Gravitational physics and its mathematical analysis

Report of Contributions

https://indico.cern.ch/e/1244166

Contribution ID: **1** Type: **not specified**

Dinner

Monday 3 June 2024 19:00 (1h 30m)

Contribution ID: **2** Type: **not specified**

Dinner

Tuesday 4 June 2024 19:00 (1h 30m)

Contribution ID: **3** Type: **not specified**

Dinner

Wednesday 5 June 2024 19:00 (1h 30m)

Contribution ID: **4** Type: **not specified**

Dinner: Raclette

Thursday 6 June 2024 19:00 (1h 30m)

Contribution ID: **5** Type: **not specified**

Dinner

Sunday 2 June 2024 19:00 (1h 30m)

Contribution ID: **6** Type: **not specified**

Lunch

Monday 3 June 2024 12:30 (1h 30m)

Contribution ID: **7** Type: **not specified**

Lunch

Tuesday 4 June 2024 12:30 (1h 30m)

Contribution ID: **8** Type: **not specified**

Lunch

Wednesday 5 June 2024 12:30 (1h 30m)

Contribution ID: **9** Type: **not specified**

Lunch

Thursday 6 June 2024 12:30 (1h 30m)

Contribution ID: **10** Type: **not specified**

Lunch & end of workshop

Friday 7 June 2024 12:30 (1h 30m)

Contribution ID: **11** Type: **not specified**

Coffee/Tea

Monday 3 June 2024 16:00 (30 minutes)

Contribution ID: **12** Type: **not specified**

Coffee/Tea

Tuesday 4 June 2024 16:00 (30 minutes)

Contribution ID: **13** Type: **not specified**

Coffee/Tea

Wednesday 5 June 2024 16:00 (30 minutes)

Contribution ID: **14** Type: **not specified**

Coffee/Tea

Thursday 6 June 2024 16:00 (30 minutes)

Contribution ID: **15** Type: **not specified**

Coffee/Tea

Monday 3 June 2024 10:00 (30 minutes)

Contribution ID: **16** Type: **not specified**

Coffee/Tea

Tuesday 4 June 2024 10:00 (30 minutes)

Contribution ID: **17** Type: **not specified**

Coffee/Tea

Wednesday 5 June 2024 10:00 (30 minutes)

Contribution ID: **18** Type: **not specified**

Coffee/Tea

Thursday 6 June 2024 10:00 (30 minutes)

Contribution ID: **19** Type: **not specified**

Coffee/Tea

Friday 7 June 2024 10:00 (30 minutes)

Contribution ID: **20** Type: **not specified**

Oppenheimer-Snyder type collapse for the Einstein-Vlasov system

Monday 3 June 2024 09:00 (1 hour)

In the seminal work by Oppenheimer and Snyder from 1939 it is shown that a homogeneous ball of dust undergoes gravitational collapse. This work has had an enormous impact on the field since it predicts the existence of black holes. In this talk I will show that the Oppenheimer-Snyder type collapse can be approximated arbitrarily well by solutions to the Einstein-Vlasov system. It is crucial for the argument to work in Painlevé-Gullstrand coordinates rather than in comoving coordinates which is standard in the case of dust. Extensions of this result to the inhomogeneous case will also be discussed. In particular, there exist inhomogeneous data for dust which give rise to naked singularities and it is thus of great importance to understand the relation between the dust solutions and the solutions to the Einstein-Vlasov system in the context of the weak cosmic censorship conjecture. This is a joint work with Gerhard Rein.

Presenter: ANDREASSON, Håkan

Contribution ID: **21** Type: **not specified**

Modified scattering for small data solutions to the Vlasov-Maxwell system

Monday 3 June 2024 10:30 (1 hour)

We will be interested in the solutions to the Vlasov-Maxwell system arising from sufficiently small and regular data. In particular, we will compare their asymptotic behavior with the ones of the solutions to the linearised system. Even if the electromagnetic fields have a nontrivial memory effect, they enjoy linear scattering since they approach, for large time, a solution to the vacuum Maxwell equations. In contrast, the distribution function merely satisfies a modified scattering statement. Due to the long-range effects of the Lorentz force, it converges along logarithmic corrections of the linear characteristics. In order to define these modified characteristics, a key step consists in identifying an effective Lorentz force governing the asymptotic behavior of the force field.

Presenter: BIGORGNE, Léo (Université de Rennes)

Contribution ID: **22** Type: **not specified**

Stability of the vacuum for the Vlasov-Poisson in a convex domain with perfectly conducting walls

Wednesday 5 June 2024 10:30 (1 hour)

We consider the Vlasov-Poisson with a perfectly conducting wall in a class of convex infinite domains and we show that small initial data lead to global solutions which satisfy a form of modified scattering, with the asymptotic data supported on a maximum cone in the domain. This is joint work with W. Huang and M. Suzuki.

Presenter: PAUSADER, Benoit

Contribution ID: **23** Type: **not specified**

Uniqueness criteria for the Vlasov-Poisson system and applications to mean-field and semiclassical problems.

Monday 3 June 2024 11:30 (1 hour)

The Vlasov-Poisson system is a non-linear PDE describing the mean-field time-evolution of particles forming a plasma or a galaxy.
In this talk I will present uniqueness criteria for the Vlasov-Poisson equation in the classical and semi-relativistic setting, emerging as corollaries of stability estimates in strong (Lˆp) topologies or in weak topologies (induced by Wasserstein distances), and show how they serve as a guideline to solve mean-field and semiclassical problems. Different topologies will allow us to treat different classes of quantum states.

Presenter: SAFFIRIO, Chiara

Contribution ID: **24** Type: **not specified**

Landau damping near the Poisson equilibrium in R^3

Monday 3 June 2024 16:30 (1 hour)

While “Landau damping” is regarded as an important effect in the dynamics of hot, collisionless plasmas, its mathematical understanding is still in its infancy. This talk presents a recent nonlinear stability result in this context. We start with a discussion of dynamics in the linearized Vlasov-Poisson equations near certain homogeneous equilibria on R^3, and see how both oscillatory and damping effects arise. Finally we will sketch how these mechanisms imply a nonlinear stability result in the specific setting of the Poisson equilibrium.

Presenter: WIDMAYER, Klaus

Contribution ID: **25** Type: **not specified**

Construction of multi-soliton solutions for semilinear equations in dimension 3

Tuesday 4 June 2024 09:00 (1 hour)

The existence of multi black hole solutions in asymptotically flat spacetimes is one of the expectation from the final state conjecture. In this talk, I will present preliminary works in this direction via a semilinear toy model in dimension 3. In particular, I show 1) an algorithm to construct approximate solutions to the energy critical wave equation that converge to a sum of solitons at an arbitrary polynomial rate in (t-r); 2) a robust method to solve the remaining error terms for the nonlinear equation. The methods apply to energy supercritical problems. This work is part of my PhD thesis.

Presenter: KADAR, Istvan (University of Cambridge)

Contribution ID: **26** Type: **not specified**

TBA

Wednesday 5 June 2024 09:00 (1 hour)

Presenter: DAFERMOS, Mihalis

Contribution ID: **27** Type: **not specified**

Extremal black hole formation as a critical phenomenon

Tuesday 4 June 2024 10:30 (1 hour)

I will present a proof that extremal black holes arise on the threshold of gravitational collapse. More precisely, I will present a construction of one-parameter families of smooth solutions to the Einstein-Maxwell-charged Vlasov system which interpolate between dispersion and collapse and for which the critical solution is an extremal Reissner-Nordström black hole. This is joint work with Christoph Kehle (ETH Zürich).

Presenter: UNGER, Ryan

Contribution ID: **28** Type: **not specified**

Linear Stability of the Schwarzschild-anti de Sitter spacetime

Tuesday 4 June 2024 16:30 (1 hour)

I will talk about joint work with Olivier Graf (Grenoble) establishing linear stability of Schwarzschild-anti de Sitter (AdS) black holes to gravitational perturbations. This is the statement that solutions to the linearisation of the Einstein equations $\mathrm{Ric} = -\frac{3}{\ell^2} g$ around a Schwarzschild-AdS metric arising from regular initial data and with standard Dirichlet boundary conditions imposed at the conformal boundary (inherited from fixing the conformal class of the non-linear metric) remain globally uniformly bounded on the black hole exterior and in fact decay inverse logarithmically to a linearised Kerr-AdS metric. The proof exploits a hierarchical structure of the equations of linearised gravity in double null gauge and relies on boundedness and logarithmic decay results for the Teukolsky system, which are obtained independently.

Presenter: HOLZEGEL, Gustav

Contribution ID: **29** Type: **not specified**

On the asymptotic behaviour of gravitational radiation in N-body problems

Tuesday 4 June 2024 17:30 (1 hour)

In the first part of the talk, I will give a historical overview of various arguments pertaining to Penrose's notion of a smooth null infinity and the peeling property. In the second part of the talk, I will then give an account of my own work: After clearly formulating the mathematically and physically relevant problems, I will explain how to set up a semi-global (i.e.˜away from the timelike infinities) scattering problem for the linearised Einstein vacuum equations around Schwarzschild suitable for capturing the far-field region of a system of N infalling masses following approximately hyperbolic orbits in the infinite past based on predictions from Post-Newtonian theory. I will finally discuss elements of the proof of a theorem that contains the solution and semi-global asymptotic analysis of this scattering problem. In particular, this theorem suggests concrete, constructive corrections to various ad hoc assumptions (such as that of peeling, but also assumptions on Cauchy data decay rates) frequently encountered in the literature.

Presenter: KEHRBERGER, Leonhard

Contribution ID: **30** Type: **not specified**

Null coordinates for quasi-periodic 1d wave operators and applications

Tuesday 4 June 2024 11:30 (1 hour)

Given a quasi-periodic wave operator $\psi_{tt} - \psi_{xx} + \mathcal{B}^{xx}(\omega t, x)\partial_{xx}$, where $\mathcal{B}^{xx} : \mathbb{T}^{\nu+1} \to \mathbb{R}$ is parity preserving, reversible and small enough and where ω is diophantine, we explain how to construct \emph{null coordinates} respecting the quasi-periodicity. In these coordinates, the principal symbol of the wave operator then has constant coefficients.

As an application, we give a novel proof of \emph{reducibility}, a typical element for the construction of quasi-periodic solutions to non-linear pdes, obtained very recently in a work of Berti, Feola, Procesi and Terracina on the quasi-periodically forced linear Klein-Gordon.

This is a joint work with Athanasios Chatzikaleas.

Presenter: SMULEVICI, Jacques

Contribution ID: **31** Type: **not specified**

On the global dynamics of relativistic fluids in cosmology

Friday 7 June 2024 09:00 (1 hour)

We are interested in the dynamical behaviour of relativistic fluids towards the expanding direction of cosmological spacetimes.
It is known that the expansion of spacetime induces a friction-like term in the fluid equation, which can prevent the formation of shocks, yielding future global solutions for small initial data.
This phenomenon is referred to as fluid stabilization. While this problem is well understood in the regime of accelerated expansion, less is known in slowly expanding spacetimes. In this talk, I will report on recent progress in understanding fluid stabilization in slowly expanding spacetimes and a possible threshold expansion rate of the universe where fluid stabilization fails. This talk is based on joint work with M. Maliborski, M. Ofner, T. Oliynyk and Z. Wyatt.

Presenter: FAJMAN, David (University of Vienna)

Contribution ID: **32** Type: **not specified**

Periodic solutions for 1d nonlinear wave equation

Wednesday 5 June 2024 11:30 (1 hour)

We consider the cubic nonlinear wave equation on an interval with Dirichlet boundary conditions. First, we review the perturbative construction of small-amplitude time-periodic solutions. Furthermore, using an appropriate numerical construction algorithm, we explore large solutions. By analysing the underlying equations, we propose a systematic approach for describing the complex structure of time-periodic solutions. This is joint work with Filip Ficek.

Presenter: MALIBORSKI, Maciej

Contribution ID: **33** Type: **not specified**

Hike

Wednesday 5 June 2024 14:00 (4 hours)

Contribution ID: **35** Type: **not specified**

Quasinormal modes for the Kerr black hole

Thursday 6 June 2024 09:00 (1 hour)

The late-time behavior of solutions to the wave equation on Kerr spacetime is governed by inverse polynomial decay. However, at earlier time-scales, numerical simulations are found to be dominated by quasinormal modes. These are exponentially damped oscillatory solutions with complex frequencies characteristic of the system. In this talk, I will present a rigorous characterization of quasinormal modes for the scalar wave equation on Kerr. They are obtained as the poles of a certain meromorphic family of operators. This construction combines the method of complex scaling near asymptotically flat infinity with the microlocal methods of Vasy near the black hole horizon.

Presenter: STUCKER, Thomas

Contribution ID: **36** Type: **not specified**

Quasinormal modes on asymptotically flat spacetimes

Thursday 6 June 2024 11:30 (1 hour)

Quasinormal modes (QNMs) are damped oscillations that play an important role in the dynamics of perturbations of stationary black hole spacetimes. They are governed by frequencies that are characteristic to the black hole under consideration and are analogous to the characteristic overtones of a vibrating drumhead. Although extensively featured in the physics literature for over fifty years, a clear and broadly applicable mathematical definition of QNMs on asymptotically flat spacetimes has remained elusive. In this talk, I will present and motivate a new characterization of QNMs on asymptotically flat spacetimes and apply it to the setting of Kerr black holes. This talk is based on upcoming work in collaboration with C. Warnick.

Presenter: GAJIC, Dejan

Contribution ID: **37** Type: **not specified**

Speaker

Contribution ID: **38** Type: **not specified**

Maurer-Cartan perturbation theory and scattering amplitudes in general relativity

Thursday 6 June 2024 16:30 (1 hour)

I will describe a differential graded Lie algebra tailored to study perturbations of Minkowski spacetime, including asymptotics. This differential graded Lie algebra is defined on the conformal compactification of Minkowski spacetime. Its Maurer-Cartan equation is equivalent to the vacuum Einstein equations, and is symmetric hyperbolic including across the boundary of Minkowski spacetime. I will compare this to Friedrich's conformal vacuum field equations. Given this differential graded Lie algebra, one can use basic Maurer-Cartan perturbation theory to construct formal power series solutions about Minkowski, which extend smoothly to null infinity. I will explain that, in low order formal perturbation theory, the radiative null asymptotics of these solutions is described by the gauge independent physical scattering amplitudes.

Presenter: NÜTZI, Andrea

Contribution ID: **39** Type: **not specified**

Leading-order term expansion for the Teukolsky equation on subextremal Kerr black holes

Thursday 6 June 2024 10:30 (1 hour)

The study of wave propagation on black hole spacetimes has been an intense field of research in the past decades. This interest has been driven by the stability problem for black holes and by questions related to scattering theory. On Kerr black holes, the analysis of Maxwell's equations and the equations of linearized gravity, can be simplified by introducing the Teukolsky equation, which offers the advantage of being scalar in nature. After explaining this reduction, I will present a result providing the large time leading-order term for initially localized and regular solutions and valid for the full subextremal range of black hole parameters. I will explain such a development follows naturally from the precise analysis of the resolvent operator on the real axis. This analysis relies on recent advances in microlocal analysis, which are used to establish the existence and mapping properties of the resolvent.

Presenter: MILLET, Pascal (Ecole Polytechnique)

Contribution ID: **40** Type: **not specified**

Speaker

Contribution ID: **41** Type: **not specified**

Global stability of cosmological fluids with extreme tilt

Friday 7 June 2024 10:30 (1 hour)

In cosmology, the equation of state of a perfect fluid is considered to be p = c_sˆ2 \rho, where c_s is the speed of sound. The simplest solution to the Einstein-Euler system, known as FLRW, representing a cosmological fluid, was discovered by Friedmann already in 1922. There is an extensive literature in physics concerning the dynamics of cosmological fluids. However, rigorous mathematical works proving the stability of homogeneous backgrounds are so far restricted to small sound speeds, up to the radiation threshold. Interesting bifurcation phenomena and instabilities are predicted for larger sound speeds. I will discuss joint work with E. Marshall and T. A. Oliynyk proving the global stability of homogeneous solutions with so-called extreme tilt, whose fluid vector field becomes asymptotically null, beyond the radiation case.

Presenter: FOURNODAVLOS, Grigorios

Contribution ID: **42** Type: **not specified**

Shock formation for the Einstein—Euler system

Friday 7 June 2024 11:30 (1 hour)

In this talk, I hope to describe elements of proving a certain stable singularity formation result for the Einstein—Euler system, which is the topic of work in progress with Jonathan Luk. I will first describe where this fits into the big picture of the study of multidimensional shocks, and why it is appropriate to call this a shock formation result. Then, I will try to describe some of the main ideas that go into proving shock formation results. Finally, I will try to describe some of the main difficulties that arise in the case of Einstein—Euler.

Presenter: ANDERSON, John

Contribution ID: **44** Type: **not specified**

Open problems session

Wednesday 5 June 2024 20:30 (1 hour)

Contribution ID: **45** Type: **not specified**

Opening

Monday 3 June 2024 08:50 (10 minutes)

Contribution ID: **46** Type: **not specified**

Welcome Apéro

Monday 3 June 2024 18:30 (30 minutes)

Contribution ID: **47** Type: **not specified**

TBA

Presenter: HE, Lili

Contribution ID: **48** Type: **not specified**

(TBA)

Thursday 6 June 2024 17:30 (1 hour)

Presenter: MASAOOD, Hamed (Imperial College London)