GRAVITY@PRAGUE 2022 POSTERS

Poster Session 1 (Monday 19/09/2022 14:30-15:30)

1.1 Benjamin Berczi (University of Nottingham):
Gravitational collapse of a quantum field
The behaviour of quantum fields around black holes has been in the forefront of research for almost half a century, since the discovery of Hawking radiation in 1974. However, we still know remarkably little about the details of the evaporation of black holes beyond first order approximations. My poster will introduce our formalism, using which a fully quantum mechanical field can be simulated to collapse into a black hole, and also how the quantum effects can be studied. It is explained how we relate the semiclassical simulations to purely classical ones using a coherent state as the chosen quantum state. Initial results of the quantum effects around the formed black hole will be presented as well.

1.2 Barbora Bezděková (Faculty of Mathematics and Physics, Charles University):
Light rays in axially symmetric spacetimes with plasma
During his stay in Prague (April 1911-July 1912) Einstein concentrated on the construction of a new (relativistic) theory of gravity. Already in its first version he noticed that a light ray propagating close to the Sun will be bent by an amount which can be observed. He also indicated the possible existence of gravitational lenses. Since then the effects of bending and lensing have been studied in a great many both theoretical and observational papers confirming general relativity with a very high precision and limiting significantly various alternative theories of gravity. It was natural to assume that the sources of gravity (of bending) are surrounded by a vacuum; only recently the effects of surrounding media (typically plasma) have been considered. In our contribution, we analyse both gravitational and plasma effects on the light rays propagating in several axisymmetric spacetimes of a physical interest. The deflection angles in vacuum and plasma medium are compared, it is shown how significantly they can differ. In particular, the Kerr and the Hartle-Thorne metrics are discussed, demonstrating the effects of different quadrupole moments of the gravitating source. An approximate analytical formula for the deflection angle in a weak gravitational field is derived for these spacetimes with plasma, and it is compared with some exact results. The inaccuracy arising from an approximate solution is discussed. The light trajectories for several plasma profiles in these spacetimes are obtained and visualised explicitly. In addition, a general formula for the light deflection angle in an axially symmetric spacetime in plasma is given. Furthermore, it is shown how this formula gets modified when it is applied for spherically symmetric spacetimes.

1.3 Calvin Chen (Imperial College London):
A cautionary case of casual causality: diagnosing (a)causality in the EFT of gravity
In recent years, causality has become a popular criterion to distinguish between effective field theories (EFTs) arising from physical and unphysical high-energy theories. A direct way to ensure a given EFT is causal is to demand a lower bound on scattering time delays, which essentially bounds the propagation speed averaged over the entire trajectory. In flat space, this is unambiguously dictated by the Minkowski light cones, but the situation is much more subtle on curved backgrounds. I will make the case that the relevant notion is the so-called infrared causality. This notion of causality will then be applied to the EFT of gravity on spherically symmetric black hole backgrounds. Careful consideration of the regime of validity shows that time delays are never resolvable (in the geometric optics sense), and therefore there is never any observable violation of infrared causality. This is consistent with gravitational positivity bounds.

1.4 Robin Eappen (Astronomical Institute of Charles University):
Formation of early-type galaxies
Studies of stellar populations in early-type galaxies (ETGs) show that the more massive galaxies form earlier and have a shorter star formation history (SFH). In this study, we investigate the initial conditions of ETG formation. The study begins with the collapse of non-rotating post-Big-Bang gas clouds in Milgromian (MOND) gravitation. These produce ETGs with star-forming

timescales (SFT) comparable to those observed in the real Universe. Comparing these collapse models with observations, we set constraints on the initial size and density of the post-Big-Bang gas clouds in order to form ETGs. The effective-radius-mass relation of the model galaxies falls short of the observed relation. Possible mechanisms for later radius expansion are discussed. Using hydrodynamic MOND simulations this work thus for the first time shows that the SFTs observed for ETGs may be a natural occurrence in the MOND paradigm. We show that different feedback algorithms change the evolution of the galaxies only to a very minor degree in MOND. The first stars have, however, formed more rapidly in the real Universe than possible just from the here studied gravitational collapse mechanism.

1.5 Edwin Genoud-Prachex (Goethe University Frankfurt):
Constraining $f(R)$ gravity with the LIGO/Virgo binary neutron star GW170817
Modifications of General Relativity may explain some cosmological observations, such as the acceleration of the expansion of the universe or the homogeneity of the CMB radiation. Interestingly, modified gravities affect the generation of gravitational waves: it is then possible to test these theories with the LIGO/Virgo observations. In this poster, I explain how we can use the event GW170817 to constrain $f(R)$ gravity, that is equivalent to General Relativity plus a scalar field.

1.6 Pawan Gupta (Utrecht University):
Binary dynamics from Einstein-Maxwell theory at second post-Newtonian order using effective field theory The detection of gravitational waves from binary black holes sources has opened the possibility to search for electric charges and "dark"charges on black holes, the latter being candidates for dark matter. This requires theoretical predictions about the effect of charges on the inspiral of binary black holes in order to place constraint on charges. The effects of these charges on the inspiral of binary black holes can be described using Einstein-Maxwell theory. They have previously been derived up to first post-Newtonian (1PN) order, and the results were recently used to place bounds on the charge-to-mass ratio on black holes. Here we use the effective field theory approach with a metric parameterization based on a temporal Kaluza-Klein decomposition with non-relativistic gravitational fields to arrive at the Lagrangian for binary motion under the influence of charges up to 2PN order.

1.7 Jason Joykutty (University of Cambridge):
Zero-damped modes and near-extremal horizons
Quasinormal modes are the gravitational wave analogue to the overtones heard after striking a bell. They dominate the signal observed during the ringdown phase after a dynamical event and are characterised by complex frequencies, which encode oscillation and exponential decay in time. As horizons become extremal, various computations (both analytic and numerical) have shown that in many cases, there exists a sequence of frequencies which become purely oscillatory in the limit and which cluster on a line in the complex plane. These are zero-damped modes and are conjectured to exist generically for near-extremal horizons. The poster briefly outlines results that can be obtained toward resolving this question; for example, one can show that these modes do arise for the conformal Klein-Gordon equation on a class of spherically symmetric black hole spacetimes.

1.8 Petr Kotlařík (ITP, Charles University):
Static thin discs with power-law density profiles
Thin discs are important structures in astrophysics. Whether treated in Newton's theory or in general relativity, in the static and axially symmetric case they generate potential determined by the Laplace equation. Though clear in principle, its solution is only known explicitly for several surface-density profiles. We show how to derive close-form potentials for the densities composed of powers of the radius. The method, due to Conway, rests on the Laplace transform of products of Bessel functions. Finite as well as infinite discs will be included, possibly empty at their centre (i.e. annular) and superposed with a black hole.

1.9 Rosa-Laura Lechuga Solis (Instituto de Ciencias Nucleares, UNAM):
Eternal inflation problem
The eternal inflation problem still remains one of the standard cosmology shortcomings. The problems arise when considering the "quantum fluctuations" on the zero mode of inflaton field in a Hubble time's scale. In the slow-roll picture this means that zero mode of inflaton field could

fluctuate infinitely and inflation would never end. A common mistake in the standard analysis is considering quantum fluctuations as stochastic, we emphasise that quantum fluctuations means uncertanties in the quantities and it lack of stochastic behaviour. As shown before in some reference for explaining the emerge seeds of cosmic structure it is necessary to incorporate continuous spontaneous localization, a modification in standard quantum mechanics which introduces a non-unitary component of evolution of the field. This leads one more time the possibility of facing eternal inflation, we point out that zero mode of inflation field is position independent. Then, it seems to end the problem but there still the possibility due to the others modes, whose physical wavelength is indistinguishable to zero mode, contribute to the problem. In this work we show that even considering those modes the problem of eternal inflation could not exist.

1.10 Krinio Marouda (CENTRA, Instituto Superior Técnico):
Testing GR with dynamical black hole formation
It is expected that Black holes play the role of a cosmic laboratory, used to test our understanding of General Relativity. GR must fail in BH interiors, but also 'near' Planck mass BHs. We explore whether this may also be true during the dynamical collapse of a finite mass black hole. We consider solutions to the Einstein field equations in order to examine departures from general relativity that would be induced by the potential dominance of higher derivative curvature invariants on the dynamics. These arise naturally in effective field theory. Our core question is: 'Can dynamical, astrophysical processes probe the quantum-gravity regime?' In this poster, I will provide numerical results from classical spacetimes with dynamical black hole formation, in an attempt to address this intriguing question.

1.11 David Matejov (Faculty of Mathematics and Physics, Charles University):
Extremal isolated horizons with Λ and the unique type D black holes
We derive the most general form of an induced metric describing the geometry of an axially symmetric extremal isolated horizon (EIH) in asymptotically (anti-)de Sitter spacetime, which complements our previous work. Moreover, we identify corresponding EIH structure in non-accelerating black holes spacetimes of the algebraic type D, that is the famous Kerr-Newman-NUT-(A)dS metric.

1.12 Paola Carolina Moreira Delgado (Jagiellonian University):
Graviton to photon conversion via parametric resonance
I will present the parametric resonance excitation of an electromagnetic field by a gravitational wave. The former is exponentially amplified, while the latter is damped. This mechanism takes place in the framework of Einstein gravity and might happen in different configurations. In a medium with the speed of light smaller than 1, in natural units, the conversion might happen in the first resonance band, while in the vacuum it occurs in the second resonance band.

1.13 Robyn Munoz (ICG, University of Portsmouth):
Simulations of a quasi-spherical collapse and gravito-electromagnetic and Petrov invariant characterisation
We study a quasi-spherical collapsing structure in an inhomogeneous universe with numerical relativity simulations. We set-up fully nonlinear initial conditions by perturbing the ΛCDM model with the comoving curvature perturbation $\mathcal{R}_c$, defined as a 3D sinusoidal. We then have a grid of quasi-spherical overdensities connected through filaments. This is implemented in the synchronous comoving gauge using a dust perfect fluid, then it is fully evolved with the Einstein Toolkit code. We find that the top-hat model is an excellent approximation at the peak of the over density where we find that there is no shear. Additionally we find the electric and magnetic parts of the Weyl tensor to be strongest along and around the filaments respectively, where we see a tendency towards a spacetime of Petrov type D. While the center of the overdensity remains essentially conformally flat, in line with the spherical collapse model, in the surrounding region we see a sort of peeling-off in action, with the spacetime transitioning between different Petrov types and production of gravitational waves.

1.14 Christian Peterson Borquez (CENTRA, Instituto Superior Técnico):
Numerical evolution of Good-Bad-Ugly-F systems as a toy model for hyperboloidal numerical relativity

The numerical solution of a system of hyperbolic PDEs all the way to future null infinity requires the knowledge of asymptotics. The Good-Bad-Ugly-F model is known to mimic the asymptotic properties of Einstein equations in generalized harmonic gauge. In this talk I will present the results of numerical evolution of this system, both in spherical symmetry and full 3D, with the scope of using these ideas to incorporate the hyperboloidal approach in numerical relativity simulations.

1.15 Jury Radkovski (McMaster University):
The amplitudes in Hořava gravity
We compute various tree-level scattering amplitudes in 3+1 projectable Hořava Gravity using Mathematica package xAct and find that they are finite in the $\lambda \to \infty$ limit. The BRST formalism is developed to check the gauge-invariance of the result. We give the argument why, in general, the scattering amplitudes should be finite. The idea is to 'integrate in' the auxiliary field into the Lagrangian, take the limit and check if all the propagators in the new theory are sufficiently well-behaved. We further check that the amplitudes in this modified theory coincide with the amplitudes in the original theory in the $\lambda \to \infty$ limit.

1.16 Sauvik Sen (Shiv Nadar University):
A quantum correction to the asymptotic rotational velocity of spiral galaxies: A MOND study
The picture of modified Newtonian dynamics (MOND) is discussed to study the problem of one-dimensional harmonic oscillator for the choice of various interpolating functions. Further, we introduce a quantum correction to the logarithmic potential of MOND to find an estimate of quantum correction to the asymptotic rotational velocity of spiral galaxies. We further discuss the possible bounds on this velocity.

1.17 Sergi Sirera Lahoz (ICG, University of Portsmouth):
Probing Horndeski modified gravity with gravitational wave ringdown
The obscure nature of dark energy suggests that General Relativity may require modifications at cosmological scales. The addition of one scalar field, generalized by Horndeski gravity, is one of the simplest and most promising options. The growing interest and data on gravitational waves offers an ideal laboratory to test gravity theories. The final phase of a black hole merger is known as the ringdown and is characterized by the so-called quasinormal modes (QNM). We search for Horndeski fingerprints on the QNM, which will be observable by LISA, therefore providing excellent tests for the theory.

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Poster Session 2 (Thursday 22/09/2022 14:30-15:30)

2.1 Sergio Ernesto Aguilar-Gutierrez (KU Leuven):
Towards an 'AdS_1/CFT_0' correspondence from the $D(-1)/D(7)$ system?
We argue that a type IIB Euclidean supergravity solution of the form $R \times S_1 \times T_8$ with imaginary self-dual $F1$ flux through $R \times S_1$ belongs to the chain of $AdS_d \times S_d \times T_{10-2d}$ vacua with (imaginary) self-dual Fd flux, where $d \leq 5$. Such vacua come from the near-horizon of $D(d-2)/D(8-d)$ branes and are supersymmetric for odd values of d. For $d = 1$ we speculate that the hallmark of conformal symmetry for the matrix model dual is a vanishing free energy. The matrix dual was recently constructed by arXiv:2101.01732 by adding matrix interactions coming from strings stretching between the $D(1)$ and $D7$ branes to the IKKT matrix model. We find that the corresponding supergravity solution indeed has vanishing on-shell action. Specific F_5 fluxes need to be switched on as a consequence of (a T-dual version of) the Hanany-Witten effect.

2.2 William Biggs (University of Cambridge):
Black tunnels and hammocks
We constructed the holographic duals to a large N, strongly coupled $\mathcal{N} = 4$ super Yang-Mills CFT defined on a four-dimensional de Sitter-Schwarzschild background. There are two distinct five-dimensional bulk solutions. One, named the black tunnel, is static and possesses two disconnected horizons. The other, the black hammock, contains only one horizon in the bulk. Holographically, these two solutions correspond to two different phases of the CFT living on the de Sitter-Schwarzschild background. The hammock horizon is not a Killing horizon, and hence possesses interesting properties, such as non-vanishing expansion and shear and allowing classical flow along it. The DeTurck method was used in order to attain the black tunnel solutions, whilst the black hammocks were found in Bondi-Sachs gauge.

2.3 Andrea Calcinari (University of Sheffield):
Towards anisotropic cosmology in group field theory
In cosmological group field theory (GFT) models for quantum gravity coupled to a massless scalar field the total volume, seen as a function of the scalar field, follows the classical Friedmann dynamics of a at Friedmann-Lemaitre-Robertson-Walker (FLRW) Universe at low energies while resolving the Big Bang singularity at high energies. An open question is how to generalise these results to other homogeneous cosmologies. We take the first steps towards studying anisotropic Bianchi models in GFT, based on the introduction of a new anisotropy observable analogous to the β variables in Misner's parametrisation. In a classical Bianchi I spacetime, β behaves as a massless scalar field and can be used as a (gravitational) relational clock. We construct a GFT model for which in an expanding Universe initially behaves like its classical analogue before 'decaying' showing a previously studied isotropisation. We support numerical results in GFT by analytical approximations in a toy model. One possible outcome of our work is a definition of relational dynamics in GFT that does not require matter.

2.4 Mattia Cesàro (Instituto de Fisica Teorica, UAM):
$\mathcal{N} = 2$ S-folds Kaluza-Klein spectroscopy
A holographic duality was recently established between a two-parameter family of $\mathcal{N} = 2$ AdS_4 solution of type IIB supergravity in the S-fold class, and the $\mathcal{N} = 2$ two-dimensional conformal manifold (CM) of a certain 3D conformal field theory. In this work, we holographically characterise the Kaluza-Klein (KK) spectrum of this CM. This is achieved by a group theory analysis, which fully determines the algebraic structure of the spectrum, and by computing the $\mathcal{N} = 2$ supermultiplet dimensions at the first few KK levels on a lattice in the CM, using new exceptional field theory techniques. The KK analysis reveals that, at least at large N, the CM is a topological cylinder bounded on only one side: this is in tension with recent refinements of a swampland distance conjecture.

2.5 Daine Danielson (University of Chicago):
Black holes decohere superpositions
We show that if a massive body is put in a quantum superposition of spatially separated states, the mere presence of a black hole in the vicinity of the body will eventually destroy the coherence of the superposition. This occurs because, in effect, the gravitational field of the body radiates soft gravitons into the black hole, allowing the black hole to acquire 'which path' information about the superposition. A similar effect occurs for quantum superpositions of electrically charged bodies. We provide estimates of the decoherence time for such quantum superpositions. We believe that the fact that a black hole will eventually decohere any quantum superposition may be of fundamental significance for our understanding of the nature of black holes in a quantum theory of gravity.

2.6 Saraswati Devi (IIT Guwahati):
Shadow of a black hole in loop quantum gravity and its super-radiance property
We perform the shadow calculation of the loop quantum gravity (LQG) motivated regular black hole (BH) recently proposed by Ashtekar, Olmedo and Singh (AOS BH hereafter). In the process, we also construct the rotating LQG inspired solution of the originally proposed static spherically symmetric AOS black hole by applying the modified Newman-Janis algorithm (NJA). We study the quantum effects on the shadows of both the non-rotating and rotating loop quantum BH solutions. It is observed that the presence of LQG inspired modifications contracts the shadow radius in both the rotating and non-rotating cases and the effect reduces with increase in the mass of the BH. We finally studied super-radiance in rotating AOS background and observed that the super-radiance condition for massless scalar field is identical to that of the Kerr case but the window for energy of scalar field to perform super-radiance in AOS is larger than that in Kerr in the low mass regime. This window becomes narrower and ultimately coincides with Kerr value as mass of the BH increases.

2.7 Sumit Dey (IIT Guwahati) :
Fluid dynamic and thermodynamic interpretation of the Einstein-Cartan field equations with respect to a generic null hypersurface
In the present work, we study the dynamics of a general null hypersurface in the Einstein Cartan (EC) theory generated by the null vector l^a. We see that under a particular relation between the torsion tensor and the null generators called the geodesic constraint, the dynamical evolution of the ingoing expansion scalar corresponding to the auxiliary null field k^a is related to the projection component $G_{ab}k^a l^b$, where G_{ab} is the analogue of the Einstein tensor in spacetime with intrinsic torsion. Similarly, the evolution dynamics of the Hajicek one-form is governed by the component $G_{ab}l^a q^b_c$, where q_{ab} is the induced metric on an orthogonal spacelike cross-section of the null surface. Using the gravitational field equations for the EC theory, we see that above mentioned evolution equations can be provided a thermodynamical and fluid-dynamical interpretation respectively. The relevant thermodynamic and fluid parameters have been properly identified. The dynamics of the Hajicek one-form has been studied in a local inertial frame and its correspondence with Cosserat fluid has been established.

2.8 Serena Giardino (Max Planck Institute for Gravitational Physics):
Thermodynamics of modified gravity
Jacobson showed that the Einstein equations can be derived as an equation of state, leading to the identification of GR with an equilibrium state of gravity and $f(R)$ gravity with a non-equilibrium one. This breakthrough made the relationship between gravity and thermodynamics even more intriguing. I will present a new approach to the thermodynamics of scalar-tensor gravity which is inspired by these results, but follows a starkly different path. Specifically, I will show how a precise description of the approach to equilibrium naturally emerges from using Eckart's first-order irreversible thermodynamics on the effective imperfect fluid describing scalar-tensor gravity. Applications of this framework to cosmology, extensions to different classes of modified theories and the formulation of two complementary pictures based on the notions of temperature and chemical potential all contribute to a new and deeper understanding of the landscape of gravity theories.

2.9 Jani Kastikainen (APC, Université Paris Cité):
Flavored ABJM theory on the sphere and holographic F-functions

In this poster, I will briefly review renormalization group monotones (F-functions) of three dimensional quantum field theories and present our work on this topic. In our work (arXiv:2112.08715), we consider holographic F-functions in a top-down AdS/CFT setup involving flavored ABJM theory on a Euclidean 3-sphere. For quenched flavor, the holographic dual is type IIA supergravity with probe D6-branes. The flavor degrees of freedom are given a mass that drives an RG flow whose IR endpoint is pure ABJM theory. At non-zero mass, we find that the theory on the 3-sphere exhibits a quantum phase transition at a critical value of the sphere radius. The transition corresponds to a topology change in the $D6$-brane embeddings whose dual interpretation is the meson-melting transition. We perform the holographic computation of the free energy on the 3-sphere and we use it to construct various candidate F-functions. We find that while the F-functions of the flavored ABJM theory have the correct UV and IR limits, they are not monotonic. We surmise that the non-monotonicity is related to the presence of the phase transition.

2.10 Mariam Mohamed (Queen Mary, University of London):
Trumpet hypersurfaces in the Schwarzschild spacetime and the cylinder near the trumpet end
The conformal properties of hypersurfaces with a trumpet end are studied in Schwarzschild spacetime. These hypersurfaces are spatial slices of the Schwarzschild metric expressed in terms of a 1-parameter family of analytical coordinates. We show that one can obtain a regular initial value problem at the trumpet end by introducing an alternative formulation of the neighbourhood of timelike infinity. The main tool for obtaining this representation is conformal geodesics. We show that the neighbourhood of the trumpet end can be covered by a non-intersecting congruence of conformal geodesics. These conformal geodesics can be used to construct a conformal Gaussian coordinate system in a neighbourhood of the trumpet end. The constraint and evolution equations are then investigated near the trumpet end.

2.11 Marica Minucci (Queen Mary, University of London):
The Maxwell-scalar field system near spatial infinity
We make use of Friedrich's representation of spatial infinity to study asymptotic expansions of the Maxwell-scalar field system near spatial infinity. The main objective of this analysis is to understand the effects of the non-linearities of this system on the regularity of solutions and polyhomogeneous expansions at null infinity and, in particular, at the critical sets where null infinity touches spatial infinity. The main outcome from our analysis is that the nonlinear interaction makes both fields more singular at the conformal boundary than what is seen when the fields are non-interacting. In particular, we find a whole new class of logarithmic terms in the asymptotic expansions which depend on the coupling constant between the Maxwell and scalar fields.

2.12 Jørgen Musaeus (School of Mathematics, University of Edinburgh):
On the $1/c$ expansion of general relativity
In this poster I present a covariant $1/c$-expansion of general relativity. This approximation has two sectors, a strong and a weak field sector. The strong field sector allows for gravitational time dilation while the weak field sector has absolute time. The weak field sector also has an implicit expansion in G which allows for a connection with post-Newtonian gravity. On the poster I will elaborate more on the differences between the two sectors and explain how their separation is related to the scaling of the matter variables with c. Then I will explore the connection between the weak field sector and the post-Newtonian approximation, and how this connection might bring an interesting new perspective on this already highly developed approximation.

2.13 Marcelo Oyarzo (Universidad de Concepcion):
New black holes and solitons in gauged supergravity and their scalar (quasi-)normal modes
This poster is about novel results regarding the problem of finding BPS solutions in $\mathcal{N} = 4$ $SU(2) \times SU(2)$ gauged supergravity in four dimensions. We construct a new supersymmetric solution in the Abelian sector of the theory which describes a 1/4 BPS soliton. Also we construct black hole solutions in the non-Abelian sector of the theory by considering the meron ansatz for $su(2)$. These configurations, including the planar case, can be identified as a new family of black holes and solitons that lead to an exact integration of scalar probes, even in the presence of a non-minimal

coupling with the Ricci scalar which has a non-trivial profile, leading to an exact expression for the frequencies. We find that the quasi-normal modes do not depend on the radius of the black hole. Therefore, this family of geometries can be interpreted as isospectral in what regards to the wave operator non-minimally coupled to the Ricci scalar. Comments regarding black hole solutions beyond supergravity are also given.

2.14 Shanmugapriya Prakasam (Chennai Mathematical Institute):
Black hole hair removal and positivity of microstate degeneracy
Black holes with identical near horizon geometries must have the same microscopic degeneracies. For K_3 compactification of type IIB string theory, Sen et al studied an apparent counter-example of this and proposed black hole hair removal as the resolution of the puzzle. Motivated by their work, we show hair removal as the resolution of a similar puzzle for $\mathcal{N} = 4$ CHL orbifold models. We also look at the degeneracy of black hole microstates with discrete $\mathbb{Z}_N$ charges for CHL black holes. These degeneracies appear as Fourier coefficients of certain Siegel modular forms. For low charges, we show that the degeneracies of black hole microstates with different $\mathbb{Z}_N$ charges are positive integers.

2.15 Jaime Redondo Yuste (Niels Bohr International Academy):
Dynamics of black hole horizons
The geometry of the black hole horizon during dynamical regimes has important phenomenological consequences. The membrane paradigm offers an intriguing perspective by connecting the evolution of the horizon to the dynamics of a fluid. In this way, physical intuitions built on our knowledge of fluid dynamics can be extrapolated to understand strong gravity phenomena. In this poster, we first review the duality between degrees of freedom of the event horizon and the evolution of a Carrollian fluid. We analyze the evolution equations for a Schwarzschild spacetime perturbed by incoming gravitational waves, as a first step towards describing dynamical scenarios. We evolve numerically these equations, and show some interesting results characterizing the geometry of the event horizon. From the point of view of the dual fluid, we observe a very particular turbulent behavior. We provide an explanation for this result by connecting our results with previous knowledge stemming from the fluid/gravity duality in AdS spacetimes.

2.16 Miika Sarkkinen (University of Helsinki):
Gravitational wave memory and its tail in cosmology
We study gravitational wave memory effect in the FRW cosmological model with matter and cosmological constant. Since the background is curved, gravitational radiation develops a tail part arriving after the main signal that travels along the past light cone of the observer. First we discuss first order gravitational waves sourced by a binary system, and find that the tail only gives a negligible memory, in accord with previous results. Then we study the nonlinear memory effect coming from induced gravitational radiation sourced by first order gravitational radiation propagating over cosmological distances. In the light cone part of the induced gravitational wave we find a novel term missed in previous studies of the cosmological memory effect. Furthermore, we show that the induced gravitational wave has a tail part that slowly accumulates after the light cone part has passed and grows to a sizeable magnitude over a cosmological timescale.

2.17 Serbenta Julius (Center for Theoretical Physics, PAN):
Geodesic bilocal operators in static spherically symmetric spacetimes
In a recent paper a new, unified formalism for geometric optics in general relativity was introduced. Two causally connected, locally flat neighbourhoods are connected by null geodesics originating in one neighbourhood and terminating in the other one. If the curvature along the trajectory is small enough, the 1^{st} order geodesic deviation equation holds. Solutions of the geodesic deviation equation are expressible in terms of four 4×4 bilocal geodesic operators, which in turn can be used to construct all optical observables. We derive the bilocal geodesic operators for all 4-dim static spherically symmetric space-times in two different ways: by variation of curves satisfying the geodesic equation with respect to their initial data, and by solving the geodesic deviation equation together with the use of Killing conserved quantities in a parallel propagated semi-null tetrad. Finally, we apply the results to study optical distance measures in Schwarzschild spacetime.

2.18 Raphaela Wutte (TU Wien):
Hyperbolic energy and gluings of initial data
The question of boundedness of energy from below in general relativity for negative cosmological constant is wide open. For time-symmetric initial data sets, this is the question of whether the energy of asymptotically locally hyperbolic spaces is bounded from below. In this poster, I give a short review of the currently known bounds and describe the construction of asymptotically locally hyperbolic spaces with constant negative scalar curvature, arbitrary high genus, and negative total mass.

2.19 Eivind Jørstad (Perimeter Institute):
Holographic complexity in $\mathbf{dS}_{d+1}$
We study holographic complexity in $(d+1)$-dimensional de Sitter spacetime. More specifically, we adopt the framework of static patch holography and compute holographic complexity using the complexity = volume, complexity = spacetimevolume and complexity = action proposals. We find that the three proposals exhibit a common divergent behaviour. In particular, the holographic complexity diverges with a particular power-law at a (finite) critical time. We regulate the divergence by introducing a cutoff surface near the asymptotic de Sitter boundary, and the subsequent growth of holographic complexity is linear in time.

2.20 Tales Rick Perche (Perimeter Institute):
The geometry of spacetime from quantum measurements General relativity describes spacetime as a 4 dimensional Lorentzian manifold. The spacetime metric allows one to compute space and time separations between events in spacetime. However, general relativity is a classical theory, and it is not expected to be valid in scales where quantum effects become relevant, such as for distances of the order of the Planck length. In regimes where quantum field theory is valid, one can instead define spacetime separations through correlation functions of a quantum field. These can then be accessed via localized quantum measurements, using particle detector models. We then show how particle detectors can be used to define spacetime separations in scales where classical rulers and clocks stop making sense.