

Grav09

April 13th - 17th 2009

Córdoba, Argentina

Program as of April 8th, 2009

	Monday	Tuesday	Wednesday	Thursday	Friday
9:10-10:00	Laszlo Szabados	H. Friedrich	Rodolfo Gambini	Jorge Pullin	Robert Beig
10:00-10:30	C O F F E E				
10:30-11:20	Carlos Kozameh	H. Kreiss	F. Lombardo	S. Dain	Esteban Roulet
11:30-12:20	O. Moreschi	O. Sarbach	Diego Mazzitelli	O. Ortiz	Héctor Vucetich
12:20-14:00	L U N C H				
14:00-14:40	Cristián Martínez	Ernesto Eiroa	<i>enjoy</i>	Andrés Aceña	R. Gleiser
14:45-15:25	Horacio Casini	M. Domínguez		<i>your</i>	Gastón Avila
15:30-16:00	C O F F E E				
16:00-16:40	Alex Giacomini	I. Ranea-Sandoval	<i>free</i> <i>afternoon</i>	M. E. Gabach	Marcos Ramírez
16:45-17:25	Fabrizio Canfora	Lucila Kraiselburd			

Participant Institutions

AEI: Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Germany.

CAB: Centro Atómico Bariloche, Argentina.

CECS: Centro de Estudios Científicos, Chile.

FaMAF: Facultad de Matemática Astronomía y Física, Universidad Nacional de Córdoba, Argentina.

IAFE: Instituto de Astronomía y Física del Espacio, Argentina.

IATE: Instituto de Astronomía Teórica y Experimental, Argentina.

JINR: The Joint Institute for Nuclear Research, Russia.

KTH: Stockholm Royal Institute of Technology, Sweden.

LSU: Louisiana State University, USA.

OALP: Observatorio Astronómico de La Plata, Argentina.

RMKI: Research Institute for Particle and Nuclear Physics, Hungary.

UBA: Departamento de Física, Universidad Nacional de Buenos Aires, Argentina.

UM: Universidad Michoacana de San Nicolás de Hidalgo, México.

UNLP: Departamento de Física, Universidad Nacional de La Plata, Argentina.

UR: Facultad de Ciencias, Universidad de la República, Uruguay.

UV: University of Vienna, Austria.

MONDAY

1. **Laszlo Szabados, RMKI: *Quasi-local conserved quantities: A canonical approach***
We recall the main approaches to quasi-local quantities, summarize the quasi-localization program of canonical GR, and discuss some recent results and ideas, such as the boundary conditions and a new functional differential equation for the Hamiltonian boundary term.
2. **Carlos Kozameh, FaMAF: *Center of Mass and Spin in Observation Space***
We define Observation space, a tridimensional space where the motion of Center of mass and intrinsic angular momentum of an isolated system takes place. Equations of motion are derived for these quantities and several particular cases are discussed
3. **Oswaldo Moreschi, FaMAF: *Progress on the particle paradigm in general relativity***
A review of our knowledge of the particle paradigm in general relativity is presented. A summary of the asymptotic structure of isolated systems, along with the physical quantities is introduced first. Next a model of the interior structure of compact objects, based on relaxed field equations is presented. A new derivation of the Lorentz-Dirac equation of motion for charged particles in Minkowski space is introduced. We end with a proposal for the determination of the equation of motion of a binary system in general relativity, which satisfy the balance asymptotic equations.
4. **Cristián Martínez, CECS: *Thermodynamics of charged black holes with a nonlinear electrodynamics source***
We study the thermodynamical properties and the stability of electrically charged black holes arising in the context of a nonlinear electrodynamics theory. The Euclidean action with a appropriate boundary term is computed in the grand canonical ensemble and the Gibbs free energy is determined. The mass, the charge and other thermodynamical quantities are identified. A generalized Smarr formula is also derived and is shown to encode the different asymptotic behaviors of the solutions. The local stability is analyzed by computing the heat capacity and the electrical permittivity and some smaller black hole are shown to be locally stable. Finally, the global stability is studied through the Gibbs free energy to determine whether the electrically charged black hole solutions are most likely than the Minkowski background and it is found that there exists a first order phase transition for a certain class of black holes.
5. **H. Casini, CAB: *Entropy localization and distribution in the semiclassical Black hole evaporation***
The structure of relativistic quantum field theory does not allow defining a localized entropy unambiguously, but rather forces to consider the shared information (mutual information) between two different regions of space-time. Using this tool we analyze the mutual information between the black hole and the late time radiation region. We show that in the semiclassical picture the information is monotonically lost to asymptotic observers no matter the interactions present in the theory. We find extensivity of the entropy as a consequence of a reduction to a two dimensional conformal problem in a simple approximation. We also analyze violations of the entropy bounds in a regularization independent way, and indicate a possible explanation for the finiteness of the black hole entropy when there is a Hagedorn maximal temperature.
6. **Alex Giacomini, CECS: *Vacuum static compactified wormholes in eight-dimensional Lovelock theory***
Exact solutions in eight dimensional Lovelock theory will be presented. These solutions are vacuum static wormhole, black hole and generalized Bertotti-Robinson space-times with nontrivial torsion. All the solutions have a cross product structure of the type $M_5 \times \Sigma_3$ where M_5 is a five dimensional manifold

and Σ_3 a compact constant curvature manifold. The wormhole is the first example of a smooth vacuum static Lovelock wormhole which is neither Chern-Simons nor Born-Infeld. It will be also discussed how the presence of torsion affects the "navigableness" of the wormhole for scalar and spinning particles. It will be shown that the wormhole with torsion may act as "geometrical filter": a very large torsion may "increase the traversability" for scalars while acting as a "polarizator" on spinning particles. This may have interesting phenomenological consequences

7. **Fabricio Canfora, CECS: *Realistic compactifications in Lovelock gravity in vacuum***

Some interesting features of Kaluza-Klein mechanism in Lovelock gravity are described. The possibility to achieve realistic compactification down to four dimensions is discussed. The issue of spontaneous symmetry breaking in vacuum is analyzed.

TUESDAY

8. **Helmut Friedrich, AEI: *Initial boundary value problems for Einstein's field equations and geometric uniqueness***

While there exist now formulations of initial boundary value problems for Einstein's field equations which are well posed and preserve constraints and gauge conditions, the question of geometric uniqueness remains unresolved. For two different approaches we discuss how this difficulty arises under general assumptions. So far it is not known whether it can be overcome without imposing conditions on the geometry of the boundary. We point out a natural and important class of initial boundary value problems which may offer possibilities to arrive at a fully covariant formulation.

9. **Heinz-Otto Kreiss, KTH: *Initial boundary value problems for second order systems of partial differential equations***

Problems concerned with wave propagation in two or three space dimensions are often formulated in terms of systems of wave equations which we have to solve numerically. Examples are Maxwell's equations, elastic wave equations and Einstein's equation of general relativity.

We want to solve the initial boundary value problems for $t \geq 0$ in a finite domain Ω in space with a smooth boundary Γ . At $t = 0$ we give initial conditions and on Γ boundary conditions which are either Diriclet conditions or relations between normal and tangential derivatives.

The most desirable properties for these problems is that there is an energy estimate and that the problem is stable against lower order perturbations. The usual way to prove the existence of an energy estimate is by integration by parts.

This is always possible for the Cauchy problem and problems with Diriclet boundary conditions. In these cases the numerical solution poses relatively few difficulties.

Physical phenomena like glancing or surface waves lead to derivative boundary conditions which are not maximally dissipative. The energy estimate does not give us a detailed understanding about the behavior of the solution near the boundary which is desirable to develop numerical techniques.

By solving a Cauchy problem we can reduce the data such that only the boundary conditions are inhomogeneous. Also, the required stability estimates are such that we can reduce the discussion to halfspace problems. For halfspace problems we will discuss a theory which is based on Fourier and Laplace transform which gives us the desired information about the solution and apply it to the earlier mentioned equations.

10. **O. Sarbach, UM: *On the instability of wormholes supported by a ghost scalar field***

We examine the linear stability of static, spherically symmetric wormhole solutions of Einstein's field equations coupled to a massless ghost scalar field. These solutions are parametrized by the areal

radius of their throat and the product of the masses at their asymptotically flat ends. We prove that all these solutions are unstable with respect to linear fluctuations and possess precisely one unstable, exponentially in time growing mode. The associated time scale is shown to be of the order of the wormhole throat's areal radius divided by the speed of light. Numerical simulations of the nonlinear field equations are also presented which suggest that the wormholes either expand or collapse and form a black hole.

11. **E. Eiroa, IAFE, UBA: *Gravitational lensing by black holes***

In the last few years, a large number of articles on strong deflection gravitational lensing appeared in the literature. When the lens is a black hole situated between the source and the observer, in addition to the primary and secondary images which correspond to photons with small deflection angles, two infinite sets of relativistic images due to photons that make one or more turns around the deflector are obtained. These relativistic images can be studied numerically or by means of an approximate analytical method called the strong deflection limit. In this talk, the topic of gravitational lensing by black holes is reviewed.

12. **M. Dominguez, IATE: *Measuring the dark matter equation of state***

The nature of the dominant component of galaxies and clusters remains unknown. While the astrophysics community supports the cold dark matter (CDM) paradigm as a clue factor in the current cosmological model, no direct CDM detections have been performed. Recently, Faber and Visser (2006) have suggested a simple method for measuring the dark matter equation of state. By combining kinematical and gravitational lensing data it is possible to test the widely adopted assumption of pressureless dark matter. According to this formalism, we have measured the dark matter equation of state using improved techniques and observations and find that is not as expected. In the light of this result, we can now suggest that our understanding of the gravitational processes involved in structure formation is incomplete unless a complete general relativistic analysis is used. We have tested our techniques using simulations and we have also analyzed possible sources of errors that could invalidate or mimic our results.

13. **I. Ranea-Sandoval, OALP: *Gravitational instabilities in Kerr space-times***

In this talk we consider the possible existence of unstable axisymmetric modes in Kerr space times. We describe a transformation that casts Teukolsky's radial equation in the form of a unidimensional Schrödinger equation, and combine the properties of the solutions of this equations with some recent results on the asymptotic behaviour of spin weighted spheroidal harmonics to prove the existence of an infinite family of unstable modes. Thus we prove that the stationary region beyond a Kerr black hole inner horizon is unstable under gravitational linear perturbations. We also prove that Kerr space-time with angular momentum larger than its square mass, which has a naked singularity, is unstable.

14. **Lucila Kraiselburd, UNLP: *The breaking of the Equivalence Principle on theories with α variable***

The *Eötvös* effect (the existence of a small difference in the acceleration of falling bodies of two different composition or structure) is one of the most sensitive indicators of changes in fundamental constants. But Bekenstein (2002) showed that in his theory, using particles as a classic static model of matter, there is no *Eötvös* effect and therefore comply with the Universality of the Free Falling and the Principle of Equivalence. In this talk, we will present results which are different from those that Bekenstein has obtained. Changing his theory, taking more realistic models of matter, using the *TH $\epsilon\mu$* techniques that were developed by Ligman-Lee (1975) and Haugan (1979); very small but measurable effects were found.

15. **Rodolfo Gambini, UR:** *The issue of time in generally covariant theories and Quantum Gravity*

16. **F. Lombardo, UBA :** *The Casimir Effect: an overview on experiments and exact calculations*

In this talk we review the recent experimental and theoretical activity in the analysis of the Casimir effect. After describing the new generation of experiments to measure the Casimir force, we present an overview on its geometry dependence, with particular emphasis on exact calculations for different geometries, like eccentric cylinders, a cylinder in front of a plane and a sphere in front of a plane. We show numerical evaluations of the Casimir interaction energy in several situations of interest, and also present a new approach for conductors with arbitrary shapes.

17. **Diego Mazzitelli, UBA:** *Long range Casimir force induced by transverse electromagnetic modes*

We consider the interaction of two perfectly conducting plates of arbitrary shape that are inside a cylinder with transverse section of the same shape (Casimir pistons). We discuss general properties of the force, in particular its dependence on the geometry of the pistons. We show that, when transverse electromagnetic (TEM) modes exist, the Casimir force decays only as $1/a^2$, where a is the distance between plates. The TEM force does not depend on the area of the plates and dominates at large distances over the force produced by the transverse electric (TE) and transverse magnetic (TM) modes, providing in this way a physical realization of the 1 + 1 dimensional Casimir effect. We briefly describe the influence of extra dimensions on the force between pistons, for the case of quantum scalar fields.

THURSDAY

18. **Jorge Pullin, LSU:** *Loop quantum gravity: overview and some recent results*

19. **Sergio Dain, FaMAF:** *Axisymmetric evolution of Einstein equations*

In this talk I will analyze the role of the mass for axially symmetric vacuum spacetimes. In particular, I will present a gauge for axisymmetric evolution of isolated systems such that the total mass can be written as a positive definite integral on the spacelike hypersurfaces of the foliation and the integral is constant along the evolution. The conserved mass integral controls the square of the extrinsic curvature and the square of first derivatives of the intrinsic metric. I will also discuss possible implications of this result for the global existence problem in axial symmetry and the stability of black holes under axially symmetric perturbations.

20. **Omar Ortiz, FaMAF:** *Numerical evidences for the angular momentum-mass inequality for multiple axially symmetric black holes*

We present numerical evidences for the validity of the inequality between the total mass and the total angular momentum for multiple axially symmetric (non-stationary) black holes. We use a parabolic heat flow to solve numerically the stationary axially symmetric Einstein equations. As a by product our method, we also give numerical evidences that there are no regular solutions of Einstein equations that describe two extreme, axially symmetric black holes in equilibrium.

21. **Andrés Aceña, AEI:** *Convergent null data expansions at space-like infinity of stationary vacuum solutions*

A characterization of the asymptotics of all asymptotically flat stationary vacuum solutions with non-vanishing ADM mass to Einstein's field equations will be presented. The characterization is given in terms of two sequences of symmetric trace free tensors, which determine a formal expansion of the

solution. The main result presented are the necessary and sufficient growth estimates on the sequences to make the formal expansion absolutely convergent in a neighborhood of spatial infinity.

22. **Gastón Avila, AEI: *The Yamabe invariant for axially symmetric two Kerr black holes initial data***

An explicit 3-dimensional Riemannian metric is constructed which can be interpreted as the (conformal) sum of two Kerr black holes with aligned angular momenta. When the separation distance between them is large we prove that this metric has positive Ricci scalar and hence positive Yamabe invariant. This metric can be used to construct axially symmetric initial data for two Kerr black holes with large total angular momentum.

23. **M. E. Gabach, FaMAF: *Cylindrical end in the extreme Bowen-York initial data***

In this talk we show some results and ideas concerning the existence and properties of the Extreme Bowen-York initial data. It has been known for a long time that the Bowen-York family of spinning black hole initial data depends essentially on one, positive, free parameter. But even when the presence of some extreme limit was suggested by numerical experiments, its very existence and main features have not been completely established. The extreme limit corresponds to making the mentioned parameter equal to zero, and it represents a singular limit for the constraint equations. We prove that in this limit a new solution of Einstein constraints is obtained and find an interesting resemblance with other families of black hole initial data, like Kerr and Reissner-Nordstrom. In particular, in this limit one of the asymptotic ends changes from asymptotically flat, to cylindrical. Moreover, the procedure we use in the proof can be easily extended to more general situations! , indicating some common scenario among black hole families, in this extreme limit. Finally, we also discuss different contexts in which these ideas prove to be useful.

FRIDAY

24. **Robert Beig, UV: *On the stationary N-body problem in GR***

25. **Esteban Roulet, CAB:**

26. **Héctor Vucetich, OALP: *Energy conservation and constants variation***

If fundamental constants vary, the internal energy of macroscopic bodies should change. This should produce observable effects. It is shown that those effects can produce upper bounds on the variation of α much lower than those coming from Eötvös experiments.

27. **Reinaldo Gleiser, FaMAF: *Exciting the unstable modes of a negative mass Schwarzschild spacetime***

Schwarzschild spacetime with negative mass M admits linear gravitational instabilities, i.e., solutions of the linearized Einstein equations that grow exponentially in time, satisfy physically appropriate boundary conditions at the singularity and infinity, and have finite energy. Since the Zerilli function does not belong to $L^2(dx)$ - x the radial tortoise coordinate- when $M < 0$, the approach to solving the linear evolution equation by expanding in modes of the radial piece of the Zerilli equation is not possible in this case, and the problems of evolving perturbations and analyzing how the unstable modes can be excited is open. We address these problems and complete the proof of linear instability of the negative mass Schwarzschild spacetime by: (i) finding an appropriate alternative to Zerilli's function, and using it to define the Hilbert space \mathcal{H} where physical perturbations belong, (ii) solving the evolution problem for generic initial perturbation data, and (iii) showing that the previously found unstable modes are actually excited by generic perturbations in \mathcal{H} initially supported away from the singularity.

28. **Nicolás Grandi, UNLP: *K-compactons as thick branes***

Fields with a non-standard kinetic term or "K-fields", allow for soliton solutions with compact support, i.e., compactons. Compactons in 1+1 dimensions may give rise to topological defects of the domain wall type and with finite thickness in higher dimensions. Here we demonstrate that, for an appropriately chosen kinetic term, propagation of linear perturbations is completely suppressed outside the topological defect, confining the propagation of particles inside the domain wall. On the other hand, inside the topological defect the propagation of linear perturbations is of the standard type, in spite of the non-standard kinetic term. Consequently, this compacton domain wall may act like a brane of finite thickness which is embedded in a higher dimensional space, but to which matter fields are constrained. In addition, we find that when gravity is taken into account, location of gravity in the sense of Randall-Sundrum works for these compacton domain walls. When seen from the bulk, these finite thickness branes, in fact, cannot be distinguished from infinitely thin branes.

29. **Marcos Ramírez, FaMAF: *On the dynamics of shells of counter rotating particles***

In this work we study the dynamics of self gravitating spherically symmetric thin shells made of counter rotating particles. We consider all possible velocity distributions for the particles, and show that the equations of motion by themselves do not constrain this distribution. We therefore consider the dynamical stability of the resulting configurations under several possible processes. This include the stability of static configurations as a whole, where we find a lower bound for the compactness of the shell. We analyse also the stability of the single particle orbits and find conditions for "single particle evaporation". In the case of a shell with particles whose angular momentum are restricted to two values, we consider the conditions for stability under splitting into two separate shells. This analysis leads to the conclusion that under certain conditions, that are given explicitly, an evolving shell may split into two or more separate shells. We provide explicit examples to illustrate this phenomenon. We also include a derivation of the thick to thin shell limit for an Einstein shell that shows that the limiting distribution of angular momenta is unique, covering continuously a finite range of values. Finally we deal with Einstein-Vlasov systems which are static, spherically symmetric and whose particles have a single value for their angular momentum. We develop a family of solutions and for some of these we analyse their thin shell limits.