International Conference on Nonlinear Waves and General Relativity

December 13-15, 2017 (Wednesday - Friday)

TITLE & ABSTRACT

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Emergence of Apparent Horizon in Gravitational Collapse

Dr. Xinliang AN
University of Toronto

In this talk, I will solve $3+1$ dimensional Einstein vacuum equations in a spacetime region up to the "center" of gravitational collapse. With both hyperbolic and elliptic techniques, I will construct spacetimes, where a "black hole" region is dynamically forming from a spacetime point. The boundary (apparent horizon) of this "black hole" region is corresponding to solutions to a family of quasilinear elliptic equations. For an open set of initial data, this apparent horizon is smooth (except at the "center") and spacelike. It is thus a dynamical horizon in the physics literature. The second law of black hole thermodynamics is further verified along it.

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On the global regularity of the Einstein-Klein-Gordon coupled system

Professor Alexandru Dan IONESCU
Princeton University

I will discuss recent work in collaboration with Benoit Pausader on the global regularity theory for certain quasi-linear evolution models. The main example I will focus on is the problem of global stability of the Minkowski space-time under the Einstein-Klein-Gordon equations of General Relativity.

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On the mathematical theory of black holes

Professor Sergiu KLAINERMAN
Princeton University

I will review some the main open problems regarding black holes in the context of asymptotically flat solutions of the Einstein vacuum equations focusing on the problem of stability.

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On the instability of naked singularities

Professor Junbin LI
Sun Yat-sen University

The cosmic censorship conjecture, one of the most fundamental question in mathematical relativity, asserts that generic singularities arising from the Einstein field equations should be hidden inside a black hole. In the context of spherically symmetric solutions of the Einstein equations coupled with a massless scalar field, Christodoulou was able to prove this conjecture in late 1990s, by showing certain instability results of the naked singularities. By finding a robust proof of Christodoulou's result, while Christodoulou's argument depends strictly on spherical symmetry, we are able to generalize the instability results in some non-spherically symmetric cases. This is joint with Jue Liu.

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Stability and instability of Cauchy horizons in general relativity

Professor Jonathan Wing Hong LUK
Stanford University

I will introduce the problem of stability and instability of the Kerr Cauchy horizon in the context of Penrose's strong cosmic censorship conjecture. After presenting a recent result on the C^0-stability of the Kerr Cauchy horizon (joint with Dafermos), I will then discuss recent progress towards the conjectural $W^{1,2}$-instability of the Kerr Cauchy horizon (joint with Oh, Sbierski and Oh–Shlapentokh-Rothman).

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Tidal energy in Newtonian two-body motion

Professor Shuang MIAO
École Polytechnique Fédérale de Lausanne

In this work, which is based on an essential linear analysis by Christodoulou, we study the tidal energy for the motion of two gravitating incompressible fluid balls with free boundaries, obeying the Euler-Poisson equations. The orbital energy is defined as the mechanical energy of the center of mass of the two bodies. When the fluids are replaced by point masses, according to the classical analysis of Kepler and Newton, the conic curve describing the trajectories of the bodies is a hyperbola when the orbital energy is positive and an ellipse when the orbital energy is negative. If the point masses are initially very far, then the orbital energy, which is conserved in the case of point masses, is positive corresponding to hyperbolic motion. However, in the motion of fluid balls the orbital energy is no longer conserved, as part of the conserved energy is used in deforming the boundaries of the bodies. This energy is called the tidal energy. If the tidal energy becomes larger than the total energy during the evolution, the orbital energy must change its sign, signaling a qualitative change in the orbit of the bodies. We will show that under appropriate conditions on the initial configuration this change of sign occurs. Our analysis relies on an a-priori estimates which we establish up to the point of closest approach. This is a joint work with Sohrab Shahshahani from UMass Amherst.

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Correspondence and Rigidity Results on Asymptotically Anti-de Sitter Spacetimes

Dr. Chung-Tse Arick SHAO
Queen Mary University of London

In theoretical physics, it is often conjectured that a correspondence exists between the gravitational dynamics of asymptotically Anti-de Sitter (AdS) spacetimes and a conformal field theory of their boundaries. In the context of classical relativity, one can attempt to rigorously formulate such a correspondence statement as a unique continuation problem for PDEs: Is an asymptotically AdS solution of the Einstein equations uniquely determined by its data on its conformal boundary at infinity?

In this presentation, we present a key step toward this problem: we establish unique continuation results for wave equations on fixed asymptotically AdS spacetimes. We will also discuss applications of these results toward symmetry extension and rigidity theorems. One example is toward determining when a symmetry on the AdS boundary can be extended into the interior.

This is joint work with Gustav Holzegel (Imperial College).

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The Stability of the Minkowski space for the Einstein-Vlasov system

Professor Jacques Alexandre SMULEVICI
Université Paris-Sud

Joint work with David Fajman and Jérémie Joudioux. We prove the global stability of the Minkowski space viewed as the trivial solution of the Einstein-Vlasov system. To estimate the Vlasov field, we use vector field and modified vector field techniques. In particular, the initial support in the velocity variable does not need to be compact. To control the effect of the large velocities, we identify and exploit several structural properties of the Vlasov equation to prove that the worst non-linear terms in the Vlasov equation either enjoy a form of the null condition or can be controlled using the wave coordinate gauge. The basic propagation estimates for the Vlasov field are then obtained using only weak interior decay for the metric components. Since some of the error terms are not time-integrable, several hierarchies in the commuted equations are exploited to close the top order estimates. For the Einstein equations, we use wave coordinates and the main new difficulty arises from the commutation of the energy-momentum tensor, which needs to be rewritten using the modified vector fields. Similar results have been obtained independently by Martin Taylor and Hans Lindblad.

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The nonlinear stability of Schwarzschild

Professor Jeremie André SZEFTEL
Université Pierre et Marie Curie

I will discuss a joint work with Sergiu Klainerman on the stability of Schwarzschild as a solution to the Einstein vacuum equations with initial data subject to a certain symmetry class.

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Scalar curvature and singular metrics

Professor Luen-Fai TAM
The Chinese University of Hong Kong

In this talk, motivated by results on structure of smooth complete noncompact or compact manifolds in terms of scalar curvature, we will discuss similar questions for metrics which may not be smooth. We will discuss a positive mass theorem for asymptotically flat manifolds for metrics with a compact singular set of codimension at least two. For singular metrics, this kind of problems have been studied by Lee, McFeron and Székelyhidi, Grant and Tassotti, Lee and LeFeloch. We will also discuss the structure of compact manifolds with possibly singular metrics in terms of scalar curvature and Yamabe invariant. In particular, we will discuss singular metrics with nonnegative scalar curvature on a torus. The discussion is motivated by some well-known results of Schoen-Yau and Gromov-Lawson for smooth metrics. This is a joint work with Yuguang Shi.

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Long time existence for semilinear wave equations on asymptotically flat space-times

Professor Chengbo WANG
Zhejiang University

In this talk, we will talk about the long time existence of solutions to semilinear wave equations of the form $(\partial_t^2 - \Delta)u = |u|^p$, for small data with sufficient regularity and decay, of size ϵ, on a large class of $(1+n)$-dimensional Lorentzian nonstationary asymptotically flat backgrounds (M, g). Under the assumption that uniform energy bounds and a weak form of local energy estimates hold forward in time, we obtain the sharp lower bounds of the lifespan for three dimensional subcritical and four dimensional critical cases. For the most delicate three dimensional critical case ($p = p_c$), we obtain the existence result up to $\exp(c\epsilon^{-2(p-1)})$, for many space-times including the nontrapping exterior domain, nontrapping asymptotically Euclidean space and Schwarzschild black hole space-time.

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On the linear stability of higher dimensional Schwarzschild spacetime

Professor Mutao WANG
The Chinese University of Hong Kong

A new proof of the linear stability of the 4-dimensional Schwarzschild spacetime generalizing the approach of Chandrasekhar is available now. In contrast to Dafermos-Holzegel-Rodnianski's proof, the new one relies on the spherically symmetry of the underlying spacetime. Despite the limited prospect of utility for more general 4-dimensional spacetimes, we discuss the application of this approach to the linear stability of higher dimensional Schwarzschild spacetimes. This talk is based on joint work with Pei-Ken Hung and Jordan Keller.

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Global regularity for the $3D$ finite depth capillary waves system

Professor Xuecheng WANG
Tsinghua University

We will talk about the global regularity, scattering, and the non-existence of small traveling waves for the 3D finite depth capillary waves system for small initial data. In particular, the bottom is assumed to be flat.

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Wave equation on Kaluza-Klein backgrounds

Professor Wai Yeung Willie WONG
Michigan State University

We discuss decay estimates for wave equations on Kaluza-Klein backgrounds with emphasis on deriving improved decay for derivatives tangential to the compact factor using physical methods. Applications will be briefly mentioned.

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On global dynamics of the Maxwell-Klein-Gordon equations

Professor Shiwu YANG
Peking University

On the three dimensional Euclidean space, for data with finite energy, it is well-known that the Maxwell-Klein-Gordon equations admit global solutions. However, the asymptotic behaviours of the solutions for the data with non-vanishing charge and arbitrary large size are unknown. It is conjectured that the solutions disperse as linear waves and enjoy the so-called peeling properties for pointwise estimates. In this talk, we provide a proof for this conjecture for the massless case.