11th Central European Relativity Seminar

February 11-13, 2021, Vienna (online)

Schedule

Thursday, 11 February

Chair: Piotr T. Chruściel

9:50-10:00 Welcome

10:00-11:00 **Harvey Reall** (University of Cambridge) – *Some recent developments in strong cosmic censorship*

Chair: David Fajman

11:15-11:35 **Grigalius Taujanskas** (University of Oxford) – *Large data decay of Yang–Mills–Higgs fields on Minkowski and de Sitter backgrounds*

11:35-11:55 **Zoe Wyatt** (University of Cambridge) – *Stabilizing relativistic fluids on spacetimes with non-accelerated expansion*

11:55-12:15 **Marica Minucci** (Queen Mary University of London) – *On the stability of Einstein spaces with spatial sections of negative scalar curvature*

12:15-14:00 Lunch break

Chair: Jérémie Joudioux

14:00-14:20 **Markus Wolff** (Tübingen University) – *On the evolution of hypersurfaces along their inverse spacetime mean curvature*

14:20-14:40 **Mariem Magdy Ali Mohamed** (Queen Mary, University of London) – *A comparison of Ashtekar and Friedrich's formalisms of spatial infinity*

14:40-15:00 **Alejandro Penuela Diaz** (AEI-Potsdam Uni) – *Constructing asymptotically hyperbolic electrically charged riemannian manifolds with controlled mass*

Chair: Jacek Jezierski

15:00-15:20 **Jinzhao Wang** (ETH) – *Outer entropy equals the Bartnik-Bray inner mass*

15:20-15:40 **Maciej Kolanowski** (University of Warsaw) – *Charges in asymptotically de Sitter spacetimes*

15:40-16:00 **Gautam Satishchandran** (University of Chicago) – *The Gravitational Memory Effect and Asymptotic States in Quantum Gravity*

Friday, 12 February

Chair: Peter C. Aichelburg

9:50-10:00 Opening the session

10:00-11:00 **Philip Walther** (University of Vienna) – *Shining light on the interface of gravity and quantum physics: precision measurements using photonic quantum interferometry*

Chair: Herbert Balasin

11:15-11:35 **Raphaela Wutte** (TU Wien) – *The Causal Structure of Warped Flat Spacetimes*

11:35-11:55 **Leonardo García-Heveling** (Radboud Universiteit) – *Causality theory of spacetimes with continuous Lorentzian metrics revisited*

11:55-12:15 **Lorenzo Gavassino** (CAMK (PAN) Warsaw) – *The Lyapunov function of relativistic dissipative hydrodynamics*

12:15-14:00 Lunch break

Chair: Piotr Bizoń

14:00-14:20 **Albachiara Cogo** (Eberhard Karls Universität Tübingen) – *Uniqueness of photon spheres and equipotential photon surfaces in geometrostatic spacetimes via potential theory*

14:20-14:40 **Léo Bigorgne** (University of Cambridge) – *Decay estimates for the massless Vlasov equation on Schwarzschild spacetime*

14:40-15:00 **Liam Urban** (University of Vienna) – *Blow-up of waves on Friedman-Lemaître-Robertson-Walker spacetimes with arbitrary Riemmannian spatial metric*

Chair: Robert Beig

15:00-15:20 **Filip Ficek** (Jagiellonian University) – *Stability of stationary solutions of nonlinear Schrödinger equations in supercritcal dimensions*

15:20-15:40 **Marius Oancea** (Albert Einstein Institute, Potsdam) – *Spin Hall effects and the localization of massless spinning particles*

15:40-16:00 **Martin Lesourd** (Harvard, BHI) – *A Construction Towards Dynamical Black Hole Formation*

Saturday, 13 February

Chair: Maciej Maliborski

9:50-10:00 Opening the session

10:00-10:20 **Hamed Barzegar** (University of Vienna) – *Future attractors of some Bianchi cosmologies with massless Vlasov matter*

10:20-10:40 **Quentin Vigneron** (CRAL, Lyon, France) – *A non-Euclidean Newtonian limit of General Relativity*

10:40-11:00 **Hannes Rüter** (Albert Einstein Institute Potsdam) – *An Implementation of DF-GHG with Application to Spherical Black Hole Excision*

11:00-11:30 Coffee break

Chair: Lars Andersson

11:30-11:50 **Eryk Buk** (University of Warsaw) – *Axisymmetric, isolated horizon in the presence of cosmological constant*

11:50-12:10 **Parth Bambhaniya** (ICC, Charusat, India) – *Precession of relativistic orbits of a particle in the black hole and naked singularity spacetimes*

12:10-12:30 **Tobias Sutter** (University of Vienna) – *Study of Vortical Null Geodesics in Kerr Spacetime*

Abstracts

Precession of relativistic orbits of a particle in the black hole and naked singularity spacetimes

Parth Bambhaniya, ICC, Charusat, India, grcollapse@gmail.com

Observation of the astrometric position of S-stars close to the Milky-way galactic center provides the unique opportunity to test the nature of Sgr-A*. W.M. Keck observatory, GRAVITY, and SINFONI groups are continuously observing the stellar motions of S-stars around the Milky-way galactic center. This observation can give a fundamental understanding of the spacetime structure and dynamics of the galactic center. In my talk, I will present a comparative study of the timelike bound orbits in naked singularity and black hole spacetimes. I will show that the precession of the relativistic orbits in the naked singularity spacetimes can be significantly different from that of in Schwarzschild black hole spacetime.

Future attractors of some Bianchi cosmologies with massless Vlasov matter

Hamed Barzegar, University of Vienna, hamed.barzegar@univie.ac.at

A mathematical cosmological model consists of three main elements: a cosmological spacetime, a theory of gravity and a matter model. As such, we consider a cosmology with Bianchi spacetimes that is governed by the Einstein equations without the cosmological constant and filled with massless Vlasov matter. Then, I will discuss the future attractors and show future stability of such models within Bianchi types I, II, and V symmetry class. The proof turns out to be more challenging compared to the corresponding massive case where the cosmological constant is absent, since the massless particles indicate less decay rates in the course of the expansion of the universe. This proof is based on an energy method for small initial data.

Axisymmetric, isolated horizon in the presence of cosmological constant

Eryk Buk, University of Warsaw, ebuk@fuw.edu.pl

We will briefly review quasi-local description of black hole horizon and present geometrical constraints (near-horizon geometry equations) induced on it by Einstein equations. Next we will present solutions to this constraints – metric of horizon – in spacetime with cosmological constant, accounting for boundary conditions introduced in order to eliminate conical singularity. Then we will show embedding of this solution in Kerr-de Sitter spacetime.

Uniqueness of photon spheres and equipotential photon surfaces in geometrostatic spacetimes via potential theory

Albachiara Cogo, Eberhard Karls Universität Tübingen,
albachiara.cogo@uni-tuebingen.de

Equipotential photon surfaces are timelike hypersurfaces in a static spacetime $(\mathcal{L}^{n+1} = M^n \times \mathbb{R}, \} = -N^2 dt^2 + {}^n g)$, which are null totally geodesic and such that the so called lapse function N is constant on the connected components of each time slice of the photon surface. Photon spheres are a special case of equipotential photon surfaces, where the lapse function is constant on their connected components, namely the constant value of N on the photon sphere does not even depend on the time slice. In this talk I will prove a uniqueness theorem for connected photon spheres and, more generally, for connected equipotential photon surfaces in a geometrostatic (static, vacuum and asymptotically flat) spacetime of dimension $n + 1 = 4$. This consists in showing that a geometrostatic spacetime $(\mathcal{L}^4, \})$ that admits such objects must be isometric to the Schwarzschild spacetime of the same ADM-mass. For this purpose, an approach via potential theory developed by Agostiniani & Mazzieri (see *On the Geometry of the Level Set of Bounded Static Potentials*, Communications in Mathematical Physics 355, n. 1, pages 261-301, 2017) will be used, allowing not to assume the regular foliation of the spacetime by the so called lapse function, used in many other methods.

Stability of stationary solutions of nonlinear Schrödinger equations in supercritcal dimensions

Filip Ficek, Jagiellonian University, filip.ficek@doctoral.uj.edu.pl

Different aspects of nonlinear Schrödinger equations (NLS) have been thoroughly investigated over the last decades, although the focus was almost exclusively on subcritical dimensions. Such situation probably comes from the breakdown of typical mathematical tools in supercritical dimensions on one hand and the lack of apparent physical motivation on the other. I will start this talk briefly presenting how one can obtain the Schrödinger-Newton-Hooke equation (Schrödinger equation with self-gravitation in the presence of a harmonic trap) as a nonrelativistic limit of AdS spacetime perturbations, giving us a motivation to consider NLS in higher dimensions. Then I will focus on supercritical dimensions, showing what do the stationary states of this system look like and finally discussing their stability.

Causality theory of spacetimes with continuous Lorentzian metrics revisited

Leonardo García-Heveling, Radboud Universiteit, l.heveling@math.ru.nl

We revisit the causal structures J^+ and K^+ on a spacetime, and introduce a new one, called k^+. The k^+-relation can be used to characterize causal curves, and for smooth Lorentzian metrics, it yields the same result as the standard J^+-relation. If, on the other hand, the metric is merely continuous, then the different causal structures become inequivalent. We compare them by investigating three properties, namely the validity of the push-up lemma, the openness of chronological futures, and the existence of limit causal curves. Depending on the definition of causal structure chosen, we show that at most two of these three properties hold for continuous metrics. In particular, by using the new relation k^+, the push-up lemma holds even when the metric is continuous, while it generally does not for the standard J^+-relation. Finally, we argue that, in general, no reasonable notion of causal structure can have all three properties.

The Lyapunov function of relativistic dissipative hydrodynamics

Lorenzo Gavassino, CAMK (PAN) Warsaw, lorenzo.gavassino@gmail.com

In the gravitational-wave era, we are opening new eyes to the cosmos, which are almost blind if we do not have reliable hydrodynamic theories to be employed in simulations or in theoretical models. Therefore, the field of relativistic hydrodynamics needs to receive a new impulse, to develop theories that are well-suited for numerical implementation. One of the most important features that a dissipative hydrodynamic model needs to exhibit is the stability of equilibrium. Unfortunately, such a simple requirement is not so easily fulfilled in a relativistic context and is strongly violated by most of the straightforward relativistic generalizations of Navier-Stokes. In this talk, I will present a new way of testing the stability of relativistic dissipative theories based on Lyapunov's direct method. The approach generalizes the Gibbs stability theory (usually employed in non-equilibrium thermodynamics) to relativistic dissipative fluids. We have applied it to the most important available theories for relativistic dissipation, shedding new light on the physical meaning of their (previously rather obscure) stability conditions.

Charges in asymptotically de Sitter spacetimes

Maciej Kolanowski, University of Warsaw, maciej.kolanowski@fuw.edu.pl

We generalize a notion of 'conserved' charges given by Wald and Zoupas to the asymptotically de Sitter spacetimes. Surprisingly, our construction is less ambiguous than the one encountered in the asymptotically flat context. An expansion around the Schwarzschild-de Sitter solution provides their physical meaning. In particular, we derive energy of gravitational waves propagating on such background with a correct limit as Λ goes to zero. Difficulties with generalization of this definition of energy to the non-linear theory are illustrated on an example of the Kerr-de Sitter solutions. Joint work with J. Lewandowski.

Decay estimates for the massless Vlasov equation on Schwarzschild spacetime

Léo Bigorgne, University of Cambridge, lb847@cam.ac.uk

In this talk we will see how to adapt the r^p-weighted energy method of Dafermos and Rodnianski in order to prove decay estimates for a non-degenerate energy flux of the massless Vlasov field through a well-chosen foliation. An essential step of this methodology consists in proving a non-degenerate integrated local energy decay estimate. For this, we take in particular advantage of the red-shift effect near the event horizon. The trapping at the photon sphere requires however to lose an ϵ of integrability in the velocity variable. Then, we will see how to obtain pointwise decay estimate on the velocity average of the Vlasov field despite the lack of a conservation law for the radial derivative.

A comparison of Ashtekar and Friedrich's formalisms of spatial infinity

Mariem Magdy Ali Mohamed, Queen Mary, University of London, m.m.a.mohamed@qmul.ac.uk

Penrose's idea of asymptotic flatness provides a framework for understanding the asymptotic structure of gravitational fields of isolated systems at null infinity. However, the studies of the asymptotic behaviour of fields near spatial infinity are more challenging due to the singular nature of spatial infinity in a regular point compactification for spacetimes with non-vanishing ADM mass. Two different frameworks that address this challenge are Friedrich's cylinder at spatial infinity and Ashtekar's definition of *asymptotically Minkowskian spacetimes at spatial infinity* that give rise to the 3-dimensional *asymptote at spatial infinity* $\mathcal{H}$. Both frameworks address the singularity at spatial infinity although the link between the two approaches had not been investigated in the literature. Our aim is to show the relation between Friedrich's cylinder and the asymptote as spatial infinity. To do so, we initially consider this relation for Minkowski spacetime. It can be shown that the solution to the conformal geodesic equations provides a conformal factor that links the cylinder and the asymptote. For general spacetimes satisfying Ashtekar's definition, the conformal factor cannot be determined explicitly. However, we provide a proof for the existence of this conformal factor. Additionally, the conditions satisfied by physical fields on the asymptote $\mathcal{H}$ are derived systematically using the conformal constraint equations. Finally, it is shown that a solution to the conformal geodesic equations on the asymptote can be extended to a small neighbourhood of spatial infinity by constructing a conformal Gaussian system on $\mathcal{H}$ and making use of the stability theorem for ordinary differential equations.

On the stability of Einstein spaces with spatial sections of negative scalar curvature

Marica Minucci, Queen Mary University of London, m.minucci@qmul.ac.uk

In this article it is shown how the extended conformal Einstein field equations and a gauge based on the properties of conformal geodesics can be used to analyse the non-linear stability of Einstein spaces with spatial sections of negative scalar curvature. This is done by considering a de Sitter-like spacetime, which is a vacuum spacetime with a de Sitter-like value of the cosmological constant. This class of spacetimes admits a conformal extension with a spacelike conformal boundary and represent the simplest application of the conformal field equations to the analysis of global properties of spacetimes. The existence and stability theorem for this type of spacetime can be proven by means of hyperbolic reduction procedures. The method that we use relies on conformal Gaussian systems that combined with the use of conformal field equations allows us to formulate initial value problems for the perturbed de Sitter-like spacetime not only on a standard initial hypersurface at a fiduciary finite time, but also on a hypersurface corresponding to the conformal boundary of the spacetime. The appeal of considering the conformal Einstein field equations rather than the Einstein field equations for our purposes is that local results for an unphysical spacetime could in principle be translated into global results for the physical spacetimes. Furthermore, in similar manner to the case of the ADM evolution equations where the Einstein field equations are recast as a set of evolution equations for an initial value problem, we can formulate the extended conformal field equations as an initial value problem performing a $1 + 3$ decomposition and obtain evolution equations along the congruence of conformal geodesics.

Spin Hall effects and the localization of massless spinning particles

Marius Oancea, Albert Einstein Institute, Potsdam, marius.oancea@aei.mpg.de

The propagation of electromagnetic or gravitational waves in spacetime can be analyzed using a WKB approximation. In the infinite frequency limit, known as geometrical optics, waves propagation is effectively described by massless particles following null geodesics. However, at large but finite frequencies geometrical optics gradually breaks down. In this regime, wave propagation can be effectively described by massless spinning particles following polarization-dependent trajectories. This is known as the spin Hall effect. While the equations of motion describing the spin Hall effect are covariant and very similar to the Mathisson-Papapetrou-Dixon equations, they depend on the choice of a timelike vector field, representing a family of observers. I will discuss the observer dependence of the position of massless spinning particles. While this is well known in flat spacetime, where it can be expressed in terms of Wigner translations, this problem is unexplored in curved spacetime.

Constructing asymptotically hyperbolic electrically charged riemannian manifolds with controlled mass

Alejandro Penuela Diaz, AEI-Potsdam Uni, alejandro.penuela@aei.mpg.de

Mantoulidis and Schoen constructed 3-dimensional asymptotically flat manifolds with non-negative scalar curvature, whose ADM mass can be made arbitrarily close to the optimal value of the Riemannian Penrose Inequality, while the intrinsic geometry of the outermost minimal surface can be “far away” from being round. The resulting manifolds, called extensions, are geometrically not “close” to a spatial Schwarzschild manifold. We will discuss the generalization to this result in the n-dimnesional case, with electric charge and with an arbitrary non positive cosmological constant.

Some recent developments in strong cosmic censorship

Harvey Reall, University of Cambridge, H.S.Reall@damtp.cam.ac.uk

The strong cosmic censorship conjecture asserts that Cauchy horizons inside black holes should be unstable. I will describe some recent work on this conjecture for the Einstein-Maxwell equations with a cosmological constant. The conjecture is violated by a near-extremal Reissner-Nordstrom-de Sitter (RNdS) black hole but respected by Kerr-de Sitter black holes. With a negative cosmological constant in 2+1 dimensions, the conjecture is violated by a near-extremal BTZ black hole. I will describe two ways of rescuing the conjecture. One involves enlarging the class of admissible initial data. The second involves quantum field theory effects.

An Implementation of DF-GHG with Application to Spherical Black Hole Excision

Hannes Rüter, Albert Einstein Institute Potsdam, hannes.rueter@aei.mpg.de

We present an implementation of the dual foliation generalized harmonic gauge (DF-GHG) formulation within our pseudospectral code bamps. The formalism promises to give greater freedom in the choice of coordinates that can be used in numerical relativity. As a specific application we focus here on the treatment of black holes in spherical symmetry. Existing approaches to black hole excision in numerical relativity are susceptible to failure if the boundary fails to remain outflow. We present a method, called DF-excision, to avoid this failure. Our approach relies on carefully choosing coordinates in which the coordinate lightspeeds are under strict control.

The Gravitational Memory Effect and Asymptotic States in Quantum Gravity

Gautam Satishchandran, University of Chicago, gautamsatish@uchicago.edu

A generic burst of classical gravitational radiation in asymptotically flat spacetimes will cause an array of freely falling test masses far from the source to experience a permanent displacement, called the "Gravitational Memory Effect". In the quantum theory, this effect (and its field theory analogs) are responsible for all "infrared divergences" in Quantum Gravity (and QFT). Hilbert space representations associated with different memories are unitarily inequivalent and, consequently, "out" scattering states live in an uncountably infinite set of unitarily inequivalent Hilbert spaces (one for each Memory). It is a priori unclear whether there exists an "in/out" Hilbert space which (1) includes states with Memory, (2) is separable and (3) unitarily implements the asymptotic symmetry group (B.M.S.). Remarkably there exists such a construction in Q.E.D. known as "Faddeev-Kulish dressing" however, we clarify that such a construction fails in Quantum Gravity. We shall further argue that a choice of Hilbert space satisfying conditions (1-3) corresponds to a (non-unique) choice of infinite-dimensional measure on the space of memories. In totality, our results suggest that there is no natural Hilbert space of "in/out" scattering states in Quantum Gravity. Therefore, this suggests the scattering between "in" and "out" states in Quantum Gravity are more appropriately described in the Algebraic framework.

Study of Vortical Null Geodesics in Kerr Spacetime

Tobias Sutter, University of Vienna, a01507794@unet.univie.ac.at

I will give a brief introduction into the equations of motion in Kerr spacetime and discuss some features resulting from them. Concentrating on vortical null geodesics (those with negative Carter constant), I will present a way to solve the equations of motion analytically and numerically. To conclude, I will present some preliminary visualisations of such vortical null geodesics, both single trajectories as well as what an observer located far away from the black hole in the region of negative radii would see.

Blow-up of waves on Friedman-Lemaître-Robertson-Walker spacetimes with arbitrary Riemmannian spatial metric

Liam Urban, University of Vienna, liam.urban@tutanota.com

We study the behaviour of solutions to the wave equation on a general class of Friedman-Lemaître-Robertson-Walker-spacetimes over $M = \mathbb{R}_+ \times \overline{M}$, where $\overline{M}$ is a closed 3-dimensional manifold equipped with an arbitrary Riemannian metric $\overline{g}$. For isotropic manifolds (M, g_{FLRW}), these spacetimes are believed to roughly describe the observable universe at large scales. Understanding the blow-up of waves in these backgrounds thus gives us an indication on how this model behaves with regards to nonlinear perturbation. To this end, we develop energy estimates adapted to the spatial geometry, which ultimately allow us to extract a smooth limit towards the Big Bang hypersurface $\{t = 0\}$ of waves rescaled by the homogeneous solution. From there, we derive open conditions on initial data on some sufficiently close spatial hypersurface to ensure that this leading term does not vanish. More precisely, the initial Neumann L2-data should both dominate the spatial Dirichlet L2-data up to order three as well as Neumann L2-data of spatial order 2 in some suitable way. Given these assumptions, an inverse polynomial blow-up of the wave towards the Big Bang singularity can be observed. In particular, one should stress that these results are obtained without any additional assumptions on the Riemannian metric $\overline{g}$. This work has been done jointly with David Fajman.

A non-Euclidean Newtonian limit of General Relativity

Quentin Vigneron, CRAL, Lyon, France, quentin.vigneron@ens-lyon.fr

I will be interested in defining a limit from general relativity, called non-Euclidean Newtonian limit, leading to a theory which is locally equivalent to Newtonian gravitation, but with a non-Euclidean geometry. It is constructed using the geometrised limit of Dautcourt, Künzle and Ehlers, corresponding to a limit from a Lorentzian manifold, carrying solutions of the Einstein equations, to a Galilean manifold. For non-Euclidean spatial geometries to be allowed in this limit, the stress-energy tensor in general relativity needs to feature additional source terms linked to the spatial Ricci curvature, especially an 'energy curvature' and an 'anisotropic stress curvature'. We discuss the relevance of these terms for relativistic cosmology.

Shining light on the interface of gravity and quantum physics: precision measurements using photonic quantum interferometry

Philip Walther, University of Vienna, philip.walther@univie.ac.at

Quantum mechanics and general relativity are two fundamentally different theories and have both been tested independently with very high precision. However, even after a century of research, the interplay of those two very different theories has never been tested experimentally. Within this talk I will present the experimental research aiming to explore this interface between quantum mechanics and general relativity by performing high-precision experiments at the level of single quanta of light, the photons. Such quantum systems allow one to examine the influence of gravity on interference effects. For this purpose, a high-precision interferometer whose paths are subject to different gravitational potentials will be used.

On the evolution of hypersurfaces along their inverse spacetime mean curvature

Markus Wolff, Tübingen University, markus.wolff@student.uni-tuebingen.de

We introduce a new inverse curvature flow on asymptotically flat Initial Data sets (M, g, K). In General Relativity, such a triple (M, g, K) arises naturally as a spacelike hypersurface of a Lorentzian manifold (L, h) with induced metric g and second fundamental form K, where (L, h) models an isolated gravitating system governed by Einsteins Equations. In the setting of General Relativity, Huisken–Ilmanen provided a proof of the Riemannian Penrose Inequality on time-symmetric $(K \equiv 0)$, asymptotically flat Initial Data sets satisfying additional physically reasonable assumptions using a weak notion of inverse mean curvature flow. Similar to inverse null mean curvature flow introduced by Moore, inverse spacetime mean curvature flow attempts a generalization of inverse mean curvature flow to non-time symmetric Initial Data sets. We develop the theory of both classical and weak solutions, where the latter are defined as solutions of a comparison principle. The main result presented in this talk is the existence of weak solutions to inverse spacetime mean curvature flow in maximal Initial Data sets. We further study the development of jump times in the interior region and the asymptotics of weak solutions. This is joint work with Gerhard Huisken.

The Causal Structure of Warped Flat Spacetimes

Raphaela Wutte, TU Wien, raphaela.wutte@tuwien.ac.at

The identification of the microscopic origin of gravitational entropy is one long-standing open puzzle in modern theoretical physics. Strominger showed in 1997 that the entropy of the three-dimensional BTZ black hole precisely matches the Cardy formula which counts states in a two-dimensional conformal field theory. Gravitational entropy can thus be reproduced via a counting of states in a dual field theory description. In this talk I discuss a particular class of three-dimensional spacetimes, dubbed warped flat spacetimes. I will present their geometric and thermodynamic properties, focusing in particular on their causal structure. Lastly, I will explain how their entropy can be accounted for through a dual field theory description. (Joint work with Stéphane Detournay, Wout Merbis and Gim Seng Ng, arXiv:2001.00020, JHEP 11 (2020) 061)

Stabilizing relativistic fluids on spacetimes with non-accelerated expansion

Zoe Wyatt, University of Cambridge, zw253@cam.ac.uk

The relativistic Euler equations are known, for a relatively general equation of state on a Minkowski spacetime, to admit unstable homogeneous solutions with finite-time shock formation. By contrast, in expanding spacetimes such shock formation can be suppressed. In this talk, I will present the stability of homogeneous solutions to the irrotational relativistic Euler equations with equation of state $P = K\rho$, where $0 < K < 1/3$, on certain Milne-like FLRW spacetimes. In particular, this provides the first case of non-dust fluid stabilization by spacetime expansion where the expansion rate is of power-law type but non-accelerated. This is based on joint work with David Fajman and Todd Oliynyk.

A Construction Towards Dynamical Black Hole Formation

Martin Lesourd, Harvard, BHI, mlesourd@fas.harvard.edu

The conjectures of Final State and Weak Cosmic Censorship concern the end state of spacetimes undergoing gravitational collapse. At present we do not have a single non-trivial class of these conjectures (i.e., not already isometric to Kerr at future timelike infinity). Combining works by An, An-Luk, Christodoulou, Corvino-Schoen, Li-Yu, we obtain a conditional statement: there exists a vacuum class of spacelike initial data sets which do not contain trapped surfaces (or MOTS) but which will yield a non-trivial class of vacuum examples if some form of Kerr Stability holds. Based on An's work the estimates we obtain also give the first dynamical formation of apparent horizons from Cauchy initial data and the first (non-spherically symmetric) dynamical spacetimes permitting to test the spacetime Penrose inequality, which is indeed verified in a region controlled by the initial data. Joint with N.Athanasiou. arXiv: 2009.03704