptotics and Beyond
Helmut Friedrich
Albert Einstein Institut, Potsdam, Germany

We revisit results on the asymptotic behaviour of solutions to Einstein's field equations with positive cosmological constant and discuss their significance in the context of the conformal cyclic cosmological models recently proposed by R. Penrose.

On the shape of rotating black holes
María E. Gabach Clement
FaMAF - IFEG

We explore the shape of axisymmetric black holes, both in stationary and dynamical regimes. We find that black hole rotation indeed manifests in the widening of their central regions, limits their global shapes and enforces their whole geometry to be close to the extreme-Kerr horizon geometry at almost maximal rotational speed.

TUESDAY 14

Particle interactions around black holes
Gustavo Esteban Romero
IAR-CONICET/FCAG-UNLP

Accreting black holes are surrounded by hot plasma. Magnetic field reconnection in this medium can result in the acceleration of charged particles up to relativistic energies. Such particles interact in the corona around the black hole giving rise to a unique phenomenology. Non-thermal radiation from the corona can be detected with current technologies and provides a unique tool to probe the extreme physics close to the black hole. In this talk I will review the current knowledge about such physics.

   Keywords: black holes - plasma - radiation: non-thermal

The linear stability problem in gravity theories
Gustavo Dotti
FaMAF, UNC

A review of the current approches to the linear stability problem in gravity theories will be made and a non-modal approach will be proposed.

Balanced equation of motion in the null gauge

Osvaldo M. Moreschi and Emanuel Gallo

FaMAF - IFEG

In trying to extend the techniques for the calculation of the equation of motion for charged particles to the realm of general relativity, the first choice is the use of harmonic coordinates. We have found that actually this type of coordinates are no suitable for this task.

In this work we present the calculation of the equation of motion for compact object in general relativity, including the back reaction due to gravitational radiation, using the null gauge.

In the past we have presented the framework for this task. In this ocassion we present the equations of motion.

WEDNESDAY 15

Rattle and shine by compact binaries mergers

Luis Lehner

Perimeter Institute for Theoretical Physics, Canada

The late stage of inspiralling compact binaries star binary gives rise to a strong emission of gravitational waves due to the highly dynamical and strongly gravitating nature of this system. If the binary contains at least a neutron star diverse processes can yield significant signals in the electromagnetic spectra and produce detectable neutrinos.

I will discuss two, relatively simple, mechanisms which illustrate excellent opportunities lie ahead for observing these systems through multiple channels and signal the upcoming revolution in astronomy as well as speculate what, current observations combined with theoretical insights may already be telling us on the nature of neutron stars.

On the linear stability of the extreme Kerr black hole under axially symmetric perturbations

Sergio Dain and Ivan Gentile de Austria

FaMAF, UNC, CONICET, Argentina

We prove that for axially symmetric linear gravitational perturbations of the extreme Kerr black hole there exists a positive definite and conserved energy. This provides a basic criteria for linear stability in axial symmetry. In the particular case of Minkowski, using this energy we also prove pointwise boundedness of the perturbation in a remarkable simple way.

Thin-shells in $F(R)$ theories
E.F. Eiroa[1,2] and G. Figueroa Aguirre[1]
[1] IAFE (CONICET-UBA), Buenos Aires, Argentina
[2] Departamento de Fisica, FCEN, UBA, Buenos Aires, Argentina.

The attempts to understand and explain the accelerated expansion of the Universe result in different theories, being the most standard ones those that use the concept of dark energy. Modifications of General Relativity have also been considered in order to describe this acceleration without employing exotic fluids, in particular the $F(R)$ gravity models, where the Einstein-Hilbert Lagrangian is replaced by a function $F(R)$ of the scalar curvature R. Within the framework of these theories, it is of interest the analysis of the behaviour of thin layers of matter by adopting the thin-shell formalism, which allows to match different solutions across a hypersurface. This formalism is characterized by certain requirements called junction conditions, which have been extended from General Relativity to $F(R)$ theories in recent years. These conditions impose some requisites to the scalar curvature, namely $F(R)$ theories generally present a continuous scalar curvature R, with the exception of quadratic $F(R)$ theories in which R can be discontinuous as in the General Relativity case. Here we review the main features of the thin-shell formalism within the context of $F(R)$ gravity.

THURSDAY 16

String theory partition functions and Wilson loops
Diego Correa
Universidad Nacional de La Plata, Argentina

I will discuss the relation between the expectation value of Wilson loops and string theory partition functions in the context of the AdS/CFT correspondence. I will focus on Wilson loops with cusp angles and their expectation values in the strong coupling limit, by studying the corresponding string theory partition functions beyond the semiclassical approximation.

Gauge fixing ambiguities in curved space-times
Alex Giacomini
Universidad Austral de Chile

It is a well known fact that for non-Abelian gauge theories the gauge fixing is only locally well defined. This means that when the gauge potential is large with respect to a suitable norm, gauge fixing ambiguities appear which would imply an overcounting of states in the path integral. In order to avoid such an overcounting Gribov proposed to restrict the path integral to the region of the potential space which is free of ambiguities. The implementation of this procedure dramatically modifies the propagator of the gluon in the infrared which becomes suppressed. This fact suggests that the Gribov approach to path integral is a promising candiate for the explanation of the confiment problem.

Up to now the overwhelming majority of research on this subject has been done in in flat space-time. Only very recently the gauge fixing problem on curved space-times has begun to attract the attention of

the scientific community. The purpose of this talk is to show some of the effects of non-trivial space-time geometry on the gauge fixing problem and its physical implications for QCD, Abelian gauge theories, and for the gravitational degrees of freedom.

Axial gravitational perturbations of an infinite static line source
Reinaldo J. Gleiser

Instituto de Física Enrique Gaviola and FAMAF, Universidad Nacional de Córdoba, Ciudad Universitaria, (5000) Córdoba, Argentina

The Levi-Civita metric, which contains a naked singularity that has been interpreted as an infinite static line source, appears, for instance, as the possible end point in the collapse of cylindrically symmetric objects such as shells of dust. The analysis of its gravitational stability should therefore be relevant in the contexts of the cosmic censorship and hoop conjectures. In this paper we study axial gravitational perturbations of the Levi-Civita metric. The perturbations are restricted to axial symmetry but break the cylindrical symmetry of the background metric. We analyze the gauge issues that arise in setting up the appropriate form of the perturbed metric and show that it is possible to restrict the perturbations to diagonal terms but that this does not fix the gauge completely. We derive and solve the perturbation equations. The solutions contain gauge-trivial parts, and we show how to extract the gauge-nontrivial components. We impose appropriate boundary conditions on the solutions and show that these lead to a boundary value problem that determines the allowed functional forms of the perturbation modes. The associated eigenvalues determine a sort of 'dispersion relation' for the frequencies and corresponding 'wave vector' components. The central result of this analysis is that the spectrum of allowed frequencies contains one unstable (imaginary frequency) mode for every possible choice of the background metric. The completeness of the mode expansion in relation to the initial value problem and to the gauge problem is discussed in detail, and we show that the perturbations contain an unstable component for generic initial data and therefore that the Levi-Civita space times are gravitationally unstable. We also include, for completeness, a set of approximate eigenvalues and examples of the functional form of the solutions.

<div align="center">FRIDAY 17</div>

Black Strings in Gauss-Bonnet Theory are Unstable
Julio Oliva

Universidad Austral de Chile, Valdivia, Chile

We report the existence of unstable, s-wave modes, for black strings in Gauss-Bonnet theory (which is quadratic in the curvature) in seven dimensions. This theory admits analytic uniform black strings that in the transverse section are black holes of the same Gauss-Bonnet theory in six dimensions. All the components of the perturbation can be written in terms of a single one and its derivatives. For this latter component we find a master equation which admits bounded solutions provided the characteristic time of the exponential growth of the perturbation is related with the wave number along the extra direction, as it occurs in General-Relativity. It is known that these configurations suffer from a thermal instability, and therefore the results presented here provide evidence for the Gubser-Mitra conjecture in the context

of Gauss-Bonnet theory. Due to the non-triviality of the curvature of the background, all the components of the metric perturbation appear in the linearized equations. As it occurs for spherical black holes, these black strings should be obtained as the short distance $r << \alpha^{1/2}$ limit of the black string solution of Einstein-Gauss-Bonnet theory, which is not know analytically, where α is the Gauss-Bonnet coupling.

Self-similarity breaking for cosmological solutions of the Einstein-Vlasov system
Ernesto Nungesser
Trinity College Dublin

We present a result concerning the late-time behaviour of solutions of the Einstein-Vlasov system with Bianchi VII_0 symmetry.

Recent developments in spherically symmetric loop quantum gravity
Jorge Pullin
Louisiana State University, USA.

We review several results obtained in spherically symmetric loop quantum since Grav 13, when we presented the vacuum exact solution to the quantum theory. These include the derivation of Hawking radiation in loop quantum gravity and the Casimir effect between spheres.

AFTERNOON TALKS

MONDAY 15

Perturbations in a tachyonic inflation
Iván E. Sánchez G.[1] and Osvaldo P. Santillán[1]
[1] Instituto de Investigaciones Matemáticas Luis Santaló, Universidad de Buenos Aires and CONICET, Buenos Aires, Argentina

In this work we calculate the spectrum of quamtum fluctuations for an inflationary model whose *inflaton* is a non-canonical scalar field of the tachionization ΛCDM model. We find that the power spectrum for small k values is $P_\zeta \sim 1/k^{\frac{1}{2}+\nu_2}$, where ν_2 depends on the barotropic index γ_0. For large k values we find that $P_\zeta \sim A$ with A a γ_0 dependent constant. We also calculate the three-point correlation function to get the primordial non-Gaussianity of the perturbation and compare the f_{NG} with the observational data of the Planck mision.

Inequality between charge and size for spherical objects
P. Anglada[1], S. Dain [1]
[1] FaMAF, Universidad Nacional de Córdoba, Córdoba, Argentina

It has recently been probed an inequality between area and charge for a spherically symmetric charged

object in an asymptotically flat spacetime, but only for the particular case in which the charge of the object is greater than its mass. In our work, by analyzing all possible configurations for a charged ball in spherical symmetry, we can state that in general relativity, if outside the ball there's an electro-vacuum region, the only possible options are that the ball satisfies the mentioned inequality, or that it is trapped or it's inside a trapped region.

Degrees of freedom in f(T) gravity
Rafael Ferraro [1,2] and **María José Guzmán**[1]
[1] Instituto de Astronomía y Física del Espacio (IAFE, CONICET-UBA), Buenos Aires, Argentina
[2] Departamento de Física, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Argentina

In this talk we will look at the open question of the interpretation of the extra degrees of freedom of $f(T)$ gravity. It is known, from previous work in the Hamiltonian formulation of this theory, that in four dimensions it has 3 extra degrees of freedom compared with the teleparallel equivalent of general relativity. There is still no clue about the interpretation of these extra degrees of freedom, however some attempts were made related with the behaviour of the theory under conformal transformations. We will review this and other attemps made in order to tackle this issue.

Symplectic formalism and the covariant phase space on Scalar Electrodynamics
M. E. Rubio[1,2], O. Reula[1,2]
[1]IFEG – CONICET
[2]Facultad de Matematica, Astronomía y Física

In this talk I will make a review of the covariant phase space formalism on field theories (Ashtekar, Bombelli and Reula, 1991) and an application on Classical Scalar Electrodynamics.

We consider the infinite dimensinoal manifold whose points are solutions of the dynamical equations of a given field theory (that is, each point represents the entire history of the system). This manifold is equipped with a closed two-form Ω, called the *pre-symplectic structure*. Degenerate directions of Ω are the infinitesimal gauge transformations of the theory and are shown to be integrable. A notion of symmetry can be constructed from this formalism, and thus obtain conserved quantities of the theory. I will discuss classical scalar electrodynamics from this viewpoint, and thus recover symmetries and their respective conserved charges.

Inestabilidades en el espacio-tiempo de Misner
P. Denaro, G. Dotti
FaMAF, UNC

El espacio de Misner es una solución a las ecuaciones de Einstein, que muestra ciertas patologías intrigantes en la estructura de cualquier espacio-tiempo, como la existencia de curvas cerradas temporales en una región no cronal, y un horizonte cronológico, lo cual fija un límite en la predictabilidad.

¿Es posible encontrar estas soluciones en el universo? La respuesta parece ser negativa, y esto se debe a que este espacio-tiempo es inestable: cualquier modificación 'pequeña' de la solución, produce una singularidad en el horizonte cronológico, previniendo que pueda accederse a la región no cronal.

En este trabajo exploraremos la inestabilidad del sistema para campos escalares y electromagnéticos. Este modelo de espacio-tiempo es matemáticamente sencillo, presenta características análogas a las observadas en agujeros negros rotantes (solución de Kerr); por tanto, es adecuado para testear la conjetura de la censura cósmica.

TUESDAY 14

Constructing a balanced equation of motion for particles in general relativity: the harmonic gauge case

Emanuel Gallo[1,2] and Osvaldo M. Moreschi[1,2]

[1] FaMAF, Universidad Nacional de Córdoba, Argentina. [2] IFEG, Conicet, Córdoba, Argentina

In the framework of asymtotically flat spacetimes, we discuss some obstructions for the implementation of balance equations for particles when an harmonic gauge is used.

Gravity as a gauge theory, affine structure and nonlinear realization of symplectic groups

Diego J. Cirilo-Lombardo

Bogoliubov Laboratory of Theoretical Physics,

Joint Institute for Nuclear Research, 141980,

Dubna (Moscow Region), Russian Federation

The aim of the present work is to explore the geometrical structure of the theories of gravitation as gauge theories from the point of view of its underlying symmetries. To this end, the nonlinear re- alization of the extended symplectic Sp(8) group is performed due the isomorphic relation between Sp(8) and the conformal affine group, that characterize gravitation. The obtained nonlinear realized Sp(8) theory is compared with the approach of MacDowell and Mansouri, and the links between them found. We show that: i) the SL(4;R) subgroup of Sp(8) is the mathematical structure which originates the gauge potentials; ii) the ten dimensional Sp(8) manifold, after imposing the standard constraints, de. . . nes a generalization of Kaluza-Klein with the four dimensional spacetime plus a six dimensional space spanned by tensorial coordinates; iv) the structure of the possible geometrical Lagrangians constructed with the Maurer-Cartan forms only can be of the forms (Einstein Hilbert type) or (Eddington type) and not as simple measures due the lack of dynamics for the gauge gravitational . . . fields, as previously conjectured by Chang and Mansouri.

Hidden symmetries and Maxwell fields on type-D vacuum spacetimes

Bernardo Araneda[1,2], Gustavo Dotti[1,2]

[1] FaMAF, Universidad Nacional de Córdoba, Argentina [2] Instituto de Física Enrique Gaviola, CONICET

Using Killing spinors and spin reduction, we can obtain scalar equations for higher spin fields on a curved spacetime. We apply this method to Maxwell fields on Petrov type D spacetimes, with focus on

the Kerr solution, and then we use adjoint operators to construct new solutions of Maxwell equations from solutions of this scalar equation. In this way, we obtain symmetry operators for both equations. We connect our results with symmetries already known, such as the Carter operator associated with the Killing tensor in Kerr spacetime. This work is in the context of the black hole stability problem.

Numerical Simulation of Superradiance in Rotating Black Holes
J. Fernández Tío[1], O. Reula[1]
[1] FaMAF, Universidad Nacional de Córdoba, Córdoba, Argentina

Through Penrose Process it's possible for a particle to extract energy from a rotating black hole. A wave-analogous phenomena it's called superradiance, where after a scattering process, an incident wave may come out of the ergosphere with more energy. We are doing a numerical simulation in order to observe this extraction.

THURSDAY 16

Self-gravitating splitting thin shells
Marcos A Ramirez
FaMAF, Universidad Nacional de Córdoba, Argentina

We present a number of solutions of Einstein equations, in the sense of distributions, involving thin shells, and analyse their stability against separation of their constituents. We consider shells composed of arbitrary non-interacting matter fields in isotropic spacetimes, with or without cosmological constant, and perform a stability analysis against separation of these constituents. There are solutions which are always stable, always unstable, and others that are initially stable and become unstable at certain point of their evolution. For the latter case, a splitting solution can be constructed, which illustrate a lack of uniqueness for the Cauchy problem. Finally, a SMS brane-world setting is considered, and it is shown that these kind of models are typically unstable in this sense.

Charged black holes in scalar-tensor gravity as gravitational lenses
E.F. Eiroa[1,2] and **C.M. Sendra**[1,2]
[1] IAFE (CONICET-UBA), Buenos Aires, Argentina
[2] Departamento de Fisica, FCEN, UBA, Buenos Aires, Argentina.

The fact that black holes distort the spacetime structure in their surroundings, affecting therefore the paths of light rays, makes them interesting to study the situation in which they act as gravitational lenses. In particular, photons passing close enough to the photon sphere can perform one or more turns around the black hole before they emerge and reach an observer. This gives place to two infinite sets of relativistic images (one on each side of the lens) that can be studied by using the strong deflection limit, which corresponds to an asymptotic logarithmic approximation for the deflection angle. In the current standard model of the Universe, a negative pressure fluid called dark energy fills it, representing about 70 % of

its total density, while the other 30 % corresponds to barionic and dark matter. Dark energy can be modeled by a self-interacting scalar field with a potential. In this work, we consider a class of static and spherically symmetric charged black holes in scalar-tensor gravity as gravitational lenses. We carry out the strong deflection limit to obtain analytical expressions for the deflection angle, and the positions and magnifications of the relativistic images. We compare the results obtained with those corresponding to the Reissner-Norström geometry, and we study the Galactic supermassive black hole as a numerical example.

Cosmic evolution of black holes and the second law of thermodynamics
Federico G. Lopez Armengol[1], Daniela Pérez[1,2] and Gustavo E. Romero[3]
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[2] IAR, CONICET, Berazategui, Argentina
[3] IAR, CONICET, Berazategui, Argentina

Macroscopic irreversible processes emerge from fundamental physical laws of reversible character. The source of the local irreversibility observed, seems not to be in the laws themselves but in the initial and boundary conditions of the equations that represent the laws. In this work we propose that the screening of electromagnetic currents by black hole event horizons in the solution of Maxwell's equations determines, locally, a preferred temporal direction for the flux of electromagnetic energy that follows the expansion of the universe. Specifically, we calculate the growth of black hole event horizons due to the cosmological expansion and accretion of cosmic microwave background radiation, for different cosmological models. We find that for the flat, open, and closed Friedmann cosmological models, the quotient of the area of the black hole event horizon and the area of a comoving space-like hypersurface is always larger than one. This implies that for any spacetime event, its causal past and future are not symmetric, causing then a net Poynting flux in the global future direction; the latter is in turn related to the ever increasing thermodynamic entropy.

Sobre el concepto de fuerza entre agujeros negros
M.Chocan[1], M.E Gabach Clement[1]
[1] FaMAF, Universidad Nacional de Córdoba, Córdoba, Argentina

En este trabajo se estudia el concepto de fuerza entre agujeros negros, asociado a singularidades cónicas. El objetivo general es entender la naturaleza de las interacciones entre agujeros negros y como afecta la presencia de una constante cosmológica a dicha interacción. Concretamente, se estudian las ecuaciónes de Einstein-Maxwell con constante cosmológica distinta de cero. En primer lugar asumimos simetría axial, no sólo porque las ecuaciónes y su tratamiento se simplifican, sino que además porque se conoce una definición robusta de fuerza de interacción entre agujeros negros en este contexto. En segundo lugar generalizamos el concepto de fuerza y estudiamos su modificación en presencia de constante cosmológica, al caso sin simetría axial. Se obtienen relaciones geométricas entre los parámetros físicos relevantes en el problema: la carga eléctrica, el área del horizonte de los agujeros, la constante cosmológica y las fuerzas de interacción.

AdS/CFT y Métodos Holográficos a Tiempo Real

P. J. Martínez[1], M. Botta Cantcheff[1], G. Silva[1]

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Se estudió la prescripción de Skenderis y van Rees para el cálculo de funciones de correlación de operadores locales en teorías de campos conformes mediante el uso de métodos holográficos dentro del marco de la dualidad AdS/CFT. Se desea comprobar si la inserción de fuentes sobre las regiones de signatura euclídea de la teoría de gravedad en esta prescripción se corresponden con estados distintos del fundamental o para perturbaciones del equilibrio térmico en la teoría de campos dual. Esta hipótesis se confirma para todas las geometrías estudiadas en el trabajo, aunque los estados generados por este mecanismo pertenecen a un subconjunto menor al de todos los estados posibles de una teoría de campos conforme.

Hyperbolicity of Non-Linear Electrodynamics.

J. Abalos[1], F. Carrasco[1,2], E. Goulart[1,2,3] and O. Reula[4]

[1,2,4] FaMAF, Universidad Nacional de Córdoba, Córdoba, Argentina

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In recent years we have witnessed a great activity in nonlinear generalizations of Maxwell's equations. They are relevant in different areas of physics, in quantum field theories, cosmological models, black holes and in the description of the dark sector are some known examples. Using a geometrical formalism developed by Geroch for the treatment of partial differential equations PDE's, we show that the equations governing the non-linear electrodynamics arising from arbitrary Lagrangian, are symmetric-hyperbolic systems provided certain geometrical conditions are satisfied. Such systems are well possed i.e guarantee the local existence and uniqueness of solutions, as well as the continuity of the initial data; desirable features of any system of equations that point to describe a physical problem. This class of equations have a dispersion relation given determined by null directions of two cones arising from corresponding effective metrics. The condition under which the theories are symmetric hyperbolic is that the intersection of these two propagation cones is non-empty.

Gravitational lens in cosmology

Ezequiel Boero and Osvaldo M. Moreschi

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Instituto de Física Enrique Gaviola (IFEG), CONICET,
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We present the study of general lenses in the case in which the background is a cosmological one; which requires slight modifications in the discussion previously published by our group.

Our equations present new terms that take into account the contribution of spacelike components of

the energy momentum tensor of the matter producing the lens.

We specialize to the case of Robertson-Walker geometries, as cosmological backgrounds.

The axis-symmetric case is studied also in the thin lens approximation.

Our equations generalize the expressions appearing in the literature; in particular, we find correcting factors that have been neglected in other studies.

Bounds for axially symmetric linear perturbations for the extreme Kerr black hole
Iván Gentile de Austria
FaMAF, UNC

We obtain remarkably simple integral bounds for axially symmetric linear perturbations for the extreme Kerr black hole in terms of conserved energies. From these estimates we deduce pointwise bounds for the perturbations outside the horizon. In this talk we will present the details and proofs of the results presented in S. Dain talk.