VII Black Holes Workshop – List of talks and abstracts

Aveiro 18-19 December 2014

Session 1

1. **Growth and decay of scalar clouds outside black holes**

   Vitor Cardoso, CENTRA-IST, Portugal

   The superradiant instability of black holes is an efficient mechanism to constrain the masses of fundamental ultralight fields, turning black holes into particle detectors. In this talk, I will describe how the instability develops in the presence of accretion and gravitational-wave emission.

2. **Black holes as particle detectors: evolution of superradiant instabilities**

   Richard Brito, CENTRA - IST, Portugal

   Black-hole superradiance is a radiation enhancement process that allows for energy and angular momentum extraction from the vacuum, even at the classical level. Various mechanisms (as diverse as massive fields, magnetic fields, anti-de Sitter boundaries, nonlinear interactions, etc...) can confine the amplified radiation and give rise to strong instabilities. Linear studies of the instability have been used to impose strong constraints on ultralight bosons or put intrinsic limits on magnetic fields around rotating black holes. However, very little is known about the development of the instability. In this talk I will discuss a quasi-adiabatic approach to attack this problem by studying the impact of gravitational-wave emission and gas accretion and see whether the nonlinear time evolution accords to the linear intuition.

3. **Kerr black holes with scalar hair**

   Carlos Herdeiro, Universidade de Aveiro, Portugal

   According to the conventional picture that emerged in the 1970s as a corollary of the uniqueness theorems, black holes are extremely constrained objects, determined only by a few global charges. For instance, two black holes with the same total mass and angular momentum must be precisely equal, in sharp contrast with stars. Such simplicity of black holes became immortalized in John Wheeler's mantra "Black holes have no hair". In this talk,I will discuss a novel mechanism that allows black holes to have 'hair' and challenges the standard paradigm. Some possible astrophysical consequences will be addressed.

4. **Kerr-Newman scalar clouds**

Carolina Benone, Universidade Federal do Pará, Brazil

Massive complex scalar fields can form bound states around Kerr black holes. These bound states – dubbed scalar clouds – are generically non-zero and finite on and outside the horizon; they decay exponentially at spatial infinity, have a real frequency and are specified by a set of integer "quantum" numbers (n,l,m). For a specific set of these numbers, the clouds are only possible along a 1-dimensional subset of the 2-dimensional parameter space of Kerr black holes, called an existence line. We make a thorough investigation of the scalar clouds due to neutral (charged) scalar fields around Kerr(-Newman) black holes. We present the location of the existence lines for a variety of quantum numbers, their spatial representation and compare analytic approximation formulae in the literature with our exact numerical results, exhibiting a sometimes remarkable agreement.

5. **On wave propagation in Schwarzschild spacetime**

Dennis Philipp, University of Bremen, Germany

The propagation of (massless) scalar, electromagnetic and gravitational waves on fixed Schwarzschild background spacetime is described by the general time-dependent Regge-Wheeler equation. We transform this wave equation to usual Schwarzschild, Eddington-Finkelstein and Painlevé-Gullstrand coordinates. After separating a harmonic time-dependence the resulting radial equations belong to the class of confluent Heun equations, i.e., we can identify two regular and one irregular singularities. Using the generalized Riemann-scheme we collect properties of all singular points and construct (local) solutions in terms of the standard confluent Heun function HeunC, Frobenius- and asymptotic Thomé series.

We study the Eddington-Finkelstein and Painlevé-Gullstrand cases in detail and obtain in each case a solution that is regular at the black hole horizon. This solution is connected to causal boundary conditions, i.e., purely ingoing radiation at $r = 2M$. To construct solutions on the entire open interval $r \in]0, \infty[$ we give an analytic continuation of local solutions around the horizon. Black hole scattering and quasi-normal modes are briefly considered as possible applications.

6. **Testing black hole superradiance with pulsar companions**

João G. Rosa, Universidade de Aveiro, Portugal

We show that the electromagnetic and gravitational radiation emitted by a pulsar orbiting a rotating black hole can, under certain conditions, be superradiantly scattered off the latter, thus amplifying the signal. We then examine the observational prospects for testing black hole superradiance using pulsar-black hole binary systems.

Session 2

1. **Averaging the average: Morphology transitions in spin precession of black-hole binaries**

   Ulrich Sperhake, DAMTP, University of Cambridge, United Kingdom

   We model the spin evolution in precessing black-hole binaries using post-Newtonian equations of motion. By choosing a particularly suitable set of variables, we are able to average the equations over the precession time scale (rather than just the orbital time scale) and thus arrive at a particularly efficient procedure for determining the spin evolution of binaries as they inspiral from astrophysical separations (~ 1 pc) to the close-to-merger stage. We identify three types of morphologies or "phases" characterized by specific resonance configurations and observe that binaries transition between these phases.

2. **Adiabatic evolution of orbits in Kerr spacetime**

   Ryuichi Fujita, CENTRA - IST, Portugal

   One of the main sources of gravitational waves (GWs) for future laser interferometer space detectors is an inspiral of a stellar mass compact object into a supermassive black hole in the center of a galaxy. The black hole perturbation theory is suitable to describe these extreme mass ratio inspirals (EMRIs) since the mass ratio can be used as an expansion parameter. If the timescale for the radiation reaction is much larger than the one for orbits, the evolution of orbits is characterized by the time-averaged rates of change of the energy, the angular momentum and the Carter constant. Using the post-Newtonian (PN) approximation in the first order black hole perturbation theory, we derive the time-averaged rates of these three parameters at 4PN for the compact object in slightly eccentric and inclined orbits around the Kerr black hole. We examine the region of the parameter space for EMRIs in which our 4PN formula achieves sufficient accuracy to detect GWs by comparing the formula with highly accurate numerical results. We will also discuss convergence properties of the 4PN formula which involves expansions in terms of a small velocity and a small eccentricity of the compact object.

3. **The Shadow of Black Holes**

   Arne Grenzebach, ZARM, University of Bremen, Germany

   In this talk I present how to calculate the shadow of a Kerr-Newman-NUT black hole with a cosmological constant analytically. For this, the existence of (unstable) spherical light rays in a region K is essential because these determine the boundary of the shadow. After transformation to celestial coordinates on the observers sky, the shadow is viewed via stereographic projection as usual. The observer is located at arbitrary Boyer-Lindquist coordinates outside of the horizon.

4. **Light rings as observational evidence for event horizons**

   Caio Macedo, Universidade Federal do Pará, Brazil

   Ultracompact objects are self-gravitating systems with a light ring. It was recently suggested that fluctuations in the background of these objects are extremely long-lived and might turn unstable at the nonlinear level, if the object is not endowed with a horizon. If correct, this result has important consequences: objects with a light ring are black holes. In other words, the nonlinear instability of ultracompact stars would provide a strong argument in favor of the "black hole hypothesis," once electromagnetic or gravitational-wave observations confirm the existence of light rings. Here we explore in some depth the mode structure of ultracompact stars, in particular constant-density stars and gravastars. We show that the existence of very long-lived modes -localized near a second, stable null geodesic - is a generic feature of gravitational perturbations of such configurations. Already at the linear level, such modes become unstable if the object rotates sufficiently fast to develop an ergoregion. Finally, we conjecture that the long-lived modes become unstable under fragmentation via a Dyson-Chandrasekhar-Fermi mechanism at the nonlinear level. Depending on the structure of the star, it is also possible that nonlinearities lead to the formation of small black holes close to the stable light ring. Our results suggest that the mere observation of a light ring is a strong evidence for the existence of black holes.

5. **Signatures of accretion on gravitational and electromagnetic waves from black holes**

   Juan Carlos Degollado, University of Guadalajara, Mexico

   Our goal is to describe the gravitational waves generated by the motion of either small compact bodies or disks of matter in the background of a rotating black hole using the perturbation theory. Specifically, we work with the curvature perturbations within the null tetrad formulations developed by Newman and Penrose. We concentrate on the non rotating black hole case, with dust infalling onto the black hole. We perform the numerical evolution for different initial distributions of the dust and obtain the corresponding gravitational wave. We also consider a charged distribution of particles and describe the combined, electromagnetic and gravitational response.

6. **Radiation from a D-dimensional collision of shock waves – exact results**

   Marco Sampaio, Universidade de Aveiro, Portugal

   The calculation of a reliable estimate for the gravitational radiation emitted in the D-dimensional head on collision of two light-like particles remains as one of the big challenges in higher dimensional gravity. In this presentation I discuss an important step towards the understanding of this problem within the perturbative framework of D'Eath and Payne. We prove rigorously, for the first time, that there is a correspondence between the order of the perturbative expansion and of an angular expansion around the axis of collision, so that the angular dependence completely factorises. We also prove that it is possible to obtain all first order asymptotic metric functions in closed form, resulting in the analytic proof of the (previously) enigmatic result that the first order inelasticity is given by the formula 1/2-1/D. We conclude with some comments on the role of the (recently constructed) Penrose diagram for the problem which clarifies the causal structure of the spacetime and the calculation of the metric functions at higher orders.

Session 3

1. **Sharp bounds on the radius of relativistic charged spheres: Guilfoyle's stars saturate the Buchdahl-Andréasson bound**

   José P. S. Lemos, CENTRA-iST, Portugal

   Buchdahl, by imposing a few reasonable physical assumptions on the matter, i.e., its density is a nonincreasing function of the radius and the fluid is a perfect fluid, and on the configuration, such as the exterior is the Schwarzschild solution, found that the radius r_0 to mass m ratio of a star would obey the bound $r_0/m \geq 9/4$, the Buchdahl bound. He also noted that the bound was saturated by the infinite central pressure Schwarzschild interior solution, i.e., the solution with $\rho_{\rm m}(r) =$ constant, where $\rho_{\rm m}(r)$ is the energy density of the matter at r. Generalizations of this bound in various forms have been studied. An important generalization was given by Andréasson by including electrically charged matter and imposing a different set of conditions, namely, $p + 2p_T \leq \rho_{\rm m}$, where p is the radial pressure and p_T the tangential pressure. His bound is sharp and is given by $r_0/m \geq 9/\left(1 + \sqrt{1 + 3\,q^2/r_0^2}\right)^2$, the Buchdahl-Andréasson bound, with q being the total electric charge of the star. For $q = 0$ one recovers the Buchdahl bound. However, following Andréasson's proof, the configuration that saturates the Buchdahl bound is an uncharged shell, rather than the Schwarzschild interior solution. By extension, the configurations that saturate the electrically charged Buchdahl-Andréasson bound are charged shells. One could expect then, in turn, that there should exist an electrically charged equivalent to the interior Schwarzschild limit. We find here that this equivalent is provided by the equation $\rho_{\rm m}(r) + Q^2(r)/\left(8\pi\, r^4\right) =$ constant, where $Q(r)$ is the electric charge at r. This equation was put forward by Cooperstock and de la Cruz, and Florides, and realized in Guilfoyle's stars. When the central pressure goes to infinity Guilfoyle's stars are configurations that also saturate the Buchdahl-Andréasson bound. It remains to find a proof in Buchdahl's manner such that these configurations are the limiting configurations of the bound.

2. **Entropy of a d-dimensional Schwarzschild thin shell and the Schwarzschild black hole limit**

   Gonçalo Quinta, CENTRA-IST, Portugal

   A d-dimensional static thin matter shell in a Schwarzschild spacetime is studied at the mechanical and thermodynamical levels. By specifying the nature of the spacetime around the shell we are led to a set of equations for the rest mass density and pressure which determine its mechanical behavior. A thermodynamic study of the shell is thus attainable by first calculating the entropy of the shell followed by a thermodynamic stability analysis. The shell is finally taken to its gravitational radius, where we recover the Bekenstein-Hawking entropy of a d-dimensional Schwarzschild black hole.

3. **Gravitational collapse with rotating thin shells and cosmic censorship**

   Jorge Rocha, CENTRA-IST, Portugal

   The study of gravitational collapse is a subject of great importance, both from an astrophysical and a holographic point of view. In this respect, exact solutions can be very helpful but known solutions are very scarce, especially when considering dynamical processes with rotation.

   I will identify a setup in which gravitational collapse of rotating matter shells can be addressed with analytic tools, at the expense of going to higher dimensions and considering equal angular momenta spacetimes. The framework for exact and perturbative studies is developed, relying on a thin shell approximation.

   I will also discuss applications of this machinery to the cosmic censorship conjecture and to constructions of stationary solutions describing matter around rotating black holes.

4. **Radiative gravitational collapse to black holes in local cylindrical symmetry**

   Filipe Mena, Universidade do Minho, Portugal

   We construct an exact model of radiative gravitational collapse in cylindrical symmetry by matching an inhomogeneous dust collapsing spacetime to an exterior which contains gravitational waves and generalises the Einstein-Rosen solution.

5. **Bouncing shells in Anti de Sitter space**

   Alexandre Serantes, University of Santiago de Compostela, Spain

   I will discuss the dynamics of a spherically symmetric thin matter shell, with linear equation of state, in global $AdS_5 \times S_5$. For a finite measure region in parameter space, besides collapsing solutions, exactly periodic solutions where the shell bounces back and forth between two given radii are found. I will comment on the existence, properties and possible holographic interpretation of these bouncing solutions.

6. **Dynamics and thermodynamics of a rotating thin shell in a (2+1)-dimensional asymptotically AdS spacetime and the BTZ slowly rotating black hole limit**

   Francisco Lopes, CENTRA-IST, Portugal

   In this work we study the dynamics and thermodynamics of a rotating thin matter shell in a (2+1)-dimensional AdS spacetime. The thin shell, i.e., a thin ring, divides two vacuum regions, the interior region and the exterior region. The interior is pure AdS, and the exterior is the rotating BTZ spacetime. The matter properties of the shell, such as the energy density, the pressure, and the shell's angular velocity are found casting the shell's energy-momentum tensor in a perfect fluid form. For a slowly rotating shell at a given temperature we study their thermodynamic stability and find the shell's entropy. When the shell is taken to its gravitational radius we show that the shell's entropy is equal to the BTZ black hole entropy.

Session 4

1. **Black holes and wormholes in theories with massive gravitons**

   Michael Volkov, University of Tours, France

   I present a review of the known black hole solutions and also describe the construction of new wormhole-type solutions within the context of the ghost-free bigravity theory.

2. **Traversable Wormholes in Distorted Gravity**

   Remo Garattini, University of Bergamo, Italy

   We consider the possibility that wormhole geometries are sustained by their own quantum fluctuations, in the context of noncommutative geometry and Gravity's Rainbow models. More specifically, the energy density of the graviton one-loop contribution to a classical energy in a wormhole background is considered as a self-consistent source for wormholes. In this semi-classical context, we consider the effects of a smeared particle-like source in noncommutative geometry and of the Rainbow's functions in sustaining wormhole geometries. Implications on topology change are also considered.

3. **Newtonian Wormholes**

   Paulo Luz, CENTRA - IST, Portugal

   A wormhole solution in Newtonian gravitation, enhanced through an equation relating the Ricci scalar to the mass density, is presented. The wormhole inhabits a spherically symmetric curved space, with one throat and two asymptotically flat regions. Particle dynamics in this geometry is studied, and the three distinct dynamical radii, namely, the geodesic, circumferential, and curvature radii, appear naturally in the study of circular motion. Generic motion is also analyzed. A limiting case, although inconclusive, suggests the possibility of having a Newtonian black hole in a region of finite (nonzero) size.

4. **Black ringoids: new higher dimensional black objects with non-spherical horizon topology**

   Eugen Radu, Universidade de Aveiro, Portugal

   We discuss the basic properties of a new class of solutions of Einstein equations reported recently in arXiv:1410.0581 – the black ringoids. These asymptotically flat black objects have an $S^{n+1} \times S^{2k+1}$ horizon topology, being supported against collapse by rotation, with $k+1$ equal magnitude angular momenta.

5. **Local well-posedness in Lovelock gravity**

   Steven Willison, CENTRA-IST, Portugal

   We address the longstanding problem of well-posedness of Lovelock theory. Some applications to black hole physics in high dimensions will be discussed.

6. **The quantum, the geon and the crystal: new insights from non-Riemmanian geometry on modified gravity**

   Diego Rubiera-Garcia, Fudan University, University

   The issue of whether the underlying structure of space-time is Riemannian or not is a foundational aspect of the idea of gravitation as a geometric phenomenon as basic as the number of spatial dimensions. Both are questions to be determined by observation. In this talk I summarize some recent results on modified gravity with non-Riemannian dynamics, where metric and connection are regarded as independent entities (Palatini approach). Specifically, I show that singularity-free solutions with geon structure arise as extensions of the Reissner-Nordstrm solution of GR. This result rises interesting relations between crystalline structures and differential geometries with non-metricity and torsion.

Session 5

1. **Black hole hair in Horndeski scalar-tensor gravity**

   Thomas Sotiriou, University of Nottingham, United Kingdom

   I will show that black holes in shift-symmetric Horndeski theory will generically have a non-trivial scalar configuration and I will discuss the properties of such black holes.

2. **Test particle motion in boson star space-times**

   Betti Hartmann, Jacobs University Bremen, Germany

   Boson stars are globally regular objects that are made of self-interacting scalar fields. Depending on the mass of the scalar field these can be as dense as neutron star or even black holes. In this talk I will discuss the test particle motion of uncharged as well as charged test particles in boson star space-times. The obtained results can be used to understand extreme-mass-ratio inspirals (EMRIs) as well as astrophysical plasmas.

3. **Gauss-Bonnet Boson Stars in aAdS5**

   Jürgen Riedel, LABORES Scientific Research Lab, Germany

   We construct boson star solutions in (4+1)-dimensional Gauss-Bonnet gravity in asymptotically Anti-de Sitter space-time (aAdS) space-time. We study the properties of the solutions in dependence on the coupling constants and investigate in detail their properties. We find that the Gauss-Bonnet correction qualitatively changes the branches of the solutions typically observed for boson stars and that these branches merge for sufficiently large values of the Gauss-Bonnet coupling to a unique branch.

4. **Asymptotically AdS and asymptotically flat Horndeski black holes**

   Adolfo Cisterna Roa, Instituto de Física, Pontificia Universidadad de Católica de Valparaíso

   Asymptotically locally AdS and asymptotically flat black hole solutions are found for a particular case of the Horndeski action. The action contains the Einstein-Hilbert term with a cosmological constant, a real scalar field with a non minimal kinetic coupling given by the Einstein tensor, the minimal kinetic coupling and the Maxwell term. There is no scalar potential. The solution has two integration constants related with the mass and the electric charge. The solution is given for all dimensions. A new class of asymptotically locally flat spherically symmetric black holes is found when the minimal kinetic coupling vanishes and the cosmological constant is present. In this case we get a solution which represents an electric Universe. The electric field at infinity is only supported by ?. When the cosmological constant vanishes the black hole is asymptotically flat.

5. **Reconstructing Static Spherically Symmetric Metrics in General Relativity**

   Sante Carloni, CENTRA-IST, Portugal

   We present a general method to reconstruct static spherically symmetric metrics in General Relativity based on the 1+1+2 covariant approach. This method allows a more complete exploration of the properties of these metrics in the case of a generic fluid and in presence of a scalar field. A number of new exact solutions are reconstructed in these cases.

6. **The interior of black holes with a cosmological constant**

   João Lopes Costa, ISCTE-IUL and CAMGSD-IST, Portugal

   We review recent results concerning the stability of Cauchy horizons in the interior of charged and spherically symmetric black holes, in the presence of a cosmological constant of any sign. Our results suggest that the strong cosmic censorship conjecture might fail in the presence of a positive cosmological constant.

   This is joint work with: Pedro M. Girão, José Natário and Jorge Drumond Silva.

Session 6

1. **Instability of extremal black holes in higher dimensions**

   Akihiro Ishibashi, Department of Physics, Kinki University, Japan

   This talk is based on arXiv:1408.0801. We establish a sufficient criterion for instability of extremal, rotating, asymptotically flat or asymptotically AdS black holes. Our criterion is that the lowest eigenvalue of a certain elliptic stability operator A on a horizon cross section be less than a certain critical numerical value. Thus, one can say that, in a certain sense, instability can be established by just analyzing the vibrations of the horizon itself, which is tremendous simplification. Our method is applicable to all presently known extremal black hole solutions, and also to rotating, extremal asymptotically AdS black holes. For the latter case, our methods show that all such AdS black holes are unstable. Our methods should also apply to prove the same statements about regular black holes sufficiently close to extremal ones.

2. **Stationary Bianchi black brane solutions and Holographic Lattices**

   Kengo Maeda, Shibaura Institute Of Technology, Japan

   We consider a persistent superconductor current along the direction with no translational symmetry in a holographic gravity model. Incorporating a lattice structure into the model, we numerically construct novel solutions of hairy charged stationary black brane with momentum/rotation along the latticed direction. The lattice structure prevents the horizon from rotating, and the total momentum is only carried by matter fields outside the black brane horizon. This is consistent with the black hole rigidity theorem and the superfluid hydrodynamics. We also numerically find a stationary Bianchi black brane solution in the Einstein-Maxwell-dilation theory in which the horizon conveys momentum along the direction with no translational symmetry just outside the horizon, evading the black hole rigidity theorem (PRL 113 (2014) 011601, JHEP 1406 (2014) 064).

3. **Gravity as (gauge theory)^2: from amplitudes to black holes**

   Ricardo Monteiro, Mathematical Institute, Oxford, United Kingdom

   We will discuss the relations between perturbative gauge theory and perturbative gravity, and look at how these relations extend to some exact classical solutions. First, we will review the double copy prescription that takes gauge theory amplitudes into gravity amplitudes. Then, we will see how the relation between the two theories can be made manifest when we restrict to the self-dual theories. Finally, we will see how these ideas can be applied to some exact classical solutions, namely black holes and plane waves.

4. **Chaotic information processing by extremal black holes and a modular discretization of the AdS_2/CFT_1 correspondence**

   Stam Nicolis, CNRS-LMPT Tours, France

   We describe the dynamics of the microstates of extremal black holes by Arnol'd cat maps. These can be shown to realize the isometries of the extremal black hole geometries at both the classical and quantum levels. They exhibit well studied properties of strong arithmetic chaos, dynamical entropy, nonlocality and factorization in the cutoff discretization N, the dimension of the Hilbert space of microstates, which are crucial for fast quantum information processing. We construct, in the process, a new kind of unitary and holographic correspondence, for $AdS_2[N]/CFT_1[N]$, the modular discretization of the near horizon and asymptotic geometry, via coherent states of both the bulk and boundary geometries.

5. **Quantum gravity corrections in Holography**

   João Gomes, DAMTP, University of Cambridge, United Kingdom

   I will review recent results on the computation of finite N effects or quantum gravity corrections in supergravity in the context of AdS/CFT. I will consider two main examples. The first is the exact computation of the entropy of a supersymmetric black hole. I will show how to compute all finite area corrections to the Bekenstein-Hawking entropy and how they conspire to give an integer which is the number of microstates. The second example concerns gravity corrections on AdS4 and their exact matching with the conjectured dual ABJM theory.

6. **On the temperature dependence of the absorption cross section for charged black holes**

   Filipe Moura, Universidade do Minho, Portugal

   We analyze the the low frequency absorption cross section of minimally coupled massless scalar fields by different kinds of charged static black holes, namely the d-dimensional Reissner-Nordstrom solution, the D1-D5 system in d=5 and a four dimensional dyonic four-charged black hole. In each case we show that this cross section always has the form of some parameter of the solution divided by the black hole Hawking temperature. We also verify in each case that, despite its explicit temperature dependence, such quotient is finite in the extremal limit, giving a well defined cross section. This precise explicit temperature dependence also arises in the same cross section for black holes with string corrections: it is induced by string corrections. The low frequency absorption cross section is therefore given in this context as a function of two quantities, one of them the black hole temperature, and not just the horizon area.

Session 7

1. **Non-minimal black hole with regular electric field**

   Alexander Balakin, Kazan Federal University, Institute of Physics, Russia

   We discuss exact static spherically symmetric solution of the non-minimally extended Einstein-Maxwell model, which describes charged black hole with regular electric field. The solution corresponds to the special case for which the non-minimal radius coincides with electric radius. The exact analytic solution for the electric field is finite at the center and has a Coulombian asymptote at infinity. The metric is shown to be regular or singular depending on the total black hole mass.

2. **Nonminimal monopoles of the Dirac type as realization of the censorship conjecture**

   Alexei Zayats, Kazan Federal University, Russia

   In 1969, Penrose formulated the so-called cosmic censorship conjecture, which assumes, in particular, that singularities have to be hidden inside of an event horizon and invisible to distant observers. We discuss a class of exact solutions of a three-parameter nonminimally extended Einstein-Maxwell model, which are attributed to nonminimal magnetic monopoles of the Dirac type. We focus on the investigation of the gravitational field of Dirac monopoles for those models, for which the singularity at the central point is hidden inside of an event horizon independently on the mass and charge of the object. We obtain the relationships between the nonminimal coupling constants, for which this requirement is satisfied.

3. **Strong magnetic fields around black holes**

   Filip Hejda, Charles University in Prague, Czech Republic

   Reviewing the basic facts about construction of "magnetised" Kerr-Newman (MKN) black holes, we focus on their extremal cases. Using generalised framework of Bardeen and Horowitz, we find spacetimes that approximate their geometries in the near-horizon limit. Analysing these results, we conclude that near-horizon description of any extremal MKN black hole can be expressed as near-horizon description of some corresponding Kerr-Newman black hole. This result can be applied to investigation of Meissner effect as well as other phenomena in the near-horizon regime.

4. **On a regular charged black hole with a nonlinear electric source**

   Hristu Culetu, Ovidius University, Romania

   A modified version of the Reissner-Nordstrom metric is proposed on the grounds of the nonlinear electrodynamics model. The source of curvature is an anisotropic fluid with $p_r = -\rho$ which resembles the Maxwell stress tensor at $r >> q^2/2m$, where q and m are the mass and charge of the particle, respectively. We found the black hole horizon entropy obeys the relation $S = |W|/2T = A_H/4$, with W the Komar energy and A_H the horizon area. The electric field around the source depends not only on its charge but also on its mass. The corresponding electrostatic potential $\Phi(r)$ is finite everywhere, vanishes at the origin and at $r = q^2/6m$ and is nonzero asymptotically, with $\Phi_\infty = 3m/2q$.

5. **Extremal rotating black holes in Einstein-Maxwell-Chern-Simons theory: radially excited solutions, non-uniqueness and near horizon geometry**

   Jose Blazquez Salcedo, Oldenburg University, Germany

   We study 5 dimensional black holes in Einstein-Maxwell-Chern-Simons theory with free Chern-Simons coupling parameter. We consider a event horizon with spherical topology, and both angular momenta of equal magnitude. In particular, we study extremal black holes, which can be used to obtain the boundary of the domain of existence. Above a critical value of the Chern-Simons coupling constant we find non-static extremal solutions with vanishing angular momentum. These solutions form a sequence which can be labeled by the node number of the magnetic U(1) potential. As the node number increases, their mass converges to the mass of the extremal Reissner-Nordstrm solution, although the near horizon geometry of the sequence is not changed. Not all near horizon solutions are found as global solutions. Non-uniqueness between extremal solutions and non-extremal ones is also found.

6. **Composite localized field solutions in the Einstein-Yang-Mills theory in AdS spacetime**

   Olga Kichakova, Oldenburg University, Germany

   We construct new finite energy both regular and black hole solutions in Einstein-Yang-Mills-SU(2) theory. They are static, axially symmetric and approach at infinity the anti-de Sitter spacetime background. These configurations are characterized by a pair of integers (m,n), where m is related to the polar angle and n to the azimuthal angle, being related to the known flat space monopole-antimonopole chains and vortex rings. Generically, they describe composite configurations with several individual components, possesing a nonzero magnetic charge, even in the absence of a Higgs field. Such Yang-Mills configurations exist already in the probe limit, the AdS geometry supplying the attractive force needed to balance the repulsive force of Yang-Mills gauge interactions. The gravitating solutions are constructed by numerically solving the elliptic Einstein-DeTurck–Yang-Mills equations.

Session 8

1. **Fishing in a Black Hole**

   José Natário, Instituto Superior Técnico, Portugal

   We show that the equation of motion for a rigid one-dimensional elastic body (i.e. a rod or string whose speed of sound is equal to the speed of light) in a two-dimensional spacetime is simply the wave equation. We then use this equation to study a radial rigid string that has partially crossed the event horizon of a Schwarzschild black hole while still being held from the outside.

2. **Banados-Silk-West effect with nongeodesic particles**

   Oleg Zaslavskii, V. N. Karazin Kharkov National University, Ukraine

   If two particles collide near a black hole, the energy in the centre of mass frame can grow unbounded (BSW effect). This happens if one of particles follows so-called critical trajectories with fine-tuned parameters. It turns out that even under the action of force such trajectories still exist, so the BSW effect survives under weak and reasonable restrictons on the behavior of a force.

   This lends support to the idea that gravitational backreaction does not destroy the BSW effect.

3. **Chiral Gap Effect in Curved Space**

   Antonino Flachi, CENTRA-IST, Portugal

   I will discuss a new type of QCD phenomenon induced in curved space. In the QCD vacuum a mass gap of Dirac fermions is attributed to the spontaneous breaking of chiral symmetry. If the curvature is positive large, the chiral condensate melts but a chiral invariant mass gap can still remain, which we name the chiral gap effect in curved space. This leads to decoupling of quark deconfinement which implies a view of black holes surrounded by a first-order QCD phase transition.

4. **Can a particle detector cross a Cauchy horizon?**

   Benito Juárez-Aubry, University of Nottingham, United Kingdom

   Cauchy horizons, such as the inner horizon in the Reissner-Nordström solution, are well known to exhibit instabilities in classical spacetime dynamics and singularities in quantum field theory. We analyse the response of an Unruh-DeWitt particle detector that falls towards a Cauchy horizon, in terms of the specifics of the horizon, the choice of the quantum state, the specifics of the detector's trajectory, and the smooth versus sharp switching of the detector. Comparisons are made with the response of a detector that falls into a Schwarzschild-like singularity.

5. **Renormalized vacuum polarization of rotating black holes**

   Hugo Ferreira, University of Nottingham, United Kingdom

   Quantum field theory on rotating black hole spacetimes is plagued with technical difficulties. In this talk, I describe a general method to renormalize and compute the vacuum polarization for rotating black holes, exemplifying with the warped AdS3 black hole. I will use a 'quasi-Euclidean' technique, which generalizes the Euclidean techniques used for static spacetimes, and I will subtract the divergences by matching to a sum over mode solutions on Minkowski spacetime. This allows us, for the first time, to have a general method to compute the renormalized vacuum polarization (and the stress-energy tensor), for a given quantum state, on a rotating black hole spacetime.

6. **Nonextensive thermodynamics and stability of black holes**

   Viktor Czinner, Universidade do Minho, Portugal

   Black hole thermodynamics has been actively investigated recently in a nonextensive framework. In this talk I will present a new approach to the problem, where the Bekenstein-Hawking entropy of a black hole is regarded as a nonextensive entropy, and the temperature function of the black hole is derived in a non-standard way to satisfy the zeroth law of thermodynamics. I will discuss the thermodynamical and stability properties of a Schwarzschild black hole in this model.