Isolated horizons and near horizon geometries, loop quantum gravity, CR structures and spacetimes, Einstein equations and the twistor equation

Conference on the occasion of Jerzy Lewandowski's 60th birthday (Jurekfest)

September 16-20, 2019
Faculty of Physics, University of Warsaw, Warszawa, Poland
`jurekfest.fuw.edu.pl`

Programme

	Monday 16.09	Tuesday 17.09	Wednesday 18.09	Thursday 19.09	Friday 20.09
8:30-8:45	**Registration**				
8:45-9:00	Lalak				
9:00-9:40	Ashtekar	Thiemann	Ma	Penrose	Mena Marugán
9:40-10:20	Chruściel	Barbero	Rovelli	Sparling	Pullin
10:20-10:50	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break
10:50-11:30	Leitner	Sahlmann	Klauder	Assanioussi	Jurkiewicz
11:30-12:10	Newman	Giesel	Louko	Dunajski	Malec
12:10-14:00	Lunch Break	Lunch Break	Lunch Break	Lunch Break	Lunch Break
14:00-14:40	Tafel	Mourão	Bengtsson	Nurowski	Dapor
14:40-15:20	Kijowski	Pawłowski	Alicki	Dobkowski-Ryłko	Bodendorfer
15:20-15:50	Coffee Break	Coffee Break	Coffee Break	Coffee Break	Coffee Break
15:50-16:30	Kowalski-Glikman	Fleischhack	Bahr	Kostecki	
16:30-17:10	Jezierski	Engle	Kisielowski	Mason	
17:10-17:50	Korzyński	Lin	Speziale		
Evening				**Dinner** Goldberg	

Monday, 16.09.2019

Zygmunt Lalak
Opening

Abhay Ashtekar
Compact binary coalescences and the BMS group

Throughout his career Jurek Lewandowski has been drawn to null surfaces, as they feature prominently in general relativity as non-expanding horizons, in the Trautmann–Bondi approach to gravitational waves, and as boundaries $\mathscr{I}^{\pm}$ in Penrose's conformal completion of asymptotically flat space-times. As an example of the science inspired by 3 decades of interactions with Jurek, I will focus on $\mathscr{I}^{+}$ that serves as the natural home for waveforms used by the LIGO/Virgo collaboration to detect compact binary coalescences (CBCs), estimate the parameters of the binaries, and test general relativity. It turns out that key geometrical structures at $\mathscr{I}^{+}$ associated with the BMS group are overlooked by the gravitational wave community at large. I will explain how these structures can be used as powerful tools to test the accuracy of waveforms in the template banks, and comment on the subtle issue of angular momentum in presence of gravitational waves.

Piotr Chruściel
Positivity of energy for asymptotically hyperbolic manifolds

I will sketch the proof of positivity of total energy for asymptotically hyperbolic Riemannian manifolds, in all dimensions.

Felipe Leitner
About the Kohn–Dirac operator on CR manifolds

CR geometry is a parabolic geometry, which naturally appears in complex analysis and is closely related to conformal geometry of spacetimes via the Fefferman construction.

I will introduce in my talk spinor fields on CR manifolds and discuss a kind of Dirac equation. I present concrete computations and lower bounds for the spectrum of the Dirac operator. In the limiting case some kind of twistor equation arises. We solve some special cases of this overdetermined equation. Finally, I will discuss vanishing results for harmonic spinors and obstructions to positive Webster curvature. The vanishing is related to Kohn–Rossi cohomology groups.

Ezra T. Newman
Standard classical mechanics sitting in standard classical GR

Approximately 60 years ago, Hermann Bondi took the major step in the study of gravitational radiation of introducing the use of null surfaces as coordinates for the study and integration of the Einstein equations. This led to the well-known Bondi mass loss theorem. In Bondi's approach to the integration procedure, he used special null surfaces (now referred to as Bondi null surfaces) where the null generators possessed (in general) non-vanishing asymptotic shear – the free radiation data. The use of this Bondi strategy over the years has become almost sacrosanct – being the central approach in almost all discussions of gravitational radiation issues. It led to the idea of an asymptotic symmetry – the BMS group. Eventually Bondi's description of null infinity became elegantly formalized via Penrose's future null infinity and associated structures. However recently an alternative picture of null infinity has been developed – now based on the (strong) similarity of the "null surfaces" to those of flat-space near null infinity. The new "null surfaces", that are now asymptotically shear-free, are very different from the Bondi surfaces. These surfaces are as similar as possible to flat-space light cones near infinity. Totally new structures – e.g., the geometric asymptotically shear-free null geodesic congruences and even the physical classical equations of motion, now appear in this new picture. The Bondi–Sachs Energy-Momentum conservations laws remain but are augmented by angular momentum (orbital and spin) conservation laws – with other results, e.g., the Abraham–Lorentz–Dirac Radiation Reaction Force.

Jacek Tafel

The Penrose inequality for the perturbed Schwarzschild initial data

We investigate the Penrose inequality $E^2 - p^2 \geq |S_h|/16\pi + 4\pi J^2/|S_h|$ for the Schwarzschild initial data with a small addition of the axially symmetric exterior curvature. For maximal data the inequality is preserved and it is saturated only for data related to special sections of the Schwarzschild spacetime. For nonmaximal data we prove the inequality in generic case.

Jerzy Kijowski

Essence of gravity theory and Einstein's attempts to unify it with electromagnetism

I present a new geometric structure which is well adapted to description of gravity. The new approach to general relativity theory, based on this structure, implies:
1) necessity of the cosmological constant already on the fundamental level (Einstein considered introduction of the cosmological constant as the "most important error which he ever committed").
2) unification of gravity with electromagnetism (Einstein considered gravitation as the "theory of a symmetric tensor g" and electromagnetism as the "theory of an antisymmetric tensor f". In 1925 he tried to propose a unification, just considering a non-symmetric metric "g+f", which was entirely unsuccessful).
3) necessity of a new type of matter (black matter???).

Jerzy Kowalski-Glikman

Semiclassical quantum gravity and quantum deformed effective theories

In my talk I will argue that there might exist a semiclassical limit of quantum gravity, in which particles and fields are described by an effective theory, similar to the theory of gravity in 2+1 dimensions. There are phenomenological signatures of such theory that might be detectable experimentally.

Jacek Jezierski

Geometry of null hypersurfaces

We discuss geometry of null surfaces (and its possible applications to the horizons, null shells, near horizon geometry, thermodynamics of black holes).

Mikołaj Korzyński

Weighing the spacetime along the line of sight

I will present a new method of probing the spacetime curvature using only optical observations (astrometry). The method is based on gravitational light bending and uses gravitational lensing as well as parallax effect to measure the curvature along the line of sight. I will also discuss briefly its possible applications.

Tuesday, 17.09.2019

Thomas Thiemann

Quantum cosmological backreactions

Quantum Gravity effects at action during the Planck era could have left fingerprints in temporary cosmological data. Since such fingerprints could be very sensitive to the details of the quantum fate of the classical singularity it would be desirable to treat the quantum theory as precisely as possible. In this talk we apply the framework of space adiabatic perturbation theory (SAPT) in order to capture quantum backreactions between the homogeneous quantum background and the inhomogeneous quantum deviations from it to second order in the latter. The formalism yields quantum corrections to the effective homogeneous contribution of the Hamiltonian constraint which can be computed systematically and to any order in the adiabatic parameter. We will present the results for the lowest order corrections and discuss the challenges that one meets when applying SAPT in quantum field theory.

Fernando Barbero

The geometric exegesis of the Dirac algorithm

I will review the geometrical interpretation of the Dirac algorithm for constrained dynamical systems and field theories. Although the justification of the method proposed by Dirac to find the Hamiltonian formulation for singular systems is clear from a dynamical point of view, a geometric perspective is also very helpful, especially when dealing with field theories defined in bounded spatial regions. As we will show, by recasting Dirac's "algorithm" in a geometric form it is possible to avoid the direct computation of Poisson brackets and solve a number of subtle issues related with the inversion of the symplectic form.

Hanno Sahlmann

Walking in Jurek's garden

Kristina Giesel

Reduced loop quantum gravity with scalar fields

In this talk we will present models that use scalar fields as reference matter in order to obtain the reduced phase space of General Relativity that will be taken as the starting point for quantization in the framework of loop quantum gravity. We will focus on two models one with one scalar field in which one obtains a partial reduction with respect to the Hamiltonian constraint only and one with four scalar fields and analyze the properties of the the quantum theories of these models. Furthermore, we will discuss in which sense these models allow a comparison between reduced and Dirac quantization.

José Mourão

Non-uniqueness of quantization, complex time evolution and generalized coherent state transforms

Space of quantizations/quantization ambiguity:
From the rather messy quantization ambiguity of a phase space M with a real polarization (or, equivalently, a maximal set of independent local preferred real observables in involution) one gets a very nice, infinite dimensional, symmetric space of Kähler quantizations. This is done, in geometric quantization, by allowing the preferred local observables (defining a polarization) to be complex-valued. If the associated polarization is appropriately nondegenerate, i.e. Kähler, than there is no problem of reality conditions.

Geometry on the space of quantizations and coherent state transforms:
Also, it becomes easier to study the quantization ambiguity as different Kähler quantizations can be linked with a geodesic (with respect to the natural Mabuchi metric on the space of Kähler quantizations) or a imaginary time canonical transformation. By appropriately lifting these geodesics to the quantum bundle one gets integral transforms relating different quantizations, the generalized coherent state transforms or Kostant–Souriau–Heisenberg (KSH) transforms. The usual coherent state transforms correspond to $M = T^*G$, where G is a Lie group of compact type, and to geodesics starting from the real vertical (or Schrödinger) polarization (which can be considered a point in the boundary of the space of Kähler polarizations) to the standard, bi-invariant, Kähler polarization.

Tomasz Pawłowski

On the dynamics of loop quantum universe

Christian Fleischhack

Uniqueness

I will review some (i.e., significantly less than 60) uniqueness results in loop quantum gravity, focusing on those that are related to Jurek.

Jonathan Engle

Uniqueness of kinematics and minimal dynamics in loop quantum cosmology

This talk summarizes some results from the last few years, done in collaboration with Hanusch, Thiemann, and Vilensky, on the uniqueness of both kinematics and dynamics in loop quantum cosmology. Besides basic physical principle, only two assumptions are required: (1.) that the theory share the same algebra of elementary operators as loop quantum gravity, reduced to the cosmological context, so that it is a 'loop quantum cosmology', and (2.) that the number of terms, naturally defined, in the quantum Hamiltonian constraint be 'minimal' – what we call the 'minimality criterion'. The model of quantum cosmology thereby selected is precisely that introduced by Ashtekar, Pawłowski, and Singh in 2006, including the same quantum Hamiltonian constraint with exactly the same ordering.

In addition, we give a parametrization of the possible quantum Hamiltonian constraints when minimality is removed. In order to define the action of dilations in the quantum theory, we also introduce, using canonical quantization techniques, a new prescription for implementing certain non-canonical transformations as a flow on the space of quantum operators.

Chun-Yen Lin

Elementary relational observables with quantum reference frames

I will provide an exposition on an approach of quantum reference frames, which serves to extract exact physical Schrödinger evolutions from any timeless canonical quantum gravity theory governed by a set of rigging maps. These derived evolutions are described by a special form of relational Dirac observables – the elementary relational observables – built on a quantum notion of Cauchy surfaces each specified by a set of reference quantum fields' eigenvalues. Deploying the idea of relational dynamics at the purely quantum level in this way, the approach has several outstanding features: (1) a fundamental principle leading to a universal computation algorithm using only the rigging map elements and applicable to the full theories and simplified models alike; (2) the explicit covariance in the quantum level among the elementary relational observables, which enjoy frame independent algebra and the eigenbases for the expansions of a physical state into the Schrödinger wavefunctions in the corresponding frames; (3) a unification between the Dirac and path-integral approaches under the algorithm, which in the context of LQG implies a spinfoam formulation of the Schrödinger propagators, with the quantum reference frames appearing as a new type of vertices associated with the reference quantum fields.

Wednesday, 18.09.2019

Yongge Ma

Isolated horizon entropy in loop quantum gravity

The quasi-local notion of isolated horizon was proposed in order to formulate the horizon of a black hole by phase space functions which can be quantized. By the isolated horizon condition, the entropy of the horizon can be calculated in the framework of loop quantum gravity. This talk is devoted to review two different approaches to calculate the entropy of isolated horizon with certain symmetry, namely the Chern–Simons theory approach and the BF theory approach. Some ideas to describe the microscopical degrees of freedom of a general isolated horizon will also be discussed.

Carlo Rovelli

Dark matter from quantum gravity

I will give some detail on the current effort to study the end of the life of the black holes and their transition to white hole.

John Klauder

The real quantum gravity

Canonical quantization is not well suited to quantize gravity, while affine quantization is. For those unfamiliar with affine quantization the talk will include a primer. This procedure is then applied to deal with three nonrenormalizable, field theoretical, problems of increasing difficulty, the last one being general relativity itself.

Jorma Louko

Second law protection theorem for Lorentz-violating black holes

Black holes in Lorentz-violating theories of gravity have been argued to violate the second law of thermodynamics by perpetual motion energy extraction. We analyse the possibility of such energy extraction in classical Penrose splitting processes in which the energy budget of incoming and escaping particles is defined with respect to time translations at an asymptotically flat infinity. We show, in a spherically symmetric setting with two species of particles in geodesic motion, that such energy extraction cannot happen in any Lorentz-violating theory in which gravity remains attractive, in the sense of a geometric inequality that we describe. This inequality is satisfied by all known black hole solutions to Einstein–æther and Hořava theories of gravity.

Based on R. Benkel, J. Bhattacharyya, J. Louko, D. Mattingly and T.P. Sotiriou, Dynamical obstruction to perpetual motion from Lorentz-violating black holes, Phys. Rev. D 98, 024034 (2018) [arXiv:1803.01624 [gr-qc]], and on work in progress with Paul Ezra and William Smith.

Ingemar Bengtsson

A discrete structure in Hilbert space

One thing that Jurek and I have in common is (I suppose) that when we were young we studied Penrose's combinatorial approach to space-time: Try to build space-time and quantum mechanics from discrete things to be found inside them. Jurek has done great work on space-time. I will describe a discrete structure that is (conjecturally) present in all finite dimensional Hilbert spaces. There are no grand conclusions yet, but there are fascinating connections to an unsolved problem in number theory.

Robert Alicki

Superradiance of quantum fields: From dry friction to black hole radiation

A quantum field weakly coupled to the rotating heat bath is studied in the framework of quantum Markovian master equation for the field's non-unitary time evolution. The bath's rotation induces population inversion for the field's low-energy modes. For bosons, this leads to superradiance, an irreversible process in which some of the bath's kinetic energy is extracted by stimulated emission and can amplify the incident waves. The wide range of possible applications is briefly discussed including rotating black holes, heating of upper stellar atmospheres, dry friction or triboelectricity. In more general terms superradiance can explain the quantum origin of singularities in purely classical theories like electrodynamics, (magneto-) hydrodynamics or general relativity. Such singularities can be visualized as macroscopic manifestation of particle-wave duality in quantum world. Namely, under specific conditions classical description in terms of macroscopic waves breaks down and must be replaced by the kinetic theory for the associated (quasi) particles.

References:
R. Alicki and A. Jenkins, Ann. Phys. (NY) 395, 69 (2018).
R. Alicki, Entropy 21, 705 (2019).
R. Alicki and A. Jenkins, https://arxiv.org/abs/1904.11997v1.

Benjamin Bahr

Operator spin foam models: coarse graining and entanglement entropy

Marcin Kisielowski

On the relation between loop quantum gravity and spin-foam models

My work with Jerzy Lewandowski focused on the problem of finding a relation between loop quantum gravity and spin-foam models. It has been conjectured that the spin-foam theory is a covariant formulation of loop quantum gravity but precise link between the theories is an open problem. Engle, Pereira, Rovelli, Livine constructed a spin-foam model whose boundary structure is compatible with the structure of some loop quantum gravity states. Our first work (in collaboration with Wojciech Kamiński) was an extension of their model to all loop quantum gravity states. While these results bring the theories closer, they do not close the debate. A direct relation would require a construction of one theory from the other. We have recently made a step in this direction by deriving a spin-foam model from the canonical loop quantum gravity coupled to massless scalar field. In my talk, I will present our two results: the generalization of the EPRL model and derivation of a spin-foam model from a model of loop quantum gravity.

Simone Speziale

The asymptotic analysis of the lorentzian KKL vertex of arbitrary valence

The spin foam formalism provides covariant transition amplitudes for loop quantum gravity in the form of a state sum model. Most work currently uses the simplicial EPRL vertex amplitude, which is dominated in the semiclassical limit by exponentials of the Regge action. Jurek's important contribution to this formalism was to show with Kamiński and Kisielowski how the EPRL definition can be generalized to provide transition amplitudes to arbitrary spin network states, and not just the simplicial 4-valent ones. In this talk I will present new results on the asymptotic analysis of the Lorentzian KKL vertex in non-simplicial cases. This turns out to include again exponentials of the Regge action, but a certain class of discrete geometries more general than Regge's appear. We will then comment on some implications.

Thursday, 19.09.2019

Sir Roger Penrose

The palatial twistor approach to Einstein lambda vacuums

For some four decades, a major obstacle to the development of twistor theory, as an approach to fundamental physics, has been the absence of a satisfactory solution to the "googly problem" whereby right-handed (i.e. self-dual) solutions of Einstein's vacuum equations might be expressible within the conventional left-handed twistor framework. However, a recent development appears to provide a way of resolving the googly issue by encoding general solutions of the Einstein Lambda-vacuum equations in terms of a non-commutative twistor algebra (palatial twistor theory), obtained via a geometric quantization procedure, and constructed directly from freely chosen generating functions of an unusual type.

George A.J. Sparling

The interplay of symplectic and projective geometry in the context of plane wave spacetimes

I will discuss properties of null geodesics in spacetime, centered around the geometric understanding of the Sachs equations of general relativity and Penrose limits, I will use the languages of projective, symplectic and complex geometries. A key role is played by perhaps surprising applications of generalizations of the idea of a cross-ratio and the associated generalizations of the Schwarzian. This is joint work with Jonathan Holland.

Mehdi Assanioussi

Graph coherent states in loop quantum gravity

We present the construction of a new complete family of coherent states, defined in loop quantum theories. The realization of these coherent states is based on the notion of graph change. We illustrate the general construction with an example of graph change, considered in both cases of Abelian and non-Abelian gauge theories. The obtained coherent states take the form of an infinite superposition of basis network states with different graphs. We further discuss some properties of these states, and their possible role in the analysis of graph-changing quantum dynamics.

Maciej Dunajski

Conformally isometric embeddings and Hawking temperature

I shall discuss some necessary and sufficient conditions for existence of a locally isometric embedding of a Ricci-flat Riemannian four-manifolds in conformally-flat five-manifolds. There is some interesting maths – the obstructions arise from a prolongation connection – as well as physics: the Hawking temperature of the Schwarzschild metric agrees with the Unruh temperature measured by an observer moving along conformal circles in five dimensions. This is based on a joint work with Paul Tod.

Paweł Nurowski

Twistor geometry of rolling bodies

Denis Dobkowski-Ryłko

Isolated horizons, near horizon geometries and the Petrov type D equation

3-dimensional null surfaces that are Killing horizons to the second order are considered. They are embedded in 4-dimensional spacetimes that satisfy the vacuum Einstein equations with arbitrary cosmological constant. Internal geometry of 2-dimensional cross sections of the horizons consists of induced metric tensor and a rotation 1-form potential. It is subject to the type D equation. The equation is interesting from both, mathematical and physical points of view. Mathematically it involves geometry, holomorphic structures and algebraic topology. Physically, the equation knows the secret of black holes: the only axisymmetric solutions on topological sphere correspond to the the Kerr / Kerr–de Sitter / Kerr–anti de Sitter non-extremal black holes or to the near horizon limit of the extremal ones. In case of the bifurcated horizons the type D equation implies another spacial symmetry. In this way the axial symmetry may be ensured without the rigidity theorem. The type D equation does not allow rotating horizons of topology different then that of the sphere (or its quotient). That completes a new local no-hair theorem. The type D equation is also an integrability condition for the Near Horizon Geometry equation and leads to new results on the solution existence issue. The NHG equation is the equation of extremal isolated horizons (Killing horizons to the 1st order). We present also the second equation satisfied by the geometry of IHs if they admit an embedding as extremal Killing horizons. The extremal horizons equations are important for the black hole existence/uniqueness issues.

Ryszard P. Kostecki

Geometrisation of quantum theory beyond pure states and Hilbert spaces

The sector of quantum mechanics described by pure states (i.e., vectors in Hilbert space) can be reformulated in terms of Kähler manifolds, with symplectic and riemannian structures corresponding to unitary (causal) and statistical (inferential) parts of a theory. Under generalisation to density matrices, and ultimately to normal states on arbitrary W*-algebras (i.e., C*-algebras with Banach preduals), the Kähler structure is no longer available. It turns out that the description and generalisation of quantum theory in the latter case can be provided using a wide class of relative entropies (for the statistical part) and Banach Lie–Poisson structures (for the causal part). The relative entropies not only generate a wide class of generalised quantum measurement prescriptions (including projective vector state reduction and partial trace as special cases), but also induce a class of Codazzi (and associated Weyl) structures on the state spaces, which become locally hessian under an additional postulate of local flatness. I will discuss the above geometrisation programme, focusing on general outlook, new results, and open problems.

Lionel Mason

Gravitational scattering on plane waves and the double copy

Joshua Goldberg

Memoir

Friday, 20.09.2019

Guillermo Mena Marugán

Primordial fluctuations in loop quantum cosmology

One of the most successful areas of development of Loop Quantum Gravity is the application to Cosmology. In this context, the study of quantum geometry effects on the very early Universe is an exciting challenge, exploring the possibility that they might have left observable traces. We revisit this issue adopting the hybrid approach, based on a canonical description of the ensemble formed by the background cosmology and the perturbations, as well as on the use of combined techniques inspired by Loop Quantum Cosmology and Fock spaces.

Jorge Pullin

Recent results in spherically symmetric loop quantum gravity

We summarize several results on spherically symmetric loop quantum gravity we have obtained over the last few years.

Jerzy Jurkiewicz

Definition of holonomies in the model of causal dynamical triangulations

We discuss a definition of the parallel transport of a vector on a 4D fractal Euclidean Riemannian manifold. We apply this definition to the case of a simplicial manifold, typical for the model of Causal Dynamical Triangulations. We show that invariant properties of the macroscopic closed holonomy loop are fully consistent with the Haar measure on the SO(4) group.

Edward Malec

Stationary tori in general-relativistic hydrodynamics: recent developments, their applications, open questions

I shall report recent results, obtained in Kraków, on stationary fluid disks/tori around spinless or spinning black holes. I shall focus on new rotation laws, that include a general-relativistic (GR) version of the familiar Keplerian rotation law. Interestingly, these GR Keplerian laws describe quite adequately a phase in recent numerical simulations of two coalescing neutron stars. This process leads to the formation of spinning black holes and tori orbiting around them; they conform to the general-relativistic Keplerian rotation.

Andrea Dapor

Effective dynamics of loop quantum gravity: Bouncing black holes and gravitational phonons

I will review the concept of effective dynamics in Quantum Mechanics, and explain its generalization to quantum gravity on a fixed graph. This requires the construction of a family of semiclassical states extending the complexifier coherent states, which can be thought of as the quantum equivalent of discrete 3-geometries. Having these states, I will then discuss the "effective dynamics conjecture": the possibility that the quantum dynamics of such semiclassical states be approximated by the dynamics generated on the phase space by the effective Hamiltonian (i.e., the phase space function obtained as the expectation value of the Hamiltonian operator on the states themselves). While the effective Hamiltonian is a phase space function, it does not coincide with the classical one due to the regularization on the graph: as such, the classical equations of motion are modified by terms that depend on the length scale(s) of the graph. The implications of this fact will be illustrated in several examples: early cosmology and spherical black holes (where singularities are replaced by asymmetric bounces), as well as corrections to linearized Einstein equations and gravitational wave propagation.

Norbert Bodendorfer

Renormalisation in LQC with SU(1,1) techniques

Coarse graining is investigated in the context of full theory embeddings of loop quantum cosmology. An analytic expression for a coarse grained Hamiltonian constraint is derived via the analogue block-spin transformations. It contains corrections labeled by the lower cutoff scale until which volumes are resolved. The error made by disregarding coarse graining effects from the regime of many small spins to few large spins is illustrated using the example of the critical density: the usually employed effective equations (which approximate the non-coarse grained dynamics in the large spin regime) overestimate the critical density by a factor of 2 as compared to the properly coarse grained (=renormalised) dynamics.

Posters

Krzysztof Andrzejewski

Charges of conformal symmetries and their applications in plane gravitational waves

Focusing on the maximal conformal symmetry of vacuum solutions to the Einstein equations, conserved charges associated with conformal generators are discussed. The meaning of these charges is given by means of the Lewis invariants which subsequently are used to solve explicitly equations of motion for a particle in some plane gravitational waves.

Paweł Ciosmak

Super quantum Airy structures

In his PhD thesis M. Kontsevich proved that two models of 2d quantum gravity are equivalent. One of the models is based on random graphs, counted by the matrix integral. The partition function of the other one is given by the intersection numbers on the moduli space of complex curves. The consequence of this result is the fact that the later partition function is annihilated by a collection of differential operators. This collection, closed under the Lie bracket, is an example of a Airy structure, a notion introduced by M. Kontsevich and Y. Soibelman in 2017. I would like to present a supersymmetric generalisation of this notion. Together with the definition and a basic theorem I will give a few examples of the super quantum Airy structures.

Maciej Kolanowski

(Anti-)evaporation of Schwarzschild–de Sitter black holes revisited

It is widely believed that in the presence of a positive cosmological constant, heavy black holes can exhibit non-standard behaviour, namely there is a possibility that such objects would grow instead of evaporating. We point out that all those results (obtained in different frameworks) rely heavily upon the identification of the Nariai spacetime with the Schwarzschild–de Sitter (Kottler) black hole. In this note we argue that it is an incorrect assumption. As a result, previous treatments need revisiting. In particular, we show that within effective action approach, there is no solution corresponding to the Schwarzschild–de Sitter black hole.

Colin MacLaurin

Cosmic cable

I examine the relativistic mechanics of a rigid cable in an arbitrary stationary spacetime. Such ropes/cables/strings have been used to examine the thermodynamics of black holes (Bekenstein 1972; Unruh & Wald 1982) or the energy in an expanding universe (Davies 1985; Harrison 1995). A curious effect of curved spacetime is the "redshift" of tension as it propagates along the cable (Gibbons 1972). I generalise this tension to a class of stationary motions, and examine the energy harvested via a certain mechanical process. Loosely, this energy is converted from gravitational potential.

Carlos I. Pérez-Sánchez

Schwinger–Dyson equations of tensor field theory as Tutte-like equations in dimension 3

The equivalence between Tutte's equations for the enumeration of discrete surfaces and the Schwinger–Dyson equations of a suitable matrix model is well-known. I will explain how the Schwinger–Dyson equations of Tensor Field Theory resemble higher-dimensional Tutte's equations and what has to be still developed to reach a perfect analogy. The focus is on dimension 3.

Lukáš Polcar

Lie series method in a perturbed black hole spacetime

We study the motion of test particles around Schwarzschild black hole perturbed by a ring-like source. In order to solve the equations of motion we employ the Lie series formalism which enables us to approximately transform our hamiltonian into action-angle coordinates, i.e. to compute the so-called Birkhoff normal form of hamiltonian. Finding this transformation is then effectively equivalent to solving the Hamilton equations. The results are then confronted with the solution obtained by numerical integration. In the future we plan to use this approximation in an astrophysical setting.