WEEK 1 Abstracts : August 25-29, 2025

Speaker: Stacey Harris
Abstract: An examination of the basic intuitions that figure in Lorentzian geometry and in some of the approaches to generalizations of that: boundaries (including singularities), low-regularity regimes, and the like.

Speaker: Shin-ichi Ohta
Abstract: In this talk, I will discuss Finsler spacetimes as a Lorentzian analogue to Finsler manifolds. Inspired by the recent breakthrough on an elliptic proof of the Lorentzian splitting theorem by Braun, Gigli, McCann, Ohanyan and Samann, we give a diffeomorphic timelike splitting theorem for Finsler spacetimes of nonnegative weighted Ricci curvature, as well as isometric translations for the special class of Berwald spacetimes. This is joint work with Erasmo Caponio and Argam Ohanyan.

Speaker: Robert McCann
Abstract: (Part 1) While Einstein's theory of gravity is formulated in a smooth setting, the celebrated singularity theorems of Hawking and Penrose describe many physical situations in which this smoothness must eventually breakdown. It is thus of great interest to reformulate the theory in low regularity. In the first lecture, we establish a low regularity splitting theorem by sacrificing linearity of the d'Alembertian to recover ellipticity. We exploit a negative homogeneity p-d'Alembert operator for this purpose. The same technique yields a simplified proof of Eschenberg (1988) Galloway (1989) and Newman's (1990) confirmation of Yau's (1982) conjecture, bringing all three Lorentzian splitting results into a framework closer to the Cheeger-Gromoll splitting theorem from Riemannian geometry. Based on joint work with Mathias Braun, Nicola Gigli, Argam Ohanyan, and Clemens Saemann: arXiv 2501.00702 arXiv 2410.12632 arXiv 2507.06836.

Speaker: Robert McCann
Abstract: (Part 2) While Einstein's theory of gravity is formulated in a smooth setting, the celebrated singularity theorems of Hawking and Penrose describe many physical situations in which this smoothness must eventually breakdown. In positive-definite signature, there is a highly successful theory of metric and metric-measure geometry which includes Riemannian manifolds as a special case, but permits the extraction of nonsmooth limits under dimension and curvature bounds analogous to the energy conditions in relativity: here sectional curvature is reformulated through triangle comparison, while and Ricci curvature is reformulated using entropic convexity along geodesics of probability measures.

The second lecture explores recent progress in the development of an analogous theory in Lorentzian signature, whose ultimate goal is to provide a nonsmooth theory of gravity. In a setting which relaxes local compactness, we describe a differential calculus for monotone curves and functions, and applications including a notion of infinitesimal Minkowskianity (that distinguishes Lorentz from Lorentz-Finsler norms), and a p-d'Alembert comparison theorem which allowed us to prove a Lorentzian splitting theorem on manifolds with regularity $g_{ij}

\in C^1$ in the first lecture. Based on joint work with Tobias Beran, Mathias Braun, Matteo Calisti, Nicola Gigli, Argam Ohanyan, Felix Rott and Clemens Saemann: arXiv 2408.15968

Speaker: Robert McCann
Abstract: (Part 3) A key inequality which underpins the regularity theory of optimal transport for costs satisfying the Ma-Trudinger-Wang condition is the Pogorelov second derivative bound. This translates to an apriori interior modulus of the differential estimate for smooth optimal maps. We describe a new derivation of this estimate with Brendle, Leger and Rankin which relies in part on Kim, McCann and Warren's (2010) observation that the graph of an optimal map becomes a volume maximizing non-timelike submanifold when the product of the source and target domains is endowed with a suitable pseudo-Riemannian geometry that combines both the marginal densities and the cost. This unexpected links optimal transport to the plateau problem in geometry with split signature, and shows the key difficulty is showing the maximizing submanifold is (uniformly) spacelike. See [85] and [33][39][46][52] at www.math.utoronto.ca/mccann/publications.