IV Black Holes Workshop, Aveiro University - List of Talks

December 19-20, 2011

Title: *Towards the Einstein-scalar field system with positive cosmological constant in spherical symmetry.*
Speaker: Artur Alho, CMAT Universidade do Minho, Portugal.
Abstract: With the Einstein-scalar field equations with positive cosmological constant in mind, we employ Christodoulou's framework, developed to study the vanishing cosmological constant case, to spherically symmetric solutions of the linear wave equation in de Sitter spacetime and de- rive expected properties: boundedness in terms of (characteristic) initial data, and a Price law establishing pointwise exponential decay to a constant. We will also discuss the relation between the linear case and the full non-linear Einstein-scalar field system.

Title: *Nernst branes in gauged supergravity.*
Speaker: Gabriel Lopes Cardoso, CAMGSD Instituto Superior Técnico, Portugal.
Abstract: We study static black brane solutions in the context of $N = 2$ gauged supergravity in four and five dimensions. Using the formalism of first-order flow equations, we construct novel extremal black brane solutions including examples of Nernst branes, i.e. extremal black brane solutions with vanishing entropy density.

Title: *Energy extraction from rotating black holes.*
Speaker: Vítor Cardoso, CENTRA Instituto Superior Técnico, Portugal.
Abstract: We study the coupling of massive scalar fields to matter in orbit around rotating black holes. It is generally expected that orbiting bodies will lose energy in gravitational waves, slowly inspiralling into the black hole. Instead, we show that the coupling of the field to matter leads to a surprising effect: because of superradiance, matter can hover into "floating orbits" for which the net gravitational energy loss at infinity is entirely provided by the black hole's rotational energy. Orbiting bodies remain floating until they extract sufficient angular momentum from the black hole, or until perturbations or nonlinear effects disrupt the orbit. For slowly rotating and nonrotating black holes floating orbits are unlikely to exist, but resonances at orbital frequencies corresponding to quasibound states of the scalar field can speed up the inspiral, so that the orbiting body "sinks". These effects could be a smoking gun of deviations from general relativity.

Title: *Anti de Sitter black holes and branes in dynamical Chern-Simons gravity: perturbations, stability and the hydrodynamic modes.*
Speaker: Térence Delsate, CENTRA Instituto Superior Técnico, Portugal.
Abstract: In this talk, I will present a 4D model for AdS/CFT where the CFT is in a chirality broken phase, fro the gravity point of view. The chirality breaking term is the dynamical Chern Simons term, i.e. the Pontryagin density coupled to a dynamical scalar field. I will first present a simple extension of the Series method to solve in principle for Quasi Normal Modes of arbitrary number of coupled equations, then I will present the results of the method applied to our specific model. I will further argue that deviation from results without the chirality breaking term involve higher order hydrodynamic quantities.

Title: *Chiral Phase Transition around black holes.*
Speaker: Antonino Flachi, CENTRA Instituto Superior Técnico, Portugal.
Abstract: I will discuss the possibility that chiral phase transitions, analogous to those of QCD, occur in the vicinity of a black hole. If the black hole is surrounded by a gas of strongly interacting particles, an inhomogeneous condensate will form. I will demonstrate this by explicitly constructing self-consistent solutions. These results suggests that no chromosphere will form around evaporating black holes.

Title: *Modified Dispersion Relations: from Black – Hole Entropy to the Cosmological Constant.*
Speaker: Remo Garattini, University of Bergamo.
Abstract: In the context of Modified Dispersion Relations (MDR) we compute black hole entropy for a Schwarzschild black hole using the brick wall model and the effect of Zero Point Energy (ZPE) connected to the cosmological constant generated by the quantum fluctuations of the graviton around a given background. We show that with an appropriate choice of Rainbow's functions connected with MDR the ultraviolet divergences are removed for both the Schwarzschild black hole and for the ZPE, in contrast to what happens in other conventional approaches. A final discussion on the connection of our result with the observed cosmological constant is also reported.

Title: *A five dimensional Newman Penrose and Geroch-Held-Penrose formalism.*
Speaker: Alfonso Garcia-Parrado, CMAT Universidade do Minho, Portugal.
Abstract: A five dimensional version of the NP and GHP formalisms is presented and some applications of them discussed. In particular we define a class of five dimensional type D Einstein spaces and fully classify them. In addition we illustrate how our formalism enables us to integrate the Einstein field equations in some cases and we present the explicit solutions found. Finally we comment about the possible existence of yet unknown black hole solutions within our class.

Title: *Physics of Trans-Planckian Gravity.*
Speaker: Cristiano Germani Ludwig-Maximilians Universitat, Arnold Sommerfeld Center, Munich, Germany.
Abstract: In this talk I will introduce a field theoretical description of a generic theory of gravity flowing to Einstein General Relativity in IR. In this framework, I will show that, if ghost-free, in the weakly coupled regime such a theory can never become weaker than General Relativity. Using this fact, as a byproduct, I will suggest that in a ghost-free theory of gravity trans-Planckian propagating quantum degrees of freedom cannot exist. The only physical meaning of a trans-Planckian pole is the one of a classical state (Black Hole) which is described by the light IR quantum degrees of freedom and gives exponentially-suppressed contributions to virtual processes. In this picture Einstein gravity is UV self-complete, although not Wilsonian, and sub-Planckian distances are unobservable in any healthy theory of gravity.

Title: *Quantum entropy of supersymmetric black holes.*
Speaker: João Gomes LPTHE Paris, France.
Abstract: In this talk I will review recent developments concerning the quantum entropy of supersymmetric black holes in string theory. I will present results on localization of supergravity on $AdS_2 \times S^2$ which allow for an exact computation of the black hole entropy. As an example we show that the microscopic degeneracy of a particular class of black holes, computed from a field theory point of view, precisely agrees with its bulk computation for any value of the charges. These results can be viewed as an instance of exact holography in the context of AdS_2/CFT_1 correspondence.

Title: *Gravitational wave sources in dynamical Chern-Simons gravity.*
Speaker: Leonardo Gualtieri, "Sapienza" University of Rome.
Abstract: Detection of gravitational waves will allow us to study, for the first time, the strong field limit of gravity, where possible deviations from general relativity may show up. A very promising theory which has recenty been proposed is dynamical Chern-Simons gravity, an extension of general relativity in which the Einstein-Hilbert action is modified by adding a parity-violating term which couples gravity to a scalar field. Gravitational waves from astrophysical processes such as black hole oscillations or extreme mass-ratio inspirals, one detected, could enable us to discriminate between general relativity and dynamical Chern-Simons gravity or, at least, to set strong constraints on the parameter space of this theory.

Title: *Regular black holes.*
Speaker: José Sande Lemos, CENTRA Instituto Superior Técnico, Portugal.
Abstract: To have the correct picture of a black hole as a whole it is of crucial importance to understand its interior. The singularities that lurk inside the horizon of the usual Kerr-Newman family of black hole solutions signal an endpoint to the physical laws and as such should be substituted in one way or another. A proposal in this direction is to replace the singular region of the spacetime by a region containing some form of matter or false vacuum configuration that can also cohabit with the black hole interior. Black holes without singularities are called regular black holes. The first regular black hole solution was found in 1967 by Bardeen and since then many interesting variants have been reported. This talk presents, first, new regular black hole solutions within general relativity coupled to Maxwell's electromagnetism and charged matter. We show that there are objects which correspond to regular charged black holes, whose interior region is de Sitter, whose exterior region is Reissner-Nordström, and the boundary between both regions is made of an electrically charged spherically symmetric coat. There are several types of solutions: regular nonextremal black holes with a lightlike matter boundary, regular nonextremal black holes with a timelike matter boundary, regular extremal black holes with a timelike matter boundary, and regular overcharged stars with a timelike matter boundary. The main physical and geometrical properties of such charged regular solutions are analyzed, and it is shown that the lightlike Barrabes-Israel solution of 1991 is recovered from our set of solutions. Second, we analyze the quasinormal mode behavior of regular black holes, in particular the Bardeen black hole, and test for their stability.

Title: *Radiating Gravitational Collapse to Black Holes in 5 Dimensions.*
Speaker: Filipe Mena, CMAT Universidade do Minho.
Abstract: We present some results about the modelling of 5-dimensional gravitational collapse to black holes. The collapsing spacetimes are matched to exterior radiating solutions which, given appropriate data, settle down to the 5-dimensional Schwarzschild solution. [Ref: Mena, Natário, Tod, in Ann. Henri Poincaré, 2010]

Title: *Perturbations and scattering of string-corrected black holes.*
Speaker: Filipe Moura, CMAT Universidade do Minho.
Abstract: We study scattering of minimally coupled massless scalar fields by general spherically symmetric black holes in d dimensions with string-theoretical alpha'-corrections. We then obtain a general formula for the low frequency absorption cross section for every black hole of this kind, which we apply to known black hole solutions. In each case we compare the results for the absorption cross section with the black hole entropy, obtained through Wald's formula.

Title: *A dimensional reduction approach to the Teukolsky equation in higher dimensions.*
Speaker: Andrea Nerozzi, CENTRA Instituto Superior Técnico, Portugal.
Abstract: We present an approach aimed at studying the Teukolsky equation in higher dimensions for space-times with symmetries that allow a dimensional reduction of the problem. In particular we study axisymmetric perturbations of a Tangherlini space-time. For this case the problem can be recast to a four dimensional problem with the introduction of some additional "quasi-matter" that comes from the higher dimensions. We show that using the symmetries of the system it is possible to reduce considerably the number of degrees of freedom of the NP formalism, namely the Ricci scalars related to the matter contribution. In this case we are able to decouple the equations for Ψ_0 and Ψ_4 if we go at one higher order in derivation.

Title: *Astrophysical signatures of theories beyond General Relativity.*
Speaker: Paolo Pani, CENTRA Instituto Superior Técnico, Portugal.
Abstract: During the last century, General Relativity (GR) passed many stringent tests, and is now accepted as the standard theory of gravity. Nevertheless, most experiments can only probe the weak-field regime, while the strong-field sector remains essentially unexplored. In this regime the dynamics of black holes and neutron stars can sensibly differ from GR, with potentially observable effects. We discuss two representative examples: (I) Eddington-inspired gravity, a theory which is equivalent to GR in vacuum but, when coupled to matter, it avoids the formation of singularities in early cosmology and in the stellar collapse; (II) the effects of higher curvature corrections on the structure of neutron stars and their possible imprints.

Title: *Holographic DC conductivities from the open string metric.*

Speaker: Da Wei Pang, CENTRA Instituto Superior Técnico, Portugal.

Abstract: We study the DC conductivities of various holographic models using the open string metric (OSM), which is an effective metric geometrizing density and electromagnetic field effect. We propose a new way to compute the nonlinear conductivity using OSM. As far as the final conductivity formula is concerned, it is equivalent to the Karch-O'Bannon's real-action method. However, it yields a geometrical insight and technical simplifications. Especially, a real-action condition is interpreted as a regular geometry condition of OSM. As applications of the OSM method, we study several holographic models on the quantum Hall effect and strange metal. By comparing a Lifshitz background and the Light-Cone AdS, we show how an extra parameter can change the temperature scaling behavior of conductivity.

Title: *Stable black holes with non-Abelian hair.*

Speaker: Eugen Radu, Carl von Ossietzky University of Oldenburg, Institute of Physics, Oldenburg, Germany.

Abstract: The electric Reissner-Nordstrom black hole may become unstable when embedded in a large gauge group, even without scalar fields. However, this requires the presence of a new lenght scale in the model. The resulting black holes have non-Abelian hair outside the horizon, being thermodynamically favoured over the Abelian black holes. Three different types of configurations are used to illustrate these aspects. These are the Einstein–Yang-Mills–AdS planar black holes, the Einstein–Yang-Mills–Chern-Simons solutions in five spacetime dimensions and the Einstein–Yang-Mills black holes with higher derivative gauge corrections in four spacetime dimensions.

Title: *Inverse scattering construction of dipole black rings.*

Speaker: Jorge Rocha, CENTRA Instituto Superior Técnico, Portugal.

Abstract: It is well known that D-dimensional vacuum gravity with $D-2$ commuting Killing vectors is integrable. For such theories a solution generating technique has been available since it was first presented by Belinski and Zakharov in 1978. This method, which was later improved by Pomeransky, has been successfully used to find new solutions.In this talk I will show how this technique can be employed in six dimensions to generate asymptotically flat dipole black rings in a five-dimensional Einstein-Maxwell-dilaton theory.

Title: *Massive vector fields on the Schwarzschild spacetime: quasi-normal modes and bound states.*

Speaker: João Rosa University of Edinburgh, UK.

Abstract: We study the propagation of a massive vector or Proca field on the Schwarzschild spacetime. The field equations are reduced to a one-dimensional wave equation for the odd-parity part of the field and two coupled equations for the even-parity part of the field. We use numerical techniques based on solving (scalar or matrix-valued) three-term recurrence relations to compute the spectra of both quasi-normal modes and quasi-bound states, which have no massless analogue, complemented in the latter case by a forward-integration method. We study the radial equations analytically in both the near-horizon and far-field regions and use a matching procedure to compute the associated spectra in the small mass limit. Finally, we comment on extending our results to the Kerr geometry and its phenomenological relevance for hidden photons arising e.g. in string theory compactifications.

Title: *Palatini $f(R)$ and $f(R,Q)$ black holes with electric charge.*

Speaker: Diego Rubiera-Garcia, Departamento de Fisica, Universidad de Oviedo, Spain.

Abstract: We study electrically charged black holes in the context of Palatini $f(R)$ and extended Palatini $f(R,Q)$ theories. In the $f(R)$ case we show that in order to obtain solutions deviating from their General Relativity counterparts, nonlinear electrodynamics with non-vanishing trace must be considered. We study the properties of some of these black holes, namely those arising by considering some particular $f(R)$ gravity and nonlinear electrodynamics model. Such properties mainly concern the existence of additional inner horizons and how the curvature singularites may be ameliorated. In the $f(R,Q)$ case we show that Maxwell theory already produces different results from that of General Relativity and thus we study the corresponding Reissner-Nordstrom black holes in this background.

Title: *Gravitational radiation from shock wave collisions in higher dimensions.*

Speaker: Marco Sampaio, Universidade de Aveiro, Portugal.

Abstract: Obtaining reliable estimates for the amount of gravitational radiation produced in transplanckian collisions in TeV gravity scenarios is an important task, to produce meaningful bounds from the LHC data (or other TeV scale experiments). In this talk, I will present a generalization to higher dimensions (arXiv:1105.2298) of a method first studied by D'Eath and Payne, to obtain such an estimate. I will start with a brief motivation for TeV scale gravity models referring the main arguments for using shock waves as a model for the colliding particles. Then I will show how to think about the problem as a perturbative expansion of flat space-time and how information can be extracted in such a framework. Finally I will present the numerical results from first order perturbation theory and will comment on how we are achieving the second order correction.

Title: *Suppression of superkicks in supermassive BBH inspiral.*

Speaker: Ulrich Sperhake, CSIC-IEEC, Barcelona, Spain.

Abstract: We discuss the effect of spin-orbit resonances in the inspiral of supermassive black-hole binaries. Assuming initial alignment of the spin of the more massive black hole with the orbital angular momentum, as predicted for "wet" black-hole systems", we find resonances to align the individual black-hole spins with each other. This results in a statistical reduction of the expected gravitational recoil generated in supermassive BH coalescence and thus provides an explanation why ejection of black holes from their host galaxies does not appear to be a likely consequence of the merger of astrophysical BH binaries.

Title: *Singularities in Classical and Quantum Gravity.*

Speaker: Yasser Tavakoli, Universidade da Beira Interior, Portugal.

Abstract: It is well known that the study of Einstein's equation of general relativity leads to predict the existence of space-time "singularities". Therefore,general relativity is expected to be an incomplete theory due to the existence of such singular solutions to the Einstein's equation; the regions where the classical framework of the theory breaks down and has to be replaced by a 'quantum theory of gravity'. But, our knowledge about the nature of singularity can help us in order to find a well-defined theory of quantum gravity. Classically, the spacetime singularities are not normally expressible by distributions, because of the nonlinearity of the gravitational force; they are characterized by the incompleteness of the geodesics: Important theorems by Penrose, Hawking and Geroch indicate that singularities are quite a general feature of solutions of Einstein's field equations, and not just a consequence of symmetry assumptions. Then, relativistic singularities seem to have a kind of 'stable' character, and to be physically very important. However, there is lack of a generic 'definition' of singular space-time: One would like to have a general criterion for deciding whether a given space-time has singularities and possibly, a classification of them. On the other hand, in the absence of such generic definition, it is rather more difficult to generalize the concept of singularities to the quantum mechanic of spacetime. In this talk, we will discuss such issues and the related open problems in the framework of the classical and quantum theory of gravity. In particular, we will study the status of singularities as endstate of gravitational collapse according to loop quantum theory.

Title: *Dynamical cosmological black holes with varying couplings and their apparent horizons.*

Speaker: Vicenzo Vitagliano, CENTRA Instituto Superior Técnico, Portugal.

Abstract: A two-parameters class of spherically symmetric and time-dependent solutions of scalar-tensor gravity introduced to model space- and time-varying gravitational couplings is analyzed. These solutions are supposed to represent central objects embedded in a spatially at universe. Various types of phenomenology emerge in various regions of the parameter space, including two black hole apparent horizons which form in addition to a cosmological apparent horizon, merge, and then disappear leaving behind a naked singularity. The limit to a static metric and the limit to general relativity are also analyzed.

Title: *Collisions of black holes in higher dimensional spacetimes.*

Speaker: Helvi Witek, CENTRA Instituto Superior Técnico, Portugal.

Abstract: Black holes in four or higher dimensional generic space-times provide an exciting playground to study fundamental physics, reaching from astrophysics to high-energy physics. If the center of mass energy is beyond the Planck scale, gravity is the dominant interaction and it will be insensitive to the particular structure of the particles, implying that the trans-Planckian scattering of particles is well described by BH scattering. This is relevant in the context of so-called TeV gravity scenarios, proposed within extra-dimensional theories of gravity. In this talk we plan to discuss recent results of fully numerical simulations of black hole collisions in more than four spacetime dimensions.

Title: *Acceleration of particles by black hole horizons: kinematic properties and near-horizon geometry.*

Speaker: O.B. Zaslavskii, Kharkov V.N. Karazin National University, Ukraine.

Abstract: A new simple and general explanation of the effect of acceleration of particles by black holes to infinite energies in the center of mass frame is suggested. It is based on kinematics of particles moving near the horizon. This effect arises when particles of two kinds collide near the horizon. For massive particles, the first kind represents a particle with the generic energy and angular momentum (I call them ''usual''). Near the horizon, such a particle has a velocity almost equal to that of light in the frame that corotates with a black hole (the frame is static if a black hole is static). The second kind (called ''critical'') consists of particles with the velocity $v < c$ near the horizon due to special relationship between the energy and angular momentum (or charge). As a result, the relative velocity approaches the speed of light c, and the Lorentz factor grows unbound. Generalization to non-geodesic motion is suggested.

Title: *Black hole dynamics in non-asymptotically flat spacetimes.*

Speaker: Miguel Zilhão, CFP University of Porto, Portugal.

Abstract: Numerical simulations of black hole binaries have typically been performed in "standard" asymptotically flat general relativity. The ability to perform full blown numerical simulations in non-asymptotically flat backgrounds has the potential to attract attention both from astrophysics and high-energy physics. In this talk, we report on recent efforts of our group to perform numerical simulations of black holes in non-symptotically flat space-times, including cylindrical and asymptotically de Sitter spacetimes.
