Abstracts

Contents

Updated: 16 December 2024

Leonardo Abbrescia
Georgia Institute of Technology, USA

Energy estimates for shock formation to the full 3D compressible Euler system without assuming additional regularity on the vorticity and entropy.

All known proofs of shock formation to the compressible Euler system in multiple spatial dimensions require the use of a "geometric" coordinate system in which the solution looks rather smooth relative to differential operators tailored to the geometric coordinates. Although this naively leads to a derivative loss in the energy estimates, Christodoulou found a way to recover the loss in his historic 2007 work on irrotational and isentropic relativistic Euler. For the full Euler system, one also must worry about a loss of derivatives in the vorticity and entropy. This was resolved by in 2018 and 2022 by Luk-Speck up to the first point of gradient blow-up and extended to a full connected component of the singular boundary by prior work joint work with Speck.

All these results required that the Cauchy data for the vorticity and entropy be as regular as the velocity, which limits the potential application to the shock development problem where the regularity across the shock is determined by the Rankine-Hugoniot jump conditions. In this talk, we will present a new robust method of closing the energy estimates without requiring additional regularity on the vorticity and entropy that could, in principle, be used to solve the unrestricted shock development problem. These energy estimates will be explained in the context of the construction of the Cauchy horizon.

Back to Contents Page →

Xinliang An
National University of Singapore, Singapore

On Black Hole Formation

In this talk, I will report several recent results toward black hole formation and naked singularity censoring.

Back to Contents Page →

John Anderson
Stanford University, USA

Shock formation for the Einstein—Euler system

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.

Back to Contents Page →

Stefanos Aretakis
University of Toronto, Canada

Observational signatures for extremal black holes

I will present observational signatures for extremal black holes. These signatures rely on the precise late time asymptotics for solutions to the wave equation on such backgrounds. I will also present asymptotics for subextremal backgrounds.

Back to Contents Page →

Sanchit Chatuverdi
Stanford University, USA

Zero viscosity limit of 1D viscous conservation laws at the point of first shock formation.

Despite the small scales involved, the compressible Euler equations seem to be a good model even in the presence of shocks. Introducing viscosity is one way to resolve some of these small-scale effects. In this talk, we examine the vanishing viscosity limit near the formation of a generic shock in one spatial dimension for a class of viscous conservation laws which includes compressible Navier Stokes. We provide an asymptotic expansion in viscosity of the viscous solution via the help of matching approximate solutions constructed in regions where the viscosity is perturbative and where it is dominant. Furthermore, we recover the inviscid (singular) solution in the limit, and we uncover universal structure in the viscous correctors.

This is joint work with John Anderson and Cole Graham.

Back to Contents Page →

Greg Fournodavlos
University of Crete, Greece

A localized construction of Kasner-like singularities

In this talk, we will give an overview of Kasner-like singularity constructions and present recent joint work with Nikos Athanasiou on localization procedure. We work with a first order symmetric hyperbolic formulation of the Einstein equations, in the second fundamental form of the Gaussian time slices and its spatial connection coefficients. Unlike in previous state of the art works, elliptic estimates are not needed to complete the construction which makes it easier to localize the argument. Also, the asymptotic data for the problem are explicitly constructed.

Back to Contents Page →

Dejan Gajic
Universität Leipzig, Germany

TBA

TBA

Back to Contents Page →

Joachim Krieger
École Polytechnique Fédérale de Lausanne, Switzerland

TBA

TBA

Back to Contents Page →

Junbin Li
Sun Yat-sen University, China

Gravitational waves perturbations to perfect fluid naked singularities

In this talk, we will discuss progress on trapped surface formation around spherically symmetric self-similar perfect fluid naked singularities due to small perturbations from gravitational waves (in a Holder space), which can be viewed as its low regularity instability in the full Einstein-Euler system.

Back to Contents Page →

Warren Li
Princeton University, USA

BKL bounces outside homogeneity

Regarding solutions to the Einstein equations in General Relativity, physicists Belinski, Khalatnikov and Lifshitz (BKL) proposed an ansatz for general spacetime metrics near (spacelike) singularities. They suggest that, near the singularity, the evolution of the spacetime geometry at different spatial points decouples and is well-approximated by a system of autonomous nonlinear ODEs, and that general orbits of these ODEs resemble a (chaotic) cascade of heteroclinic orbits called “BKL bounces”. In this talk, we present recent work verifying the validity of BKL’s heuristics in a large class of symmetric, but spatially inhomogeneous, spacetimes which exhibit (up to one) BKL bounce on causal curves reaching the singularity. In particular, we prove AVTD behavior (i.e. decoupling) even in the presence of inhomogeneous BKL bounces. The proof uses nonlinear ODE analysis coupled to hyperbolic energy estimates, and one hopes our methods may be applied more generally.

Back to Contents Page →

Jonathan Luk
Stanford University, USA

Late time tail of waves on dynamic asymptotically flat spacetimes, part I

We will present a general method for understanding the precise late time asymptotic behavior of solutions to linear and nonlinear wave equations in odd spatial dimensions. In the setting of stationary linear equations, we recover and generalize the Price law decay rates. However, in the presence of a nonlinearity and/or a dynamical background, we prove that the late time tails are in general different(!) from the better-understood case of linear equations on stationary backgrounds.

Back to Contents Page →

Siyuan Ma
Academy of Mathematics and Systems Science,CAS, China

TBA

TBA

Back to Contents Page →

Georgios Moschidis
École Polytechnique Fédérale de Lausanne, Switzerland

Weak turbulence on Schwarzschild-AdS spacetime

In the presence of confinement, the Einstein field equations are expected to exhibit turbulent dynamics. The simplest example of such behaviour is described by the AdS instability conjecture, put forward by Dafermos and Holzegel in 2006; this conjecture suggests that generic small perturbations of the AdS initial data lead to the formation of trapped surfaces when reflecting boundary conditions are imposed at conformal infinity. However, whether a similar scenario also holds in the more complicated case of the exterior region of an asymptotically AdS black hole spacetime has been the subject of debate.

In this talk, we will show that weak turbulence does emerge in the dynamics of a quasilinear toy model for the vacuum Einstein equations on the Schwarzschild-AdS exterior spacetimes for an open and dense set of black hole mass parameters.

This is joint work with Christoph Kehle.A

Back to Contents Page →

Sung-Jin Oh
University of California, Berkeley, USA

Late time tail of waves on dynamic asymptotically flat spacetimes, part 2

We will present a general method for understanding the precise late time asymptotic behavior of solutions to linear and nonlinear wave equations in odd spatial dimensions. In the setting of stationary linear equations, we recover and generalize the Price law decay rates. However, in the presence of a nonlinearity and/or a dynamical background, we prove that the late time tails are in general different(!) from the better-understood case of linear equations on stationary backgrounds.

Back to Contents Page →

Todd Oliynyk
Monash University, Australia

Localised Big Bang Stability

Since the 1920s, it has been known that the spatially homogeneous and isotropic Friedmann-Lemaître-Robertson-Walker (FLRW) spacetimes generically develop curvature singularities in the contracting time direction along spacelike hypersurfaces, known as Big Bang singularities, both in vacuum and across a wide range of matter models. For many years, it remained unclear whether these big bang singularities were physically relevant. A partial resolution to this question came in 1967 when Hawking established his singularity theorem, which guarantees that a cosmological spacetime will be geodesically incomplete for a large class of matter models and initial data sets, including highly anisotropic ones. While Hawking's singularity theorem ensures that cosmological spacetimes are geodesically incomplete for many initial data sets, it is silent on the cause of the geodesic incompleteness. It has been widely anticipated that the geodesic incompleteness is due to the formation of curvature singularities, and it remains an outstanding problem in mathematical cosmology to rigorously establish theconditions under which this expectation is true and to understand the dynamical behaviour of cosmological solutions near singularities.

In this talk, I will begin by introducing the FLRW and Kasner solutions of the Einstein-scalar field equations, which are exact, spatially homogeneous solutions that play a distinguished role in the analysis of Big Bang singularities. After briefly providing historical context for the FLRW and Kasner solutions in the development of cosmology, I will define what it means for an FLRW/Kasner big bang singularity to be stable. With this notion in hand, I will then discuss the recent influential FLRW and Kasner Big Bang stability proofs by Rodnianski-Speck and Fournodavlos-Rodnianski-Speck. One aspect of these stability results to which I will pay particular attention is their global nature. I will then discuss recent work done in collaborationwith Florian Beyer and Weihang Zheng, where we improve upon the Fournodavlos-Rodnianski-Speck big bang stability result by establishing the localized stability of Kasner big bang singularities in 4 spacetime dimensions over the full range of Kasner exponents where quiescent behaviour is expected. Localized stability is a stronger notion of stability that has interesting physical consequences, which I will briefly discuss at the end of my talk, time permitting.

Back to Contents Page →

Jan Sbierski
The University of Edinburgh, UK

TBA Singularity structure of FLRW spacetimes at low regularities

This talk investigates the structure of the Big Bang singularity in a variety of FLRW spacetimes. It is straightforward to compute scalar curvature invariants to determine whether a curvature singularity is present which excludes a continuation as a strong solution to the Einstein equations. In this talk the focus is on capturing the singularity structure at the level of the connection and the metric itself, determining which geometric quantities blow up and in which regularity class the solution breaks down.

Back to Contents Page →

Dawei Shen
Columbia University, USA

Global stability of Minkowski spacetime with minimal and borderline decay

---

The global stability of Minkowski spacetime has been proven in the celebrated work of Christodoulou-Klainerman in 1993. In 2007, Bieri extended the result of Christodoulou-Klainerman under lower decay and regularity assumptions on the initial data. In this talk, I will introduce my recent work, which extends the result of Bieri to minimal decay assumptions. Moreover, I will also discuss another recent work, which proves that the exterior stability of Minkowski holds with decay which is borderline.

Back to Contents Page →

Jeremie Szeftel
Sorbonne University, France

TBA

TBA

TBA

TBA

Back to Contents Page →

Martin Taylor
Imperial College London, UK

TBA

TBA

Back to Contents Page →

Wendelin Werner
University of Cambridge, UK

TBA

TBA

Back to Contents Page →