Foundations of Relativistic Viscous Hydrodynamics: toward a Well-Posed Theory

Supervisor: Juan Valiente Kroon

Research Group: Geometry, Analysis & Gravitation

Project description:

Relativistic hydrodynamics describes the motion of fluids in regimes where relativistic effects become significant. Such descriptions apply to a variety of physical phenomena, ranging from quark-gluon plasmas (fluids with flow velocities near the speed of light) to black hole accretion disks (fluids interacting with strong gravitational fields). Research in relativistic hydrodynamics is a hot topic, offering opportunities for interplay between mathematical analysis, numerical simulation, and theoretical and experimental physics.

In this project, the Supervisors aim to train the student in the mathematical tools involved in the study of relativistic fluids by investigating the following broad open problem: Can the geometric ideas that have been so successful in the study of relativistic perfect fluids be generalized to better understand viscous fluids at large scales?

While much is known about the PDEs used to describe relativistic perfect fluids ("Einstein-Euler is well-posed"), few analogous results hold when dissipation is taken into account. This project investigates the role played by higher-order dissipation and equations of state when Einstein's Equations are coupled to fluids. Recent progress has been made for viscous systems using symmetries, restrictions on viscosity terms, and simplifications to the equation of state of the fluid. In these special cases, one can employ techniques from PDE Theory, Dynamical Systems and Numerical Analysis to obtain analytical and qualitative results. However, application of conformal techniques remains largely uncharted.

Guided by advances in cosmology, conformal methods and dynamical systems approaches will be used to probe viscous fluids in various regimes of astrophysical interest. A successful research programme will result in a catalogue of restrictions emerging on the associated equations of state when higher order viscosity terms are considered. The researcher will build a knowledge base in PDEs, conformal methods and Mathematical Relativity as well as learning innovative techniques for future work in mathematical physics.

Further information:

How to apply

Entry requirements

Fees and funding