Mathematical Physics of Gravity and Symmetry

Rapport sur les contributions

https://indico.math.cnrs.fr/e/12202

ID de Contribution: **1** Type: **Non spécifié**

Model spaces as constrained Hamiltonian systems

mercredi 20 novembre 2024 09:30 (1 heure)

Three dimensional gravity in Fefferman-Graham or BMS gauge is entirely described by the coadjoint representation of its asymptotic symmetry group. A group-theoretical attempt at quantization requires one to quantize not only individual but the whole collection of coadjoint orbits. This is where model spaces come in. We propose a definition of a model space for generic Lie groups in terms of constrained Hamiltonian systems and begin by studying its quantization in the simplest case of SU(2).

Based on work in preparation done in collaboration with Thomas Smoes

Orateur: BARNICH, Glenn (Université libre de Bruxelles)

ID de Contribution: **2** Type: **Non spécifié**

Memory effects from symmetries for a vacuum gravitational plane wave

jeudi 21 novembre 2024 09:30 (1 heure)

Memory effects are persistent modifications of relatives observables (relative distance, relative velocity, etc …) between test particles induced by the passage of a gravitational wave. These radiative effects stand as ones of the last predications of general relativity yet to be confirmed. On the one hand, modeling these memory effects is crucial for developing accurate waveform templates to be confronted with future observation. On the other hand, these radiatives effects are intimately related to the asymptotic symmetries of asymptotically flat spacetimes, thus revealing the fine structure of the infrared regime of gravity. In this talk, I will discuss the realization of memory effects in a non-asymptotically flat spacetime which corresponds to a pp-wave. I will review the recent classification of the different memory effects (displacement, velocity, etc…) induced by this simple exact non-linear radiative solution of GR. I will also review key theorems relating these memories to the explicit and hidden symmetries (associated to Killing tensors) of the spacetime geometry. This will provide a pedagogical example where memories can be treated fully analytically, the methods discussed here being applicable beyond this framework. This talk is based on the recent published article: https://inspirehep.net/literature/2796995

Orateur: BEN ACHOUR, Jibril (ENS Lyon / ASC LMU Munich)

ID de Contribution: **3** Type: **Non spécifié**

Quasi-normal mode expansions of black hole perturbations: a hyperboloidal Keldysh's approach

mercredi 20 novembre 2024 14:30 (30 minutes)

We study asymptotic quasi-normal mode expansions of linear fields propagating on a black hole background, in order to achieve this we exploit the compactified hyperboloidal approach in order to cast quasi-normal modes as eigenfunctions of a non-selfadjoint problem and we adopt a Keldysh scheme for the spectral construction of resonant expansions. The role of the scalar product structure in the Keldysh construction is clarified, although it is key to provide a notion of scale, it is proven to be non-necessary to construct a unique quasinormal mode time-series at null infinity. We present (numerical) comparison with the time-domain signal for test-bed initial data, we demonstrate the efficiency and accuracy of the Keldysh spectral approach. Polynomial tails following the Price law are recovered and the importance of the contribution of highly-damped modes to the early time behaviour is illustrated and presented as an introduction to the question of the convergence of the asymptotic series.

Orateur: BESSON, Jérémy (AEI Hannover / Université de Bourgogne)

ID de Contribution: **4** Type: **Non spécifié**

Wilson Loops & Euclidean Wormholes

mardi 19 novembre 2024 15:30 (1 heure)

Euclidean wormholes are exotic types of gravitational solutions that still challenge our physical intuition and understanding. After reviewing universal properties of asymptotically AdS wormhole solutions from a gravitational (bulk) point of view and the paradoxes they raise, I will describe some concrete (microscopic) field theoretic setups and models that exhibit such properties. These models can be reduced to matrix integrals and crucially involve correlated ("entangled") sums of representations of the boundary symmetry group. Our final focus will be the example of heavy correlated Wilson loops in $\mathcal{N} = 4$ SYM and related "bubbling wormhole" geometries in type IIB SUGRA.

Orateur: BETZIOS, Panos (University of Gent)

ID de Contribution: **5** Type: **Non spécifié**

Null infinity and the black hole horizon: new conserved quantities from a geometric duality

vendredi 22 novembre 2024 11:00 (1 heure)

I will present a unified treatment for the boundary geometry of asymptotically flat spacetime and black hole horizons. This geometric duality implies an exact inversion isometry for extremal, non-rotating horizons, which will be used to relate and derive new infinite towers of conserved quantities. This is a work in collaboration with Shreyansh Agrawal and Panagiotis Charalambous.

Orateur: DONNAY, Laura (SISSA)

ID de Contribution: **6** Type: **Non spécifié**

Ti and Spi: extended boundaries at time- and spatial-infinity

mercredi 20 novembre 2024 11:00 (1 heure)

Orateur: HERFRAY, Yannick (Université de Tours)

ID de Contribution: **7** Type: **Non spécifié**

Integrable Hidden Structures in the Dynamics of Perturbed Black Holes

mardi 19 novembre 2024 14:00 (1 heure)

In this talk we discuss the presence of integrable hiddenstructures in the dynamics of perturbed non-rotating black holes (BHs). This can also be considered as a seed for a wider program of an effective identification of "slow"and "fast"degrees of freedom (DoFs) in the (binary) BH dynamics, following a wave-mean flow perspective. The slow DoFs would be associated with a nonlinear integrable dynamics, on which the fast ones propagate following an effective linear dynamics. BH perturbation theory offers a natural ground to test these properties. Indeed, the decoupling of Einstein equations into wave master equations with a potential provides an instance of such splitting into (frozen) slow DoFs (background potential) over which the linear dynamics of the fast ones (perturbation master functions) evolve. It has been recently shown that these wave equations possess an infinite number of symmetries that correspond to the flow of the infinite hierarchy of Korteweg-de Vries (KdV) equations. Starting from these results, we talk about the presence of integrable structures in BH perturbation theory, first in Cauchy slices and then in hyperboloidal foliations. This second step introduces a splitting of the master equation into bulk and boundary contributions, unveiling an underlying structural relation with the slow and fast DoFs. This insight represents a first step to establish the integrable structures associated to the slow DoFs as bulk symmetries of the dynamics of perturbed BHs.

Orateur: LENZI, Michele (ICE-CSIC)

ID de Contribution: **8** Type: **Non spécifié**

Exploring the asymptotics of scalar fields near spatial infinity

mardi 19 novembre 2024 11:00 (1 heure)

Conformal geometry tools allow us to study global geometric aspects of a spacetime using local differential geometry. In this talk, I will focus on a particular conformal representation of Minkowski spacetime which allows us to study the asymptotics of massless fields near spatial infinity. I will briefly discuss the analysis of the asymptotics of the wave equation in the context of this conformal representation and its application in the calculation of asymptotic conserved quantities associated with this field. This talk is based on [arXiv:2408.03389].

Orateur: MAGDY, Mariem (Instituto Superior Técnico)

ID de Contribution: **10** Type: **Non spécifié**

Lie-Poisson Equations: from Quantum Liquids to Gravity

vendredi 22 novembre 2024 09:30 (1 heure)

I argue that translation-invariant dynamical systems on Lie groups are ubiquitous in Nature. Numerous examples are provided, ranging from basic mechanics and hydrodynamics to the edge modes of topological insulators and quantum gravity. The geometric approach to such setups yields observables that are natural but surprisingly overlooked in the literature, notably including Berry phases that probe the symplectic geometry of coadjoint orbits. [Based on arXiv:2408.03991]

Orateur: OBLAK, Blagoje (CNRS, Université Claude Bernard Lyon 1)

ID de Contribution: **12** Type: **Non spécifié**

An inflationary cosmology from Anti-de-Sitter wormholes

jeudi 21 novembre 2024 11:00 (1 heure)

There are various proposals as to what initial state can give rise to an inflationary cosmology. The two most popular ones are the no boundary (Hartle-Hawking) and the tunneling (Vilenkin) proposals. Both of them explain only part of the observations and lead to some paradoxes. In this talk, I will review these proposals and I will propose a novel initial state (wavefunction) of the universe which in the far past has asymptotically AdS boundary conditions. In the semiclassical limit it is a Euclidean wormhole solution that can give rise to an expanding universe upon analytic continuation to Lorentzian signature. This proposal evades some of the issues that plagued the no boundary and the tunneling proposals. Moreover, the asymptotic AdS conditions in the Euclidean past could in principle allow for the description of inflationary cosmologies and their perturbations within the context of holography, leading to microscopic models.

Orateur: PAPADOULAKI, Olga (CNRS, Ecole Polytechnique)

ID de Contribution: **13** Type: **Non spécifié**

Scattering of Dirac Fields in Black Hole Interiors

mercredi 20 novembre 2024 14:00 (30 minutes)

Scattering problems in black hole interiors are an indispensable tool in the study of strong cosmic censorship. I will present joint work with M. Mokdad where we construct a scattering theory for the massive and charged Dirac field in the interior region of a sub-extremal Kerr-Newman(-anti)-de Sitter black hole. In this work, we show existence, uniqueness, and asymptotic completeness of scattering data for Dirac fields from the event horizon of the black hole to the Cauchy horizon. Our approach relies on constructing the wave operators where the Hamiltonian of the full dynamics is time-dependent. I will also discuss the utility of second-order symmetry operators of the Dirac equation and how their absence in the most general case complicates the analysis.

Orateur: PROVCI, Milos (University of Münster)

ID de Contribution: **14** Type: **Non spécifié**

Black hole perturbations in modified gravity as a first-order system

jeudi 21 novembre 2024 14:00 (1 heure)

The study of perturbations around a black hole is crucial for the investigation of stability of the solution, as well as the modelization of gravitational waves emitted during the ringdown phase of a binary black hole merger. In general relativity, such perturbations are recast into two decoupled Schrödinger equations; in modified theories of gravity, this is often no longer possible due to the existence of additional fields. In this work, we reformulate the perturbation equations into a first-order system for GR and various modified gravity theories. This allows us to systematically define the proper boundary conditions for the computation of quasi-normal modes in these theories, using an algorithm that decouples the perturbation equations asymptotically. We illustrate this method by numerically computing quasi-normal modes in the Minimal Theory of Massive Gravity (MTMG).

Orateur: ROUSSILLE, Hugo (ENS Lyon)

ID de Contribution: **15** Type: **Non spécifié**

Integrability in the Dynamics of Binary Black Holes

mardi 19 novembre 2024 09:30 (1 heure)

The scientific exploitation of gravitational wave observations depends strongly on the models of the signals that we use for their detection, mainly for binary black holes. These models, known as waveform models, are obtained from Einstein's equations (or their equivalent in alternative theories of gravity). The way of obtaining them is via different perturbative schemes and/or numerical relativity, which involve complex computations. Nevertheless, the shape of the waveform of a binary black hole appears to be both simple and universal. In this sense, it has been argued that the dynamics should admit a separation into "fast and slow"degrees of freedom, such that the latter are described by an integrable system of equations, accounting for the simplicity and universality of the waveform. In this talk, I will describe the efforts in this direction and how integrability can play a crucial role in this important problem.

Orateur: SOPUERTA, Carlos (ICE-CSIC, IEEC)