Week 3 Abstracts: Sept. 8-12, 2025

Speaker: Ruobing Zhang
Abstract: A Poincaré-Einstein manifold is a complete non-compact Einstein manifold with negative scalar curvature which can be conformally deformed to a compact manifold with boundary, called the conformal boundary or conformal infinity. Naturally, such a space is associated with a conformal structure on the conformal infinity. A fundamental theme in studying these geometric objects is to relate the Riemannian geometric data of the Einstein metric to the conformal geometric data at infinity which is also called the AdS/CFT correspondence in theoretical physics. In this talk, we will explore some new techniques from the metric geometric point of view, by which one can establish some new rigidity, quantitative rigidity, and regularity results.

Speaker: Ariadna Leon Quiros
Abstract: In 1977, D. C. Robinson developed a method for proving static vacuum Black Hole uniqueness in General Relativity. This method has recently been generalized to higher dimensions by C. Cederbaum, A. Cogo, B. Leandro, and J. Paolo dos Santos. It turns out that the same philosophy can prove several geometric inequalities. In my talk, I will show how to adjust this approach to prove the Riemannian Positive Mass Theorem. If time permits, I will discuss other related results. This is joint work with C. Cederbaum and B. Meco.

Speaker: Roland Steinbauer
Abstract: The cut-and-paste method is a procedure for constructing null thin shells by matching two regions of the same spacetime across a null hypersurface. Originally proposed by Penrose, it has so far allowed to describe purely gravitational and null-dust shells in constant-curvature backgrounds. In this paper, we extend the cut-and-paste method to null shells with arbitrary gravitational/matter content. To that aim, we first derive a locally Lipschitz continuous form of the metric of the spacetime resulting from the most general matching of two constant-curvature spacetimes with totally geodesic null boundaries, and then obtain the coordinate transformation that turns this metric into the cut-and-paste form with a Dirac-delta term. The paper includes an example of a null shell with non-trivial energy density, energy flux and pressure in Minkowski space. https://arxiv.org/abs/2508.00231 This is joint work with Miguel Manzano and Argam Ohanyan.

Speaker: Andrea Mondino
Abstract: TBA

Speaker: Zhizhang Xie
Abstract: In this talk, I will present my joint work with Jinmin Wang and Guoliang Yu on a new index theorem for manifolds with singularities, such as manifolds with corners and, more

generally, manifolds with polyhedral-type boundary. As an application, we obtained a positive solution to Gromov's dihedral rigidity conjecture. This conjecture concerns comparisons of scalar curvature, mean curvature and dihedral angles for compact manifolds with polyhedral-type boundary, and has very interesting implications in geometry and mathematical physics.
Further developments of this new index theorem have led us to a positive solution of Gromov's flat corner domination conjecture. As a consequence, we answered positively a long standing conjecture in discrete geometry — the Stoker conjecture.

Speaker: Gilbert Weinstein
Abstract: In this talk,I will discuss our recent result. Either there is a counterexample to black hole uniqueness, or the following statement holds. Axisymmetric, complete, simply connected, maximal initial data sets for the Einstein equations of nonnegative energy density with ends that are either asymptotically flat or asymptotically cylindrical, admit an ADM mass lower bound given by the square root of total angular momentum. Moreover, equality is achieved only for a constant time slice of an extreme Kerr spacetime. The proof is based on a novel flow of singular harmonic maps with hyperbolic plane target, under which the renormalized harmonic energy is monotonically nonincreasing. Relevant properties of the flow are achieved through a refined asymptotic analysis of solutions to the linearized harmonic map equations. This is joint work with Qing Han, Marcus Khuri, and Jingang Xiong.

Speaker: Eric Ling
Abstract: In 2018 Galloway and I established the following cosmological singularity theorem: If a spacetime satisfying the null energy condition contains a compact Cauchy surface with a positive definite second fundamental form (i.e., it's expanding in all directions), then the spacetime is past null geodesically incomplete unless the Cauchy surface is a spherical space (i.e., a quotient of the three-sphere). In this talk, some rigidity results of this singularity theorem will be addressed. Namely, we aim to answer the question: if the second fundamental form is only positive semidefinite and the spacetime is past null geodesically complete, then what can be said about the global structure of the Cauchy surface? In this case we show that the Cauchy surface (or a finite cover thereof) is necessarily a surface bundle over a circle with totally geodesic fibers. Our results make use of the positive resolution of the virtual positive first Betti number conjecture, which is a consequence of Agol's proof of the virtual Haken conjecture. We also identify several instances when passing to a cover is unnecessary. Lastly, we can relax the assumption on the second fundamental form provided the spacetime contains a U(1) isometry group. Several examples of our results will be discussed. This is joint work with Carl Rossdeutscher, Walter Simon, and Roland Steinbauer.